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D1.3: Success Stories and Good Practices Guide

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Abstract

This deliverable represents the first release of the H-CLOUD Success Stories and Good Practices Guide. It identifies and describes initiatives that provide added value to what is currently considered state of the art within the European cloud landscape and presents recommendations for future actions in the cloud computing field.

Keywords:

Cloud computing, cloud federation, edge computing, green IT

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Dissemination Level		
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DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

This deliverable represents the first release of the H-CLOUD Success Stories and Good Practices Guide. It identifies and describes initiatives providing added value to what is currently considered state of the art within the European cloud landscape and presents challenges and recommendations for future actions in the cloud computing field.

The deliverable is part of the outcomes of the H-CLOUD project. H-CLOUD leads coordination and support activities for the consolidation and growth of the cloud computing research and innovation community in Europe, bringing together innovators, policy makers, cloud computing researchers, industry stakeholders, and users into a participatory and sustainable open forum. To address the challenges and opportunities arising at the research, technology, policy, standardisation, and organisation levels, H-CLOUD provides the community with a rich set of collaborative content, tools, and actions to overcome fragmentation and increase collaboration in Europe and beyond, while aligning on a common direction to help create a strategic research, innovation, and deployment agenda for cloud computing in Europe.

Success stories and good practices in this deliverable have been identified primarily through a series of executive interviews, complemented by desk research.

The qualitative research encompasses European initiatives that have taken place or are being developed on a local, national, European, or global level and have been collected from different sources. Taking as reference the sources used in D1.1 Cloud Computing Portfolio (i.e., H2020 cloud-related funded projects, IDC's industry cloud tracker, and IDC Government Insights research), the research expanded beyond these sources and included the GAIA-X use-case directory, the International Data Spaces (IDS) use-case directory, and the Cloud28+ directory, as well as major EU telecommunications companies and governments' websites.

The interviews aimed at assessing whether the cloud-related initiatives could be considered success stories and good practices based on five identified criteria: business impact, technology innovation, organisational structure, data governance, and environmental & sustainability performance.

For this first release of the Success Stories and Good Practices Guide, via desk research, we identified 65 potential success stories relating to cloud computing, federated cloud, edge computing, and green computing. Out of 65 initiatives, 29 were considered to include good practices, following interviews performed from June to September 2020. Within the public sector, 10 relevant cases were identified; 11 were identified in the private sector, 6 in research and innovation (R&I), and 2 in public-private partnerships (PPPs).

The research highlighted that many challenges are being addressed with creative solutions, but there is still a long way to go to come up with a general set of good practices that can be applied broadly.

The key success factor in **federation** is adoption/participation. As indicated in both the H-CLOUD Green Paper and good-practices analysis, an increase in the number of users of shared, community, or federated services generates a positive network effect. However, it must be noted that it is difficult to achieve widespread adoption and collaboration due to, among others, organisational resistance and the presence of competing companies. Realising the benefits of collaborative programmes such as community clouds and federated clouds revolves around an ability to bring people together through the service lifecycle, from design and financing to implementation, operations, and consumption. The good practices identified succeeded in this by creating organisational and cultural change mechanisms that foster collaboration and by establishing structures and processes that make the collaborative supply of cloud services efficient, effective, and compliant with regulations – in particular, compliance with data laws and policies.

With reference to **edge** good practices, a business impact is present across the majority of the initiatives analysed (Vivacity Labs, Axis, and the City of Valencia, among others), which underlines how technology suppliers and end-user organisations are looking at edge

innovation to gain business benefits. As identified in the initiatives analysed, technology innovation represents another big-impact area. The approach of distributing computing capabilities is not a new trend, but edge can be seen as an emerging technology, with hardware and software platform innovations opening up new possibilities. Moreover, when edge computing is combined with other emerging technologies/innovation accelerators, it offers great potential. The main challenges to emerge from the interviews relate to technology – edge innovation still being in its infancy and difficulty in utilising developments in chip manufacturing (silicon), hardware infrastructure, and software platforms – and compliance (i.e. hurdles related to GDPR compliance).

Green IT is increasingly an important topic in the cloud industry, with several cloud service providers announcing ambitious goals with regards to CO2 neutrality. The question is, Will the shift to edge deployments make the entire infrastructure more or less efficient and sustainable? We have not yet found evidence to answer this question in the initiatives analysed, most of which indicate that green IT is a by-product of IT infrastructure transformation rather than a strategic priority. Nevertheless, some of the interviewees stated that green IT represents an important aspect in the development of their initiatives. The next release of this deliverable will focus on deepening knowledge in this area.

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1 INTRODUCTION

This section outlines the background, methodological approach, and structure of this document.

1.1 Background

H-CLOUD leads coordination and support activities for the consolidation and growth of the cloud computing research and innovation community in Europe, bringing together innovators, policy makers, cloud computing research, industry stakeholders, and users in a participatory and sustainable open forum. To address the challenges and opportunities arising at the research, technological, policy, standardisation, and organisational levels, H-CLOUD provides the community with a rich set of collaborative content, tools, and actions to overcome fragmentation and increase collaboration in Europe and beyond, while aligning on a common direction to help create a strategic research, innovation, and deployment agenda for cloud computing in Europe.

Starting from the Cloud Computing Portfolio (D1.1), this deliverable aims to:

- Identify the positive outcomes of the work undertaken by the European cloud community, highlighting success stories and good practices
- Develop recommendations for the implementation of future actions in the cloud computing field

Together with D1.1, this deliverable will populate the Online Catalogue and Knowledge Transfer (D1.5).

1.2 Methodological Approach

The identification of success stories and good practices in this deliverable is based on desk research and a series of interviews.

The qualitative research encompasses European initiatives that have taken place or are being developed at a local, national, European, or global level and have been collected from different sources. Taking as reference the sources used in D1.1 Cloud Computing Portfolio (i.e., H2020 cloud-related funded projects, IDC's industry cloud tracker, and IDC Government Insights research), the research expanded beyond these sources and included the GAIA-X use-case directory[1], the IDS use-case directory[2], and the Cloud28+ directory[3], as well as major EU telecommunications companies and governments' websites.

The interviews aim to assess whether cloud-related initiatives could be considered success stories that include good practices based on five identified criteria: business impact, technology innovation, organisational structure, data governance, and environmental & sustainability performance.

The methodology used in this report adopted the following steps, implemented between June 2020 and September 2020:

a) The creation of an evaluation grid to identify the features of a success story and/or a good practice

b) The creation of an interview guide

c) Desk research to expand the list of initiatives identified in D1.1

[1] https://www.data-infrastructure.eu/GAIAX/Navigation/EN/Home/home.html
[2] https://www.internationaldataspaces.org/get-involved/#usecases
[3] https://cloud28plus.com/EMEA/search?content_type=offerings

d) The selection of the most relevant initiatives to be contacted for interview

e) The conduction of interviews

f) The elaboration of interview results

g) The presentation of the main results of the analysis (i.e. the production of this deliverable)

1.3 Structure

This deliverable is structured as follows:

- Section 1 outlines the background, methodology, and structure of the deliverable.
- Section 2 provides an explanation of the criteria used to identify success stories.
- Section 3 presents the initiatives and provides an analysis of their success in terms of business impact, technology innovation, organisational structure, data governance, and environmental performance.
- Section 4 concludes the deliverable with the lessons learnt from the cases presented and proposes some recommendations on how to overcome challenges.

2 SUCCESS STORIES – INTERVIEW GUIDE STRUCTURE

The research undertaken for this deliverable aims to identify examples of success stories and good practices in the European cloud computing landscape. In particular, the objective is to identify initiatives particularly successful in relation to three main areas: cloud federation, edge computing, and green IT.

As part of the interviews conducted, we have looked for valuable input and expertise from a selection of organisations from both the R&I and the deployment contexts. For a case to be classified as a success story/identified as a good practice, the initiative concerned needed to fulfil at least two of the following outcomes/impacts:

- Business success
- Technology innovation
- Successful governance/organisational structure
- Efficient and effective data governance
- High environmental and sustainability performance

Business Success: The initiative should show a combination of results about users, offering, and revenues. A success story should be beyond the proof-of-concept (PoC) stage (i.e. actual usage in production for some real scenarios) and should demonstrate good performance in at least two of the following areas:

  - Uptake: service user numbers equal to or better than planned
  - Uptake growth rate: positive user growth – above a certain threshold (10%) compared with the previous year
  - Revenue growth: positive revenue growth – above a certain threshold (5%) compared with the previous year
  - Customer satisfaction: measured and higher than expected
  - High quality offering: equal to or better than planned, measured by the number, scope, and quality of the services delivered
  - Increase in usage volume: measured as an increase in transactions compared with the previous year

Technology Innovation: The initiative should offer highly innovative cloud services based on cutting-edge technologies – edge computing – with a disruptive impact on business processes. The main questions to identify a success story in this case are:

  - Does the initiative include at least one innovation accelerator – augmented reality/virtual reality (AR/VR), blockchain, artificial intelligence (AI), the Internet of Things (IoT), edge, and/or next-gen security?
  - Does the initiative have an impact on business processes?

Governance/Organisational Structure: The initiative should deploy a successful cloud federated model (or another collaborative model, such as a procurement alliance) and have a substantial breadth of representation of the stakeholder ecosystem. For an initiative to be identified as a success story, one or more of the following should be achieved:

  - An organisational structure that successfully supports active collaboration and stakeholder participation
  - Participant-organisation numbers by country, industry, and company size equal to or better than planned

Data Governance: The initiative should have efficient and effective data governance (an excellent performance in at least one aspect). To be considered a success story, the initiative should show an excellent performance in at least one of the following aspects:

- Data protection compliant with regulations and good practices
- The implementation of data sovereignty for stakeholders
- Effective and efficient data sharing
- Efficient and effective data security

Environmental and Sustainability Performance: The initiative should address green computing/energy efficiency. For an initiative to be identified as a success story, one or more of the following elements should be present:

- The use of efficient IT cloud architecture and resources
- The use of renewable energy sources
- The use of energy efficient technologies

The methodology described above allowed us to identify some interesting cases within the cloud computing landscape. However, another objective of this deliverable was to develop guidance and recommendations for future actions in the cloud computing field. For this reason, the interviews included questions to identify technical, legal, and economic barriers and to collect lessons learnt. In this respect, interviewees were asked to provide a description of the barriers encountered during the implementation of the initiatives, if any, and how they addressed and potentially overcame those barriers.

All success stories and good practices have been annotated in 'record cards' (Annex 1).

3 SUCCESS STORIES AND GOOD PRACTICES ANALYSIS

The first release of the Success Stories and Good Practices Guide includes 65 potential success stories, identified via desk research, relating to cloud computing, federated cloud, edge computing, and green computing. Out of 65, 29 initiatives were considered to include good practices, following interviews performed from June to September 2020. Within the public sector, 10 relevant initiatives were identified; a further 11 were identified in the private sector, 6 in R&I, and 2 public-private partnerships. In the following sections, more detailed descriptions of the initiatives are provided. Each one includes general information on the initiatives, their relation to the H-CLOUD key area, and an explanation of the good-practice success criteria met by the initiative.

Area	No. of initiatives listed as potentially including good practices	No. of initiatives identified as using good practices
Public sector	17	10
Private sector	31	11
Research & innovation	14	6
Public private partnerships	5	2
TOTAL	**65**	**29**

Table 1: Overview of Initiatives Analysed by Sector

While public sector and PPP initiatives were considered successful, particularly in relation to the governance model, private sector and R&I initiatives seemed to have outstanding results in relation to business success and technology innovation.

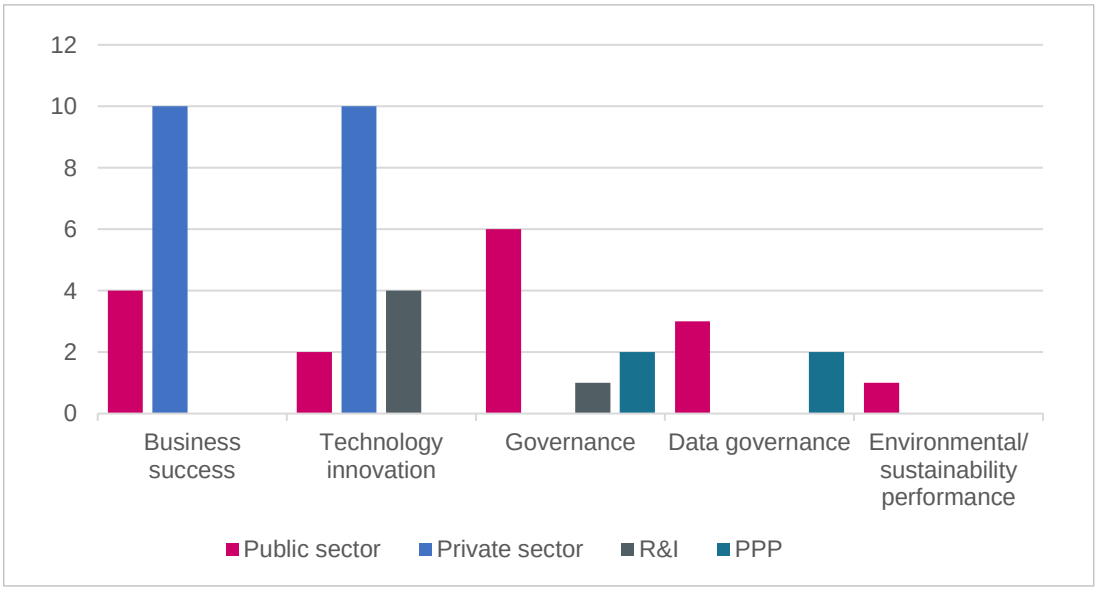

Figure 1: The Distribution of Initiatives That Include Good Practices by Sector and Success Criterion

3.1 Description of Stories

3.1.1 Public Sector

European public administrations have shared their IT resources for over 30 years to achieve economies of scale in procurement, skills, and operations. The 10 cases analysed here offer a wide variety of experiences; in fact, they represent 10 different countries, 9 of which are EU members, plus the UK. And they cover all layers of government, from national to regional/state to local/city (see *Table 2* below).

Name of the program	Country	Level of Government	Relevance for H-Cloud Key Areas	Status of the Initiative	Type of Good Practice
STATENS IT	Denmark	National	Federated cloud	In production	• Business impact • Governance and organizational change
Regional government IT shared service center		Regional	• Federated cloud • Green IT	In production	• Business impact • Sustainability
G-Cloud	UK	All levels	Federated cloud	In production	• Business impact • Data governance
Irish Government Cloud	Ireland	National	Federated cloud	In development	Governance and organizational change
Logius	Netherlands	National	Federated cloud	In production	• Governance and organizational change • Technology innovation
Austrian Federal Government EGIZ and BRZ	Austria	National	Federated cloud	In production	Governance and organizational change
City of Valencia	Spain	City	Edge computing	In production	Business impact
Ministry of Transport, Information Technology, and Communications	Bulgaria	National	Federated cloud	In development	Data governance
Polish Common State IT Infrastructure Program – WIIP	Poland	National	Federated cloud	In production	Data governance
SPOTES	France	National	Federated cloud	In development	Governance and organizational change

Table 2: Summary of Public Sector Initiatives Featuring Good Practices

At least 8 of them have followed a common journey, whereby the government launched programmes to centralise IT services and then leveraged the shared service centre to embrace the cloud computing paradigm. It must be noted that the business model for shared service centres varies across cases. Some of the analysed examples invested primarily to centralise the delivery of IT operations, while others acted primarily as brokers/buyers of services purchased on behalf of multiple government institutions from external service providers. When these jurisdictions transitioned to the cloud, those that had built a central IT operations centre invested first to become full integrators of private and public cloud services, while those that were primarily brokers and buyers of services set up marketplaces for public cloud services.

In the context of the H-CLOUD study, these experiences are relevant because they provide important lessons/learnings, particularly in terms of governance and organisational change that can be applied to federated cloud programmes. They provide some evidence around green IT sustainability, but mostly as a by-product of the efficiencies that come from centralising and modernising the delivery of IT infrastructure and operations. One of them, the City of Valencia, provides anecdotal evidence in the context of understanding the uptake and impact of edge computing in government. It indicates that European governments are at a very early stage of discovering potential use cases of edge – for instance, in the context of Smart Cities.

Statens IT

Statens IT[4] is the shared IT service centre for the whole of the Danish central government. It operates under the umbrella of the Danish Ministry of Finance. Statens IT started as a cost efficiency programme in 2010. It currently serves 30,000 government end-users; if one includes education institutions, that figure goes up by an additional 15,000 users.

Statens IT's portfolio encompasses end-user computing services, such as helpdesk and IT infrastructure & operations services, such as data-centre and application management. Statens IT leverages cloud computing in three ways:

- GovCloud.dk: Statens IT runs a community cloud within Statens IT data centres. It offers infrastructure-as-a-service (IaaS) solutions built on OpenStack and platform-as-a-service (PaaS) solutions built on HPE MapR software[5].
- Service brokerage for public cloud services: In particular, Statens IT is building capabilities to evaluate and procure services centrally, from AWS, Microsoft, and IBM, and to offer a federated identity system so that each government ministry and agency can securely consume those services.

Statens IT includes good practices related to **business impact, governance, and organisational change from federated clouds**, although challenges remain in terms of technology innovation.

- Business impact: In the past 10 years, Statens IT has grown to serve 30,000 government end-users; if one includes education institutions, that goes up by an additional 15,000 users. The key performance indicators that they focus on are customer satisfaction, continuity of operations, competitive pricing, reliable projects, and high-level information security.
- Governance: The first phase of the programme had a slow start because few government agencies – especially the largest ones – wanted to give up their IT experts and assets to the central shared service. The Ministry of Finance eventually mandated the usage of Statens IT. But, to compensate for the mandate, they created mechanisms for Statens IT 'customers' to influence decisions. This happens via a governance board and via a customer board. These boards take care of strategic decisions regarding the

[4] https://statens-it.dk/english/
[5] https://www.hpe.com/us/en/software/data-fabric.html

long-term roadmap and the business model. Working groups cover specific topics. All of these layers of governance involve customer representatives. Statens IT is solely funded by 'customer' demand. Prices are calculated by dividing the cost of operations by estimated demand. This chargeback model is a strong incentive to align with customer needs.

- Organisational change: All the people initially transferred from individual departments and agencies to Statens IT were operations people. They did not have a digitally enabled business innovation perspective in mind. And they depleted each ministry of technical skills. So, when Statens IT started to return to 'selling' services to ministries, few understood the technical language on the demand side. Statens IT then started to put together a service catalogue to make their offerings more structured. They joined Euritas[6] to learn from peers around Europe, and they invested in personnel certification and security clearance to offer high-quality information assurance. All of these organisational change investments improved relationships with customers.
- Technology innovation: Statens IT is trying to go above and beyond the provisioning of federated identity management (e.g. single sign-on) for commercial cloud services. In particular, they are trying to build 'shared tenant' with sub-tenants for each user that could be swapped, so that they can avoid having to purchase a lot of new licenses. However, the technology suppliers' terms and conditions make it difficult to implement this concept of 'consolidated clients'.

Regional Government Shared IT Service Centre

This is the shared service unit of a regional government. (The interviewee expressed a preference to remain anonymous.) The unit provides:

- Private cloud infrastructure services (via three data centres)
- System and technical architecture services
- Database administration services
- Solutions and products – essentially, shared applications, such as collaborative tools, virtual agents, and identity and access management

The unit serves regional government departments, local departments, and health authorities in the region.

In 2014, the share service centre started a community cloud programme with the intention of offering IaaS to the same users to which the unit has offered other services for over 20 years. An additional aim was to provide a platform to collaborate across the local small and medium-sized enterprise (SME) ecosystem.

This regional government shared service centre includes good practices related to **business impact and sustainability for federated cloud and green IT**, although challenges remain in terms of data governance and technology innovation.

- Business impact: The cloud strategy empowered this regional shared service centre to work with other industries and, in particular, to drive revenue growth with local technology SMEs. Local technology SMEs that have IT solutions – PaaS and software as a service (SaaS) – that need an infrastructure provider to host their services can rely on the shared service centre. The value-add for the SMEs is twofold: They can use a certified data centre, which qualifies them for public tenders, and they obtain access to support services to configure and maintain IaaS virtual machines, which hyperscalers would not offer to small companies.

[6] https://www.euritas.eu/

- Green IT: The implementation of the cloud data centre based on virtual machines reduced the energy bill by over 50% in just one year, even though the new data centre hosted more data and higher workloads.
- Data governance: The regional shared service centre being accountable for data governance, including for sensitive data managed on behalf of healthcare authorities, has driven investment into owned data centres, instead of experimenting with public cloud.
- Technology innovation: A lack of public cloud skills and pricing thresholds that hyperscalers have in their terms and conditions have limited the ability to experiment with public cloud services in a more agile manner.

G-Cloud

In the UK, the move to cloud started with the 2011 Government Cloud Strategy[7]. The G-Cloud programme entailed five elements that the 2011 strategy spearheaded:

- A cloud-first policy[8] (first issued in 2013) mandates that central government 'departments remain free to choose an alternative to the cloud but will need to demonstrate that it offers better value for money,' whereby 'cloud first' means 'public cloud rather than a community, hybrid, or private deployment model'. The policy is not mandatory, but 'strongly' recommended for the rest of the UK public sector.
- The Digital Marketplace[9] enables any supplier that is pre-qualified through framework contracts to advertise and sell its services.
- A standardised cloud information assurance[10] approach includes a pan-government accreditation mechanism that suppliers must undergo. The mechanism is based on a formal and independent process similar to the ISO 27001 standard and based on the Government Protective Marking Scheme, which guides the classification of information.
- A coordinated governance assigned responsibilities in the initial phases of the programme for proofs of concepts to various public sector entities, but it then centralised the scaling and operations of the programmes into the Government Digital Service (GDS)[11] and the Crown Commercial Service (CCS)[12]. GDS is in charge of defining and disseminating the strategic and technical guidelines for digital transformation across government, such as the Technology Code of Practice[13]. CCS is in charge of managing pan-government procurement programmes, including the G-Cloud framework, which qualifies suppliers to sell via the Digital Marketplace.
- Crown Hosting[14] data centres, a public private partnership, offers managed private cloud services to those organisations that are not ready to migrate all of their systems to public cloud or to build and run their own private cloud data centres.

G-Cloud includes good practices related to **business impact and data governance for federated cloud**.

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[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/266214/government-cloud-strategy_0.pdf
[8] https://technology.blog.gov.uk/2019/10/31/cloud-first-is-here-to-stay/ and https://www.gov.uk/guidance/government-cloud-first-policy
[9] https://www.digitalmarketplace.service.gov.uk/
[10] https://www.ncsc.gov.uk/collection/cloud-security
[11] https://www.gov.uk/government/organisations/government-digital-service
[12] https://www.gov.uk/government/organisations/crown-commercial-service
[13] https://www.gov.uk/government/publications/technology-code-of-practice/technology-code-of-practice
[14] https://crownhostingdc.co.uk/

- Business impact: As of Q1 of fiscal year 2020/21 (June 2021), the cumulative value of cloud services purchased through the Digital Marketplace[15] amounted to £6.43 billion, out of which £5.11 billion was purchased by central government departments and agencies, to which the cloud-first policy mandate applies. The Digital Marketplace has also made it easier for SMEs to do business in the public sector, which was one of the strategic goals of G-Cloud. By May 2013, there were over 700 suppliers, over 80% of which were SMEs.
- Data governance: One of the key factors that drove up the level of trust of UK government CIOs in cloud was the common and transparent approach to information assurance adopted by G-Cloud. Policies are issued and overseen by the Government Digital Service, which is a part of the Cabinet Office, and by the National Cyber Security Centre, a part of Government Communications Headquarters (GCHQ) – a British intelligence and security agency. The key information assurance milestones of the G-Cloud programme included the launch of a pan-government accreditation mechanism. The pan-government accreditation mechanism was particularly helpful for smaller government agencies that could not afford a thorough review and audit of services, as it enabled them to make their own decisions (which remained their full responsibility) based on a standard accreditation mechanism. The information assurance guidelines that formed the basis of the pan-government accreditation mechanism were:
    - A formal and independently verified process similar to the ISO 27001 standard
    - The Government Protective Marking Scheme (GPMS), which describes how 'government classifies information assets to ensure they are appropriately protected, to support public sector business and the effective exploitation of information, and to meet the requirements of relevant legislation and international/bilateral agreements and obligations.'

The pan-government accreditation process had certain drawbacks. In particular, it proved rather slow and expensive for both buyers and suppliers. As a result, in 2014, the UK government took two steps to streamline it. Firstly, in April 2014, a simplified GPMS entered into force. The new GPMS classifies information assets into official, secret, and top secret. Secondly, at the end of July 2014, the Government Digital Service (GDS) issued a communication that indicates that suppliers on G-Cloud will no longer need to obtain pan-government accreditation and that G-Cloud will also stop accepting new accreditation submissions. G-Cloud suppliers are instead required to self-certify their services, and buyers will become responsible for assessing and selecting the most appropriate cloud services to meet their individual security requirements. However, cloud services that connect to the Public Services Network (PSN)[16] still require pan-government accreditation (PGA).

Irish Government Cloud

The 2016 Irish Government ICT Strategy[17] followed three key principles:

- Digital services transformation
- Data sharing solutions and skills
- The Build to Share concept: If there is a good idea, build it once, build it well, and make it available for others to share.

15 https://app.powerbi.com/view?r=eyJrIjoiNTEyMTZhZDAtZGNiNi00OWQxLWI5ODYtMjg1ZWNlMmNkODVhIiwidCI6IjlmOGMwZDc5LTNlODctNGNkMy05Nzk5LWMzNDQzMTQ2ZWE1ZSIsImMiOjh9

16 https://www.gov.uk/government/publications/public-services-network-psn-service-compliance/psn-compliant-services

17 https://ictstrategy.per.gov.ie/

The Build to Share part of the strategy aimed to bring together 20 departments. So, a roadmap for hybrid delivery was seen as an opportunity to scale ICT infrastructure capabilities. The roadmap included two steps:

1. Step 1, Guidance:[18] The policy left the option open for private vs. public based on data sensitivity and other factors, including:
    a) The availability of commercial solutions for different workloads/use cases
    b) The complexity of migrating core legacy systems
    c) The need to audit systems, whereby auditors want to see the physical security, which is difficult with public cloud
    d) Accessibility for users outside government, in which case, it is easier to build the systems outside of the government firewall
2. Step 2: Build government private cloud capability with the ability to burst to hyperscaler services. The environment is fairly cheap and reliable, and full automation enables remote maintenance, which has proven very valuable during the COVID-19 crisis. But it cannot cope with huge scalability requirements. For instance, www.gov.ie was getting 70,000 hits per minute after the COVID-19 announcements; the web server is hosted on AWS, because it was not scalable in private cloud.

The Irish government Build to Share strategic programme includes good practices related to **governance and organisational change for federated cloud**. The strategy implementation governance includes three tiers:

- Civil service management board: This includes secretary generals of every department; the government CIO gets invited twice a year and shows a dashboard about the progress of the strategy.
- Sub-group: These are co-chaired by two of the most influential secretary generals (finance department and welfare department). This is where the collective decision making happens about the overall government digital strategy.
- ICT advisory board: This is the head of IT of every department; in some departments, this is a role reporting to the secretary; in others, they are more junior, and they discuss more technical and tactical guidelines and action plans.

The success at the central government level is driving the CIO's office to consider a memorandum of understanding to enable local governments to access some resources, but local councils are still very independent and have their own shared service entity[19].

Logius

Logius[20] employs about 500 people. It is a shared service entity that provides critical digital services for the Dutch public sector, such as:

- Dutch digital ID for citizens (DIGID)
- Freight/Port customs declaration management systems (XBRL-based declarations)
- Dutch digital ID for businesses

To deliver its services, Logius uses two infrastructures:

- A data centre platform acquired from another government entity that supports applications of national interest, such as DIGID

[18] https://www.gov.ie/en/publication/078d54-cloud-computing-advice-note-october-2019/
[19] https://www.lgma.ie/en/
[20] https://www.logius.nl/english

- A data centre that supports less critical applications

Logius includes good practices related to **technology innovation and organisational change for federated cloud**.

- Technology innovation: Logius considers cloud computing a key pillar for agility. Logius is working on developing a Kubernetes container-based orchestration layer that aims to rollout to AWS, Azure, and government private cloud data centres, representing a truly interoperable orchestration layer for agile deployment. The orchestration layer, which Logius is building on open source (OpenStack and OpenShift), aims to include all the capabilities necessary to manage cloud federation, from service catalogue to performance dashboard and backup.
- Organisational change: The Logius internal operating model and culture is changing to offer more agile and scalable services to government departments. Big product/application silos were broken up in 2019. In the production house, planning is carried out in three-month cycles. Everything is based on business-case discussions that rigorously evaluate potential demand, legacy migration costs, and other factors. The challenge is that large agencies and departments have a disproportionate level of influence, which may create biases in decision making.

Austrian Federal Government

The Austrian government started a digital reform process almost 20 years ago. Austria was lagging behind in terms of the EU's eGovernment Benchmark. So, the decision was taken to create two agencies at the federal government level, which took the lead in digital transformation programmes:

- The eGovernment Innovation Centre (EGIZ)[21] is in charge of strategic innovation. EGIZ focuses on the feasibility and prototyping of new solutions. EGIZ has an unbiased perspective of companies selected to do the work to implement those solutions in a production environment. One of EGIZ's strategic goals is to ensure openness and interoperability are the gold standard for government technology innovation. Any organisation, down to the municipal level, can leverage the work of EGIZ. The need to do so is particularly urgent in small to medium-sized public administrations because, internally, they have the resources only to carry out day-to-day activities.
- The Federal Computing Centre (BRZ)[22] is the operating arm. It provisions finance applications, citizen web portals and registries, scanning and printing services, and business intelligence (BI) and analytics solutions for the federal government.

The Austrian Federal Government's initiative includes a good practice related to **governance for federated cloud**. Separating innovation (EGIZ) from implementation (BRZ) has helped the Austrian Federal Government focus all government innovation decisions on interoperability standards, feasibility, and prototyping, as defined in a minimum set of guidelines. At the operational level, the key goal is to keep the service catalogue commercially competitive in the long run for the Austrian Federal Government by continuously adjusting the balance of the service portfolio between what is shared and what is left to the individual ministries. EGIZ and BRZ collaborate closely. But they are managed and funded separately – EGIZ is contracted for work by the Federal Ministry of Digital and Economic Affairs, while BRZ is partially funded through a chargeback model – to maintain the independence of decision making. And they have a different set of expertise. In fact, EGIZ is mostly staffed by academic researchers, while BRZ is staffed by IT management experts. Committee meetings every six months are held to foster alignment with CIOs in each ministry. The challenge is that decision making, particularly at EGIZ, is very much dependent on political commitment to advance work. So, it becomes very hard to keep the political focus on the value of IT innovation when politicians have their

[21] https://www.egiz.gv.at/en/
[22] https://www.brz.gv.at/en/

own short-term electoral goals in mind; the most innovative projects may produce benefits only in the long term.

The City of Valencia

The Valencia Smart City Project[23], which began in July 2014, aimed to the integrate data and processes of municipal services into a platform that would help improve the efficiency and responsiveness of administration. This project, which includes 17 initiatives, aims to provide the city with new solutions in five different areas – mobility, governance, environment, society, and wellbeing.

The València City Platform (the VLCi Platform) is the first Smart City commercial platform deployed in Spain that uses the European FIWARE Smart City context broker. The core capability of the VLCi Platform consists of the integration of data from many municipal information systems (population registries, integral water cycle, mobility, municipal assets, digital services, and the national statistical office [INE]), with data feeds from devices that are deployed in the city (environmental noise and traffic sensors, traffic control cameras, lighting controllers, municipal building controllers, etc.).

The Valencia Smart City project is an example of the potential value of integrating systems of records data (e.g. enterprise resource planning [ERP] and citizen registries) with feeds from IoT and edge computing. The Valencia initiative includes a good practice related to **business impact for edge computing** because of how it uses the data integrated on the platform to improve citizen services. During the COVID-19 crisis, the data platform was used to offer citizens updated and consolidated information and communication through the Information Unified COVID19 site[24] and AppValència. These services provide real-time information about the crisis, such as dynamics dashboards, information on municipal services, news and tweets from the municipality, and an overview of the situation on a national level. The website also has a section called New Normal, which provides guidelines for various activities – work, shopping, restaurants, beaches, hotels, sports, cultural events and venues, transport, and so forth.

The Ministry of Transport, Information Technology, and Communications of Bulgaria

The Ministry of Transport, Information Technology, and Communication is in charge of designing and implementing policies that impact the development of critical physical and digital infrastructure for the country. One critical area that the ministry oversees is the construction of transport infrastructure, and it is investigating the usage of data to make more informed decisions about planning, construction, inspection, and maintenance. In particular, the ministry is studying the value of the huge volume of data generated during the construction phase, such as data that becomes relevant for timely maintenance and the avoidance of incidents, data that can be used for predictive analytics for preventive maintenance, and data to enhance the effectiveness of initial investments.

The ministry considers cloud an enabler of more advanced analytical capabilities. But it also considers **federated cloud** to have no value without appropriate **data governance**, which would enable information sharing across the ministry, local governments, the private sector (e.g. engineering and construction companies), and even European Union countries. Hence, the ministry is working on an initiative to establish data sharing good practices for data governance relating to the construction of transport infrastructure. The challenge is that, in the different Member States, legislations mandate different requirements in terms of documents to be collected in the construction phase. This prevents the transnational use of data. Legal interoperability is needed.

[23] http://smartcity.valencia.es/en/
[24] https://coronavirus.valencia.es/

Transport infrastructure construction phase data includes both technical data and contract implementation data. All of that could be fed into a cloud-based open data space that can be then analysed to detect anomalies that could trigger preventive maintenance. For example:

- Certification laboratories/bodies control whether construction materials are compliant with safety regulation. Different legislations mandate different requirements in terms of the certification process (who signs the certificates) and governance (national or regional government audit and oversight responsibilities).
- Testing standards can be different. For instance, in Bulgaria, some of the bridge load design and testing standards are, or were until very recently, based on normative documents implemented during the soviet era.
- Construction projects have different timings. Depending on how long the project is, reporting requirements differ regarding how to document problems that arise during the project. These audit logs could be used as red flags for predictive maintenance.

Polish Common State IT Infrastructure Program

Wspólna Infrastruktura Informatyczna Państwa – the Polish Common State IT Infrastructure Program (WIIP) – aims to increase the security of data processed by public administration entities and optimise the costs of ICT systems. WIIP's strategic goal is to optimise existing ICT resources and applications in public administration by providing modern and cost-effective solutions. This way of operating public administration will enable priorities to be set in terms of security improvement, comprehensive migration plans, and balancing the use of cloud solutions.

WIIP comprises multiple projects and initiatives. Two of the planned deliverables are:

- Government Cloud: This comprises private cloud for central and local government and is currently in development; some services are already available. The Government Cloud will be completed in 2022. For now, it offers basic IaaS services. There are plans to gradually add more complex IaaS services, and the service catalogue will expand to include everything as a service (XaaS).
- Cloud Service Provision System (ZUCH): ZUCH is a marketplace through which certified cloud partners can offer their cloud services in the government sector in Poland. ZUCH was launched in Q2 2020 and currently has more than 20 tech partners.

The WIIP initiative includes a good practice related to **data governance for federated** cloud. WIIP used the same approach as that taken for the UK's G-Cloud and adapted it to the Polish context so as to follow clear guidelines established by the Ministry of Digitalisation regarding both government users of services and tech suppliers participating in the programme.

- Classified data (confidential) CANNOT be stored or processed in any cloud.
- Sensitive data can be stored and processed in Government Cloud (private cloud).
- Personal data (and systems handling such data) that has to be GDPR compliant may be stored or processed in public cloud BUT only if the data centre is located in Poland.

Other data (from small systems, websites, office apps, and open data databases) may be stored and processed in public clouds that use data centres located in Europe.

Tech suppliers that want their cloud services to be available to public administrations are certified before being accepted into the ZUCH. Verification is formal (whether a company is legitimate, pay taxes, has no debts, and is generally a reliable partner), as is security verification (whether all norms, certificates, and security policies are met). Each provider must complete a questionnaire. Service providers must be verified by the ministry before being added to the marketplace to ensure their services meet all requirements. The biggest challenge was to standardise services criteria for providers willing to join ZUCH: Services must be compliant with regulations and security policies in terms of both technologies and

pricing/invoicing. Achieving this took a long time – especially as providers differ significantly in the ways they offer their services. In some cases, the ministry decided to focus on the comprehensiveness of services rather than on individual parameters. Framework agreements have also been introduced.

SPOTES
SPOTES is a marketplace for IT services for government employees that the Ministry of Ecological Transition is developing and piloting on behalf of French government digital agency DINUM.

The marketplace is now running on the ministry's private cloud and is based on OpenStack. The service catalogue includes:

- Workplace services
- Collaborative tools
- IaaS
- PaaS
- Helpdesk support
- Architecture and methodology

Services are available both individually and as packaged solutions.

SPOTES includes good practices in **governance and organisational change for federated clouds.**

The main challenges were to change the minds of engineers and end users and to shift the focus from IT assets to a user-oriented service value chain – service choice, ordering, payment, and support. To tackle these challenges:

- Joint governance committees with representatives from all ministries were set up.
- A common service taxonomy was defined.
- Access to services was granted to all ministries by offering different authorisation profiles/roles.
- Common key performance indicators (KPIs) were defined and are monitored – user experience, number of transactions, number of registered users, number of tickets, and number of offerings.
- Knowledge is shared through events, seminars, educational material, and blogs made available in the marketplace.

The ministry has received funding from DINUM to act as a pilot user for SPOTES.

3.1.2 Private Sector

Private sector organisations in Europe generally build their own cloud services and cloud marketplaces and are less inclined to federate their offerings, as the business model for federation is not clear and the security standards and auditing mechanisms are not established. The 11 identified initiatives that feature good practices offer a wide variety of experiences; in fact, they represent 10 different countries, 8 of which are EU members, plus the UK and Norway. They come from different industries and cover very different solutions (see Figure 3).

Despite their vastly different use cases, important lessons can be learnt around the necessity for substantial economic investment in marketing solutions and achieving broad market

acceptance, the need to have a standardised data structures to create federation, and the necessity to decide at which levels federation should happen.

Name of the program	Country	Relevance for H-Cloud Key Areas	Status of the Initiative	Type of Good Practice
Polymore	Germany	• Federated cloud • Green IT	In development	• Business impact • Technology innovation
ThreeFold Network	Belgium	Federated cloud	In development	• Business impact • Technology innovation
Citynetwork	Sweden	Federated cloud	In development	• Business impact • Technology innovation
AquaCloud	Norway	Federated cloud	In development	• Business impact • Technology innovation
CloudSME	Germany	Federated cloud	In development	• Technology innovation
Cloud 28+	European	Federated cloud	In development	• Business impact
Vivacity Labs	UK	Edge	In development	• Business impact • Technology innovation
BrianzAcque	Italy	Edge	In development	• Business impact • Technology innovation
Axis	Italy	Edge	In development	• Business impact • Technology innovation
Worldsensing	Spain	Edge	In development	• Business impact • Technology innovation
Leading EU car manufacturer	Poland	Edge	In development	• Business impact • Technology innovation

Table 3: Summary of Private Sector Initiatives that Feature Good Practices

Aquacloud

Aquacloud[25] is an innovation project from the Norwegian aquaculture sector that collects and consolidates data sets from different aquaculture companies to solve a shared problem – predicting and preventing the outbreak of sea lice. Aquacloud has built a central repository for data that integrates the production systems of aquaculture companies. Over time, it has become clear that the real benefits are the establishment of a shared data model based on an updated standard for collecting relevant data and an ability to share this data across a wide ecosystem. The importance of creating a meaningful governance framework became apparent. In fact, the project has evolved from a pure-sea-lice forecasting asset into an industry hub that includes companies from multiple subsectors of the industry. Aquacloud includes good practices related to **business impact and technology innovation**.

CloudSME

[25] https://seafoodinnovation.no/whatwedo/aquacloud/

CloudSME[26] emerged from the CloudSME Project and is today a private sector company that specialises in the commercialisation of MiCADO technology, which was developed under the EU funded COLA project. It is a highly scalable multicloud Kubernetes orchestration engine, specialising in supporting compute-intensive simulations. CloudSME includes a good practice related to **technology innovation**.

CloudSME works closely with the universities that helped develop the technology and focuses on taking MiCADO to market. Reaching a broader market and obtaining relevant certifications are challenges still to be overcome.

Cloud28+

Cloud28+ is an initiative that was started by HPE in 2015 to provide a marketplace through which European cloud providers could showcase their cloud services built on HPE and OpenStack technology. Since its foundation, Cloud28+ has evolved into a global initiative, with more than 1,000 cloud service providers active in the marketplace. For this reason, Cloud28+ includes a good practice related to business impact.

The most important requirement for being in the marketplace is ensuring that all participants comply with their self-declared security and compliance standards. Furthermore, it quickly became clear that a substantial marketing budget would have made European customers aware of the Cloud 28+ marketplace, enabling participating partners to gain traction.

The key learning from Cloud28+ is the need for a strong partner like HPE to drive the development, management, and marketing of a digital cloud service platform, with marketing being the most expensive component.

Polymore

Polymore[27] is a start-up owned by Kraussmaffei that helps clients find the right business partners for plastics compounders and converters in a few clicks. Polymore matches user requests with the most suitable suppliers. Through Polymore's web interface, suppliers create offers and buyers fill out online requests. Once offers have been made, buyers can directly contact the respective suppliers for more details and/or to negotiate terms. Sustainability is a part of Polymore's business model, as the platform enables full-circle plastics production. As a part of this principal, Polymore includes reusable materials and post-industrial waste (by-products) in its portfolio, thus helping to improve the sustainability of Polymore users and the plastics industry as a whole. Polymore's parent company, Kraussmaffei, is also active in lobbying. The Germany-based company adheres to green computing principals, using renewable energy sources and energy-efficient technologies to reduce its CO2 footprint.

The Polymore initiative includes good practices related to **business impact, green IT, and technology innovation**.

- Business impact: Polymore has many website visitors (web traffic/impressions), offers online marketing, has many registered and active users, and records many transactions. Polymore's business achievements include:
    - 60,000 tons of plastics requested – 80% recycled
    - 200–300 unique visitors per week
    - 2–3% click-through rate
    - Hundreds of sellers in the portfolio of traders and producers

  Polymore is also increasing its revenue through subscription/membership fees.

[26] https://cloudsme.eu/
[27] https://www.polymore.com/en/buyers

- Technology innovation: Through its online platform, Polymore enables customers and suppliers to connect with each other, thus satisfying both stakeholders. The platform does not allow the sharing of customers' personal data. Polymore relies on AWS to protect data.

Polymore is struggling to find an AI solution to automate matchmaking, which is currently done manually. To circumvent this problem, Polymore currently utilises AWS's microservices. Nevertheless, from a sustainable point of view, Polymore meets all European Commission requirements.

ThreeFold Grid

ThreeFold Grid[28] is a peer-to-peer network of storage and compute capacity developed by ThreeFold Technologies (TFT). It creates a decentralised, privacy focused, and secure resource pool of participants that add their compute and storage capacities to a grid. TFT has developed its own operating system, which turns any server or storage system into a node of the grid, with the same security attributes, and federates all of the diverse compute resources into one unified resource pool (the grid). All resources that are added are managed by blockchain, so there is full transparency and immutability of the resources added. TFT solves the problem of IT hardware diversity by adding its own operating systems to every resource, large or small, before including them in the grid.

ThreeFold Grid includes good practices related to **business impact and technology innovation**.

- Business impact: ThreeFold Grid is growing at a double-digit rate, with country-level projects increasing. This is because ThreeFold Grid enables the establishment of peer-to-peer networks at different levels – at the community level, regional level, country level, and global level, depending on the defined scope. Another key area of growth is partner adoption. These features have enabled TFT to increase its audience.
- Technology innovation: Blockchain is the main technology innovation driver for ThreeFold Grid. Other technology innovations have also expanded – for example to non-profit foundations, technology companies, municipal councils, and large organisations. Furthermore, the compute-and-storage grid is TFT's first major use case to prove the technology and potentially deliver a meaningful impact for humanity and the planet.

By covering all key areas, TFT is clearly taking the European Commission goals seriously. TFT has created an independent peer-to-peer network in which every organisation can participate, has added its own resources to the grid, and is being compensated for it. TFT enables a true bottom-up cloud-based federated initiative and has developed a mechanism to manage the technical aspects of federating highly diverse resources in a secure and efficient way – in contrast to the highly centralised global cloud providers, which effectively build the whole infrastructure themselves.

Using green and efficient energy and technology, TFT combines IT innovation with a forward-looking vision aimed at improving human lives and the planet. The barriers the company faced related to costs, complexity, non-scalability, and security. No legal barriers arose, and the economic barriers have been overcome with other solutions that ensure sovereignty, scalability, sustainability, and security.

City Network

City Network[29] is a European cloud service provider headquartered in Sweden and provides scalable and cost-effective cloud services from its own data centres around the world. Its public

[28] https://threefold.io/
[29] https://citynetworkhosting.com/

cloud platform, City Cloud, enables customers to get instant access to cloud computing power and complete control over where and how their data is stored. Its hosted private cloud service is used in industries such as finance, healthcare, and the public sector. Beyond that, City Network offers managed cloud services, professional cloud services, and cloud training services.

City Network includes good practices related to the **business impact of cloud and technology innovation**.

- Business impact: Customers (especially in finance, healthcare, and the public sector) and revenues are growing exponentially. This also enabled City Network to help European organisations develop their skills by educating their employees and customers in the latest cloud-native technologies available in Europe.
- Technology innovation: City Network drives technology innovation internally by building leading cloud services – in particular, for highly regulated industries. It invested into AI through partnerships with European AI companies. City Network is also engaged in the GAIA-X process and will support the GAIA-X initiative.

City Network can be considered a valuable asset for Europe because of its approach and potential towards cloud federation. City Network offers an OpenStack-based public cloud service that can be federated with other OpenStack-based public cloud services, of which there are 20 across Europe. Because OpenStack is an open-standards-based technology stack for infrastructure provision and management, federating OpenStack-based clouds is easier than federating other clouds.

Barriers to participation in cloud federation initiatives include huge investments in infrastructure. In addition, there is no customer demand at the moment to justify such investments. However, the GAIA-X initiative could provide a technology to implement and to ensure greater data sovereignty across Europe. City Network would benefit from GDPR and if the data protection authorities were to enforce the Schrems II ruling about the inadequacy of the EU-US Privacy Shield. Moreover, it would be better if European companies and European public sector organisations bought from European-headquartered cloud providers instead of large cloud providers headquartered outside of the EU.

Vivacity Labs

Vivacity Labs[30] is a British company that provides artificial intelligence-based products and services to support municipalities in traffic management. Its solutions leverage images and videos to gather anonymous movement data. The company provides both AI-enabled sensors (cameras) and a platform for data communication, storage, and management. Insights relate to how roads are being used, classifying different road-user types (car, truck, pedestrian, cyclist, …) and how they interact on the road. This more recently includes measuring social distancing and interaction between people. The company has more than 3,000 sensors deployed around the world, but it is mainly active in the UK. Vivacity Labs' use of edge includes the deployment of smart cameras running AI at the edge and leveraging edge computing platforms, like edge GPUs, to run image detection and analysis and to extrapolate anonymous insights sent from the camera to the software platform. The key drivers behind edge, for Vivacity Labs, are:

- A desire to run AI locally, at the Edge, to support low latency use cases
- A desire to reduce bandwidth and camera connectivity costs
- Privacy by design, including deleting sensitive and/or personal information before it leaves the sensor (depending on the use case implemented)

[30] https://vivacitylabs.com/

Vivacity Labs includes good practices related to **business impact and technology innovation.**

- Business impact: The company measures success at different levels (using various KPIs). The number of sensors (cameras) deployed worldwide (but primarily in the U.K.) currently exceeds 3,000. Revenues have grown consistently since 2015, doubling every year. Other KPIs include:
    - Client adoption and usage KPIs: the number of accesses to data on the dashboard/via an API; the number of customers buying sensors (currently 60%); and the number of cities adopting sensors (increased from 20 in January 2020 to 30 in July 2020)
    - Use-case-level KPIs: results achieved by the use case for the customer, such as achieving and improving traffic throughput and savings through more efficient traffic (e.g. the number of cyclists using a junction)
- Technology innovation: Vivacity Labs mainly researches and develops software solutions and algorithms to extract the highest value from a combination of innovative technologies, such as AI, IoT, and edge. Innovation is driven by the internal design and development of technology and AI algorithms to better use edge hardware and address new needs in the market. Another key element from the technology standpoint is involvement in the technology ecosystem for every aspect.

The main barriers and obstacles that Vivacity Labs faces relate to technology standardisation and proving to potential customers Vivacity Labs' ability to deliver above-minimum standards. Talent attraction in the technology field is another significant barrier. Vendor lock-in is not currently an issue.

Vivacity Labs being a small and young company – one that interacts with large government organisations and provides evidence on financial stability – is sometimes a barrier. As such, additional effort is needed, such as the provision of financial guaranties, a list of partners (e.g. consulting companies), and customer references.

From an economic standpoint, working with governments can be challenging, as the company charges for the cameras used (capital expenditure), as well as recurring fees for the software running on the cameras. Predictable revenues are useful for research and development (R&D), which is continuous, but government entities still often prefer capital expenditure.

BrianzAcque

BrianzAcque[31] is a public company that manages wastewater and water treatment in Brianza, a territory in Northern Italy comprising 56 towns and villages and approximately 900,000 inhabitants. The company started the Casette dell'acqua initiative to distribute outdoor high-quality filtered drinking water dispensers (the Casette) throughout the territory for the citizens. The water can be dispensed as still, sparkling, and cooled. In a similar way, the company is distributing indoor dispensers – in schools, libraries, and so forth. The target is to reduce the use of plastic bottles across the territory, with benefits including less traffic, less pollution, and lower consumption of plastic.

The Casette dispenser can be seen as a multifunctional edge IoT device able to run cloud-native applications locally that have been developed as a part of a larger architectural digital transformation of the company. Each outdoor dispenser includes a technological solution to monitor the status of the dispenser, count how much water has been delivered, manage maintenance, provide communication to users via a screen, and manage the security of the data and data transmission. Each dispenser is managed with a micro PC, which is deployed at the edge and features tailored Linux OS and custom applications for different functions.

[31] http://www.brianzacque.it/

IoT components continuously exchange data with the central cloud platform, which manages the IoT network and provides the information shared on the screens of the dispensers. The screen can share information regarding water provision and water quality, as well as public utility information from BrianzAcque and partners (e.g. local government).

BrianzAcque includes good practices related to **business impact and technology innovation**.

- Business impact: The main KPIs relate to the number of Casette installed (currently 70, with a target of 100 in total in 2021, covering the whole territory); the number of dispensers installed (currently 50, with a target of 80 in total by end of 2020); and the number of litres dispensed (10 million litres in 2019, with a strong increase expected for 2020, even though the COVID-19 outbreak forced the temporary closure of Casettes in spring 2020).

  Another significant KPI is how the service to citizens evolves in terms of information about water quality and customer service. Despite being difficult to monitor and monetise, usage patterns say a lot about this.

- Technology innovation: The main aspect of innovation relates to the mix of IoT, edge, and cloud computing and the capabilities that mix enables. The initiative had a huge impact on company processes, as it is a part of a more general digital transformation of the company, whereby the whole architecture has shifted to services enabled by cloud-native applications on a single cloud platform.

All the technical complexities have been governed and managed by an external IT solution provider, which is a primary actor in the digital transformation of the company overall. The main technical issue resulting from digital transformation has been implementing change management in the internal IT department. On the legal side, the only barrier is that of data regulation. The IT provider manages these barriers in all of their complexities, ensuring that all the solutions are GDPR compliant and meet the highest security standards.

Leading European Car Manufacturer

A factory (located in a CEE country) of a leading European car manufacturer has developed an initiative related to the real-time monitoring of its uninterrupted power supplies (UPSs) and UPS management system. The factory is equipped with about 50 UPSs, placed in rack cabinets located around the plant, and two heavy-duty galaxy-class UPSs that support two data centres. The data centres host all the IT infrastructure for the office and production parts of the factory. The initiative tied to the new UPSs was driven by the following challenges:

- The very difficult management of dispersed infrastructure – a lack of visibility and UPS status information collected manually by administrators
- Lack of predictive maintenance – service work often performed after breakdowns
- The instability of UPSs when operating in an emergency state
- Alerts only displayed on the UPS panel

The IT department initiated the project for replacing the business-critical UPSs, choosing UPSs equipped with sensors for collecting data about the UPSs' statuses – sensors capable of conducting basic analysis at the edge, as well as visualising the data on each UPS screen and transmitting the data. The UPS manufacturer provided the company with a UPS management application, which helps IT administrators detect failures and potential threats. All of the data transmitted from all UPSs is collected and further analysed in the data centres for a holistic view of the overall power infrastructure. Despite all the data being collected in the data centres for further use, the edge capabilities are key to initial analysis and fast reaction to problems/alarms.

The leading car manufacturer initiative includes good practices related to the **business impact of edge and technology innovation.**

- Business impact: Several KPIs have been used to measure the success of the project:
  - No downtime due to power failure (Power failures have been eliminated.)
  - A massive reduction in failure time
  - The removal of reliance on battery power in emergency status
  - Information visibility – the ability to visualise data both centrally and locally, using the internal analysis and visualisation capabilities on the UPSs
- Technology innovation: The main aspect of innovation relates to the use of IoT in the USPs. The devices are equipped with sensors that capture various parameters, analyse the data, and generate alerts and triggers based on the locally gathered data (i.e. at the edge).

The benefits of the initiative were substantial enough to overcome the barriers, especially since the project was financially predictable and financed from the IT budget.

Worldsensing

Worldsensing designs and builds sensing solutions to remotely monitor critical assets (and the structural health thereof) within mining, construction, and rail networks, helping engineers to monitor and anticipate geotechnical incidents, such as ground movements/landslides, to ensure the safety of workers, passengers, and citizens. The company offers a suite of products to wirelessly connect a wide range of 3rd party geotechnical sensors, as well as edge gateways capable of data collection, data analysis, and network management at the edge. Data is then sent to a cloud location for further analysis.

Worldsensing leverages edge capabilities by using dataloggers and edge gateways. The dataloggers are battery powered and have limited capabilities in terms of computing power. These devices connect wirelessly to the edge gateway using standard IoT connectivity. Each edge gateway is equipped with computing and storage capabilities and is able to gather data, translate different formats, manage the network, perform basic data analysis and visualisation, and, in some cases, generate alerts. Each gateway is connected to a public or private cloud location for central data analytics, storage, dashboard, and alarms, using various connectivity types, depending on availability. The edge devices are resistant to harsh environmental conditions (water, dust, temperature, and vibration) and consume very little energy. Edge is needed to ensure the continuity of service in remote locations where connectivity is unreliable.

Worldsensing includes good practices related to the **business impact of edge and technology innovation.**

- Business impact: Being a product company, key metrics have always been driven by the number of devices sold. Revenues have been increasing constantly since 2016. Another interesting KPI is how much money Wordsensing customers/partners save by deploying the company's solutions, which adds to the other measured benefits derived from the real-time availability of geotechnical data, such as the increased safety of workers, citizens, and the environment. The overall result is usually high return on investment (ROI), depending on the project setup.
- Technology innovation: The Worldsensing solution is at the crossroads between IoT (the dataloggers) and edge (where the data is processed). The solution relies on a centralised (cloud) platform to which all data is sent from dataloggers; edge is critical in delivering value. Cloud is used as a central resource for central data analytics, storage, dashboard, and alarms, and it enables remote device management. The company is very much focused on edge-network infrastructure. It relies on engineering service provider partners to integrate and deliver the final solution to customers. Nevertheless, the company has historically been active in developing a decentralised and coordinated edge-to-cloud management ecosystem. In this regard, in 2017,

Worldsensing was awarded the mF2C H2020 project[32] – Towards an Open, Secure, Decentralised and Coordinated Fog-to-Cloud Management Ecosystem.

The company's focus is primarily on R&D – developing new solutions and leveraging the latest technology trends on the market (LoRa LPWAN and 5G, batteries for sensors, and new edge servers/gateways with increasing computing and storage capabilities).

Barriers for Worldsensing are both technical and legal. The most important edge-computing-related technical barrier lies in overcoming limited power and maintaining battery life for dataloggers. In addition, new connectivity deployments, worldwide, such as 5G, have been slower than expected, and this has had a technological impact in terms of balancing edge and cloud in remote areas. The evolution of new connectivity standards and ecosystems (e.g. LoRaWAN) and their adoption are key to enabling Worldsensing to integrate its solutions with those of other players in the industrial market.

From a legal standpoint, Worldsensing products operate in the free ISM radio bands, worldwide, and are subject to various governments' decisions. Public authorities are usually slow to define clear certification frameworks to regulate wireless communications in their territories, making the commercial exploitation of such technologies difficult.

Axis

Axis[33] is an IP camera producer, developing products that use open standards and are scalable and easy to integrate into different platforms. Axis has embraced open standards and edge to guarantee lower connectivity levels and server loads. Axis is focusing on developing its proprietary hardware platform, which features a deep-learning processing unit (DLPU). The application layer has been developed partially internally and partially leveraging third-party developers. This will enable the camera to perform different tasks by leveraging edge hardware (e.g. security applications, business management applications, and camera plug-ins) and offers the possibility to develop features and change the camera's scope. The cameras have an internal computing platform for analysis and to run applications that usually run on servers. These applications support insights (metadata) and facilitate other layers of the solution (e.g. different connectivity platforms that would be difficult to integrate elsewhere, cybersecurity, and the management of the device or of other devices (e.g. turning on smart lighting via motion detection). Axis's aim is to move integration complexity to the edge camera to ease partners' integration, development, and use of software. Even though new intermediate edge architectures are now being developed, Axis sees no need to adopt/incorporate them at the present time.

Axis includes good practices related to the **business impact of edge and technology innovation.**

- Business impact: This is measured via the usual business KPIs – revenues (despite not always being meaningful, as video surveillance is a growing sector) and profits – and other metrics, including the number of sensors sold, the number of ecosystem apps running in its systems, the number of cameras running edge analytics in relation to the total, the number of cameras (around 300–400 cameras per city of 1 million inhabitants), the number of edge-enabled cameras per use case (e.g. traffic monitoring), and the numbers of partners and partner apps migrating to the edge (which is growing fast).
- Technology innovation: The edge solutions are mainly connected via IoT to the cameras. The innovation lies in developing cameras that are computing platforms. 5G could be a very interesting technology innovation to adopt in the future: 5G can be very relevant in a video surveillance scenario, but only if the cameras have edge capabilities

[32] https://www.mf2c-project.eu/index.html#
[33] https://www.axis.com/en

– mostly, for scalability, latency, and bandwidth. Axis's approach to innovation is driven by the hardware platform, and this pushes innovation to the software development side.

Problems Axis faces in developing its solutions include IoT standardisation and cloud legislation. A more standard approach to IoT connectivity would help and would have a positive impact on software development, particularly for Edge. Legislation to ease cloud usage would be very useful. Leveraging cloud apps is currently difficult in Europe. Deregulation and easier governance are needed. Axis overcomes such barriers by using on-premises solutions and by targeting early adopters and the most advanced users.

3.1.3 Research sector

The cases presented here are all based on research and innovation projects conducted or still running in the EU between 2016 and 2020. Each project was/is funded by the Horizon 2020 (H2020) funding programme of the European Commission. All of these projects have similar organisational structures:

- Lead organisation: often a research institute or university, led by a principal investigator.
- Academic partners: partnering researchers with complementary areas of expertise and complementary project tasks.
- Industrial partners: large and small organisations that offer inputs (perhaps proprietary) to the proposed project and/or that represent target use cases for the planned innovation. EC-funding favours projects that involve SMEs, and most projects include their participation.
- Multinational: EC-funding also favours projects whose partners come from across the EU – ideally, from both large and small Member States.
- Specific time frames and funding, along with well-defined deliverables specified as part of the initial project proposal.

For EC-funded projects, the 'success' of each project does not have to be guaranteed, in contrast to a commercial project, where achieving the objectives is usually required for payment – for example, the software has to do what is specified. Nevertheless, projects are often deliberately structured to generate outputs that correlate with success in the real world: positive case studies with partners; the creation of open-source software, along with documentation; promotion, outreach, and dissemination activities; and support for the creation of spin-off companies, patents, licenses, etc.

Despite these structural supports for 'success', these and other cases have generally not been successful in a practical sense; for example, the software created is only adopted by the project partners and not by any organisation outside of the project. This is, unfortunately, the norm for EC-funded research projects in this area. Difficulties and 'gaps' related to the adoption – or, ideally, penetration – of the solutions flowing out of these projects will be discussed later in this report.

Name of the program	Relevance for H-Cloud Key Areas	Status of the Project	Type of Good Practice
Helix Nebula Science Cloud	Federated cloud	Complete, with follow-on projects in progress	• Governance and organizational change • Collating objective information to counter distrust between the two sides
RestAssured	Federated cloud (secure data)	Complete, with follow-on projects in progress	• Technology innovation

LightKone	Edge, possibly federated cloud	Complete, with start-up	• Technology innovation
RADON	(possibly edge and green IT)	In progress	(too early)
COLA	Federated cloud	Complete, with follow-on projects in progress	• Technology innovation
SUNFISH	Federated cloud	Complete; new project applied for	• Governance and organizational change • Technology innovation

Table 4: Summary of Research Sector Initiatives That Include Good Practices

Helix Nebula Science Cloud

Helix Nebula Science Cloud[34] was the follow-on project to Helix Nebula[35] and has in turn been succeeded by two follow-on projects, Archiver[36] and OCRE[37]. All of these projects focus on enabling the research community to use commercial cloud services rather than investing in their own infrastructure. The sequence of projects and their evolution represent an interesting case study on the challenges of using commercial cloud to meet some very specific, yet innovative, requirements where the 'business case' is still evolving.

In the research context, there is no 'business case' (there is no direct ROI on research), and the Helix Nebula experience highlights how this makes justifying a shift to a new way of doing things difficult – especially given the technical, cultural, organisational, and financial barriers involved in such a shift. It should be seen as a cautionary tale for the adoption of cloud – and for other new technological approaches, such as edge computing and Big Data, and other new application areas, where paradigm shifts are expected (e.g. in healthcare or agriculture) rather than incremental operational savings. Helix Nebula is based on a stepwise codesign approach, bringing providers and customers together, which is essential to enable related solutions in the future.

Helix Nebula (June 2012–May 2014) started by bringing providers and 'buyers' together to discuss requirement and create technical and service architectures to frame the work, with the intention of creating a marketplace of cloud services that is structured to align with customer needs.

Three key challenges were encountered:

- Procurement: Despite success in defining the marketplace's operation, it was still difficult for customers (various research communities and infrastructures) to 'purchase' services through the marketplace, since this did not align with the procurement processes that were imposed on the institutions that were legally making the purchases.
- Trust: Despite the collaborative work on the technical details of Helix Nebula, customers were still unsure about the service offers being made and hesitant to take advantage of them. Some of this came from the perceived higher costs of these offers compared with customers' traditional on-premises capital expenditure-based infrastructures. Some of this related to a traditional distrust of commercial companies among academic institutions.

[34] https://www.hnscicloud.eu/
[35] https://www.helix-nebula.eu/
[36] https://www.archiver-project.eu/
[37] https://www.ocre-project.eu/

- Service definition: The providers built a technical catalogue of services that aligned with their practices, but these services did not align well with the buyers' needs. Buyers had difficulty identifying the services they needed, and certain services were assumed by providers to also be needed but overlooked by buyers, creating service gaps that reduced trust in what was being offered.

HN Science Cloud (Jan 2016–Dec 2018) addressed these issues directly by engaging in a codesign process, using a pre-commercial procurement framework to specify requirements from a small number of customers (the 'buyers group'), inviting specific proposals from commercial providers, and developing solutions using an iterative process resulting in two suppliers (consortia) delivering validated solutions for customers. This structure directly addressed the procurement challenge, and its collaborative codesign nature enabled the building of trust between the two sides. In addition, specific project tasks addressed concerns around 'value for money' and comparative pricing, with detailed total cost of ownership (TCO) studies conducted for both research infrastructures and commercial offers and with specific use cases identified that made sense for each procurement approach. Testing and certification processes were established to objectively assess whether requirements were met, addressing the research community's subjective concerns about commercial providers. Finally, responsibility for creating the completely integrated service needed by buyers, as defined by their requirement, was clearly placed on providers, so that buyers could be sure they were getting a complete solution.

HN Science Cloud is widely seen as a success. It has triggered a re-evaluation of 'owned' research IT infrastructure, triggering growing use of cloud-based tools in research. For example, CERN, a key partner in both Helix Nebula and HN Science Cloud, has increased its use of cloud-based machine-learning tools, using AI to improve the capabilities and performance of the CERN research infrastructure (particularly the Large Hadron Collider – LHC). It has refined the understanding of the community of how to procure IT infrastructure – making sure these long-term procurements are fit for purpose for the mix of IT applications that in fact should be hosted on 'owned' infrastructure.

The project has spurred two follow-on projects:

- **Archiver** (Jan 2019–Dec 2021) uses the same pre-commercial procurement model as HN Science Cloud, with some refinements, to procure commercially based long-term data storage capabilities that meet the needs of the research community. This uses the same collaborative, iterative codesign process developed in HN Science Cloud, delivering complete solutions to well-defined problems, funded through an accepted procurement process.
- **OCRE** (Jan 2019–Dec 2021) is exploring an alternative to the slow process that constrains research procurement, allowing vendors to qualify themselves through an initial process and then convert awarded procurement amounts into vouchers that can be distributed to researchers and used as credit to enable access to smaller amounts of cloud capacity. In addition to simplifying the financial aspects of cloud migration for individual researchers, OCRE strives to give those researchers confidence in the specification process so they know they are buying a solution that will work.

These projects collectively feature the following good practices:

- Creating explicit mechanisms to support organisational and cultural change across multiple organisations: The first project (Helix Nebula) identified cultural and organisational differences between cloud service providers and organisations from the research community – including prejudice against commercial providers and the cloud in the research community and differing assumptions about procurement practices. HN Science Cloud's pre-commercial procurement (PCP) approach enabled these differences to be aired in a structured, goal-oriented context and solutions to be found that worked for both sides.

- Assembling objective information to counter distrust between the two sides: HN Science Cloud conducted detailed TCO studies to resolve disagreements and misperceptions about the comparative costs of cloud-based and owned infrastructure, as well as establishing automatic testing suites to objectively validate functional performance and compliance with specifications.

RestAssured

RestAssured[38] (Jan 2017–Dec 2019) set out to provide end-to-end security for sensitive data, with four components: '(1) fully homomorphic encryption to process data without decryption, with cloud enablement of SGX hardware for protected data processing, (2) sticky policies for decentralised data lifecycle management, (3) models@runtime for data protection assurance, and (4) automated risk management for run-time data protection'.

- Project partner IBM successfully developed Parquet Modular Encryption (PME), improving security for Parquet, a common storage service used with Apache Spark. This has been adopted by the Apache Spark user community, and uptake has been significant. However, this approach does not achieve fully homomorphic encryption, and additional data protection is needed (using Secure Enclave CPUs for local processing, as well as Transport Level Security for data transmission).
- Project partner IT Innovations, the University of Southampton's innovation unit, has refined a System Security Modeller, which can perform risk assessments of static IT configurations. IT Innovations has embedded this capability in several service offerings, along with a productised SpydeRisk security compliance documentation tool. (The level of uptake is unknown.)
- The architecture developed to implement 'sticky policies' was found to be complicated and cumbersome.
- Similarly, automated risk management, particularly the automated evaluation of data queries against privacy policies, remains a challenging research problem.

From a good-practice standpoint, the RestAssured project was well managed and adapted to both research challenges and evolving partner priorities, but it offers no specific learnings.

LightKone

The goal of LightKone[39] (Jan 2017–Dec 2019) was 'to develop a scientifically sound and industrially validated model for doing general-purpose computation on edge networks.' LightKone approached this objective by rejecting the idea that data collected at the edge should be transported to a central cloud to continue storage and processing and instead worked to create a robust architecture for independent edge networks.

A key component of this architecture is the 'conflict-free replicated data type' (CRDT), which allows particular pieces of data to exist in multiple places across a network, and for the copies of that data to remain consistent without centralised synchronisation or continuous communication. (CRDT is used by other solutions and companies – for example, the Redis and Riack data systems, TomTom navigation system, and Facebook's Apollo data system.) The CRDT's resiliency makes it ideal for use in edge networks, and the LightKone project has built a unified programming model, with three implementations (Antidote, Lasp, and Legion) adapted to specific edge circumstances, all based on the CRDT, as well as the gossip networking protocol. LightKone successfully applied these technologies to a number of use cases, and the solution was achieved at the edge in each case, without requiring centralised computation or control in the cloud.

[38] https://restassuredh2020.eu/
[39] https://www.lightkone.eu/

Success stories:

- LightKone's solution for Peer Stritzinger, a German industrial IoT company, has seen growing adoption. This solution motivated the development of a lightweight edge-computing device (GRiSP), which is now reaching quantity production.
- The LightKone programming model is being commercialised by Paris-based start-up Concordant.

LightKone envisions the growth of edge computing without relying on any cloud-based resources, but such a new architecture would represent a significant paradigm shift.

From a good-practice standpoint, LightKone achieved significant success with a novel approach, including the creation of a promising commercialisation venture, but it does not offer any specific learnings. Given the promise of LightKone's developments, one would hope to see go-to-market plans and wider adoption of this approach, but LightKone's next steps remain confidential.

RADON

RADON[40] (Jan 2019–Dec 2021 – in progress) aims to create a DevOps framework to develop and manage microservices-based applications that can optimally exploit serverless computing technologies. The end goal is to broaden the adoption of serverless computing technologies within the European software industry, which will enable improved cloud efficiency and utilisation.

The current RADON framework includes:

- The graphic modelling of the application
- Decomposition tools to help break up applications into modules/functions suitable for implementation as microservice/functions-as-a-service/serverless infrastructure, as well as specifying the details of this infrastructure
- Tools to detect defects in infrastructure (Using microservices transforms potential programming errors into infrastructure errors.)
- The continuous testing of the combined suite of applications, microservices, and underlying infrastructure.

The project will deploy and test the development environment in real-world software development teams and assess effectiveness and productivity. For example, one use case is converting hardware controllers to software: An engineering firm is a partner in the project and needs a robust development environment that can create quality software alternatives to well-tested hardware solutions.

If successful, RADON will help software development teams better utilise the growing trend toward serverless computing, which will improve the utilisation of cloud technologies and offer related business and environmental benefits.

From a good-practice standpoint, it is too early to identify any good practices employed in the RADON project.

COLA

COLA[41] (Jan 2017–Sep 2019) addressed the following challenges: (1) describing the structure of containerised/virtualised applications and their behaviour to control their lifecycles in a cloud-agnostic way, (2) supporting the deployment and run-time orchestration and optimisation of such applications, taking various QoS parameters into account, and (3) creating and running

[40] https://radon-h2020.eu/

[41] https://project-cola.eu/

near production level applications in the cloud. COLA's MiCADO solution extends state-of-the-art virtual machine management beyond the level offered by Terraform and extends container management beyond the level offered by Docker Swarm and Kubernetes. COLA makes it easier to manage applications across hybrid- and multi-cloud environments. Using COLA, application developers can create cloud-enabled applications from existing applications with minimum effort and can make them available to customers.

Technically, the COLA project was very successful. The EC ranked COLA among the top 10 projects submitted under its H2020-ICT-06-2016 cloud computing call. This was achieved despite the rapid rate of change in cloud tools at the time, with the originally targeted Occupus and Docker Swarm tools overtaken in the cloud developer market by Terraform and Kubernetes, respectively. COLA was able to manage this transition with modest effort, highlighting the intelligent design of the MiCADO solution.

From a business standpoint, MiCADO is now being used in several follow-on research projects (e.g. DigitBrain and Asklepios), and commercial marketing is handled by CloudSME. Generally, commercial adoption of MiCADO has been very slow.

From a good-practice standpoint, it is difficult to pinpoint the source of COLA's success in creating a technically strong, production-ready tool that is relevant in the fast-moving cloud development tools market. Nevertheless, it has resulted in a promising spinoff research product, supported by a dedicated company.

SUNFISH

SUNFISH[42] (Jan 2015–Dec 2017) prototyped and demonstrated the secure interoperation of separate cloud systems using a federation-as-a-service approach. This approach goes beyond the adoption of interoperability standards, since those standards are still a work in progress. The approach also avoids creating a separate entity to manage the federation – instead, setting up robust peer-to-peer protocols for creating, operating, and eventually dismantling a federation.

The Sunfish architecture is built on a variety of tools/functions that address security and privacy in particular and SLA compliance in general. These capabilities are fundamental to Sunfish architecture, representing 'privacy by design', rather than being 'bolted on' as is sometimes seen in other efforts.

Sunfish assumes blockchain and distributed-ledger technology (DLT) can be used in the future to ensure the verifiability of communication among federation partners, to manage compliance with contractual terms (smart contracts), and to register the status of resources across the federation. DLT will also pave the way for cultural and organisational change, allowing hierarchically 'equal' departments to collaborate on projects without problems of rivalry or territoriality. Unfortunately, the computational burden and latency of proof-of-work DLT prevented adoption at the time of the project, but emerging proof-of-stake schemes should enable this ability in planned future implementations.

Sunfish focused on several public-administration use cases:

- Taxation (Italy): The Ministry of the Economy and Finance (MEF) handles payroll processing for over 2 million public-sector employees. Payroll taxes are calculated based on the employee's home address. MEF requires access to the home addresses of police employed by the Ministry of the Interior (MIN), but these addresses are personal information, and Italian law prevents their disclosure outside of MIN because of possible threats to police. Sunfish's secure federated cloud services enable the correct calculation of payroll taxes without exposing home addresses (even to another ministry of the Italian government).

[42] http://www.sunfishproject.eu/

- Taxation (Malta): Maltese businesses submit payroll information, financial statements, and accounting records to the Malta Taxation Department to calculate tax payments and refunds. Large organisations have internal IT resources to manage electronic submission of such data, but this is an onerous requirement for small organisations. Sunfish's secure federated cloud services make it easy for some small organisations to link their SaaS financial accounting services with the Taxation Department.
- Public Safety (UK): The UK's efforts against cybercrime are organised into nine regional cybercrime units, each of which is required to independently manage and store the data and evidence collected in its investigations, while at the same time enabling authorised access to this data from other units as investigations proceed. Transferring data outside each unit was not possible, nor was the merging of all units' data into a separate entity to enable search, analysis, and/or processing. Sunfish's secure federated cloud services enable cybercrime units to search other units' data without actually exposing or transferring that data to the other units.

From a good-practice standpoint, Sunfish demonstrates a technical solution (distributed ledger technology – specifically, smart contracts) that can help solve a key problem of data governance – namely, automatically supporting data subjects (or data stewards acting on their behalf) in responding to requests to access or exchange private data. Many implementation challenges remain, such as the need for 'social engineering' to ensure data subjects are sufficiently engaged to appropriately set up such smart contracts.

3.1.4 Public Private Partnerships

Name of the program	Relevance for H-Cloud Key Areas	Status of the Initiative	Type of Good Practice
IDS	Federated cloud	In development	• Data governance
GAIA-X	Federated cloud	In development	• Governance and organisational change • Data governance

Table 5: Summary of PPPs That Include Good Practices

IDS

In 2014, the German Federal Government and the Fraunhofer Institute partnered with key German industry players to launch International Data Spaces (IDS)[43], a project that aims to improve European data sovereignty. IDS created a secure data space to help organisations from different industries monetise their data resources through cloud-based secure exchange and the easy combination of data in value chains – the foundation for smart services, innovative solutions, and automated business processes.

IDS includes a good practice related to **data governance for federated cloud**. IDS provides a reference architecture, a formal standard, and reference implementations, including sample code. The two foundational elements of IDS are:

- IDS connector: The IDS connector acts as a gateway. It can be implemented in different ways, depending on the scenario – on micro-controllers, sensors, mobile devices, and servers and in the cloud. Due to the container architecture, the IDS connector also enables the trusted execution of apps – those that can sovereignly process data from different sources. These software services will not run in an ERP system, behind the

[43] https://www.fraunhofer.de/en/research/lighthouse-projects-fraunhofer-initiatives/international-data-spaces.html

firewall, but on cloud platforms – that is, 'at the centre' of the ecosystem. The connector is therefore a suitable execution component for Amazon Web Services (AWS), Data Intelligence Hub (DIH), SAP HANA, and so forth, because it enables the platforms to offer a secure environment in which data sovereignty is guaranteed[44]. Domain-specific application profiles enable embedding in specialist domains with different requirements (see DIN SPEC 27070).

- Certification: The certification concept confirms the conformity of components (connectors) and organisations with IDS architecture from independent organisations (e.g. PwC, TÜV, and Fraunhofer). This ensures that the organisations have taken all necessary measures for an IDS-compliant operating environment and use components that have been implemented according to the connector variant.

IDS has been able to apply these concepts to use cases that have business relevance in specific industries, such as the predictive maintenance of industrial equipment and shipment planning in logistics value chains. However, the existing applications involve bilateral data exchanges between two enterprises. It has not yet been scaled to multilateral data exchanges.

GAIA-X

At its digital summit on October 29, 2019, the German Federal Ministry for Education and Research — together with the Federal Ministry for Economic Affairs and Energy (BMWi) — unveiled its vision for a connected cloud-based data infrastructure for Europe. GAIA-X[45] has two main goals:

- To win back the sovereignty of European citizen and company data by ensuring that such data does not leave European soil unintentionally
- To reduce dependency and the risk of lock-in by enabling service and data portability

By delivering on those two strategic goals, GAIA-X expects to encourage cloud-sceptic European organisations (particularly SMEs) to take advantage of cloud, while maintaining control of their data, and to foster the creation of an open digital innovation ecosystem in which data can be collected and shared securely, while adhering to European privacy regulation. It is not intended to compete with global hyperscalers; it will be a layer on top of their services.

GAIA-X includes good practices related to **governance and data governance for federated clouds.**

- Governance: GAIA-X has two tiers of governance:
  - Tier-1: During the first year after launch, the central programme management office was led by BMWi and it coordinated the work of founding members. This central PMO made the final decisions about long-term strategy, operating model, business model, and rules for other entities to participate in the programme and be certified as GAIA-X nodes. On September 15, 2020, the 22 founding members co-signed incorporation papers for GAIA-X's L'association internationale sans but lucratif (AISBL), a non-profit association that will be responsible for securing funding and commitment from members to fulfil the initiative's vision. The founding members and co-signers of AISBL include: 3DS OUTSCALE, Amadeus, ATOS engineering, Beckhoff Automation, BMW, Bosch, CISPE, DE-CIX, Deutsche Telekom, Docaposte, EDF, Fraunhofer Gesellschaft, German Edge Cloud, IMT, International Data Spaces Association, Orange, OVH, PlusServer, Safran, SAP, Scaleway, and Siemens.

[44] www.internationaldataspaces.org/
[45] https://www.data-infrastructure.eu/GAIAX/Navigation/EN/Home/home.html

- Tier-2: This has several workstreams, in which a large number of organisations participate, from regional government data centres in Germany to European vendors such as OVH and global cloud providers like IBM.

The GAIA-X project is divided into different workstreams for specific topics:

- User ecosystems and requirements
- Technical implementation
- A cross-functional unit known as the Joint Requirements Expert Tribe: This unit consists of two groups that are convened on a flexible basis and that deal with topics in which interdependency between the workstreams is strong. The project structure is agile in that it can be adapted over time, in line with framework conditions, and guarantees collaboration across separate topics.
- Data governance: From a data governance perspective, GAIA-X expands on the archetypes and processes developed by International Data Space to deliver:
  - The implementation of secure federated identity and trust mechanisms (security and privacy by design)
  - Sovereign data services, which ensure the identity of the source and receiver of data, as well as data access and usage rights
  - Easy access to the available providers, nodes, and services, with data provided through federated catalogues
  - The integration of existing standards to ensure interoperability and portability across infrastructures, applications, and data
  - The establishment of a compliance framework and certification & accreditation services
  - The contribution of a modular compilation of open-source software and standards to support providers in delivering secure, federated, and interoperable infrastructure

3.2 Analysis of Good Practices by H-CLOUD Key Area

3.2.1 Cloud Federation

Cloud federation has the potential to realise the economies of scale of a large cloud provider, while ensuring that both end users and small and medium-sized suppliers of technology services are not locked into one monolithic infrastructure and platform. However, many questions remain regarding the feasibility of cloud federation:

- What are the incentives to do it?
- Who guarantees that all participants in the federation live up to the same security standards?
- What is the commercial model?
- How do you ensure that all participants can deliver the same minimum service level?
- What is the right governance structure?
- How do you create customer trust in the federation?
- How do you advertise and market the federation?
- How do you technically set up the federation?

The initiatives featuring good practices that were analysed as part of this research offer learnings to overcome those challenges from multiple points of view.

Business Impact: The key success factor for federation is adoption/participation. As indicated by public-sector initiatives featuring good practices, such as Statens IT and G-Cloud, an increase in the number of users of shared, community, or federated services generates a positive network effect. Higher participation drives economies of scale in terms of procurement and management. Good-practice knowledge sharing across participants favours continuous improvement in terms of technology and governance innovation. The French government's SPOTES programme defines and monitors a set of KPIs that tracks participation from multiple perspectives: user experience/satisfaction, number of transactions, number of registered users, number of tickets, and number of services offered.

However, it must be noted that it is difficult to achieve widespread adoption and collaboration. That is because:

- The federation may replace someone's authority or job, so it will encounter organisational resistance.
- The federation may include multiple industries, with multilateral collaboration having no clear business case but requiring commitment to and experimentation with innovative use cases, an example being IDS.
- The federation may include competing companies that are concerned about disclosing trade secrets.
- The business case for the individual participating cloud providers might not be clear; business demand from customers might not be present; and the funds available for marketing the federation may be limited.

Technology Innovation: The good practices analysed are advancing the federated cloud technology innovation frontier along three main paths:

- Cloud provisioning and deployment across multi-cloud environments; for instance:
    - Logius is developing a Kubernetes container-based orchestration layer that aims to enable service rollout to AWS, Azure, and government private-cloud data centres. This orchestration layer, built on open source (OpenStack and OpenShift), aims to include all the capabilities necessary to manage a cloud federation, from service catalogue to performance dashboard and backup.
    - COLA's MiCADO solution extends virtual machine management beyond the level offered by Terraform and container management beyond the level offered by Docker Swarm and Kubernetes.
    - CloudSME is taking a container orchestrator technology to market that allows organisations to use multiple cloud platforms and move their workloads and data independently of the underlying infrastructure.
    - City Network is one of 20 OpenStack-based cloud providers in Europe, and it is building an open-standards-based cloud infrastructure that could be federated with other OpenStack-based cloud providers – if customer demand for it exists.
    - ThreeFold Grid offers a blockchain-based solution whereby any organisation can supply compute resources to the federated cloud grid based on an installed common operating system with security attributes included, and the whole federated infrastructure is managed automatically by blockchain.
- Securing access to federated resources; for instance:
    - Sunfish assumes blockchain and DLT can be used in the future to ensure the verifiability of communication among federation partners, to manage

compliance with contractual terms (smart contracts), and to register the status of resources across the federation.

- Reducing the cost of operating across multicloud environments; for instance:
    - Statens IT building a shared tenant-based system with sub-tenants for users that can be swapped so that the user organisation can avoid purchasing a lot of new licenses.

Governance/Organisational Change: Realising the benefits of collaborative initiatives, such as community clouds and federated clouds, revolves around the ability to bring people together through the service lifecycle, from design and financing to implementation, operation, and consumption. This requires:

- Creating organisational and cultural change mechanisms that foster collaboration; for instance:
    - The first Helix Nebula project identified cultural and organisational differences between cloud service providers and organisations from the research community – including prejudice against commercial providers and the cloud in the research community and differing assumptions about procurement practices. HN Science Cloud's PCP approach enabled these differences to be aired in a structured, goal-oriented context and solutions to be found that worked for both sides. HN Science Cloud assembled objective information to counter distrust. It conducted detailed TCO studies to resolve disagreements and misperceptions about the comparative costs of cloud-based and -owned infrastructure, as well as establishing automatic testing suites to objectively validate functional performance and compliance with specifications.
    - The French government's SPOTES invests in knowledge sharing through virtual events, seminars, educational material, and blogs that are made available on the marketplace to maintain momentum even during the COVID-19 crisis.
    - The Danish Statens IT initiative joined Euritas to learn from peer government IT modernisation programmes around Europe. The initiative invested in personnel certification and security clearance, to offer high-quality information assurance, and in training, to enhance technical personnel-customer relationship capabilities, to better align their offerings with the needs of individual government departments.
- Establishing structures and processes that make the collaborative supply of cloud services efficient, effective, and compliant with regulations; for instance:
    - Cloud28+ created a federation at the service catalogue level, whereby participating cloud vendors advertise their services through the Cloud28+ digital platform and marketplace.
    - G-Cloud realised an efficient and effective marketplace for certified cloud providers that want to supply services to the UK public sector.
    - The Austrian Federal Government separated technology innovation (EGIZ) from technology implementation (BRZ) to focus all government innovation decisions on interoperability standards, feasibility, and prototyping and then to define a minimum set of guidelines. At the operational level, the key goal is to keep EGIZ's service catalogue commercially competitive in the long run for the Austrian Federal Government. EGIZ and BRZ collaborate closely, but they are managed and funded separately so as to maintain independent decision making. They also employ different sets of expertise.

- The Irish central government established a three-tiered IT governance model that includes: a) a civil service management board, which includes secretary generals of every department, with the government digital strategy discussed twice a year; b) a subgroup co-chaired by two of the most influential secretary generals (from the Finance Department and Welfare Department), where collective decision making happens about the government's digital strategy; and c) an ICT advisory board, including the heads of IT of every department, where more technical and tactical guidelines and action plans are discussed.
- The work of GAIA-X is divided into different workstreams for specific topics: a) user ecosystems and requirements, b) technical implementation, and c) a cross-function unit known as the Joint Requirements Expert Tribe. This unit consists of two groups that are convened on a flexible basis and that deal with topics when interdependency between the workstreams is strong. The project structure is agile in that it can be adapted over time, in line with framework conditions, and guarantees collaboration across separate topics.

Data Governance: The analysed good practices are advancing federated cloud data governance capabilities along two main paths:

- Information assurance guidelines and certifications for suppliers of cloud services: Public sector and public private partnership good practice examples offer the most important learnings here. In fact, G-Cloud, WIIP, GAIA-X, and IDS have put in place a certification process that is used consistently to verify supplier's compliance with information assurance policies, before they are authorised to provide the service, and to audit them when they are operating in the environment.
- Data interoperability architectural standards and principles: Multilateral multi-industry programmes like GAIA-X and IDS strategically focus on interoperable data exchange. For instance, the IDS connector is a container architecture that can be implemented in different ways, depending on the scenario – on micro-controllers, sensors, mobile devices, and servers and in the cloud.

Environmental Sustainability: The economies of scale of cloud data centres have a positive impact on environmental sustainability. Cloud data centres can afford to invest in features like power-saving stand-by modes, energy monitoring software, and efficient cooling systems and can increase server utilisation rates through virtualisation and automation. The public-sector regional IT shared service centre interviewed as part of this study provides evidence of how even a medium-sized private cloud data centre can reduce its energy bill by more than 50%. However, two factors must be considered for the realisation of environmental sustainability benefits:

- The energy efficiency of the existing IT infrastructure to be replaced with cloud: The more modern, virtualised, and efficient the legacy infrastructure is, the lower is the potential positive impact of cloud.
- The expected growth of IT infrastructure demand: Cloud's elastic pricing and provisioning models often induce a growth in usage, hence offsetting the energy efficiency per unit with overall growth in consumption.

3.2.2 Edge Computing

Edge-related good practices can be divided into two main categories: what edge allows today, as a combination of already available resources, technologies, and approaches, often in collaboration with cloud; and how different aspects of edge technology are being developed and innovated.

Business impact: The business impact is present across all the private initiatives analysed and in the City of Valencia initiative, which underlines how end-user organisations are looking at edge innovation to gain business benefits. Nevertheless, each initiative measures success and business impact in a different way. The City of Valencia's Smart City initiative focuses on a data-sharing platform that enables the delivery of a broad list of services. In the private sector, the number of edge endpoints deployed, the number of locations in which such solutions are deployed, and the number of clients adopting such solutions are, generally speaking, good KPIs for indicating the success of an initiative and its ROI. Additional KPIs include:

- Measuring how clients use the edge platform, the number of accesses to edge information, and the number of to edge applications is a popular way of understanding success (e.g. Vivacity Lab, Axis, and Wordsensing)
- Measuring the outcomes of the use case supported is another key point. These initiatives clearly underline that edge is not a universal fit; the solution, the technology, and the partner ecosystem are strictly dependent on use-case needs, which is why the business success of the edge initiative in question relates strictly to the success of the use case supported. Vivacity Labs measures this through traffic efficiency on roads equipped with edge intelligent cameras, and BrianzAcque via the volume of water dispatched and the service level delivered to citizens. A leading car manufacturer based in the EU correlates success in a factory in CEE with the service availability obtained by continuously monitoring uninterrupted power supplies. Wordsensing looks at how much customers/partners are saving by deploying the company's solutions, as well as the increases in the safety of workers, citizens, and the environment that edge-based geotechnical data management enables.

Technology innovation is another big impact resulting from the initiatives analysed. The approach of distributing computing capabilities is not a new trend, but edge can be seen as an emerging technology, with hardware and software platform innovations opening up new possibilities. Moreover, when edge computing is combined with other emerging technologies/innovation accelerators, it offers great potential. The LightKone research initiative, for example, focuses on a new architecture for computing and storing data at the edge, guaranteeing continuous alignment without the need for the core. The private initiatives researched feature, in particular, solutions that combine the Internet of Things, artificial intelligence, and analytics. Both Axis and Vivacity Lab, for example, enable artificial intelligence at the IoT edge (in smart cameras), with the former focusing on the deployment of more efficient hardware and the latter focusing on algorithm deployment. The solutions of BrianzAcque and the leading car manufacturer are based on the collection of IoT sensor data. Likewise, Worldsensing gathers IoT data, with its solution adding a layer of data analytics at the edge.

3.2.3 Green IT

Green IT is increasingly an important topic in the cloud industry, with several cloud service providers announcing ambitious goals with regards to CO2 neutrality. However, compute needs will only increase globally, and offsetting the carbon emissions for computing will require clear goals and a focused strategy.

Compute efficiency can be increased by moving to a highly virtualised, or even better containerised, infrastructure that is centralised in a data centre. The regional government shared services centre that was analysed managed to reduce its electricity bills by 50% by

moving to a highly virtualised architecture. Containers are even more efficient than virtual machines.

The question is, Will the move to edge deployments make the entire infrastructure more or less efficient and sustainable? So far, we have not found evidence from the analysed projects to answer this question. We have not found projects or initiatives that were primarily looking at green IT. Green IT has emerged as a by-product of deploying modern compute paradigms, such as virtual machines, containers, and microservices.

4 CONCLUSIONS

When looking for good practices in the areas of cloud, federation, edge, and green IT, the research found that many challenges are being addressed with creative solutions, but there is still a long way to go to come up with a general set of good practices that can be applied broadly.

The main challenges that have emerged through the interviews centre around ability to identify business incentives, create a viable governance model, and make a business impact in the European market. If one objective is to improve the market penetration of European solutions in the areas of cloud, federation, edge, and green IT, then stronger incentives for users to adopt them and for companies to develop and market these solutions are needed. When there is no customer demand, it is likely that such solutions will not mature or be adopted.

Federated Cloud

Federation projects are more successful in the public sector than in the private sector because the strategic incentive is strong to have full control over and sovereignty of IT infrastructure in the public sector, whereas the business incentives to create a federation are absent in the private sector.

The key challenges identified in the H-CLOUD Green Paper are confirmed by the good-practice research effort:

1. Coordinated/Federated approaches must be structured around the objectives of their stakeholders, balancing community focused initiatives with pan-European solutions.
2. Universal challenges including defining, evolving, selecting, agreeing on, and managing the architecture, technical standards, and tools for federated clouds and for distributed data access and exchange.
3. Federated data has great potential to support the secure private sharing of data held by many different organisations.

We have learned of ways to overcome these challenges. For example, Cloud28+ created a community of service providers with a shared business interest. These providers publish their services using a joint service catalogue on the Cloud28+ platform; City Network has adopted OpenStack as its underlying technology to enable federation at the technology architecture level; and Aquacloud, Polymore, and GAIA-X are working to provide a standard data model to create value for participants in their ecosystems.

Edge Computing

The H-CLOUD Green Paper highlighted various edge-relate challenges, mostly resulting from ad-hoc innovation from different initiatives in this space, often without coordination or even collaboration on basic principles and standards. Concerns include ROI on standard edge investments, the scalability and affordability of solutions, especially for SMEs, and interoperability.

Many of the initiatives featured in this report are actually active in researching and developing new solutions that leverage edge computing as a key part of their solutions. For these initiatives, the business case is often quite clear, as edge is seen as the enabler of use cases that could not be developed in other ways, thus diminishing doubt regarding ROI for edge solutions. The edge cases analysed did not reach the level of complexity of cloud computing, whereby scalability has become the ability to orchestrate and automate workloads across thousands of devices. In the edge cases researched, due to the use cases involved, scale was not an issue.

Among the challenges the organisations interviewed have are standardisation, interoperability, and vendor lock-in, especially related to IoT and software development for edge platforms.

The main challenges related to edge computing emerging from the interviews are technological and legal:

- Technological aspects: Edge innovation is still in its infancy. Developments in chip manufacturing (silicon), hardware infrastructure, and software platforms are creating new possibilities, but coping with technology advances is challenging. Companies like BrianzAcque rely on partners to manage innovation. Those that, instead, want to drive innovation, such as Vivacity Labs, try to attract talent in universities, which is not an easy task. When innovative solutions are being developed, technical standards can sometimes be an obstacle. Vivacity Labs, Axis, and Worldsensing all view standards as a barrier, especially with regard to IoT connectivity, for which many standards are available. No plans exist for a common industry standard.
- Legal aspects mainly relate to GDPR compliance. Companies found it difficult to adapt to the new legislation. But other regions are now adopting similar policies, which places companies already equipped to comply with GDPR standards at an advantage.

The analysis of good practices has revealed some actions that would be beneficial for the edge environment, the first of which is to invest in building the skills needed to sustain the next wave of innovation. Deep technical skills around firmware and software development, hardware infrastructure optimisation, and AI algorithm elaboration are key. Skills to integrate multiple technologies into complex solutions will also be important. As the telecom sector evolves towards the new standard, which supports edge-to-cloud integration by its nature, it is crucial to bring to market a mature 5G strategy, across multiple countries, connected to the development of the European edge ecosystem. Easing and rationalising regulations and governance concerning cloud in Europe is also recommended. Edge and cloud are part of the same data-flow continuum. Having strict regulations that are not aligned with worldwide standards could slow the adoption of edge-to-cloud solutions and hinder market development.

Green IT

Green IT is the least developed area of the three, with the fewest identified initiatives featuring good practices. In order to drive awareness and accountability in this area, it is important to create a set of KPIs on which projects, initiatives, and private companies need to report. Further research in this area is needed before we can identify relevant challenges and provide good examples of how to successfully overcome those challenges.

Some Observations on Effective Research and Innovation Projects

Numerous research & innovation projects have been funded by the EU with the intention of reducing obstacles in the adoption of cloud computing, edge computing, and other emerging technologies. The projects explored in detail in this report should be regarded as typical. In addition to the structural characteristics described earlier, they share a number of other practices, which should be regarded as positive:

- The active participation of organisations, including public administrations and SMEs, and well-defined use cases, with solutions successfully developed and prototyped by the projects
- The development of reusable toolkits, methodologies, and ontologies and a strong emphasis on creating open-source components, without excluding commercial solutions
- The exploration of various exploitation models – from public sector entities participating in projects that become operators of the services to disseminating toolkits so that commercial providers can embed them into their own solutions and creating dedicated legal entities (private or PPPs) to become operators

Unfortunately, these practices are necessary but insufficient for successful exploitation. Two common scenarios illustrate the challenges:

- Projects tasked participants to become operators of the services, but these usually failed to expand and gain scale. These projects were valuable for the participating entities because they empowered project participants to experiment with leading-edge solutions. Many developed solutions were based on open standards, so technical reusability was guaranteed but business reusability was not. No mechanisms existed to resource important product management, marketing, and sales management and support functions, which are critical for the commercial success of an IT product. As a result, few organisations outside of the projects adopted these solutions.
- Projects deliberately promoted the uptake of reusable standard components among existing IT suppliers that already had the product management, marketing, and sales and support services capabilities needed, and somewhat better adoption was achieved. One example of such a project is FIWARE. Although not strictly a cloud project, FIWARE was initiated as an EC-funded project. It blossomed into a framework of open-source platform components and achieved good uptake. In particular, its core capability – as a context broker that aggregates and processes data by making it relevant for specific use cases through RESTful APIs – is experiencing good uptake in the Smart Cities space across many European countries, including Spain, France, Italy, and Portugal. One of the key success factors of FIWARE was the creation of a foundation that included the participation of ATOS engineering, Orange, and Telefónica. The foundation nurtured the community by empowering developers and users to adopt FIWARE, promoting the platform across the ecosystem, continuously augmenting its capabilities, protecting the trademark and code of conduct, and validating usage through quality assurance, training, and advisory services.

APPENDIX – RECORD CARDS

This appendix includes a transcription of each interview conducted with each initiative identified as including good practices. Each one represents a record card, describing the initiative and focusing on the challenges and success factors involved.

Name	Typology
Austrian Federal Government	Public
Bulgarian Ministry of Transport	Public
City of Valencia	Public
GDS (GCloud)	Public
Irish Government Cloud	Public
LOGIUS	Public
Polish Common State IT Infrastructure Programme (WIIP)	Public
Regional government shared IT services centre	Public
SPOTES	Public
Statens IT	Public
Aquacloud	Private
Axis	Private
BrianzAcque	Private
City Network	Private
Cloud28+	Private
CloudSME	Private
Leading European car manufacturer	Private
Polymore	Private
ThreeFold Grid	Private
Vivacity Labs	Private

Name	Typology
Worldsensing	Private
COLA	R&I
Helix Nebula Science Cloud	R&I
LightKone	R&I
Radon	R&I
RestAssured	R&I
SUNFISH	R&I
GAIA-X	PPP
IDS	PPP

Table 6: Record Cards Overview

Austrian Federal Government

Identification	
Name of interviewee	Prof. Dr. Reinhard Posch
Title	Founder of the Institute of Applied Information Processing and Communications
Organisation	Graz University and Austrian Federal Government
Country and location	Austria
Sector	Public sector

Initiative	
Description of the initiative	The Austrian government started a digital reformation process 20 years ago. Austria was lagging behind in the EU rankings. One of the key actions consisted of separating strategy from implementation. At the policy/strategy level, the focus is on feasibility and prototyping so as to define a minimum set of strategic guidelines. At the operational level, the key goal is to deliver IT services that are commercially competitive. The eGovernment Innovation Center (EGIZ) is in charge of strategic innovation. Scope of work: feasibility and prototyping; unbiased from the perspective of companies that are selected to do the work. The goal is to make sure that openness and interoperability are the gold standards for government technology innovation. Any organisation, down to the municipal level, can leverage the work of EGIZ. The need to do so is particularly urgent in small to medium-sized public administration because, internally, such organisations have the resources only to carry out day-to-day activities. BRZ is the operating arm. It provisions finance systems, citizen web portals, and registries for the federal government. EGIZ and BRZ collaborate closely, but they are independent. For example, they are currently working to integrate pictures from passports and driving licenses with school grades to create an official school record that can help citizens apply for jobs.
Timing of the initiative	Approximately 20 years ago
Key stakeholders	All levels of government, with federal government acting as the primary policy/strategy orchestrator

Initiative	
Funding	The EGIZ and BRZ are owned by the Federal Ministry of Digital and Economic Affairs, but they are managed and funded separately.
Technical solution	n/a
Relation to H-CLOUD key areas	Like in all member states, public cloud is hardly used in core government business in Austria. Barriers: • **The need to be the master of what is happening with the systems:** Imagine that a tech supplier wins a procurement contract. The question then becomes: 'Does the administration have the capability to ensure continuity of service – for example, in the COVID-19 situation?' The public sector cannot say, 'If I cannot produce a passport for you, I'll reimburse you with €10,000.' So typical service level agreements and operating level agreements that work in the private sector do not apply in the public sector. There need to be different options, such as the ability to replicate a portable copy of the data in the private cloud. • **Vendor lock-in:** For instance, the Austrian government is in discussion with SAP to make some of their cloud solutions work in both public and private cloud environments to provide government agencies with more control over interoperability. • **Data protection:** Hyperscalers move at least the metadata across borders. 'You cannot ask citizens to approve of data being transferred out of the EU.' In Germany, the government tried to avoid O365, and Austria is still in discussion with Microsoft. In small municipal governments, this is a problem because those small administrations are unaware of the risks, yet they are still responsible for the data. The main policy solution that Austria is aiming for is to differentiate between 'normal' data and 'sensitive' data – the better classification of data.
Business model	The E-Government Innovation Center is staffed by university researchers and contracted for work by the Federal Ministry of Digital and Economic Affairs. BRZ is also owned by the Federal Ministry of Digital and Economic Affairs and charges some fees for its services.

Impacts	
Business success	BRZ goal is to keep its service catalogue commercially competitive in the long run for the Austrian Federal Government by continuously adjusting the balance of its service portfolio between what is shared and what is left to the individual ministries. EGIZ's goal is to drive innovation that can foster open and interoperable tech solutions for the whole Austrian public sector.
Technology innovation	At EGIZ, innovation is very much dependent on political commitment to advance work; it involves a lot of back and forth with all stakeholders, so it becomes very hard to keep the political focus on the value of IT. Politicians have their own short-term outcomes that they need to focus on.
Governance / Organisational structure	There are CIOs in every ministry. There is a committee meeting every six months. They discuss strategic innovations in particular. Ministries, landers, and communities are obligated to use approved EGIZ concepts, interfaces, methodologies, and standards for solution design and procurement.
Data governance	Data protection is a serious matter – not only from a GDPR-compliance standpoint, but also because not all public administrations have the resources and skills to ensure that citizen data is treated properly. There needs to be a clear demarcation of responsibilities. EGIZ does not operate any systems that touch citizen data. For instance, once the solution design to integrate passport/driving license pictures with school diplomas is completed, the responsibility for running such a system will be entrusted to the Ministry of Interior.
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	Standardising data sharing and user interfaces across multiple proprietary systems to avoid vendor lock-in, in both legacy on-premises environments and the cloud.
Legal barriers	Data sovereignty and data protection concerns.
Economic barriers	Other key barriers are organisational. Getting agreements across public administrations to collaborate on service and data sharing is complex because of different missions and program priorities. Political pressures make things even more difficult.

Bulgarian Ministry of Transport

Identification	
Name of interviewee	Yasen Markov
Title	Head of department – Risk Management, Prevention, and Administration of Irregularities
Organisation	Ministry of Transport, Information Technology, and Communications
Country and location	Bulgaria
Sector	Public administration / transportation

Initiative	
Description of the initiative	Cloud computing is interesting because it can enhance the speed and scalability of data analysis and reporting, but it is merely a technical solution. There are other data governance challenges to be solved, such as what data to collect and how to collect it and make it comparable across EU member states. One critical area is the construction of transport infrastructure. A lot of transport infrastructure data is generated during the construction phase – data that becomes relevant for timely maintenance and the avoidance of incidents and data that can be used for predictive analytics for preventive maintenance, as well as for enhancing the effectiveness of the initial investments. Recently, Mr. Markov attended the online Bridges forum[46], organised by the Federal Ministry of Transport and Digital Infrastructure, where a case study relating to bridge infrastructure predictive maintenance based on drone surveillance data was presented. However, there was no discussion about the construction phase. The challenge is that in the different member states' legislations mandate different requirements in terms of documents to be collected in the construction phase. This prevents the transnational use of data. There is a need for 'legal interoperability'. The transport infrastructure construction phase data includes both technical data and contract implementation data. All of that could be feed into a big data repository. The data can then be analysed to detect anomalies that could trigger preventive maintenance. For example: • There are certification laboratories/bodies that control what construction materials comply with national

[46] https://www.eu2020.de/eu2020-en/events/-/2343062

Initiative	
	requirements. Different legislations mandate different requirements in terms of the certification process (who signs the certificates) and governance (national or regional government audit and oversight responsibilities). • Testing standards can be different. For instance, in Bulgaria, some of the bridge load design and testing standards are still – or at least were until very recently – based on normative documents implemented 40–50 years ago. • Construction projects have different timing. Depending on how long the project is, there are different reporting requirements on how to document problems that arise during the project. These audit logs could be used as red flags for predictive maintenance. A year and a half ago, Mr Markov proposed transportation as a topic for Horizon 2020 – namely, the implementation of a common standard for the exchange of such road infrastructure construction data between the transport infrastructure owners and operators. Mr Markov and his team have not looked at sensors for monitoring the conditions of roads and bridges once they are operational, such as bridge vibration sensors or data from carmakers on how bumpy or slippery certain sections of a road can be. Mr Markov mentions the Transport Research Cloud report[47] as one document that may be of interest for the H-Cloud study. Another such document, with regard to possible use cases, is the STRIA Road Map on Infrastructure[48].

[47] https://trimis.ec.europa.eu/sites/default/files/documents/ki0318383enn.en_.pdf
[48] http://smart-transportation.org/stainaction/stria-roadmap-on-transport-infrastructure-2019-update-report-now-available/

City of Valencia

Identification	
Name of interviewee	Ramón Ferri Tormo
Title	Head of Smart Valencia
Organisation	City of Valencia
Country and location	Spain
Sector	Public sector

Initiative	
Description of the initiative	The Valencia Smart City Project (a.k.a. the VLCi platform project) – which began in July 2014 and was initially to integrate data and processes related to municipal services into a platform that would help the administration improve efficiency and responsiveness – includes 17 initiatives and aims to provide the city with new solutions in five different areas: mobility, governance, environment, society, and wellbeing. The VLCi platform is the first smart city commercial platform deployed in Spain that uses the European FIWARE Smart City context broker. Key capabilities include: • Information acquisition – collects data from the sensors and information systems of Valencia's various city council services • Information distribution – manages huge amounts of information from multiple sources • Information storage and analysis – statistical and predictive analysis based on Big Data analytics • Information availability – report generation, dashboards, and open data management During the COVID-19 emergency, Valencia focused its response to the COVID-19 crisis on providing information and support to citizens and managing the situational awareness required by the Municipal Operational Coordination Centre (CECOPAL) to guarantee the continuation of municipal services and the provision of crisis management from Valencia City Council. The core of the solution is the VLCi platform, where data and information from many municipal information systems (population, integral water cycle, mobility, electronic headquarters, municipal buildings, etc.) is consolidated with information from devices deployed in the city (environmental noise and traffic sensors, traffic control cameras, lighting controllers, etc.).

Initiative	
	Valencia offers its citizens updated and consolidated information and communication through a COVID-19 unified information site[49] and an app (AppValencia). These solutions provide real-time information about the crisis, including dynamic dashboards displaying information provided by the city's platform (water management, traffic flow, air quality, noise level, etc.), including useful information from municipal services, news and twitter feeds of municipal accounts, and an overview of the situation at the national level. The website also has services embedded from other public entities, such as the National Statistical Office (INE), which provides maps to indicate every day (although not in real-time) what percentage of population is on the move vs. the percentage staying at home. The website also has a section called 'New Normal', which provides guidelines for various activities – work, shopping, restaurants, beaches, hotels, sports, cultural events, transport, and so forth.
Timing of the initiative	See the previous paragraph
Key stakeholders	Telefonica, the Polytechnic University of Valencia, the University of Valencia, InnDEA Valecia, Esri, Cap Gemini, and Deloitte
Funding	At the end of December 2016, an agreement was signed between public business entity Red.ES and Valencia City Council. This agreement grants Valencia financing for its Impulse VLCi proposal within the 2nd Call for Smart Cities, launched in 2015. The sum granted amounts to approximate €6 million. Telefonica won the contract, for which tenders were submitted from 10 strong market players. Telefonica's quote was €3.9M with a 4-year contract period, with the option to renew for another 2 additional years (1 plus 1).
Technical solution	VLCi is based on FIWARE.
Relation to H-CLOUD key areas	VLCi is hosted as a private cloud instance in the Telefonica data centre.
Business model	n/a

[49] http://coronavirus.valencia.es

Impacts	
Business success	The platform aggregates information across the city's previously siloed systems, analyses it, and delivers insights to city service managers to make evidence-based and timely decisions. Information is also published on the Open Data Portal – not only for the citizenship to view, but also for developers and businesses that want to reuse the data through APIs to build new services.
Technology innovation	Valencia wants to make VLCi available to Spanish universities. Instances of the platform will be made available through containers to be run in universities' private clouds. The business objective is to allow academic researchers to work with city data, i.e. to give them access to very rich datasets. Universities can then develop new components for FIWARE, which the city could reuse. Universities' engineering departments can also help certify devices for connectivity, which can then be procured by the city for new IoT/edge projects. The university pays for the data centre, and the city requires the contractor to deploy the instance through containers – for example, for 6 months.
Governance / Organisational structure	n/a
Data governance	All the data that VLCi brokers is non-sensitive data
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	Ramon Ferri is the head of the ITU U4SSC city platform thematic group[50]. The goal of this program is to make the platform available to other cities, with a focus on medium-sized to large cities. There are four working groups: • Sharing city best practices • Data interoperability – better integration of health data between regional government and local government, which was a big problem for Valencia during the pandemic • Architecture – defining the key principles and guidelines on the key capabilities that enable smart cities (One of the

[50] https://www.itu.int/en/ITU-T/ssc/united/Pages/thematic-groups.aspx

Obstacles/Barriers	
	focus areas is to look for future capabilities around AI and edge.) • Improving preparedness and resilience, with focuses on health, tourism, and resilience The output of this collaboration will be standards and guidelines – so, no real federated products.
Legal barriers	n/a
Economic barriers	n/a

GDS (GCloud)

Identification	
Organisation	Various interviews and secondary research on G-Cloud were conducted by IDC over the past 10 years, both with UK government representatives and tech suppliers
Country and location	UK
Sector	Public Administration

Initiative	
Description of the initiative	The UK government is ahead of the curve compared with other countries in Western Europe in terms of cloud computing adoption. The move to the cloud started with the 2011 Government Cloud Strategy[51]. The UK government was led by a Conservative-LibDem coalition. Austerity measures were a big focus for the HM Treasury. Cloud computing was considered the key to unlocking the oligopoly of large systems integrators and outsourcers, like Accenture, HP-EDS, Capgemini, IBM, Capita, Fujitsu, BT, and a few others, which had locked many central government departments in all-encompassing 5–10-year deals. This oligopoly resulted in the loss of skills that were incrementally outsourced to these firms. It yielded limited innovation because the contracts were built around SLAs focused on ongoing systems operation and maintenance. And SMEs were left out of public sector procurement, unless as subcontractors to large firms. This approach to procuring and deploying IT capabilities was also ill-equipped to respond to the increasing demand for the agile and fast-paced digital transformation of government processes and programs. Any business innovation need was tackled by specifying detailed functional requirements, which resulted in rigid and siloed custom-built solutions that were hard to integrate and reuse beyond individual government programs. Cloud computing offered a completely different approach. Standard services, instead of custom-built code, could be purchased on a modular consumption basis. But the transition from the old paradigm required a comprehensive program that addressed procurement, skills, cultural change, information assurance, and budgetary hurdles. The G-Cloud program entailed five elements that the 2011 strategy spearheaded: • A cloud first policy – first issued in 2013 – which mandates that central government 'Departments remain free to choose an alternative to the cloud but will need to demonstrate that it offers better value for money,'

51 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/266214/government-cloud-strategy_0.pdf

Initiative	
	whereby cloud first means 'public cloud rather than a community, hybrid, or private deployment model.' The policy is not mandatory, but 'strongly' recommended for the rest of public sector. • The Digital Marketplace[52], whereby any supplier that is pre-qualified through framework contracts can advertise and sell its services. • A standardised cloud information assurance approach. • Coordinated governance, which, in the initial phases of the program, assigned responsibilities for proofs of concepts to various public sector entities, but then centralised the scaling and operations of the programs into the Government Digital Service (GDS) and the Crown Commercial Service (CCS). GDS is in charge of defining and disseminating the strategic and technical guidelines for digital transformation across government, such as the Technology Code of Practice. CCS is in charge of managing pan-government procurement programs, including the G-Cloud frameworks, and qualifies which suppliers can sell on the Digital Marketplace. • Crown Hosting data centres is a public-private partnership that offers managed private cloud services for those organisations that are not ready to migrate all of their systems to the public cloud or to build and run their own private cloud data centres.
Timing of the initiative	2011-ongoing
Key stakeholders	n/a
Funding	The initiative was funded by the UK HM Treasury
Technical solution	The Digital Marketplace is a publicly accessible, searchable database of services offered under G-Cloud frameworks. The service began in 2012.
Relation to H-CLOUD key areas	Cloud and federated cloud
Business model	The Digital Marketplace – initially the Appstore and then the CloudStore – has been the flagship initiative of the G-Cloud program. It greatly increased the maturity of buyers and providers, notwithstanding the fact that the volume of cloud services purchased through the Marketplace is still small relative to the total ICT spending of the government sector. In fact, in fiscal year 2019, the total G-Cloud services purchased through the marketplace were approximately £1.4 bn across the whole of public sector (including central government, devolved

[52] https://www.digitalmarketplace.service.gov.uk/

Initiative	
	administration, local governments, the NHS, schools, colleges and universities, and housing providers), against a total ICT spending that is estimated at above £10 bn. Services are classified into 3 lots: • **Lot 1:** Cloud Hosting (IaaS) and (PaaS): Cloud platform or infrastructure services that can help buyers do at least one of the following: deploy, manage, and run software, or provision and use processing, storage, or networking resources. • **Lot 2:** Cloud Software (SaaS): Applications that are typically accessed over the internet and hosted in the cloud. • **Lot 3:** Cloud Support, including planning, setup and migration, training, security services, quality assurance and performance testing, and ongoing support of cloud hosting and cloud software.

Impacts	
Business success	As of Q1 of fiscal year 2020/21 (June 2021), the cumulative value of cloud services purchased through the Marketplace[53] amounts to £6.43 billion, of which £5.11 billion is from central government departments and agencies, to which the cloud-first policy mandate applies. Lot 3 type of services account for over 60% of all services purchased through the Digital Marketplace, clearly indicating that consuming public cloud IaaS, PaaS, and SaaS is a complex endeavour for the government, which requires specialist support to migrate from legacy systems, integrate across hybrid multi-sourced environments, manage risk and security, and master technical and organisational capabilities.
Technology innovation	On the demand side, G-Cloud gave public sector departments the opportunity to transform their legacy architecture by developing and scaling business innovations much more rapidly and at lower cost. Initially, these tended to focus on net new workloads or workloads that deal with non-sensitive datasets, such as web servers for citizen portals and open data portals, collaborative tools, and backup storage systems. Over time, the transition to the cloud has entailed more sensitive business systems. For instance, in the first half of 2020, the HMRC announced a plan for more than 600 services to migrate to cloud; the Financial Conduct Authority signed a contract for an SaaS

53 https://app.powerbi.com/view?r=eyJrIjoiNTEyMTZhZDAtZGNiNi00OWQxLWI5ODYtMjg1ZWNlMmNkODVhIiwidCI6IjlmOGMwZDc5LTNlODctNGNkMy05Nzk5LWMzNDQzMTQ2ZWE1ZSIsImMiOjh9

Impacts	
	ERP solution; and HMCTS signed a contract for a cloud-based video platform for remote criminal hearings.
Governance / Organisational structure	n/a
Data governance	One of the key factors that drove up the level of trust among UK government CIOs of cloud was the transparent common approach to information assurance adopted by G-Cloud. Although other European governments had similar initiatives, they were not promoted with the same strength. Moreover, the European Union did not have the power to influence member state government approaches beyond the policy guidelines put forward by the EU's cloud computing and cybersecurity strategies. In the UK, policies are issued and overseen by the Government Digital Service, part of the Cabinet Office, and by the National Cyber Security Centre, part of Government Communications Headquarters (GCHQ), which is a British intelligence and security agency. The key information assurance milestones of the G-Cloud program included the launch of a pan-government accreditation mechanism, which became operational a few months after the launch of CloudStore, in 2012. As of July 2014, approximately 60 services offered by more than 10 different providers had received G-Cloud pan-government accreditation. The pan-government accreditation mechanism was particularly helpful for smaller government agencies that could not afford a thorough review and audit of services. These agencies could thus make their own decisions (which remained their full responsibility) based on a standard accreditation mechanism. The information assurance guidelines that formed the basis for the pan-government accreditation mechanism were: • A formal and independently verified process similar to the ISO 27001 standard • A Government Protective Marking Scheme (GPMS). The latter is the policy that describes how 'government classifies information assets to: ensure they are appropriately protected; support public sector business and the effective exploitation of information; and meet the requirements of relevant legislation and international/bilateral agreements and obligations.' The legacy GPMS classified information assets in six categories (Unclassified, Protect, Restricted, Confidential, Secret, and Top Secret), which directly matched the business impact levels (BIL, or IL) – 1, 2, 3, 4, 5, and 6 – used to assess the risks of loss of confidentiality, integrity, and availability of government information and ICT systems. (It must be noted that the exact match between the GPMS and BIL was a one-way only relationship.)

Impacts	
	The pan-government accreditation process was not without drawbacks. In particular, it proved rather slow and expensive for both buyers and suppliers. As a result, in 2014, the UK government took two steps to streamline it. Firstly, in April 2014, a simplified GPMS entered into force. The new GPMS classifies information assets into Official, Secret, and Top Secret. Secondly, at the end of July 2014, the Government Digital Service (GDS) issued a communication that indicates that suppliers on G-Cloud will no longer need to obtain pan-government accreditation and that G-Cloud will also stop accepting new accreditation submissions. G-Cloud suppliers are instead required to self-certify their services, and buyers will become responsible for assessing and selecting the most appropriate cloud services that meet their individual security requirements. However, cloud services that connect to the Public Services Network (PSN) still require Pan-Government Accreditation (PGA). Cloud information assurance policies and practices took into account interdependencies with broader government strategic objectives – for instance, with cybersecurity strategies. In the UK, from 1 October 2014, all government suppliers must comply with the new Cyber Essentials controls when bidding for public sector contracts that involve handling sensitive and personal information and the provision of certain technical products and services. The Cyber Essentials scheme was developed by the government in consultation with industry: 'It covers the basics of cybersecurity in an organisation's enterprise or corporate IT system. The implementation of these controls can significantly reduce the risk of prevalent but unskilled cyber-attack'.[54] Although not directly related to G-Cloud information assurance policies, the scheme's set of five critical controls have become a key complement to reduce the government's (IT and non-IT) supply chain levels of cybersecurity risk. The Cyber Essentials scheme assurance framework explicitly describes how cloud services create additional interdependencies among buyers and suppliers.
Environment and sustainability performance	Making it easier for SMEs to do business with the public sector was one of the strategic goals of G-Cloud. By May 2013, there were over 700 suppliers, over 80% of which were SMEs.

Obstacles/Barriers	
Technical barriers	n/a
Legal barriers	n/a
Economic barriers	On the supply side, G-Cloud created a level playing field for a whole new set of suppliers. SMEs were the first beneficiaries.

[54] https://www.cyberstreetwise.com/cyberessentials/files/scheme-summary.pdf

Obstacles/Barriers	
	They have captured over 40% of G-Cloud cumulative business. UK Cloud, Specialist Computer Centres, Mastek, BJSS, and other UK suppliers scaled from small specialists to medium-sized and large companies that can compete with global IT vendors. However, the SME share of G-Cloud framework business decreased slightly over time because major cloud vendors, like Microsoft, IBM, Amazon Web Services (AWS), and Google, started to capture larger contracts. AWS entered the competition in 2013 with the G-Cloud 4 framework and Google only in 2018. The companies that struggled the most were the traditional systems integrators and IT outsourcers, which were slow to change their business models to adapt to shorter and smaller contracts and modularised consumption-based solutions.

Irish Government Cloud

Identification	
Name of interviewee	Barry Lowry
Title	Irish Government CIO
Organisation	Department of Public Expenditure and Reform, Irish Government
Country and location	Ireland
Sector	Public administration

Initiative	

Description of the initiative	In 2016, Mr Barry Lowry (the interviewee) was appointed to his current position. He has since helped design and implement the Government ICT Strategy[55] following three key principles:
	Always honour the past by building on what his predecessors had done and considering international best practices, such as the UK Government Digital Service.
	• Always invite people to create the future. Shortly after his appointment, all departmental CIOs gathered for a 2-day workshop, in June 2016, to discuss and align priorities.
	• Earn the right to ask for more by demonstrating the benefits.
	When all the government department CIOs gathered in a hotel in June 2016 they worked on:
	• Digital services transformation
	• Data sharing solutions and skills
	• A 'BUILD TO SHARE' concept: If there is a good idea, build it once, build it well, and make it available for others to share. Examples of shared solutions so far include:
	  ○ EDRM system
	  ○ Shared desktop
	  ○ Government cloud: There was already a Government Network. A state data centre project was set up, which has so far undergone planning and permission and is now being procured. The business case was built around cost/competitiveness against co-location alternatives. Everybody was opposed to co-location

[55] https://ictstrategy.per.gov.ie/

Initiative	
	○ Electronic ID
Timing of the initiative	The BUILD TO SHARE part of the strategy aimed to bring together 20 departments: 3 large ones – namely, finance, employment affairs and social protection, and agriculture/food & marine – which provided pretty good services; the rest offered variations of mediocre. A roadmap for hybrid delivery model of ICT infrastructure was created, including two steps: 1) **Step 1** – Guidance: The policy left the option open for private vs. public based on data sensitivity. Other factors driving the choice included: a. Availability of commercial solutions: If you are buying an HCM system, the best solutions exist in the cloud, so the type of workload guides the choice. b. A lot of the legacy core systems cannot be migrated to public cloud, so it does not make sense to run them on AWS or Azure. c. Some systems are audited quite frequently, and auditors want to see physical security, which is difficult for public cloud. d. If users are outside government, it is easier to build them outside of the government firewall. 2) **Step 2** – Build a government private cloud, but with ability to burst to Microsoft and Amazon services. The environment is fairly cheap and reliable. Full automation enables remote maintenance, which has proven very valuable during the COVID-19 crisis. But it cannot cope with huge scalability requirements. For instance, www.gov.ie was getting 70,000 hits per minute after COVID-19 announcements. The web server is hosted on AWS because it was not scalable in the private cloud. CHALLENGES: The state data centre aims to build the greenest in Europe, but the approval process was slow. ISO 27001 certification takes a lot of time and energy. Some civil servants like to work for the government (as opposed to working for or being transferred to an external company), so the government retained the capability to run private cloud internally, rather than as a managed service, like the UK government did.
Key stakeholders	All central government departments
Funding	No
Technical solution	n/a
Relation to H-CLOUD key areas	Cloud
Business model	n/a

Impacts	
Business success	Make shared services available across central government • EDRM system • Shared desktop • Government cloud: By 2022, there will be cloud provisioned infrastructure. • Electronic ID, which went from <10,000 users to 750,000
Technology innovation	Looking at innovation in various areas – particularly, where cloud could help scale new services: • IoT/Edge computing and analytics for agricultural policy decision making – for instance, monitoring crop yields to decide whether to convert them into forests • Working on a project to use a blockchain-powered app that can help validate education certificates when applying for a job; collaborating with an insurance company and other European governments, but some EU member states are not open to using smartphone apps because of privacy concerns over iOS and Android
Governance / Organisational structure	Operational governance – three tiers: • Civil service management board – the secretary general of every department: Barry gets invited twice a year, and there is a dashboard available about the progress of the strategy. • Sub-group – co-chaired by two of the most influential secretary generals (of the spending/finance department and the welfare department): This is where the collective decision making happens among digital leaders across all departments. • ICT advisory board: This is the head of IT of every department; in some departments, this is a role that reports to the secretary; in others, they are more junior They are considering a memorandum of understanding (MoU) to enable local governments to access some of the resources, but local councils are still very independent and have their own shared services entity[56].
Data governance	n/a
Environment and sustainability performance	n/a

[56] https://www.lgma.ie/en/

Impacts	
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	The government does not want to do bleeding edge innovation; they prefer to start small, with basic services such as identity management and analytics, and then scale through more advanced solutions such as blockchain and ML/AI.
Legal barriers	More than legal, the barriers are political: • Politicians want to retain control over data. • Politicians want to control how data is used; for example, do they really want to leverage IoT/satellite and analytics to analyse in more detail land usage and determine whether farming grants should be directed to convert farms into forests? Similarly, at the EU level, if the EC decided to go down the path of EUCF, the practical implementations could be slowed down by discussions around the member state in which EUCF would be located.
Economic barriers	The cost of renting data centre space: The value of EC support cannot stop at 'We make something available and you figure out how to use it,' because the difficult part is not in setting up standards or a marketplace; the complexity is in implementation at the use-case level. So, the EU strategy should be built from the bottom up because reusable federated cloud and edge capabilities need to be ready to be applied to practical problems.

LOGIUS

Identification	
Name of interviewee	Martin Dias D'Ullois
Title	Product Owner for Logius private cloud
Organisation	Logius (owned by the Ministry of Internal Affairs, which is in charge of the whole Digital Government Agenda)
Country and location	Netherlands
Sector	Public sector

Initiative	
Description of the initiative	Logius has about 500 people (some self-employed). It provides critical digital services for the Dutch public sector: • Dutch digital ID for citizens (DIGID) • Freight/Port customs declaration management systems (XBRL-based declarations) • Dutch digital ID for businesses Logius is always part of a value chain where multiple services are connected in a federated manner. For instance, digital ID can be used to log in to Tax Agency digital services. The process is quite structured: • Every Dutch citizen is assigned a national ID number. • The national ID number is used to ask for the DIGID that Logius maintains. • The ministry that provides the service needs to ask for certification to use DIGID for their services. There is a certification and audit process. • From the technical perspective, a custom interface usually needs to be set up between DIGID and the ministry. Logius is trying to make DIGID more open and reusable as a service, but it is not yet fully there.
Timing of the initiative	n/a
Key stakeholders	Public sector
Funding	n/a
Technical solution	n/a

Initiative	
Relation to H-CLOUD key areas	Cloud and federation
Business model	n/a

Impacts	
Business success	n/a
Technology innovation	Technology wise, cloud computing is a pillar of agility that uses Kubernetes container-based architecture. It creates a multi-cluster multi-data centre solution and needs at least three data centres to run clusters. Martin's team is building an orchestration solution based on open source (OpenStack, OpenShift) – Cloud Native Computing Foundation. Dashboard, orchestration, and backup are all considered in the roadmap. Logius has two platforms: • A single data centre platform acquired from other government entities • A second data centre platform that supports non-critical applications The orchestration layer aims to converge the pipelines to deploy services from both platforms. The desired outcome is to be able to rollout to AWS, Azure, and the government private cloud data centre, creating a truly interoperable orchestration layer for agile deployment. A European service repository for reusable building blocks in terms of IaaS and PaaS management would be really useful in this context.
Governance / Organisational structure	Logius is owned and funded by the Ministry of Internal Affairs. This is a change compared with the previous governance, whereby digital government was split between the Ministry of Internal Affairs and the Ministry of Economic Affairs. However, each ministry still has its own CIO, and there is a government-wide CIO, so strategic decisions are hard to align. There is a process to decide on innovation – for example, on the development of the building blocks for a cloud management & orchestration solution. There's a rigorous process to evaluate demand; the number of users needs to be big enough. The challenge is political influences – for instance, from large agencies, such as the Tax Agency and the Ministry of Health – which may create biases.

Impacts	
	There is a need to meet transnational requirements, such as EC eIDAS, which need to be embedded in the roadmap. The Logius internal organisation is really changing the traditional 'product' focus. Big islands were broken up in 2019. In the production house, planning is in three-month cycles. Everything is based on business case discussions. The focus is on delivering value in a fast and agile manner.
Data governance	n/a
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	n/a
Legal barriers	There are big contracts: The data centres are not Logius's; they are procured through contracts. Using two Equinix data centres. Starting new contracts for security operation centres (SOCs). Not using public cloud services, with the exception of minor workloads across the government, which are in the Azure or AWS clouds, but not very popular. Logius is considered critical infrastructure: It was categorised as such during the COVID-19 outbreak, with very stringent business continuity and data protection limits applied.
Economic barriers	There are some governmental data centres, but they are not yet mature. For example, global load balancing with redundancy for every service is not available. In the future, Logius foresees four government data centres. The director of the main data centre was unaware of H-Cloud and GAIA-X. The Ministry of Defence wants to maintain its own infrastructure.

Polish Common State IT Infrastructure Programme (WIIP)

Identification	
Organisation	Ministry of Digital Affairs
Country and location	Poland, Warsaw
Sector	Public administration

Initiative	
Description of the initiative	Wspólna Infrastruktura Informatyczna Państwa – The Common State IT Infrastructure Programme (WIIP) The WIIP program is responsible for increasing the security of data processed in the ICT systems of public administration entities and optimising the maintenance costs of these systems. The program covers the introduction of uniform high standards regarding IT system protection and support for public administration entities in the running of these systems, and the provision of the services necessary for the construction, development, and maintenance of these systems. Such contributions will ensure public administrations provide a high level of services to the public. The WIIP program assumes the optimisation of existing ICT resources and applications in public administration by providing modern and cost-optimised IT. Such an approach to public administration enables priorities to be set in terms of increasing the level of security, comprehensive migration plans, and balancing the use of cloud solutions. The WIIP program comprises the following projects and initiatives: • The Common State Information Infrastructure Project (WIIP), implemented under POPC – Axis 2.1 'High Accessibility and Quality of Public E-Services' • The Innovative Administration Platform (PIA) project, which includes, among others, the GovTech competition platform, ZUCH, and joint applications • A project to modernise the existing infrastructure of integrated state registers • Additional initiatives: government administration communication platform, the EBRD project, data embassy, and a data processing centre for administration.
Timing of the initiative	On 24 September 2019, the Council of Ministers adopted a resolution on the Common State Information Infrastructure initiative, which is a response to the arrangements adopted on 25 September 2018 by the Economic Committee of the Council of Ministers.

Initiative	
	First services were launched in Q1 2020.
Key stakeholders	WIIP is a public administration initiative, with the main stakeholder being the Ministry of Digitalisation. The program's partners are: • Naukowa i Akademicka Sieć Komputerowa – Państwowy Instytut Badawczy (National Research Institute under the supervision of the Ministry of Digital Affairs) • Centralny Ośrodek Informatyki (Central IT Centre) • GovTech Polska.
Funding	Yes, some initiatives and works within WIIP projects are financed from the EU budget under the POPC 2.1 program – high accessibility and quality of public e-services.
Technical solution	All systems and applications are developed internally (using ministry resources) but with cooperation from some partners. The main concept is based on the UK's G-Cloud, but with everything adjusted to comply with Polish regulations.
Relation to H-CLOUD key areas	WIIP is a federation of clouds: • **Government Cloud:** This is a private cloud for central and local government and is currently in development; some services are already available. This will be completed in 2022. Currently, basic IaaS services are available, with plans to gradually add more complex IaaS services. Over time, the services catalogue will expand to include XaaS (everything as a service). • **Cloud Services Provision System (ZUCH):** On this platform, verified cloud partners can offer their cloud services to the government sector in Poland. ZUCH was launched in Q2 2020 and is now open to partners. Partners include Netia, Hostersi, and Oktawave. As an element of WIIP, a national data processing centre will be developed as a green data centre – with the efficient and modern use of energy to optimise costs and to follow the trend for green data centres. For example, photovoltaics will be utilised.
Business model	The main idea behind WIIP is to offer a cloud platform for central and local government. Commercial cloud providers are to become partners in this project. Their services will be available to public administration organisations via the Cloud Services Provision System. But security is the key, and the ministry, in cooperation with other organisations, will establish a set of rules concerning which data and systems can use cloud:

Initiative	
	• Classified data (confidential) CANNOT be stored or processed in any clouds. • Sensitive data can be stored and processed in the Government Cloud (private cloud). • Personal data and systems with personal data that have to be GDPR compliant may be stored or processed in public cloud, BUT only when the data centre is located in Poland. • Other data (small systems, websites, office apps, and open databases) may be stored and processed in public clouds when the data centres are located in Europe.

Impacts	
Business success	This initiative will be successful if we see a growing number of providers joining the Cloud Services Provision System (ZUCH) and a growing number of government organisations reach out to use cloud. It is a little too early to tell what hard data KPIs will be applied. It will be important to see a large number of Polish/local providers join ZUCH. Finally, the ministry would like to see ZUCH as a role model solution for other countries and governments in Europe. The Ministry would also like this platform to become a part of a wider European cloud federation so that clients in Poland could use cloud services offered on similar platforms in other countries.
Technology innovation	The WIIP platform does not directly employ any innovation accelerators (AR/VR, blockchain, AI, IoT, or edge) with the exception of security; security is a key element of this initiative. It is important to know that WIIP is planned as a key platform for any projects run by public administrations. Therefore, if projects involve the previously listed accelerators (AI, VR, or IoT), these projects will still use WIIP's infrastructure and cloud services platform.
Governance / Organisational structure	The current organisational structure successfully supports active collaboration and the participation of stakeholders, in terms of both project development and the process of expanding the pool of external partners. ZUCH was launched a few months ago and already has close to 40 registered partners; it is running successfully, as intended. Government Cloud is a part of WIIP. The whole project is run by the Central IT Centre. Government Cloud will be managed by the Ministry of Digital Affairs, with COI support.

Impacts	
	As stated above, ZUCH is an element of WIIP. The COI plays a vital part in development; the ministry manages the platform. However, as is usual in central government, the ministry needs to cooperate with other ministries (e.g. when defining security levels for various data sources and systems to make sure data within the Ministry of Health and the Ministry of Justice is handled correctly). Ultimately, everything must be approved by the prime minister, but it is more on a legal/approval level, as opposed to being about the concept and technology.
Data governance	Data protection and regulatory compliance are the key elements of the projects – how the system can be used, depending on data type within public administration, as described above. It is crucial to note that partners that want their cloud services to be available to public administration customers must be verified before they can use ZUCH. Formal verification – company legitimacy, taxes paid, no debts, and so on – establishes whether the prospective partner is reliable. Security verification is included – norms, certificates, security policies, and so on. The prospective partner must complete a questionnaire. The Ministry of Digital Affairs must also verify each service the prospective provider wants to add to ensure the service is safe and meets all requirements. ZUCH also verifies buyers – for example, checking whether the system data will be placed in public cloud and, if so, whether it is categorised correctly.
Environment and sustainability performance	As a new data centre for administration, the National Data Centre will be a green data centre.
Focus on SME	SMEs are not the target group for this project in any way or form (unless very small local government organisations). WIIP and ZUCH are open to SMEs that wish to offer their services on the platform. The Ministry considers this openness to be a good way to promote local GovTech initiatives (hence the partnership with GovTech Poland).

Obstacles/Barriers	
Technical barriers	• The most challenging aspect was to standardise services criteria for providers willing to join ZUCH. Services must be compliant with regulations and security policies in terms of technologies, pricing, and invoicing. This took a long time – especially since various providers differ significantly in the ways they offer their services. The ministry eventually resolved the issues involved. In some cases, the ministry decided to focus more on the comprehensiveness of a service rather than on its individual parameters. Also, framework agreements have been introduced. The ministry understands that standardisation is important but cannot be done to the detriment of any providers whose offerings might be discriminated against due to such issues. • The ministry decided to introduce ZUCH to offer various services to various customers and ensure technical diversity within central and local government. • ZUCH is based on the UK's G-Cloud, which presents a partial legal barrier and a partial technical barrier. The Polish systems had to be adjusted to be compliant with local regulations. • Governmental Cloud is not a barrier as such, but it is a project that is still in a relatively nascent state; it will be finalised within the next 2 years. So, to some extent, it is a challenge for data and systems that cannot use public cloud but which require cloud a.s.a.p.
Legal barriers	• Public procurement regulations are not prepared for or suited to cloud delivery models. A dynamic procurement model exists, but it is not very common and not often used. The level of uncertainty around how it will be adopted in the future is high. • The split between central and local administration is legally problematic – for example, what to do about local governments that process sensitive data (which should be processed in governmental cloud) but have local budgets so cannot use central government cloud. One solution, which is in a very early stage, is to create 'cloud regions' to be used on a local government level.
Economic barriers	• There are always potential budget limitations. Governments – especially on a local level – might find other needs more pressing than IT, cloud in particular. • Split between central and local administration is legally problematic – mostly, in term of budget allocation, EU funding, etc. The question relates to how to use local government budgets in central government projects. This will need time to resolve.

Regional government shared IT services centre

Identification	
Organisation	Regional government shared IT services centre
Sector	Public sector

Initiative	
Description of the initiative	This is the shared services unit of the regional government. Their data centre services constitute multiple services: • Infrastructure services: There are three data centres. One is ready for sunsetting; one of the other two is certified to the highest standards – TIA-942 – working 24/7 to support, in particular, healthcare users. • System and technical architecture services • Database administration services • Solutions and products: These are essentially shared applications, like collaborative tools (email, Sharepoint), virtual agents (e.g. Citrix), and Active Directory. All regional and municipal governments, as well as hospitals, emergency contact centres and community centres, GPs, and public health services, rely on the centre for their critical IT infrastructure. • 220 municipalities • 3 healthcare authorities and 2 research centres • 10+ regional government entities
Timing of the initiative	Community cloud IaaS program started in 2014
Key stakeholders	Public sector and SMEs
Funding	Yes, participating to R&I projects
Technical solution	n/a
Relation to H-CLOUD key areas	Cloud, federation, and green
Business model	The primary business model is to sell services to regional and municipal public administrations. The centre also aims to earn 20% of revenues from small and medium-sized private enterprises.

Impacts	
Business success	Business success is defined in terms of cost-quality and the take up of services by public administration.
Technology innovation	Investments on data centres were driven by the need to control data – particularly for healthcare entities that the centre serves – to maintain accountability, business continuity, and data sovereignty. That has driven the implementation of a community cloud architecture for IaaS. Some public cloud is used – for instance, O365 for the majority of users, but not all. The centre manages overall 60,000 mailboxes; it was not possible for operational and data protection reasons to migrate all of them. The centre is starting to work on containerisation, but there is no clear demand for hybrid cloud from the end users yet. They are considering using storage as a service from public cloud providers, but often the volume/price thresholds that the CSPs set in their contracts are too high. The centre is also working to implement a totally new infrastructure, based on hyperconverged equipment and software defined network (VMware-based). This full virtualisation of the network also helps with disaster recovery: Everything is fully replicated. This will also make the centre ready for the hybridisation of cloud services.
Governance / Organisational structure	The centre is a private company but 100% owned by the regional government. So, essentially, it is a public corporation subject to public sector procurement, budgeting, and other regulatory requirements. All strategic decisions are made by a board that reports to regional elected officials. It has a dual system of governance. At the technical architecture level, the centre is quite independent, as long as it follows those strategic guidelines.
Data governance	Investments in data centres were driven by the need to control data – particularly for the healthcare entities that serves – to maintain accountability, business continuity, and data sovereignty.
Environment and sustainability performance	In 2013, the data centre infrastructure energy bill was €1 million. In 2014, with more data and higher workloads, some rationalisation drove a saving of €400,000. In 2019, with the new data centre, with all the latest technology and physical architecture and automation, the bill was €300,000, having changed all island, heating, and cooling systems, etc.
Focus on SME	In the new strategy to work with other industries, the centre is focusing on driving revenue growth with local SMEs – in particular, SMEs that have IT solutions (PaaS and SaaS) that

Impacts	
	need an infrastructure provider to host their services. The centre differentiates in two ways: • For companies that want to bid for public sector business, they offer a certified data centre. • For SMEs that do not have the skills to work with hyperscalers, the centre offers value-added support services to configure and maintain the virtual servers, backup services, etc. the centre works with the regional branch of the national industry association to market services. It set up a dedicated relationship management structure.

Obstacles/Barriers	
Technical barriers	The inability to migrate/port all 60,000 mailboxes to O365 is an indication of the gap in terms of internal resources, both skills and infrastructure.
Legal barriers	The regional government is accountable for data protection and feels more in control by having the data in its own data centres – particularly sensitive data, like healthcare data.
Economic barriers	The contract/pricing volume threshold sometimes makes it difficult to experiment with public cloud.

SPOTES

Identification	
Organisation	Ministry of Ecological Transition
Country and location	France
Sector	Public administration

Initiative	
Description of the initiative	SPOTES – which is a part of DINUM/SNUM, the government IT organisation, and the digital transformation agenda – is a marketplace for IT services for government employees. The ministry has received funding from DINUM to act as the pilot user for SPOTES.
Timing of the initiative	It was announced at VIVATEC 2019.
Key stakeholders	French government direction interministérielle du numérique (DINUM) and other central government ministries
Funding	French government
Technical solution	The marketplace is now running on the ministry's private cloud, which is based on OpenStack.
Relation to H-CLOUD key areas	Federated cloud
Business model	n/a

Impacts	
Business success	The service catalogue includes: • Workplace services • Collaborative tools • IaaS • PaaS • Helpdesk support • Architecture and methodology Services are available both individually and as packaged solutions. They started by defining a taxonomy.

Impacts	
	There are currently over 50 services published by different entities in the ministry, including events, seminars, educational material, and blogs. The KPIs that they monitor include: • User experience • Number of transactions • Number of registered users • Number of tickets • Number of offerings • Time saved by end users (by finding products rapidly)
Technology innovation	n/a
Governance / Organisational structure	There are governance committees with representatives from all ministries. In terms of user governance, all ministries will have access, with different kinds of profiles being defined.
Data governance	Three layers of services were defined: 1) most secure, provided by three ministries (Ministère de l'Interieur, Ministère de la Transition écologique et solidaire, …) 2) all government 3) commercial services, with framework contracts to be set up for the whole government The French Agency for Security provides certification. Authentication services are based on what the government already has in place and are API driven.
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Economic, technical, and legal barriers	The main challenge they had to face was engineers and end users changing their minds. They had to shift the focus from IT assets to a user-oriented service value chain – finding a service, ordering, payment, support.

Statens IT

Identification	
Name of interviewee	Peder Wiese
Title	Head of Digitalisation/CTO
Organisation	Statens IT
Country and location	Denmark
Sector	Public administration

Initiative	
Description of the initiative	Statens IT started as a cost efficiency program. It currently serves 30K government agency end users; including education institutions, that goes up by an additional 15K. Statens IT was built as a shared IT service centre for the whole of the Danish central government and placed under the umbrella of the Ministry of Finance. All of the people initially transferred were operations people. They did not have a digitally enabled business innovation perspective in mind. And they depleted each ministry of technical skills. So, when they started to go back to 'selling' services to the ministries, STATENS was possibly talking in a technical language that nobody on the demand side could understand. They then started to put together a service catalogue to make their offering more structured. The catalogue is still in PDF, but there are plans to make it web based. They joined Euritas to learn from peers around Europe. They invested in personnel certification and security clearance to offer high-quality information assurance.
Timing of the initiative	Over 10 years ago
Key stakeholders	Public sector
Funding	Solely funded by ‘customer’ demand. Prices calculated by dividing the cost of operations by the estimated demand. No central budget granted.
Technical solution	Statens IT brokers services from external providers and provides its own services. **External service brokerage** Each customer has a Statens IT identity. Statens IT manages the single sign on for external service providers.

Initiative	
	They have tried to build a 'shared tenant' setup with Microsoft to avoid having to purchase a lot of new licenses, with subtenants for each user that could be swapped. However, Microsoft apparently did not like this concept of 'consolidated clients', so they are now trying to set up an agreement of transferring licenses, thus finding a contractual solution. They are learning this approach from the Danish environmental portal (dmp.dk), which provides shared IT environmental services to Danish counties. For example, they are trying to build cost profiles for different user types. A lot of assumptions are being made to be able to budget for these services. Currently, Statens IT does not use AWS. They are starting to use IBM cloud services; the initial indication is that IBM is more mature in terms of service delivery/engagement models than Microsoft. **Government-Owned Data Centre Services** GovCloud is the community cloud being run within Statens IT data centres. The services are set up to comply with GDPR. Tenants are separate. GovCloud.DK includes all layers: • OpenStack – IaaS • MapR solution from HPE – PaaS services: 2 customers in operation, but 20 customers that are doing PoCs. However, Statens IT is evaluating the option of phasing out MapR, or using it only for IoT to feed analytics, but then using open source for other workloads. There is also a traditional managed on-premises setup for legacy application. This can be connected with GovCloud.
Relation to H-CLOUD key areas	Cloud and federation
Business model	Statens IT is trying to align with commercial pricing, while covering the cost of Statens IT. But that is hard because it is difficult to estimate the volume of workloads. So, finalising the price per CPU, rack, etc., very few applications can be metered. Core applications will move to GovCloud over time, starting with BI/AI. That is the roadmap for a 'Statens IT 2.0'. The team is trying to understand how to make it only SaaS and not have to re-engineer the entire stack. For example, they are looking at enabling the Jitsi.org web conference platform (similar to Zoom), offering a privately hosted service.

Impacts	
Business success	There is recognition among customers that Statens IT adds value – for instance, on information security. That is good, but it also constantly challenges the organisation's maturity. Statens IT has 4 major goals in the current strategy period: • A high level of customer satisfaction and stable operations • Competitive pricing • Reliable projects • A high level of information security
Technology innovation	n/a
Governance / Organisational structure	Governance. This is an area of continuous improvement. Being IT operations people, we had a tendency to communicate in technical terms. And there were no more technical people in the customer organisations. So, we needed to set up several layers of governance. There is no opting out of Statens IT. A governance board and a customer board meet every six weeks to improve dialogue. And then there are working groups on specific topics. For instance, when you go into the application areas that are common across ministries, costs can be reduced by consolidating to one database server with multiple instances. Such topics are discussed in working groups.
Data governance	All services are natively GDPR compliant
Environment and sustainability performance	STATENS It is currently designing a new data centre to be operational in early 2021. Energy efficiency is a key part of the design, as it was with our current data centre, but the development of technology has moved quite a bit since we built our current data centres. Also, STATENS It is currently making a study of energy consumption at the end user workspace – and the results of this study will be an active component in coming purchases. (Statens IT owns the end-user laptops, screens/terminals, printers, and related services.)

Aquacloud

Identification	
Name of interviewee	Joern Torsvik
Title	Project Manager
Organisation	Aquacloud
Country and location	Norway
Sector	Aquaculture
Company size	10 part-time employees dedicated to project; over 100 participating in the wider project

Initiative	
Description of the initiative	Aquacloud was established in 2017 and is a Big Data project anchored in the aquaculture industry's need to solve common challenges in order to create sustainable growth. Sea lice have been identified as a threat to the growth of the aquaculture industry, so leading aquaculture companies came together to share data to solve this problem and identify and prevent new outbreaks of sea lice in their fish farms. The initial scope of this initiative was to establish a secure database for storing data and to use advanced analytics to identify where sea lice outbreaks were probable. This part of the project celebrated some success. However, data quality and dependability were insufficient to reach the ambitious goals at the time.
Timing of the initiative	The idea for Aquacloud started in 2016, when awareness of digitalization and the application of IT in the seafood industry started to grow. The project was officially launched in 2017.
Key stakeholders	Some private companies saw the opportunity to come together to understand and solve some of the biological challenges in the aquaculture industry and to create sustainable growth for the industry. The idea was to combine data from multiple companies to create a base strong enough to solve these biological challenges. The project is run by NCE Seafood Innovation and began with the following cluster members: Lerøy Seafood Group ASA, Grieg Seafood ASA, Mowi ASA, Bremnes Seashore AS, Lingalaks AS, Eide Fjordbruk, and Bolaks AS clusters. The project has developed substantially since 2017. Today, the project involves an even broader group of leading aquaculture companies.

Initiative	
Funding	Aquacloud is financed through partner contributions, Innovation Norway, and Siva (since 2019) through the financing of Ocean Innovation Catapult Centre.
Technical solution	The initial scope of the Aquacloud initiative was to establish a secure database for storing data and to use advanced analytics to identify where sea lice outbreaks were probable. The Aquacloud project partnered with IBM to provide the technology platform, which integrates with production systems of the aquaculture companies to extract their data into a common data repository. Based on the collected data, the aim is to predict and prevent sea lice outbreaks. The project has evolved from being purely a sea-lice forecasting asset to becoming a hub of industry activities, including companies from multiple subsectors of the industry. Because data quality was an issue in the initial phase of the project, Aquacloud has now launched several workflows to address data standardization needs in the industry: • **Sensor Data** – an open IoT-based standard allowing equal access to aquaculture sensors and systems • **Fish Health** – common standards for areas such as mortality causes and fish group identification, as well as digital information exchange between various health and welfare entities • **Environmental Data** – to review the environmental section of NS9417 standard on unambiguous terminology and methods for documentation of production
Relation to H-CLOUD key areas	Federation
Business model	The business model is the collaboration of leading aquaculture businesses in Norway. They collaborate to remove common obstacles to growth in the industry. They share data from their production systems in a common data repository.

Impacts	
Business success	The definition of success has changed over the lifetime of the project. At first, success was defined as solving the sea-lice prediction problem to achieve sustainable growth for the aquaculture industry. During the project, the most important success criteria has become the learning curve that comes from collaboration. Improving data quality has also emerged as a success criterion, as well as identifying next steps and widening the stakeholder group to achieve networking effects and drive the adoption of

Impacts	
	data standards. Ultimately, the goal is to drive innovation through shared data.
Technology innovation	The next step for Aquacloud is to include IoT and Edge technologies for monitoring the fish.
Governance / Organisational structure	The project is running on specific project funding at the moment, and the long-term structure has not yet been decided. The plan is to move to a commercial model that will make Aquacloud self-sustainable, but it will remain a non-profit organization. Aquacloud is governed under a steering committee from the participating companies.
Data governance	Achieving a common data structure is the key goal of the Aquacloud project to enable effective and efficient data sharing while ensuring the data sovereignty of the stakeholders. Aquacloud is compliant with regulations and best practices. Rules around data usage (for example, for research) and data monetization are still evolving.
Environment and sustainability performance	Aquacloud uses highly virtualized data centres and is very focused on green computing and energy efficiency. The Aquacloud project is dedicated to the use of renewable energy sources and energy efficient technologies.
Focus on SME	Four large companies operate in the aquaculture industry on the west coast of Norway, but most companies in this industry are SMEs. Aquacloud is attracting more members, and most of them will be SMEs.

Obstacles/Barriers	
Technical barriers	The biggest technical barrier was around data classification. We had to identify and classify data into, for example, a) data that is already shared, b) data that is harmless to share, c) data that is sensitive from a business perspective, and d) data that is illegal to share from an antitrust perspective. Other challenges included a lack of a common data standard; many manual entries of data into the system, which created problems with data quality; how to access various submerged environmental sensors; and how to transfer data and make it available in a standardized way, offering access to data across multiple systems. We launched a new standard in September, with broad participation from industry players. We then started to work on an industry standard for data from environmental monitoring. This standard defines the semantics around monitoring, at what depth you need to measure the temperature, and how we measure fish health and welfare. We also needed a common language for why fish die or disappear to

Obstacles/Barriers	
	improve biological efficiency. We started working with a Norwegian university to conduct mortality analysis for fish, and we mapped a wide range of different mortality causes into eight categories to strengthen the quality and potential of combined data sets in the project. There was also a realization that, when the participating companies expose their data through the platform, they lose direct control of their data, as it is shared so efficiently and potentially reaches many stakeholders. We discussed how to best share data – for example, in real-time, with a time delay, and anonymized to maintain data confidentiality. Another technical challenge relates to the data platform. How can we continuously load data from all partners and enhance and improve the quality of data streams so that we can make aggregated datasets available for innovation in the aquaculture industry.
Legal barriers	We had to build a legal framework that takes various multilateral relationships into account – data providers, IT providers, data and consumers.
Economic barriers	No economic barriers at the moment. We are exploring the mutual benefits of sharing data for all participating companies.

Axis

Identification	
Name of interviewee	Andrea Sorri
Title	Director, Business Development Smart City
Organisation	Axis
Country and location	Turin, Italy
Sector	Private, technology
Company size	3400 employees worldwide

Initiative	
Description of the initiative	Edge computing is part of the natural development of our company. We are a producer of IP cameras. Our products are scalable, use open standard, and are easy to integrate into various platforms. Together with open standard, edge is the philosophy driving what we do, as it guarantees lower connectivity levels and server loads.
Timing of the initiative	The development of edge camera capabilities started 10 years ago. We have improved our hardware platform and our developer partner ecosystem over time. Currently, we are launching a proprietary platform with a DLPU (a deep learning process unit) as the latest evolution. The application layer needs to become more scalable from a developer standpoint.
Key stakeholders	We sell only to our channel network/distributors. Nevertheless, we foster and drive a partner ecosystem on the hardware and software sides to ensure easy integration with other platforms and solutions and to stimulate software developers (AI, bid data, analytics, management platforms…) to work with our products. Our end-customers for edge-distributed solutions are in retail, for people counting, pure monitoring in retail and banking, and government/authorities for traffic management use cases (statistics, average time, and intersection monitoring). We have both private and public customers for critical infrastructure perimeter control.
Funding	Not using EU funding
Technical solution	The cameras have an internal computing platform for analysis and to run applications that usually run on servers. Apps (video analysis, audio analysis) can be proprietary or third party. Applications support insights (metadata) and facilitate other layers of the solution (e.g. different connectivity platforms that

Initiative	
	would be difficult to integrate elsewhere, cybersecurity, and the management of the device or of other devices – e.g. turning on smart lighting via motion detection). Our aim is to move integration complexity to the edge camera to ease our partners' integration, development, and use of software for our platform. We focus on the device edge. New intermediate edge architectures are a new trend. We're open to them, but we don't yet need them.
Relation to H-CLOUD key areas	Edge
Business model	We primarily develop the hardware and part of the software. We sell the hardware to a distributor, and an SI usually integrates it with the software platform and other applications.

Impacts	
Business success	Video surveillance is a growing sector per se. The edge part is a tech inevitability that people do not always want. Our metrics beyond the usual business KPIs (revenues, profits) are: • The number of sensors sold • The number of ecosystem apps running on our systems • The number of cameras running edge analytics in relation to the total • The number of cameras (A city of 1 million inhabitants usually has around 300–400 cameras.) • The number of edge-enabled cameras per use case (e.g. traffic monitoring) • The number of partners and partner apps migrating to edge (This is growing fast.)
Technology innovation	Our edge solutions are mainly connected via IoT. 5G could be very interesting in the future. Video surveillance can be very relevant when coupled with 5G, but only if the cameras have edge capabilities – mostly for scalability, latency, and bandwidth. In our case, innovation is driven by the hardware platform, and this pushes innovation to the software development side.
Governance / Organisational structure	The partner ecosystem is driven by new features that can be leveraged in smart cameras. Usually, new features are not used for complexity reasons, but we encourage our partners to find smart ways of using new features.

Impacts	
Data governance	Data that is transmitted outside of the domain of our cameras can be anonymous or not, depending on the application or use case (e.g. people counting or license-plate recognition). Our aim is to provide the maximum amount of flexibility. We are also working to ensure different types of secured connectivity and data transmission from our cameras. When data leaves a camera, the data is outside of our domain.
Environment and sustainability performance	n/a
Focus on SME	Have you conducted activities related to SMEs? Not via a direct focus, but our solutions work as well for SMEs' needs as they do for those of large enterprises.

Obstacles/Barriers	
Technical barriers	There are no major technical barriers, but more standardisation around IoT and wireless connectivity would be good. There are a lot of protocols out there (e.g. Sigfox, LoRa, and NbIoT), and it would be good to have more standardisation. Standardisation in general would also be good for developers. It would be easier for them if a platform emerged as the main edge platform for software development. This is especially true with edge.
Legal barriers	Legislation to ease cloud usage would be very useful. Leveraging cloud apps is currently difficult in Europe. Deregulation and easier governance are needed. At present, we overcome such barriers by using on-premises solutions. We also target early adopters and the most advanced users.
Economic barriers	There are always economic barriers. Regarding edge, we try to communicate the added value of the edge approach, and we promote TCO in our communication. Such communication is more complex to create, but it usually works.

BrianzAcque

Identification	
Name of interviewee	Enrico Pivari (BrianzAcque), Maurizio Galotti (Plurimedia)
Title	Responsible for the Casette dell'Acqua project
Organisation	BrianzAcque
Country and location	Monza, Italy
Sector	Public owned Utility
Company size	322

Initiative	
Description of the initiative	BrianzAcque is a public company that manages the water cycle and sewerage systems in Brianza, a territory in Northern Italy encompassing 56 villages, with a total of 900,000 inhabitants. Casette dell'acqua is an initiative to distribute high-quality filtered drinking water dispensers (Casette) outside throughout the territory for citizens. The water can be dispensed as still, sparkling, and cooled. In a similar way, the company also distributes indoor dispensers to schools, libraries, etc. The target is to reduce the use of plastic bottles across the territory, with benefits connected to less traffic, pollution, and plastic consumption.
Timing of the initiative	The first Casette were installed in 2015 and 2016. The indoor dispensers started in 2019. As of now, the next targets are to install new cassette covering the entire Brianza territory (in northern Italy) and possibly to upgrade the Casette with new features, providing new services to citizens.
Key stakeholders	Local government is the customer and key stakeholder. End users and key stakeholders are citizens that use Casette dell'acqua as a drinking water supplier. Other stakeholders include public health authorities, which are responsible for water quality control.
Funding	No EU funding – all local government public funding for Casette and Brianzacque funding for dispensers.
Technical solution	The Casette dispenser can be seen as a multifunctional IoT device able to run locally cloud-native applications that have been developed as part of the architectural digital transformation of the company. Each outdoor dispenser includes a technological solution to monitor the status of the dispenser, measure how much water has been delivered, manage maintenance, provide

Initiative	
	communication to users using a screen, and managing the security of the data and the data transmission. Edge intelligence is at the IoT level. The single Casette is managed with a micro PC deployed at the edge with tailored Linux OS and custom applications for different functions. IoT components continuously exchange data with the central cloud platform, which manages the IoT devices and provides information to be shared on the screen. The screen can share information regarding the water service and water quality, as well as public utility information from BrianzAcque or other partners (e.g. local government). All technical aspects are governed and managed by an external IT solution provider.
Relation to H-CLOUD key areas	Cloud, edge
Business model	BrianzAcque is a public utility company, so the service is delivered under this framework. During the summer season, the water at Casette dell'acqua is free. In other seasons, it has a symbolic cost. Each user accesses the system using a magnetic card. End consumers pay for the water with prepaid top-up cards.

Impacts	
Business success	KPIs: • The number of Casette installed: now more than 70, with a target to expand to 100 in 2021, covering the whole territory • The number of dispensers installed: now 50, rising to 80 by end of year • The number of litres dispensed: 10l million in 2019, with a strong increase expected for 2020 • How the service to citizen has evolved in terms of information about water quality and customer service This last KPI is significant, even though it covers an area that is difficult to monetise and is not always monitored. This KPI is mostly about what drives usage.
Technology innovation	The initiative primarily uses a mix of IoT, edge, and cloud computing. It has had a huge impact on the company's processes, as this project is framed within the general digital transformation of the company, whereby the whole architecture has shifted to services enabled by cloud-native applications on a single cloud platform.

Impacts	
Governance / Organisational structure	Local government and public health authorities are key stakeholders, along with citizen. The relationship relates not only to the service delivered (water to citizens), but also to the information shared: We are forced by law to exchange data with public health authorities for quality control. But we are also very open with local governments and citizens about the data we gather from water analysis. Another important stakeholder is the IT provider that manages a great part of the solutions for BrianzAcque.
Data governance	GDPR governs the data that public administrations handle. In this case, the IoT layer, data transit, and the application layer are all encrypted on https at the maximum level of security, ensuring data handling exceeds compliance with GDPR.
Environment and sustainability performance	n/a
Focus on SME	No

Obstacles/Barriers	
Technical barriers	No major technical barriers exist because this initiative has leveraged past experiences with cloud-native applications. The main issue was change management with internal IT due to digital transformation. BrianzAcque leverages the experience of the IT provider on the complexity of the cloud platform and applications.
Legal barriers	The only barrier is relative to data regulation. The IT provider manages this complexity in order to • Ensure solutions are GDPR compliant • Ensure high security standards with https and encryption
Economic barriers	Casette is a funded project, and there are no particular economic barriers. On the IT side, having a consumption-based model on an all-cloud-native platform and application helps pay for only what we use.

City Network

Identification	
Organisation	City Network
Country and location	Sweden
Sector	Cloud service provider
Company size	n/a

Initiative	
Description of the initiative	City Network is a European cloud service provider headquartered in Sweden. City Network provides scalable and cost-effective cloud services from its own data centres around the globe. With City Cloud, which is the company's public cloud platform, customers get instant access to cloud computing power and complete control over where and how their data is stored. For industries operating under specific regulations, City Network offers cloud computing power with built-in regulatory compliance. The company's managed services span all of its operations and enables customers to build public, private, and hybrid cloud solutions.
Timing of the initiative	City Network was founded in 2002
Key stakeholders	City Network is a European-headquartered cloud service provider operating globally. City Network is very active in the OpenStack community.
Funding	No EU funding. City Network is a private company.
Technical solution	City Network offers a public cloud service called City Cloud; a hosted private cloud service; compliant cloud services for regulated industries, such as finance, healthcare, and the public sector; and compliant-office services. In addition, City Network offers managed cloud services, professional cloud services, and cloud training services.
Relation to H-CLOUD key areas	Cloud
Business model	City Network is an independent private company that is heavily engaged in the OpenStack community. The business model is similar to that of hyperscalers, whereby infrastructure and cloud services in general are sold at a per-second-of-usage rate. By offering public, compliant, and private cloud, all regulatory levels can be satisfied, from banking and healthcare to government agencies.

Impacts	
Business success	Success is defined through: • Revenue growth for the business • new customers, especially in regulated industries such as the public sector, healthcare, and finance • Customer success stories: One bank went from implementing 50 user stories per month to 700 user stories per month on the City Network platform using infrastructure as code and automation tools made available through the City Network platform. • Helping to develop skills, knowledge, and insight in Europe by educating employees and customers in the latest cloud-native technologies, conducting R&D in Europe, and creating partnerships with leading European companies in related areas, such as AI/ML
Technology innovation	City Network drives technology innovation internally by building leading cloud services, especially for highly regulated industries. The focus is on open-source technologies, infrastructure as code, and adherence with GDPR and industry regulations. Investment into AI is through partnerships with European AI companies.
Governance / Organisational structure	Governed as a private company
Data governance	City Network is ISO 9001, ISO 14001, ISO 27001, ISO 27010, ISO 27013, ISO 27015, ISO 27017, and ISO 27018 certified – internationally recognised standards for quality, sustainability, and information security. The company's services are available from more than 20 data centres around the world. With its compliant cloud, City Network ensures that customers comply with demands originating from specific laws and regulations concerning auditing, reputability, data handling, and data security, such as Basel, Solvency, and GDPR. City Network also engages in the GAIA-X process and will support the GAIA-X initiative.
Environment and sustainability performance	n/a
Focus on SME	City Network customers range from SMEs to large enterprises.

Obstacles/Barriers	
Technical barriers	Using open-source technologies like OpenStack is a good way to build skills and competencies with employees and customers. Participating in cloud federation would require investment in infrastructure, but there is no customer demand at present that would justify this investment. Potentially, the GAIA-X initiative could provide an interesting technology to implement and to ensure greater data sovereignty across Europe. City Network provides a compliant version of Microsoft Office for European public sector organisations.
Legal barriers	For City Network, it would be very beneficial if the EU would enforce GDPR and if the data protection authorities across Europe would enforce the recent Schrems II ruling about the inadequacy of the EU-US Privacy Shield as a mechanism for data transfers to the US. City Network also believes that greater awareness of the impact of the US CLOUD Act on European organisations is needed. This would lead to greater demand from European customers for data localisation and storing data within the EU with European cloud providers. City Network specialises in highly regulated industries like the public sector, healthcare, and finance, so regulation is actually good for City Network, as it creates complexity for the customers, which City Network helps to solve.
Economic barriers	European cloud providers like City Network would benefit economically if European companies – especially European public sector organisations – bought from European-headquartered cloud providers instead of large cloud providers headquartered outside the EU. There is a significant buying power in the European public sector, which could be used to create demand for European-provided public cloud services. That demand would in turn lead to further investment in and the growth of European cloud service providers, which would make them more competitive and enable them to develop more services.

Cloud28+

Identification	
Name of interviewee	Xavier Poisson Gouyou Beauchamps
Title	Vice President, Service Providers and Cloud28+ Worldwide
Organisation	HPE
Country and location	France, Paris
Sector	IT
Company size	Large enterprise

Initiative	
Description of the initiative	Cloud28+ is a worldwide cloud computing community and marketplace where cloud service providers can federate and showcase their cloud offerings and thought leadership; build new partner alliances; create new services; and take advantage of digital marketing services to avoid advertising costs while accelerating visibility. It was developed and is sponsored by Hewlett Packard Enterprise (HPE).
Timing of the initiative	Cloud28+ was originally launched in Europe in March 2015, with the aim of accelerating cloud adoption in Europe. It opened up to members worldwide in November 2016, at which point it had around 330 member companies and offered around 1,300 infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS) services.
Key stakeholders	HPE and cloud service providers that are interested in federating their services and amplifying them on the market
Funding	Cloud28+ is funded by HPE and Cloud28+ members
Technical solution	Cloud28+ is a digital business platform where service providers can publish their cloud services and find partners with which to to create new solutions, promote themselves, and exchange information. Customers can find cloud services, software products, professional services, and deployable applications. Cloud28+ is based on an HPE-developed cloud-native, API-driven digital business platform, which can be deployed in public or private cloud. Cloud28+ taxonomy is available and licensed under the Creative Commons Attribution 4.0 International License (CC BY 4.0).
Relation to H-CLOUD key areas	Federation

Initiative	
Business model	Cloud28+ is financially supported by HPE, with contributions from its members. The aim of the platform is to promote cloud service providers that are building local and regional cloud services built on HPE technology.

Impacts	
Business success	Since its launch in 2015, the cloud28+ community has expanded beyond Europe and is now a global initiative. It now has more than 1,200 partners in more than 100 countries, with 85,000 services published and federating 790+ datacenters.
Technology innovation	Cloud28+ enables its partners to offer innovative technologies based on underlying HPE technology. Cloud28+ is actively participating in GAIA-X and working on cloud-edge solutions.
Governance / Organisational structure	Cloud28+ is an active community of cloud service providers from around the globe.
Data governance	n/a
Environment and sustainability performance	n/a
Focus on SME	Partners of all company sizes can join Cloud28+: Most partners are medium-sized local or regional service providers.

Obstacles/Barriers	
Technical barriers	It is important to decide at which level federation should take place: at the infrastructure level or the service level. Cloud28+ has decided to create a service catalogue so that local and regional service providers can advertise and federate their services, applications, and professional services.
Legal barriers	N/A
Economic barriers	It takes a substantial marketing budget to market a digital platform like Cloud28+. After four years, the platform became self-funded through the offering of partner marketing services and solutions tied to the core intellectual property underlying it.

CloudSME

Identification	
Name of interviewee	Andreas Ocklenburg
Title	CEO
Organisation	CloudSME
Country and location	Germany
Sector	IT
Company size	5 employees

Initiative	
Description of the initiative	CloudSME is a competence centre for cloud-based HPC simulation. Its vision is to provide vendor independent cloud technology to support sustainable growth and digitalization in Europe and to increase Europe's competitiveness in the worldwide economy.
Timing of the initiative	The CloudSME project ran as a European funded project from 2013 to 2016. It was funded by the European Union under grant agreement No: 608886. Since 2016, CloudSME has been operating as an independent commercial company.
Key stakeholders	CloudSME is a private company that works very closely with research institutions, universities, and participates in EU-funded projects.
Funding	CloudSME receives EU funding through its participation in EU projects, such as DIGITBrain, CloudiFacturing, and, previously, the COLA project.
Technical solution	CloudSME is commercializing MiCADO technology developed through the COLA project. The MiCADO framework supports the autoscaling of applications on two levels: • Scaling at container level (based on Kubernetes) • Scaling at virtual-machine level (originally based on Occupus, but now based on Terraforms)
Relation to H-CLOUD key areas	Cloud, federation
Business model	CloudSME is collaborating with a number of service providers that are using MiCADO technology. CloudSME is commercializing MiCADO technology. CloudSME operates on an

Initiative	
	open source model, offering the technology under an open source license and offering commercial support services.

Impacts	
Business success	CloudSME works with a number of European cloud service providers that are using MiCADO technology.
Technology innovation	CloudSME works with open standards and open source technologies that enable organizations to use multiple cloud providers and move their workloads and data between them.
Governance / Organisational structure	CloudSME is a private company.
Data governance	N/A
Environment and sustainability performance	N/A
Focus on SME	N/A

Obstacles/Barriers	
Technical barriers	MiCADO technology needs to be matured/developed into a 1.0 version.
Legal barriers	No legal barriers
Economic barriers	CloudSME mostly experiences economic barriers: While EU funding is available for the development of technologies like MiCADO, not enough funding is available to commercialize the technology. Commercialization and getting the right certifications, such as from CNCF, is costly and takes two or three years, which needs to be financed if the money does not come from paying customers.

Leading European car manufacturer

Identification	
Country and location	Poland
Sector	Automotive
Company size	1,000+

Initiative	
Description of the initiative	UPS real-time monitoring and management system The CEE-country-located factory of a leading European car manufacturer is equipped with about 50 UPSs, placed in rack cabinets, located in different places in the factory, and two heavy-duty Galaxy-class UPSs supporting both data centres (DCs). The DCs host all IT infrastructure for the office and production parts of the factory. The initiative tied to the new UPSs was driven by the following challenges: • The very difficult management of dispersed infrastructure – a lack of visibility and UPS status information collected manually by administrators • Lack of predictive maintenance – service work often performed after breakdowns • The instability of UPSs operating in an emergency state • Alerts only displayed on the UPS panel
Timing of the initiative	The initiative took place in Q2 2020 and is now completed.
Key stakeholders	This initiative has been driven entirely internally, in collaboration with the UPS provider.
Funding	Only company funds
Technical solution	The IT department was the initiator of the project – namely, the replacement of business-critical UPSs. All UPSs can now gather sensor data, enabling status monitoring, basic analysis, data visualisation on monitors, and data transmission via LAN and dedicated VLAN infrastructure. The UPS manufacturer provided the company with the UPS management application, which helps IT administrators detect failures and potential threats. All data transmitted from all the UPSs is collected and analysed in data centres for a holistic view of the overall power infrastructure.
Relation to H-CLOUD key areas	Edge

Initiative	
Business model	Purely internal initiative

Impacts	
Business success	Several KPIs have been used to measure the success of the project. The benefits are as follows: • No downtime due to power failure (Power failures have been eliminated.) • A massive reduction in failure time • The removal of reliance on battery power in emergency status • Information visibility
Technology innovation	Edge and IoT. UPSs are equipped with sensors and the ability of analyse data and generate alerts and triggers from insights gathered locally, at the edge.
Governance / Organisational structure	Not for this initiative
Data governance	The company decided not to share the data with the UPS vendor due to a restrictive security policy.
Environment and sustainability performance	n/a
Focus on SME	No

Obstacles/Barriers	
Technical barriers	None. There were some challenges with shutting down individual UPSs, as the IT system needed to be available all the time. This was therefore only done during production downtimes.
Legal barriers	None. All data is collected and analysed in the factory.
Economic barriers	None. The project was financially predictable, calculated well, and financed from the IT budget. It was supported by an integrator and technical specialists from the UPS provider.

Polymore

Identification	
Name of interviewee	Josef Art
Title	Business Director
Organisation	Polymore
Country and location	Germany
Sector	Plastic industry
Company size	n/a

Initiative	
Description of the initiative	A new B2B online marketplace for the procurement and sale of compounds, masterbatches, recycled materials, and post-industrial materials in Europe. Polymore connects compounders and plastic processors for simple and secure trade in products.
Timing of the initiative	Planning started in mid-2018, and the project was launched in 2019.
Key stakeholders	**Owner:** KraussMaffei Technologies **Market side:** plastics converters, suppliers of plastics materials, plastics users, and registered partners **Other marketplaces:** plastics producers and their shops KraussMaffei is a machinery company, so it is not a competitor of plastics producers. The plastics market is fragmented. The steel market is very regulated, with very clear standard steel types. Different companies deliver exactly the same kinds of steel. In plastics, there is no standardisation or catalogue of plastics. I have this problem, and I need a solution – find technical experts. I do know my technical requirements, but I need these material parameters – descriptions of the properties needed and/or the problem to be solved. **Suppliers:** A buyer purchases material, and a supplier delivers it.

Initiative	
	Both have to register. A 'matchmaker' solution is used to assess all registered suppliers manually to find the perfect match or to provide the best solution. The requirement is to automate manual matchmaking using AI.
Funding	Only funded by Krass Maffei. Public funding is too slow; the procedure is too slow and does not work with the timeline, which is relatively short.
Technical solution	Run on AWS, with many microservices; now moving beyond this to virtual and to server option such as VSL virtual storage. The main service runs on AWS cloud, with shared services and microservices.
Relation to H-CLOUD key areas	The business model is green (following the trend in business). The plastics industry is moving to a circular economy to reduce the CO2 footprint of plastics. The portfolio contains reusable materials and post-industrial waste. Mother company KM is active on the lobbying side.
Business model	The initiative is in a ramp-up and data collection phase. Collaboration to scale the business model could involve bringing together market information, deal by deal, collecting a lot of information. The model is a combination of people and data collection. The value of the database is massive. In a year from now, there could be huge business opportunities from combining data and services.

Impacts	
Business success	Success is measured through unique website visitors and online marketing services – impressions, clicks, registrations, active users dealing with us. The situation now: • 60,000 tons requested – 80% recycled • 200–300 unique visitors per week • Click through rate: 2–3% Several hundred sellers in the portfolio of traders and producers. Subscription fee, membership fee for suppliers, safe channel for suppliers
Technology innovation	n/a

Impacts	
Governance / Organisational structure	n/a
Data governance	GDPR: personal customer data sharing between Polymore and machinery not allowed Data security: external audit from data security specialist, procedural rules The project uses AWS, as AWS also provides security. Customers and partners agree to terms and conditions on data protection. Huge value of data.
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	n/a
Legal barriers	n/a
Economic barriers	n/a

ThreeFold Grid

Identification	
Name of interviewee	Chris Hutton & Geert Machtelinckx
Title	Cofounder
Organisation	ThreeFold Tech
Country and location	Belgium
Sector	Autonomous and Federated Peer-to-Peer Internet Technology
Company size	Approximately 60 employees

Initiative	
Description of the initiative	ThreeFold Grid is a peer-to-peer network of storage and compute capacity powered by ThreeFold autonomous cloud technology and developed by ThreeFold Tech (TFT). TFT has developed its own stateless operating system (ZERO-OS), which is hardware agnostic and enables a fully decentralised, autonomous, and secure resource pool of compute, storage, and networking capacity. ZERO-OS federates all stakeholders, including enterprises, service providers, and government agencies, which can contribute their digital assets to a meshed utility of compute and storage capacity. ZERO-OS secures all participating infrastructure by removing all human interfaces and presenting a zero-hacking surface. Interfacing with the system is only via 3BOT, a virtual systems administrator. All workloads are recorded on a blockchain database (BCDB) to ensure an immutable record and consensus for every workload. Commissioning a workload is only possible with the use of a private key (through an automated 'smart contract for IT' process), which ensures data privacy and sovereignty in every case.
Timing of the initiative	The evolution of ThreeFold technology started almost 20 years ago with the inception of core elements created in iterations over time that now amount to the autonomous and decentralized cloud platform available today. TFT was spun off from its incubator in 2018 and saw the inception of ThreeFold Grid. Today, this key flagship project bears testimony to the technology delivering on its promise, with nearly 90PB of storage and 24,000 CPU cores across 21 countries, having encompassed nearly €20m in infrastructure. The next phase focuses on the onboarding of an extensive partner ecosystem and an extensive marketing campaign to raise further market awareness in target industries.

Initiative	
	Further, the expansion of ThreeFold Grid into emerging markets and more distributed locations is the focus as ThreeFold seeks to embrace new and existing industry stakeholders to contribute/invest in infrastructure and grow the footprint of available decentralised capacity.
Key stakeholders	Industries include IT, public sector, and education. The partner ecosystem consists of CISPE, ThreeFold Foundation, Hewlett Packard Enterprise, DigiByte, Stellar, TomoChain, Harmony, Selfkey, Dash, WaykiChain, and Skale, Stellar, Crystal Twin, Tag, Solidaridad, Beliive, Seeds, Artheon VR Museum, Join Plus Idea, Green Edge, LZW, Crystal Home, Earthproject, Genblue, Money of Good, Vlinder, Covid Fighters, Crystal, Shareitt, Social, Cicolab, FlowGen, Kleos, Cloud28+, and Jimber, among others.
Funding	No EU funding at present, but TFT has responded to a few strategic RFTs and is preparing for others. TFT is actively engaged with the European Commission.

Technical solution	A 3-layered approach, as follows:
	• Capacity layer/ZOS: enables decentralised, privacy-focused, and ultra-secure stateless capacity, presenting millions of HW resources – anywhere, any form factor – as one federated, meshed cloud utility; any Linux IT (containerised) workload can run on the ThreeFold grid.
	• Autonomous layer/3BOT: virtual sys admins and digital self:
	  ○ Sys admin ensures capacity is autonomous and minimises human intervention – deployed anywhere, lower costs, and reduced risk/improved security.
	  ○ Digital self: represents you and me in the digital world, offering all needs for a digital life, guaranteeing our privacy and sovereignty, and ensuring equality and that everyone can take part in the internet economy.
	• Experience layer: taking full control of your digital life – peer-to-peer applications as use cases (social media, video chat, office, …)

Relation to H-CLOUD key areas	All, cloud, federation, edge, green Plus: peer to peer, decentralised, sovereign, and autonomous
Business model	Circular economy, supply and demand: • Farmers: ○ Private/Company

Initiative	
	○ Existing service/cloud providers ○ OEMs (that missed the cloud race) ○ Community networks ○ Property developers ○ Solar generators ○ Etc. • Capacity users: ○ Blockchain partners ○ ACI partners ○ Decentralised apps (dapps) ○ New app trends/industries: IOT, VR, big data, AI 5G, etc. ○ Any user that needs either decentralised infrastructure (telecom, gaming, etc.) or decentralised data (healthcare, education, finance, etc.) • Overall peer-to-peer model with the following economic model: ○ Circular economy ○ Farmer instead of miner ○ When you contribute capacity to their blockchain, you are rewarded with a ThreeFold token. ○ ThreeFold Token (TFT) = s digital medium for the exchange of value within the ecosystems; farmers receive two incomes: - Farming tokens: rewarded monthly with x number of tokens, depending on how much capacity they provide - Cultivation tokens: income when reservations are made ○ TFT are traded publicly as they are needed by capacity users for making reservations ○ TFT are only minted as a result of commissioning capacity to ThreeFold Grid meaning each token is backed by the capacity itself. TFT are designed as a utility token to buy capacity on ThreeFold Grid and are not intended as speculative. Farmers are measured and rated on the market in an Uber-like system. Two types of farming:

Initiative	
	• DOI farming: Anyone can provision capacity, but with no secure boot process; infrastructure is not secure because it is not booted. • Certified farming: This is securely booted capacity supported by ThreeFold with an SLA.

Impacts	

Business success	The interviewee defines success as follows:
	• Firstly, the largest P2P cloud available today
	• The first and only, now coming to market (stats) with no Initial Coin Offering (ICO)
	• Growth and adoption to follow
	  ○ Growth: country-level farming projects to come on board with sovereign decentralised internet capacity – MEA SP, UK Solar Generator, HPE Strategic Alliance, and Smart Africa Alliance including HPE
	  ○ Adoption: +30 BC partners to come on board and +30 ACI partners already on board, including a large social media platform
	Reasons to consider the initiative successful:
	• Our reason for being resonates with a large and quickly growing audience.
	• The timing is perfect for the EU data landscape, with a major push from the EC.
	• Social awareness relating to data privacy and sovereignty is growing fast.
	• To our knowledge, no tech addresses the problem to this extent.

Technology innovation	The initiative includes blockchain as an innovator accelerator. Ecosystem → 2 entities: • A not-for-profit foundation spearheads the ThreeFold Network as the primary use case for our technology – governed by multiple councils, a truly decentralised organisation. • A Belgian for-profit tech company with traditional governance structure that focuses on tech innovation based on community and market feedback The ThreeFold Grid is our first major use case to prove our technology and the opportunity to deliver a meaningful impact for

Impacts	
	humanity (socially and economically) and for the planet (environmentally).
Governance / Organisational structure	The organisational structure successfully supports the active collaboration and participation of stakeholders. There is a fast-growing partner ecosystem and an expanding community (farmers, ambassadors, token holders, etc.).
Data governance	Individual users have full control over all aspects of their digital lives (data and applications, generating permanent streams of data), protected by their own private keys. Data is not visible to capacity owners and can be encrypted and dispersed (a mechanism also used in RAID systems). The full network is secured (the private overlay IP-network part of ZOS). GDPR by design, as the owner remains in full control of the data; third parties have no access unless by consent.
Environment and sustainability performance	High energy efficiency achieved by reducing layers of complexity. A very efficient storage system has improved energy efficiency by 50–100 fold (depending on the workload). Unused HDD capacity can be turned off (under test, released in August 2020), reducing the energy need for less-used/unused nodes by 80–90%. Local capacity reduces the distances traversed by data, as most is stored locally, which reduces dependency on network infrastructure. No need to concentrate hardware in hyperscale data centres: The density of hardware can be low, reducing the need for cooling infrastructure and reducing power density. The autonomous design reduces the need for skills and human dependency, which is traditionally the biggest cost and risk factor in delivering ICT systems.
Focus on SME	Have you conducted activities related to SMEs? Equality is a key driving factor, which means all levels of society and business are included and are able to participate in the digital circular economy.

Obstacles/Barriers	
Technical barriers	Everything had to be built from scratch because a traditional IT stack could not address this challenge due to the following: • Unscalable • Insecure

Obstacles/Barriers	
	• Too costly • Too complex (layers) • Tech providers too centralised • Technology back doors Question: How can we deploy capacity anywhere, in any size, and resolve the support/operational and security problems resulting from this decentralisation? Autonomy is the critical success factor. Reducing the human factor in operating and securing IT systems ensures capacity can be deployed anywhere, on demand, in any form factor, with no dependency on people to operate the infrastructure and secure the data. We had to rearchitect the solution from the ground up. But that gave us the opportunity to address issues such as energy efficiency and privacy.
Legal barriers	No legal showstoppers yet, as the platform design empowers all necessary stakeholders, the first being society itself. By design, government, GDPR, AML, KYC, etc. are all addressable and possible in the platform itself (work in progress). For the ThreeFold Grid use case, the legal status of cryptocurrencies is still a barrier in parts of the world, but the design of the token (backed by true capacity) and the benefit that the technology brings from the privacy, AML, and GDPR perspectives will help to address the reservations expressed by regulators.
Economic barriers	The importance of cloud, and the compute and storage digital infrastructure itself as the substrate of the digital economy, is undisputed. Global economies now realise the value of data in this economy and that the economic value is being exploited by just a few large organisations. There is now global awareness that data sovereignty is a must for economic growth and that the digital infrastructure that empowers this economy needs to support this key attribute. Furthermore, industry trends such as IoT, artificial intelligence, virtual reality, and machine learning all required distributed and decentralised infrastructure at the edge of the network, in close proximity to users (i.e. edge computing). ThreeFold technology enables exactly this. To answer your question, economic barriers are overcome with a solution that directly addresses the above agenda and ensures sovereignty, scale, cost efficiency, sustainability, security, etc. and thereby dramatically reduces entry costs. The extraordinary times we find ourselves in with COVID-19 only serves to amplify our dependency on the internet and the role it

Obstacles/Barriers	
	plays in our digital economy; it is our only way forward as humanity.

Vivacity Labs

Identification	
Name of interviewee	Peter Mildon
Title	COO
Organisation	Vivacity Labs
Country and location	UK, London
Sector	Private, technology
Company size	45 employees

Initiative	
Description of the initiative	The company provides artificial intelligence-based products and services to support municipalities in traffic management, leveraging images and videos to gather anonymous movement data. The company provides both AI-enabled sensors (cameras) and the platform for data communication, storage, and management. The cameras run AI at the edge, leveraging edge computing platforms (edge GPUs) to do the image detection and analysis and to extrapolate anonymous insights that are sent out to the software platform. Insights are about how roads are being used, classifying different types of road user (car, truck, pedestrian, cyclist, …) and how they are interacting on the road. This more recently includes measuring social distancing and interaction between people. The company has more than 3,000 sensors deployed around the world, but it is mainly active in the UK. The initiative to integrate data into sign traffic control has two different orders of benefit: • Society benefit – limiting traffic and time spent in traffic • Environmental benefit – for example, minimising time at conjunctions and facilitating pedestrians and cyclists, depending on the policies the customer wants to implement Edge is used in conjunction with CLOUD: • Edge is needed at the sensor level to implement AI and support low latency use cases, reducing bandwidth and connectivity costs, and to have privacy by design, deleting personal information before it leaves the sensor • Cloud is usually the choice for running the software platform and data management

Initiative	
	• Decision making (policy implementation) can be done at different levels (sensor, cloud, hybrid), depending on the case
Timing of the initiative	The company started with these initiatives in 2015. Since then, the technology has evolved, as has the company's capability to design AI algorithms. First step was to look at single conjunctions. But, to achieve the full benefit on traffic control, the next step is to enable different conjunctions in the same city at the same time governed by a single policy. This is now a prototype and is demonstrating journey time saving and the ease with which policies for environmental issues can be changed.
Key stakeholders	Local governments and municipalities are the usual clients. Central government is usually a key stakeholder, as it provides financing. Transport authorities are also a key stakeholder, especially from the policies and standardisation standpoint. Finally, road users are stakeholders, as they are analysed (anonymously) and benefit from the solution (efficient journeys). Data has also been provided to academic institutions to help them model human behaviour.
Funding	Projects are usually funded by central government (e.g. Innovate UK), but the company also gained funding under Horizon 2020 project SynchroniCity for gathering the data of active travellers during IoT trials in multiple European cities (including Eindhoven and Helsinki).
Technical solution	The solution uses edge GPUs with ML and AI algorithms to extrapolate insights from images and video signals, classifying different road-user types (car, truck, pedestrian, cyclist, …) and how they interact. The insights are sent to a cloud platform and delivered via a dashboard available for the customer or as an API to integrate into other platforms (e.g. Smart City platforms).
Relation to H-CLOUD key areas	Edge
Business model	The company provides the sensor (camera, hardware device) and a software (service) model. So, ideally, the customer has a capital purchase and a recurring license (or SaaS) for the data management platform. The solution is flexible enough to meet clients' requirements (e.g. no capital outlays and the rental of hardware sensors on top of the data service subscription). Often, public administrations prefer capital expenditures to recurring revenue models, so flexibility is needed. The software running at the edge can be a capital purchase, which adds further complexity to licencing, as the other part of the software is licensed or paid as a service.

Impacts	
Business success	Levels of success vary. Revenue growth (doubled revenues each year and planning to reach 3M by end of 2020), but also a number of different KPIs. Number of sensors active and running: 3,000 devices all over the world. Looking at smart junction initiatives, the KPI is achieving and improving traffic throughput and saving costs through more efficient traffic (e.g. the number of cyclists using the junction). Sensor only: Success can be quantifying the benefit of something else, such as the construction of a new pavement: Is this investment paying off as expected as regards usage, user types, traffic, etc.? Client adoption and use: KPIs are the number of accesses to our data on the dashboard/in the API, the number of customers buying more sensors (60% now), and the number of cities adopting sensors (increased from 20 to 30 in 6 months, from January 2020 to July 2020).
Technology innovation	Leveraging technologies such as AI, IoT, edge: Edge is critical for the following features: data protection by design (personal data deleted before leaving the sensor), latency to support real-time use cases, and bandwidth saving (avoiding sending large video streams). Innovation is driven by the internal development of technology and the deployment of AI algorithms designed to improve the use of edge hardware to address the new needs of the market. Edge has relevance for business processes, as it is fundamental to the solutions provided. Being a small company, Vivacity Labs' involvement in the technology ecosystem started with the company's founders.
Governance / Organisational structure	Stakeholders are local and central governments, industry bodies and standardisation authorities, transport departments, and investors in the industry – all of which gather industry data.
Data governance	n/a
Environment and sustainability performance	Overall, the company and project consume a small amount of CO2 (net, i.e. output vs consumption). In terms of sustainability, we need to develop an algorithm to improve edge and server efficiency. Using algorithms that perform at twice the speed of their predecessors means we consume less power. But hardware is developing more slowly than software.
Focus on SME	No

Obstacles/Barriers	
Technical barriers	Standards are not keeping pace with innovation, which opens room for innovation (i.e. lack of constraint). When challenged by standards, we need to establish confidence in the market; we need to prove that we can more than meet standards. Talent attraction is also linked to technical barriers, and we try to find talent in universities. From a supply-chain standpoint, having a partner may result in lock-in, as we have to deploy software for a given technology platform. This is problematic if we want to try a new platform. Finally, demonstrating how technology works (e.g. reinforcement learning) to customers is always challenging. You always have to prove the solution will work in any possible scenario.
Legal barriers	Challenges in government procurement. This is less an issue for small government bodies. Bigger government organisations present barriers regarding evidence of financial stability, the longevity of the company, etc. In such cases, we either work with partners (consulting, large entities) that can meet such requirements for us or provide detailed financial documentation to support our case.
Economic barriers	Local governments tend to have capital available for capex rather than budgets for recurring service fees (opex). Our team focuses on edge software deployment, so predictable revenues would be preferable. In those cases, we try to embed a part of the future service fee into the capital expenditure for the sensor.

Worldsensing

Identification	
Name of interviewee	Albert Zaragoza
Title	CTO
Organisation	Worldsensing
Country and location	Spain, Barcelona
Sector	Private, Technology
Company size	Approx. 100 employees

Initiative	
Description of the initiative	Worldsensing designs and builds sensing solutions to remotely monitor critical assets (and the structural health thereof) within mining, construction, and rail networks. The company offers a suite of products to wirelessly connect a wide range of 3rd-party geotechnical sensors. Solutions include edge gateways capable of data collection, data analysis, and network management at the edge. Data is then sent to a cloud location for further analysis. Worldsensing solutions help engineers monitor and anticipate geotechnical incidents, such as ground movement and landslides, to ensure the safety of workers, passengers, and citizens.
Timing of the initiative	The company started commercialising its products over 10 years ago. Edge processing has been a key part of Worldsensing's portfolio since the beginning and the launch of the first geotechnical monitoring product, in 2016. Since then, Worldsensing has continuously included new features and edge capabilities.
Key stakeholders	Worldsensing has mostly private sector customers in the construction, mining, and transportation sectors. It has developed a broad network of local technical partners (i.e. engineering service providers) that deploy and use Worldsensing solutions to provide monitoring services to end customers. Government and public bodies are often stakeholders, as they provide regulation. The reliable, objective instrumentation and monitoring data that is collected using Worldsensing’s solutions offers transparency to insurance companies, public agencies, infrastructure funds, and asset owners, who/that increasingly require automated monitoring to be a standard part of safety programs around the globe.

Initiative	
Funding	A venture capital (VC)-backed company
Technical solution	In general, the sensors used to monitor the condition of geotechnical and physical assets are analogue and are widely dispersed across remote and hard-to-access locations. The company's solutions include data loggers that are compatible with analogue and digital sensors. These feed the collected data to edge gateways. The dataloggers are battery powered and have limited capabilities and computing power. They connect wirelessly to an edge gateway using standard IoT connectivity (e.g. LoRaWAN). The edge gateway is equipped with computing and storage capabilities and is able to gather data, translate different formats, manage the network, perform basic data analysis and visualisation, and, in some cases, generate alerts. The gateway is then connected to public or private cloud for central data analysis, storage, dashboard, and alarms using different types of connectivity, depending on availability. The edge devices are resistant to harsh environmental conditions (water, dust, temperature, and vibrations) and consume very little energy. Edge is needed to ensure continuity of service in remote locations where connectivity is unreliable. The core edge processing device is the gateway. But, as hardware capabilities improve (storage, computing, and battery efficiency) over time, new edge features in the dataloggers will be enabled. Cloud is mainly used as the aggregation layer for companies with many sites, but a large part of computing will remain at the edge. The latest evolutions in connectivity, such as 5G, will contribute to increasing edge capabilities moving forward. Worldsensing's core industries will benefit from new connectivity technologies. Currently, it is difficult to ensure power and connectivity at many construction, railway, and mining sites. Worldsensing's main technological differentiation is experience: The company has worked with edge computing technologies since long before they became a trend. Worldsensing's focus on industrial sites and harsh environments has pushed the company to explore the limits of industrial IoT technology to deliver the best solutions to customers and partners. For industrial environments, edge can be defined as the place where end devices such as Worldsensing's dataloggers and gateways compute, deliver services, and access the rest of the monitoring network. As edge devices, these nodes are capable of computing and storing data onsite without directly sending data to the cloud, which is especially important in remote locations. Worldsensing designs and builds all of its dataloggers from scratch, which enables the company to control power consumption and ensure rugged hardware components. Worldsensing partners thus work with networks that can operate for up to 10 years without intervention, networks that are resistant to all weather conditions (from -40C to +80C). Such networks

Initiative	
	offer significant ROI for industrial companies, where installation and maintenance costs tend to be high compared with those in other industries.
Relation to H-CLOUD key areas	Edge
Business model	Worldsensing sells to a global network of local partners, such as engineering service providers, that deploy and use Worldsensing solutions to provide monitoring services to end customers. Until now, the business model has been based on selling network infrastructure to engineering service providers and/or end customers. The company is now moving to a service-based approach, whereby a customer pays for the devices, plus software and services.

Impacts	
Business success	Being a product company, our key metrics have always been driven by the number of devices sold in a given period. Revenues have been increasing since 2016. Another interesting KPI is how much money our customers/partners save by deploying our solutions, which adds to the other measured benefits derived from the real-time availability of geotechnical data, such as the increased safety of workers, citizens, and the environment. The overall result is usually high ROI, depending on the project setup.
Technology innovation	Our technology solutions are at the crossroads between IoT (the dataloggers) and edge (where the data is processed). Our solutions rely on a centralised (cloud) platform to which all data is sent from the dataloggers, so edge is critical in delivering value. The company invests a lot in R&D to develop new solutions and to leverage the latest technology trends on the market – LoRa and 5G on the connectivity side, batteries for sensors, and new edge servers/gateways with increased computing and storage capabilities.
Governance / Organisational structure	n/a
Data governance	Being a European company has pushed Worldsensing to align its internal processes with GDPR principles and various national legislations around Europe. These high privacy requirements are a unique business opportunity, since many other countries worldwide are adopting GDPR-related practices as a standard in data governance and security.

Impacts	
Environment and sustainability performance	n/a
Focus on SME	No

Obstacles/Barriers	
Technical barriers	The most important technical barrier that edge computing overcomes lies in its ability to perform low-power computing operations – in this case, enabling long battery life for dataloggers in situations in which power is limited. Technology has been developing fast for such solutions, and Worldsensing invests heavily in R&D to maintain its lead over its competitors. New connectivity deployments, worldwide, such as 5G, have been slower than expected, and this has had a technological impact in terms of balancing edge and cloud in remote areas. The evolution of new connectivity standards and ecosystems (e.g. LoRaWAN) and their adoption are key to enabling Worldsensing to integrate its solutions with those of other players in the industrial market.
Legal barriers	As our products operate in the free ISM radio bands, worldwide, we are subject to various governments' decisions. Public authorities are usually slow to define clear certification frameworks to regulate wireless communications in their territories. For instance, Israel has not yet established a clear set of rules for the different frequencies, making the commercial exploitation of such technologies difficult.
Economic barriers	We are a VC-backed company. As such, we are constantly investing in our growth. Expanding our commercial footprint worldwide and R&D investments are our core practices.

COLA

Identification	
Name of interviewee	Tamas Kiss
Title	Professor in distributed computing
Organisation	Westminster University, coordinator of the COLA project
Country and location	United Kingdom
Sector	Academia

Initiative	
Description of the initiative	SMEs and public sector organizations increasingly investigate the possibilities to use cloud computing services in their everyday business conduct. Accessing services and resources in the cloud on demand and in a flexible and elastic way could result in significant cost savings due to more efficient and convenient resource utilization that also replaces large investment costs with long-term operational costs. Nevertheless, the uptake of cloud computing among SMEs and in the public sector is still relatively low due to limited application-level flexibility and security concerns. The **Cloud Orchestration at the Level of Application (COLA)** project aims to increase the adoption of cloud computing services in the above-mentioned two strategic target communities. Typical industry and public sector applications require resource scalability and efficient resource utilization in order to serve a variable number of customers with dynamic resource demands and to suitably optimize resource consumption and costs. However, the dynamic and intelligent utilization of cloud infrastructure resources from the perspective of cloud applications is not trivial. Although several efforts have been made to support intelligent and coordinated deployment and, to a lesser extent, the run-time orchestration of cloud applications, no comprehensive solution has emerged until now that could be applied in large-scale near-operational-level industry trials. The overall objective of the COLA project is, by building on and extending current research results, to **define and provide a reference implementation of a generic and pluggable framework that supports the optimal and secure deployment and run-time orchestration of cloud applications**. COLA will demonstrate the applicability and impact of the solution via large-scale near-operational-level S**ME and public sector pilots and demonstrators** and will define a clear pathway for the innovation to be delivered to the market.
Timing of the initiative	The COLA project ran as a research project between 2016 and 2019. The outcome of the project is MiCADO technology, which is now being taken to market by CloudSME, a commercial start-

Initiative	
	up from Germany. The principles are also being used in current EU-funded projects like DigitBrain and Asklepios.
Key stakeholders	The consortium[57] includes 10 companies and four research organisations from six European countries – the United Kingdom, Hungary, Sweden, Switzerland, Spain, and Germany. The coordinator of the COLA project is Dr Tamas Kiss, the University of Westminster (UK). Project structure: The core technical team developed MiCADO technology. The key stakeholders were: the University of Westminster, MTA Sztaki (Hungarian Computer Science Institute), CloudBroker, ScaleTools, SISC Swedish ICT AB, CloudSigma, Balasys, Inycom, Sarga, Brunel University London, Saker solutions, Outlandish, CloudSME, and The Audience Agency. The project developed three application case studies to prototype the solution: 1) Inycom (Spain), Sarga (the local government of Aragon): a social-media data-mining solution for the analysis of Twitter feeds; the service had a very imbalanced load and needed an autoscaling solution. 2) Brunel University London and Saker Solutions: a simulation consulting company that ran an evacuation simulation with thousands of replications concurrently, using MiCADO to allocate the right numbers of resources in cloud. 3) UK-based software company Outlandish and The Audience Agency, collecting ticket sales data from events, analysing demographic data, and providing information to venues about who to target with marketing campaigns; a huge database that is growing exponentially; dynamically changing application capabilities.
Funding	Project COLA is an Innovation Action that is funded by the European Commission as part of the Horizon2020 Programme.
Technical solution	Project COLA (Cloud Orchestration at the Level of Application) aims to increase the adoption of cloud computing services among SMEs and public sector organizations. Typical industry and public sector applications require resource scalability and efficient resource utilization in order to serve a variable number of customers with dynamic resource demands and to suitably optimize resource consumption and costs. However, the dynamic and intelligent utilization of cloud infrastructure resources from the perspective of cloud applications is not trivial. Although several efforts have been made to support intelligent and coordinated deployment and, to a lesser extent, the run-time orchestration of cloud applications, no comprehensive solution has emerged until now that could be applied in large-scale near-operational-level industry trials. The overall objective of the COLA project is, by building on and extending current research results, to define and provide a reference implementation of a generic and pluggable framework

[57] http://project-cola.eu/cola-project-consortium/

Initiative	
	(the MiCADO framework) that supports the optimal and secure deployment and run-time orchestration of cloud applications. COLA will demonstrate the applicability and impact of the solution via large-scale near-operational-level SME and public sector pilots and demonstrators and will also define a clear pathway for the innovation to be delivered to the market. To overcome the problem of the manual allocation of resources for applications, the MiCADO framework has been developed as part of the COLA project. The MiCADO framework supports the autoscaling of applications on two levels: 1) Scaling at container level (based on Kubernetes) 2) Scaling at virtual-machine level (based on Occupus) The application will be defined in a TOSCA-based application description, which is divided into three parts: 1) The specification of the services 2) The specification of the virtual machine 3) The specification of the scaling rules for both levels After commissioning the service, it can be controlled and maintained in various ways. Through the integrated dashboard, various aspects of the application can be visualized in their production environments. The dashboard is encrypted by means of self-signed or provided TLS/SSL and is secured via login. Via a secured REST interface, applications can be started, stopped, updated, or listed. All components have detailed logs, which are stored centrally for more experienced users.
Relation to H-CLOUD key areas	Cloud and federation
Business model	MiCADO is now an open source community, with two universities and CloudSME contributing to it. CloudSME is a start-up that emerged from another EU project, which is tasked with the commercialization of MiCADO and provides value-added services on top of MiCADO. The commercialization effort is through open source routes to market: building an open source community and providing value added services on top. The next step would be to register MiCADO with the Cloud Native Computing Foundation when funding is available to do so.

Impacts	
Business success	We need to differentiate between project success and business success. What matters is that the COLA scored 6 out of 7 in a technological-outcome evaluation, which is a very high score for a European project. With regards to the long-term sustainable business success of MiCADO technology, we will have to see. Currently, the number of clients using the software is limited, but the product has a future. The route to reaching more customers is clear – through the MiCADO-scale.eu commercial website and through the marketing efforts of CloudSME targeted at prospects. MiCADO is also used in new EU-funded projects like DigitBrain, Conversatile, and Asklepios. It would be beneficial for maturing and commercializing MiCADO technology if it were used by a larger number of European funded initiatives, but also by European cloud service providers.
Technology innovation	Additional technology innovation will be added to MiCADO technology, especially in the area of edge computing. In new research initiatives Askeplios, Conversatile, and DigitBrain, MiCADO technology is used with industry sensors and edge solutions, deployed within an edge-cloud ecosystem. MiCADO will support edge technologies, and significant funding has been secured to do so. MiCADO is also extending to graphical user interfaces, like Jupiter Hub and Jupiter Notebook In addition, MiCADO will be extended with AI logic to create optimization patterns, which can move MiCADO technology from reactive scaling based on monitoring data to predictive scaling, concentrating on requirements from AI applications.
Governance / Organisational structure	The consortium includes 10 companies and four research organisations from six European countries – the United Kingdom, Hungary, Sweden, Switzerland, Spain, and Germany. The coordinator of the COLA project is Dr Tamas Kiss, the University of Westminster (UK).
Data governance	N/A
Environment and sustainability performance	MiCADO optimizes resource utilization in the cloud.
Focus on SME	MiCADO can be used by all company sizes.

Obstacles/Barriers	
Technical barriers	The biggest technology challenge was the very quick change of technology. In 2016, Kubernetes was in its infancy. The COLA project started with Docker Swarm and then switched to Kubernetes half-way through the project, as Kubernetes emerged as the de-facto standard. The lesson learned is that you need to design your application in a modular way so you can make changes easily. Towards the end of the project, open source virtual orchestrator Occopus was replaced by the Terraform orchestrator tool because Terraform is also emerging as a de-facto standard for orchestration. This work only took two or three weeks, even though Occopus was a major component of MiCADO's architecture.
Legal barriers	In the COLA project, we tried to overcome legal barriers from the beginning, keeping it open source to reduce legal challenges.
Economic barriers	The economic barriers to the commercial success of MiCADO are significant. The EU funding available is not enough to drive commercialization and to market the product. You need a huge marketing budget to make MiCADO known to customers, which does not exist at this point.

Helix Nebula Science Cloud

Identification	
Name of interviewee	Robert Jones
Title	Senior member of the scientific staff
Organisation	CERN, partner Helix Nebula Science Cloud initiative
Country and location	Multiple locations/countries
Sector	Research
Company size	n/a

Initiative	
Description of the initiative	The Helix Nebula Science Cloud (HNSC) initiative is a partnership between industry, space agencies, and science to establish a dynamic ecosystem, benefiting from open cloud services for the seamless integration of science into a business environment. The interviewee works at the European Organisation for Nuclear Research (CERN), a partner of the initiative.
Timing of the initiative	The work started in 2016 and was completed at the end of 2018. Next steps: • Open Cloud for Research Environments (OCRE)[58]: The OCRE project provides the main near-term procurement opportunity for the public research and education sector to exploit the results of HNSciCloud in the context of the European Open Science Cloud (EOSC). • Archiver project[59]: The experience gathered and lessons learned from Helix Nebula are being applied in the execution of the ARCHIVER project.
Key stakeholders	Research organisations and academic institutions are the main stakeholders. Researchers, research groups, and research infrastructure players are also users, as are codevelopers of technology (including suppliers).
Funding	An EC funded project (70% from EC funding, for the procurement budget, and 30% from buyers)

[58] https://www.ocre-project.eu/
[59] https://www.archiver-project.eu/

Initiative	
	Precommercial procurement (PCP)
Technical solution	n/a
Relation to H-CLOUD key areas	Cloud services integration (IaaS plus some other services, e.g. identity management and data management)
Business model	Collaboration with other businesses was done through commercial proposals (potentially, from commercial consortia) to offer services to the 10 members of the buyers' group. Helix Nebula is not a federation. Services are integrated by the bidding consortia, as per their own agreements, and then offered to the buyers' group, as per defined terms of service. For instance, IBM was one consortium. Some consortia included universities and research communities (but not from the buyers' group). None of them was led by a research organisation. The consortium needs to have commercialisation capacity and the intent to offer resulting services to others. The precommercial procurements entailed a framework agreement among 10 procuring organisations. It followed fixed phases focused on the co-development of infrastructure as a service, plus a few other services, like data management. 10 reasonable tenders were submitted to the initial request for tenders (RFT); 4 were selected for co-development/design; 3 were selected for prototyping; and then 2 finalists were selected to implement the pilots (2, not 1, to avoid lock-in). There was only one interaction between the buyers' group and the market before the HNSC RFT was released. Under PCP (due to being limited to R&D), 50% of the activities must be performed in Europe. The process ended up very fit for purpose. From the 2 finalists (T-Systems and the RHEA consortium), services are now being used in various contexts. (Commercial exploitation was an RFT requirement.) • T-systems: Mundi Web Services is a part of DIAS, supporting access to Copernicus data. • RHEA: SixSquared got additional business for their Nuvla cloud brokerage platform, but Nuvla has pivoted to edge. The Nuvla broker is being used by Exoscale (RHEA's underlying CSP). The Nuvla broker was better for smaller jobs – too complicated for CERN. Lessons learned: A financial broker like Booking.com is needed for cloud services: • To support 'put' options, etc. (reserving capacity for possible needs)

Initiative	
	• To deal with public money procurement hoops – an ability to change suppliers without month-long procurement delays • To provide better support for SWIPO and make it an integral part of the concept Archiver project opportunities exist for the other 8 bidders from the HNSC project – long-term data preservation services (4 procuring organisations). HNSC might be considered a small marketplace, since the resulting services are made available to others, but it is not nearly as broad as G-Cloud. Lessons learned from Helix Nebula Science Cloud: • More time is needed for market preparation. Lessons learned from Archiver so far: • A very country-centric market organisation • VAT registration issues hitting OCRE • Lead procurer (CERN) not subject to VAT • Not a full DSM in the EU – VAT, associate member states (EU GDPR legislation).

Impacts	

Business success	PCP itself was successful: 2 conformant offers are up and running. More use cases than initially perceived. Pent-up demand in the research community to use cloud services.
	Project has identified a number of trends and issues and has gained advanced knowledge from the stakeholders.
	• Keeping up with trends: GPUs: more available to lease than to buy:
	  ○ But Obstacle: NVidia licensing issues – data centre license, gamer license, capacity licensing, time to access/flexibility to access
	  ○ 9 months from purchase decision to commissioning/GA – vs. 1 month
	• Evolution in buyer's understanding:
	  ○ Total-cost-of-ownership (TCO) studies – things have changed
	  ○ Now at CERN – concerted effort to develop more accurate costing for these resources
	  ○ Costing framework from ECAR in US – power and rent frequently missing

Impacts	
	○ Compared costs to rented data centre; Wigner in HU (comparison from 2 or 3 years ago); comparable prices for compute, but in-house cheaper for huge quick-access storage; mapped to workloads; simulations cheaper commercially • Networking – use GEANT; federated ID management
Technology innovation	The initiative included machine learning as an added use case (continues today). • Perform ML training offsite. Train the model and deploy internally. • However, triggering systems (for LHC) have to be in house. The inclusion of high-performance computing (HPC) should allow for process acceleration, but this is still a small proportion of CERN's needs. How do you drive innovation? Who is involved within the organisation and across the partner ecosystem? (Also related to governance) • Developed new approaches and now implementing in OCRE – working to procure large-scale commercial cloud capacity for research use, ~€10M. • It may take until 2024 for this to really work due to other challenges and pressures – legislation (GDPR compatibility, ISO 27000 certification, etc.) • Note: CERN is not subject to GDPR (intergovernmental organisation); EMBL; WHO; Archiver (consortium of buyers); GSuite. (CERN tools have undefined statuses with regard to GDPR.) • GDPR is one of the selection criteria for HNSciCloud (certification); data had to be hosted in EU MS. • Learnings captured in EOSC innovation cycle – separating EOSC core from EOSC exchange. Core should be stable. Exchange marketplace – allows steady innovations.
Governance / Organisational structure	n/a
Data governance	n/a
Environment and sustainability performance	Green computing/energy efficiency was not present in HNSciCloud, but it was in Archiver. • Archiver is considering using power usage effectiveness (PUE) in specifications, but this is still challenging.

Impacts	
	• Wigner (HU) data centre RFT (8 years ago): attempted to specify renewable sources, but arguments about definitions thereof could not be included in the specifications.
Focus on SME	The design of the PCP was intended to allow for the participation of SMEs. The follow-on Archiver and OCRE projects were intended to improve accessibility for SMEs as potential suppliers/consortium members.

Obstacles/Barriers	
Technical barriers	n/a
Legal barriers	None. We used an off-the-shelf agreement from CERN. Defined the framework agreement – describes the 4-3-2 PCP selection process (described above) and included the EC conditions[60]; also incorporated learnings from the project SLA-Ready[61]. HNSC did not sign standard provider agreements with individual suppliers. Providers' standard contracts varied enormously. There is an international standard, but it was not used. GEANT doing OCRE using an international standard agreement. Signed a special acceptable-use-policy document (standard).
Economic barriers	The promoters of the initiative had to describe market potential to potential bidders (more time spent on this in the Archiver project). Needed to spend more time describing PCP procurement processes. HNSciCloud Deliverable D7.3 describes the challenge because there were many intermediaries between users and deciders. Also, budgetary aspects: Buyers had limited understanding of their existing unit costs to compare with supplier's offers. Typically considered capex, rather than converting to standard unit cost of usage.

[60] Details on tendering process available at https://www.hnscicloud.eu/sites/default/files/Deliverable%202%202%20HNSciCloud_Public%20Deliverable%2012_12_2016%20final%20V1.1.pdf

[61] https://www.sla-ready.eu/

LightKone

Identification	
Name of interviewee	Peter Van-Roy
Title	Department of Information Engineering
Organisation	Université Catholique de Louvain, partner of LightKone project
Country and location	Belgium, Louvain-la-Neuve
Sector	Academia

Initiative	
Description of the initiative	The slogan is 'lightweight compensation for networks at the edge'. The idea is we are looking at the exponential growth of the internet of things. We're looking at edge computing architectures, and we noticed that existing big companies have already invested a lot in cloud and are pushing out, towards the edge. But this is actually complex because the edge is very large; it is actually moving faster than cloud. Our goal was to help it along by improving data management – by making the data management more automated, adding abilities to make data transfer simpler between the edge and the cloud.
Timing of the initiative	It's an H-2020 project that ran from the beginning of 2017 to end of 2019. It was the successor of another project, called Sync-Free, which ran from 2013 until 2016.
Key stakeholders	The stakeholders are four companies and five academic partners. Accademia partners: UCL, INESC TEC, UPMC, NOVA LINCS, and TUK Industry partners: Scality, Peer Stritzinger GmbH, Gluk Advice BV, UPC, and Guifi.net It's a very classic organisation, with five academia partners and four industry partners. Project organisation: We start by finding what industry partners need. Then we make technology in cooperation with them, and they implement and evaluate it. This represents classic collaboration between academia, research, and industry.

Initiative	
	The four partners cover most of the cloud-edge spectrum, from heavy-edge very-cloud-oriented Scality to extreme edge Gluk agriculture and Stritzinger manufacturing architecture, with the Guifi community network in between.
Funding	Horizon 2020
Technical solution	The development of Artifacts for data consistency at the edge and in the cloud. Principle: lateral data-sharing and convergent data management using automatic forms of data consistency between the edge and the centre so that programmers don't have to spend all their time sending data back and forth.
Relation to H-CLOUD key areas	edge, green, cloud
Business model	The industry partners are extending their core businesses. For example, Stritzinger is doing automatic manufacturing using RFID tags. Stritzinger actually already has tools that it sells to Bosch, in Germany, for automated manufacturing. Bosch used our technology to integrate partial information to achieve consistency, and it is now part of Bosch's core technology inside its next-generation product. Stritzinger created a start-up company, called Concordant. This work started during the last year of the project, in 2019. Three of the partners (Sorbonne University, Kaiser State University, and Nova University, in Lisbon) got together and are working on a start-up. We have development engineers and investors, so this is wrapping up right now, in 2020. This is a start-up company that using the technologies developed.

Impacts	
Business success	n/a
Technology innovation	The initiative included edge and IoT technologies that impact business processes.
Governance / Organisational structure	The number participant organisations and their types are described below. Academic: • UCL (Coordinator) – Belgium • INESC TEC – Portugal • UPMC – France • NOVA LINCS – Portugal

Impacts	
	• TUK – Germany SMEs: • Scality – France • Peer Stritzinger GmbH – Germany • Gluk Advice BV – The Netherlands • UPC – Spain • Guifi.net – Spain
Data governance	No sensitive data is directly managed.
Environment and sustainability performance	Edge computing in general is very green. Anything you push away, push to the edge, will reduce energy consumption.
Focus on SME	All the industry partners are SMEs. There's a lot of opportunity now for SMEs outside of the cloud – without necessarily using cloud. Big companies, of course, have a lot of money invested in cloud, so they want to make it profitable. But SMEs don't have that, so there's an opportunity to do things that don't necessarily need cloud, which is actually much cheaper. For a lot of the SMEs, it's much cheaper to try to do computations outside of the cloud. In our project, we found that you can do many things completely outside. Of course, cloud can give you additional functionality, but it's not essential. You can do many things without cloud. My view is that SME and garage-style computations now offer a lot of opportunity in IoT.

Obstacles/Barriers	
Technical barriers	n/a
Legal barriers	n/a
Economic barriers	SMEs sometimes have problems with liquidity and local strategy problems. For Stritzinger, in the original project, there was no GRiSP or extreme edge computing. Stritzinger invented that during the project. Then four of the partners immediately started using this new technology. That was not the original plan, which helped Stritzinger a lot of course. Many SMEs are small companies without huge marketing budgets that generate business mostly by reputation and from references.

Radon

Identification	
Name of interviewee	Giuliano Casale
Title	Academic in the Department of Computing
Organisation	Imperial College London, coordinator of the Radon project
Country and location	UK
Sector	Academia

Initiative	
Description of the initiative	The focus is providing development tools to improve the adoption of function-as-a-service (FaaS) microservices in the cloud. FaaS is seen as improving performance and efficiency (e.g. better utilisation of compute resources), but implementing applications with FaaS is at best an art at this point. Stakeholders include engineering and software development companies, as well as companies with use cases. For example, one use case is converting hardware controllers to software. An engineering firm needs a robust development environment to create quality software alternatives to well-tested hardware solutions.
Timing of the initiative	RADON is an EU funded project. It is now halfway through its implementation.
Key stakeholders	Focusing on service computing: FaaS, microservices (one of the first focuses of the project), and applicability Use-case providers: • Ingegneria Informatica (IT) • ATC (GR) (medium sized) • Praqma (bought by Fcode, not previously involved in R&D) – software engineers, developers, CD/CI → SME involvement
Funding	100% EC grant
Technical solution	
Relation to H-CLOUD key areas	Could apply to cloud (FaaS), federation (potentially), edge Also enables the adoption of FaaS, which improves utilisation – therefore, green

Initiative	
Business model	n/a

Impacts (how to identify a best practice)	
Business success	The success of the project will depend on the successful adoption of tools to develop real-world software solutions using FaaS, but also identifying practical issues for adoption and next steps for the improvement of the development environment.
Technology innovation	The initiative includes IoT/edge to some extent, as well as exposing and mitigating security issues in FaaS-based architectures. It should accelerate the adoption of FaaS, which should make software development more effective.
Governance / Organisational structure	Traditional EC-funded project structure, research partners, development partners, SMEs, and end-user partners
Data governance	n/a
Environment and sustainability performance	The initiative addresses green computing/energy efficiency and highly virtualised data centres.
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	Too soon to define (project ongoing)
Legal barriers	Too soon to define (project ongoing)
Economic barriers	Too soon to define (project ongoing)

RestAssured

Identification	
Name of interviewee	Eliot Salant
Title	Researcher
Organisation	IBM Research Israel, coordinator of RestAssured project
Country and location	Different EU countries
Sector	n/a

Initiative	
Description of the initiative	Providing and E2E security solution for data in the cloud
Timing of the initiative	Finished in December 2019
Key stakeholders	End-user companies, 2 use cases (SME: Dactenx, University of Southampton, Oxford Computer Consultants, Thales)
Funding	EC funded project
Technical solution	The objective was to demonstrate the overall solution – exploitation by use-case partners. There was not a good solution for protecting data at rest. A focus on Apache Parquet files with SPARC, which are not protected at rest. Created a solution for encryption of Parquet files – encrypted columnar data, different keys by column. Dr. Ygon Goshinsky (IBM) is the principal researcher on this. Apache Parquet is now adopting this encryption approach as a community standard. Also requires secure enclave, used for data processing – Intel SDX (also AMD), plus secure communication using Transport Layer Security. Allows E2E security in this particular case. Created a toolkit for the attestation of software for compatibility with SDX. University of Southampton: modelled configurations and performed static risk analysis – allowed users to refactor the application to be more secure based on risks. Mike Surridge from U Southampton (IT innovations? spinoff/consulting) has a black box that implements this risk assessment – still a research capability. **Thales**: focussed on security policies University of Duisburg-Essen: want to automatically reconfigure architecture to mitigate risk (found by University-of-Southampton tool) – perhaps not as feasible as originally thought. FOG Protect – next project – addressing added concerns about data leakage from microservices. Based on K8s-based IBM data

Initiative	
	mesh. The data mesh is based on Istio: The focus is to better control envoy sidecars (the part of Istio architecture that manages communication flows). Protecting against attacks injected into workflows. **E. Salant:** My personal view is that this will have limited capability at the edge; it requires stronger security, such as Transport Layer Security (the updated version of SSL, or Secure Sockets Layer).
Relation to H-CLOUD key areas	(Cloud, federation, edge, green) The focus is security, so it applies to all but green.
Business model	As project coordinator: aiming for a PoC that gets people thinking about what is possible. Create the REST Assured framework, which is a collection of open-source code. There are some proprietary products, but design documents are openly available. A focus on building technical knowledge.

Impacts	
Business success	The Parquet encryption community standard was a good outcome: It allows encrypted files in the cloud. Parquet encryption is widely employed. **Oxford Computer Centre:** They use risk analysis tools in their consulting business.
Technology innovation	
Governance / Organisational structure	Best practice: You need to be flexible. Don't have plans carved in stone. Tech changes and partners change direction. Always keep a plan B in mind.
Data governance	2 aspects – infrastructure level: good solutions for data at rest/in motion/in processing; to manage privacy: identify leakage points – have clear policies. The challenge is the policy enforcement point (PEP): Data queries must be evaluated against policy. It is an open research issue to decide whether a query is acceptable.
Environment and sustainability performance	REST Assured: While security was achieved, there are concerns about the performance overhead of Parquet encryption. Follow-on FogProtect project: IBM is working to improve the performance of the data mesh. Another follow-on ProTego project (in healthcare) – working with HL7 'FHIR' data standard objects encrypted in Parquet and featuring Azure Active Directory (AAD) protection and tamper protection. The project started 1.5 years ago.
Focus on SME	

Obstacles/Barriers	
Technical barriers	There wasn't a good solution for protecting data at rest, but we created a solution for a limited case.
Legal barriers	n/a
Economic barriers	n/a

SUNFISH

Identification	
Name of interviewees	Francesco Paolo Schiavo; Vladimiro Sassone
Organisation	Italian Ministry of Economy; University of Southampton
Country and location	Italy; UK
Sector	Public authority; academia

Initiative	
Description of the initiative	SUNFISH prototyped and demonstrated the secure interoperation of separate cloud systems using a "federation-as-a-service" approach. This approach extends beyond the adoption of interoperability standards, since those standards are still a work in progress. The approach also avoids creating a separate entity to manage the federation; instead, robust peer-to-peer protocols are set up, enabling a federation to be created, operated, and eventually dismantled.
Timing of the initiative	Started in January 2015 and completed in December 2017
Key stakeholders	Public administrations
Funding	An H2020-funded project
Technical solution	Sunfish architecture is built on a variety of tools/functions that address security and privacy in particular and SLA compliance in general. These capabilities are fundamental to the Sunfish architecture ("privacy by design"), rather than being "bolted on", as is sometimes seen in other efforts.
Relation to H-CLOUD key areas	Cloud federation, edge
Business model	Sunfish is contemplating the future use of blockchain and distributed ledger technology (DLT) as a way of ensuring the verifiability of communication among federation partners, to manage compliance with contractual terms (smart contracts), and to register the status of resources across the federation. DLT would also pave the way for cultural and organizational changes, allowing hierarchically "equal" departments to collaborate on projects without problems of rivalry or territoriality. Unfortunately, the computational burden and latency of "proof of work" DLT prevented adoption at the time of the project, but emerging "proof of stake" schemes should enable this ability in planned future implementations.

Impacts	
Business success	Sunfish started a new path to private cloud and has strengthened activities with the Ministry of Defence. This is a great opportunity to improve knowledge in the cloud space. Blockchain is also seen as a success story, especially for public administration, starting with the Ministry of Defence and agencies for social security and pensions. Indeed, Sunfish realized a common blockchain for the whole public administration. Other ministries are now willing to cooperate with Sunfish. Sunfish also thinks that change management in the ministry is very successful; employees are thinking and working differently. Sunfish tried to solve public administration problems – data security, data control, and democratic governance – through a decentralised platform.
Technology innovation	Sunfish is realising a completely new cloud-based system that uses distributed computing across various administrations. Under this system, each cloud is interoperable with the other clouds from the other public administrations.
Governance / Organisational structure	A standard agreement was then drawn up on federation participation. Smart contracts typical for democratic governance were used to define federation entry and exit, the computational parts to be federated, and the environments to remain segregated. The platform itself was used to manage requirements. Sunfish focused on several public-administration use cases: • **Federation of application (payroll calculation) - Italy:** The Ministry of the Economy and Finance (MEF) handles payroll processing for over 2 million public sector employees. Payroll taxes are calculated based on the employee's home address. MEF requires access to the home addresses of police staff employed by the Ministry of the Interior (MIN), but these addresses are personal information, and Italian law prevents their disclosure outside of the Ministry of the Interior because of possible threats against police. Sunfish's secure federated cloud services enabled the correct calculation of payroll taxes without exposing sensitive home-address information (even to another ministry of the Italian government). • **Federation of data (taxation) - Malta:** Maltese businesses submit payroll, financial statements, and accounting records to Malta's Taxation Department to calculate tax payments and refunds. Large organizations have internal IT resources to manage the electronic submission of this data. But, for small organizations, this is an onerous requirement. Sunfish's secure federated cloud services make it easy for some small organizations to link their SaaS financial accounting services to the Taxation Department.

Impacts	
	• **Data secrecy (police investigation) - UK:** The UK's efforts against cybercrime are organized into nine regional cybercrime units, each of which is required to independently manage and store the data and evidence collected in its investigations, while also enabling authorized access to this data from other units as investigations proceed. Transferring data outside of each unit was not possible, nor was the merging of all units' data into a separate entity to enable search, analysis, or processing. Sunfish's secure federated cloud services enabled cybercrime units to search other units' data without actually exposing or transferring that data to the other units.
Data governance	n/a
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Technical barriers	The project had performance problems, but the research project was able to help with this, with cloud federation under consideration as part of the solution. Blockchain could also help to solve specific problems. As an isolated example, Sunfish expected far more interest from the Italian government and public administrations in solving a real problem – too many small, inefficient, and insecure data centres.
Legal barriers	Sunfish believes one federation is not sufficient, as a European-wide federation of clouds is needed, as are a high level of agility and an ability to carve out areas of this federation for specific groups of interests. In the UK, the Police has 32 different independent forces, regulated by very tight laws. For example, it might be illegal for one police force to ask a specific question of another. Brexit is another legal barrier.
Economic barriers	Sunfish expected far more interest from the Italian government and public administrations in solving a real problem – too many small, inefficient, and insecure data centres.

GAIA-X

Identification	
Name of interviewee	IDC interviewed executives of the GAIA-X program management office at the German Federal Ministry of the Economy and Energy (BMWi), as well as executives at participant companies in the launch of GAIA-X.
Country and location	Started in Germany, but extended to other European countries
Sector	Cross industry

Initiative	
Description of the initiative	At its digital summit on October 29, 2019, the German Ministry for Education and Research – together with the Ministry of Economics – unveiled its vision for connected cloud-based data infrastructure for Europe. GAIA-X has two main goals: • To win back sovereignty for European citizen and company data by ensuring that data does not leave European soil unintentionally • To reduce dependency and the risk of lock-in by enabling service and data portability By delivering on those two strategic goals, GAIA-X expects to encourage cloud-sceptic European organisations (particularly SMEs) to take advantage of cloud while maintaining control over their data and to foster the creation of an open digital innovation ecosystem in which data can be collected and shared securely, while adhering to European privacy regulations. It is not intended to compete with global hyperscalers; it will be a layer on top of their services.
Timing of the initiative	2019 – ongoing
Key stakeholders	The GAIA-X program is led by the German Federal Ministry for Economic Affairs and Energy (BMWi), which initiated it with German industry giants like SAP, T-Systems, Siemens, and Bosch. GAIA-X has proactively involved governments and industry players from other European countries, starting with France and, more recently, adding Italy, the Netherlands, Finland, Austria, and Spain. The French government and BMWi have already issued formal joint communication about collaborating on the GAIA-X roadmap. Participation has quickly grown – from 20 companies in October 2019 to over 150 in the first few months of 2020. The 22 founding members are: 3DS OUTSCALE, Amadeus, Atos engineering, Beckhoff Automation, BMW, Bosch, CISPE, DE-

Initiative	
	CIX, Deutsche Telekom, Docaposte, EDF, Fraunhofer Gesellschaft, German Edge Cloud, IMT, International Data Spaces Association, Orange, OVH, PlusServer, Safran, SAP, Scaleway, and Siemens.
Funding	Sponsors: government and members
Technical solution	GAIA-X plans to transform decentralised infrastructure services, such cloud and edge, into a homogeneous, user-friendly system. It is planned as a peer-to-peer network in which GAIA-X certified organisations – known as 'nodes' – can rent server capacity to each other. It is also intended to offer machine learning and artificial intelligence as a service to organisations – especially to SMEs through standardised APIs. The GAIA-X framework will operate at the SaaS and PaaS layers, and, depending on use cases, at the IaaS layers, where the market does not already offer a solution. The result will be a connected data infrastructure that enhances the digital sovereignty of cloud service users, as well as the scalability and competitive positioning of Europe-based cloud service providers. GAIA-X federation services are grouped into four domains: • Identity and Trust: Includes federated identity management, access management. and trust • Federated Catalogue: Contains concepts and results concerning core architecture elements and their relationships with each other, such as self-description, service governance, and monitoring and metering to ensure interoperability • Sovereign Data Exchange: Ensured by usage control mechanisms and an overarching security concept • Compliance: Includes a definition of the relationship between service providers and consumers, the rights and obligations of participants, and onboarding and certification processes to implement security and data protection requirements
Relation to H-CLOUD key areas	
Business model	n/a

Impacts	
Business success	n/a

Impacts	
Technology innovation	Technical implementation of GAIA-X Federation Services will focus on the following areas: • The implementation of secure federated identity and trust mechanisms (security and privacy by design) • Sovereign data services, which ensure the identity of source and the receiver of data and which ensure access to and usage rights for the data • Easy access to the available providers, nodes, and services, with data provided through federated catalogues • The integration of existing standards to ensure interoperability and portability across infrastructure, applications, and data • The establishment of a compliance framework and certification and accreditation services • The contribution of a modular compilation of open source software and standards to support providers in delivering a secure, federated, and interoperable infrastructure
Governance / Organisational structure	Governance has two tiers: • **Tier 1:** During the first year after launch, the central program management office was led by BMWi, which coordinated the work of founding members. This central project management office made the final decisions about long-term strategy, operating model, business model, and rules for other entities participating in the program and be certified as GAIA-X nodes. On September 15, 2020, the 22 founding members co-signed the incorporation papers for GAIA-X AISBL, a non-profit association that will be responsible for securing funding and commitment from members to fulfil the initiative's vision. • **Tier 2:** There are several workstreams – technical architecture, use cases, operating model, data sovereignty policy, and regulation – in which a larger number of institutions are participating, such as German regional government data centres, European vendors like OVH, and global cloud providers such as IBM. The GAIA-X project is divided into different workstreams for specific topics: 1) User ecosystems and requirements 2) Technical implementation There is also a cross-functional unit known as the 'joint requirements' expert tribe. This unit consists of two groups, which convene on a flexible basis and that deal with topics where there is a strong interdependency between the workstreams. The project structure is agile, can be adapted over time in line with

Impacts	
	framework conditions, and guarantees collaboration across separate topics.
Data governance	n/a
Environment and sustainability performance	n/a
Focus on SME	n/a

Obstacles/Barriers	
Economic, technical, and legal barriers	• If GAIA-X is to succeed, the German government and other stakeholders in the initiative must answer tough questions in detail. • It must start with a clear **vision.** What is the real purpose of GAIA-X? If the main issue is data sovereignty, then GAIA-X should focus on strengthening existing data governance and identity management regulations that can be laid on top of existing cloud services (from hyperscalers or others). If the aim is to reduce lock-in or dependency, then data exchange and interoperability services should be the primary focus. If the goal is to foster the adoption of cloud services among European SMEs, then its instruments need to be policy related. This should include increasing IT literacy or offering tax credits to incentivise the creation of the aggregators and orchestrators of cloud services to make them more accessible and affordable for SMEs. If the goal is to foster an innovation ecosystem, then GAIA-X will need to act as a data exchange broker. It will need to coordinate with programs that fund R&D and accelerate the commercialisation of cloud services through technology transfer and demand pooling across countries, industries, and other policy instruments. • The vision must align with a **service strategy**. The document published by the German government describes various services, including a repository of software components, identification services, node exchange services, certification, and standards. These are well-aligned with the vision of data sovereignty and reducing data dependency. However, providing these services across industries will take a gargantuan effort, particularly with the proliferation of data sources, including the Internet of Things (IoT) and edge devices. A data exchange for all industries would require too much mapping of different IT and OT data formats. To reduce the effort, an option would be to build industry-specific data exchanges. To be sustainable, it would need to

Obstacles/Barriers	
	attract one or two other large European countries to pool enough market demand. • The service portfolio must be supported by state-of-the-art architectural capabilities and delivery models. One of the advantages of hyperscalers is their continuous cycle of innovation, which offers customers a wide range of choices in terms of capabilities for different workloads. The published plan states, 'The project creates added value by placing itself above existing hyperscaler/cloud providers as a type of multilateral administrative layer; this connects the production infrastructure and clouds with higher-level semantics and data exchange services, thus simplifying interface management.' It does not aim to compete with existing service providers, but it does not explain how the 'multilateral administrative layer' will be developed or delivered or by whom. Will the GAIA-X 'central organisation at the European level' have its own developers? Will it develop capabilities externally, but then manage them? Will they contract out the delivery (operations, maintenance, helpdesk, etc.)? • The capabilities will be delivered efficiently and effectively and will ensure continuous innovation only if the **operating and governance model** defines clear responsibilities. If GAIA-X is to be a federation of nodes, what will the role of the GAIA-X central organisation be, which the plan indicates could take the form of a European cooperative society? Where will the organisation be located? If more EU member states beyond Germany and France join to grow the critical mass of the initiative, will they want to have the power to appoint executive roles in exchange for having it located in Germany? Who will fund central organisations? Who will pay for services? Will cloud service providers be asked to pay to connect to it? Will enterprises that want to exchange data have to pay a fee to the central organisation or only to the ecosystem of app developers that will create services on top of GAIA-X? The list of organisations and experts that contributed to the current plan is German-centric, so these questions will arise up as new countries join. • The final and perhaps most difficult question relates to the **reaction of hyperscalers** to such a move. The reaction so far has been muted from AWS and Microsoft, but it is clear that the move would be viewed as restrictive, perhaps acting as an anchor to growth in the sector by drawing dividing lines along geographic boundaries for those opting into Gaia-X and those that are not. Most large-scale cloud providers already have in-country infrastructures that are subject to national and international laws on data governance and sovereignty. Building a dedicated cloud infrastructure, regardless of its eventual shape, that is free from potential data

Obstacles/Barriers	
	sovereignty issues would require procurement that excludes vendors not subject to such inter-territorial legislation. If a vendor that was part of such an infrastructure was acquired by a U.S. company, would they then need to be excluded from the project? The procurement challenges of Gaia-X alone are not insignificant and need to be clearly thought through.

IDS

Identification	
Organisation	Fraunhofer Institute
Sector	Public administration and research

Initiative	
Description of the initiative	In 2015, the Federal Ministry of Education and Research in Germany launched an initiative for International Data Spaces (IDS), which aims to drive European data sovereignty. IDS created a secure data space that enables organisations from different industries to monetise their data resources through the secure exchange and easy combination of data in value chains, creating the foundation of smart services, innovative solutions, and automated business processes. IDS is a critical part of GAIA-X and provides expertise and partners to the initiative. More than 100 organisations, which are mostly from Germany but include some from other countries, such as Spain and the Netherlands, are already collaborating in the International Data Space (for example, in industrial, materials research, pharmaceuticals, and healthcare). IDS use cases are developed collaboratively between end-users and technology companies, like Bayer, Thyssenkrupp, and T-Systems. The Fraunhofer Institute plays a key role in developing software components and ensuring that the connectors – data flow policies and application policies – that technology companies make available are interoperable with the standard messaging architecture. IDS provides data policy/governance and interoperability services for European users of cloud services. There are 100 members, mostly from Germany. There are currently eight hubs (Germany, Netherlands, Finland, Spain, …). The objective of the International Data Spaces Association (IDSA) is to establish a standard for data sovereignty – for the trust-worthy, self-determined exchange of data.
Timing of the initiative	Started in 2015
Key stakeholders	Members belong to major industries and include software companies and research institutions.[62]
Funding	Funding comes from the German Federal Government's Ministry of Education and Research and IDS members.
Technical solution	IDS provides a reference architecture, a formal standard, and reference implementations, including sample code. IDS is a concept analogous to the internet based on peer-to-peer

[62] More info here https://www.internationaldataspaces.org/the-association/

Initiative	
	communication, but not a platform. Internal/External: IDS addresses ecosystems and corporate networks. Certification: The certification concept confirms the conformity of components (connectors) and organisations with the IDS architecture by independent organisations (PwC, TÜV, and Fraunhofer). This ensures that the organisations have taken all necessary measures for an IDS-compliant operating environment and use components that have been implemented according to the reference architecture. IDS connectors standardise message hubs, policy applied to the data flow, and policy applied to the application. For higher security levels, it also goes into hardware trust anchors. IDS connector: The IDS connector acts as a gateway. It can be implemented in different ways, depending on the scenario: on micro-controllers, sensors, mobile devices, and servers in the cloud. Due to the container architecture, the IDS connector also allows trusted execution of apps – those that can sovereignly process data from different sources. These software services will not run in an ERP system behind the firewall, but on cloud platforms, i.e. 'in the centre' of ecosystems. The connector is therefore a suitable execution component for Amazon Web Services (AWS), Data Intelligence Hub (DIH), SAP HANA, etc., because it enables the platforms to offer a secure environment in which data sovereignty can be guaranteed. Domain-specific application profiles enable embedding in specialist domains with different requirements (see DIN SPEC 27070).
Relation to H-CLOUD key areas	Federated cloud and edge computing
Business model	n/a

Impacts	
Business success	Examples of use cases[63]: • Thyssen Krupp, managing logistics and negotiating arrival and departure slots – Policies: GPS coordinates are not sent to Thyssen. • Predictive maintenance for facilities – Policies: Production information about those facilities is not exchanged with the maintenance company.
Technology innovation	n/a

[63] https://www.internationaldataspaces.org/success-stories/#_usescases

Impacts	
Governance / Organisational structure	There are two tiers of participants to IDS: • You can be a user without being a member of the association • Members of the association (most of the time) contribute to the standards and the software development
Data governance	n/a
Environment and sustainability performance	n/a

Obstacles/Barriers	
Technical barriers	GAIA-X takes IDS and leverages the existing work to take a step further in terms of data sovereignty: • It aims to define a layer above the cloud system. The user looks at a catalogue of cloud providers; the layer provides the ability to apply policies, manage contracts with vendors, etc. • GAIA-X nodes aim to include IaaS, PaaS, and potentially edge device, but, at the IoT layer, it gets very complicated Differences between IDS and GAIA-X: • IDS – data sovereignty and data exchange • GAIA-X – services and more infrastructure related
Legal barriers	n/a
Economic barriers	Currently, the use cases are bilateral data exchanges, not multilateral data exchanges. Scaling to a true multilateral ecosystem is difficult because of concerns over intellectual property and personal data protection and the lack of a clear business case. The Fraunhofer Institute only develops prototypes. In the IDS association, members like SAP, Siemens, and T-Systems will provide connectors with their software. But they will prioritise the use cases that are most relevant to cross-sell and upsell their proprietary solutions.