D3.4 POLICY RECOMMENDATIONS

WP 3

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PROJECT SUMMARY

The internet of things (IoT) has a revolutionary potential. A smart web of sensors, actuators, cameras, robots, drones and other connected devices allows for an unprecedented level of control and automated decision-making. The project Internet of Food & Farm 2020 (IoF2020) explores the potential of IoT-technologies for the European food and farming industry.

The goal is ambitious: to make precision farming a reality and to take a vital step towards a more sustainable food value chain. With the help of IoT technologies higher yields and better-quality produce are within reach. Pesticide and fertilizer use will drop and overall efficiency is optimized. IoT technologies also enable better traceability of food, leading to increased food safety.

Nineteen use-cases organized around five trials (arable, dairy, fruits, meat and vegetables) develop, test and demonstrate IoT technologies in an operational farm environment all over Europe.

IoF2020 uses a lean multi-actor approach focusing on user acceptability, stakeholder engagement and the development of sustainable business models. IoF2020 aims to increase the economic viability and market share of developed technologies, while bringing end-users' and farmers' adoption of these technological solutions to the next stage. The aim of IoF2020 is to build a lasting innovation ecosystem that fosters the uptake of IoT technologies. Therefore, key stakeholders along the food value chain are involved in IoF2020, together with technology service providers, software companies and academic research institutions.

Led by the Wageningen University and Research (WUR), the 70+ members consortium includes partners from agriculture and ICT sectors and uses open source technology provided by other initiatives (e.g. FIWARE). IoF2020 is part of Horizon2020 Industrial Leadership and is supported by the European Commission with a budget of €30 million.

EXECUTIVE SUMMARY

The IoF2020 project aims to support establishing an IoT ecosystem in the agri-food domain in order to bring Europe in a leading position in the area of Smart Farming. The illustration below shows the set up the IoF2020 project. Core is the IoF2020 Ecosystem itself which is based on the physical layer (shared with other industries) and the IoT infrastructure and architecture, which includes standardisation and is as well shared with other IoT application fields. In order to have a beneficial IoT system, the whole picture needs to be taken into account and it is the basis for policy action in this area.

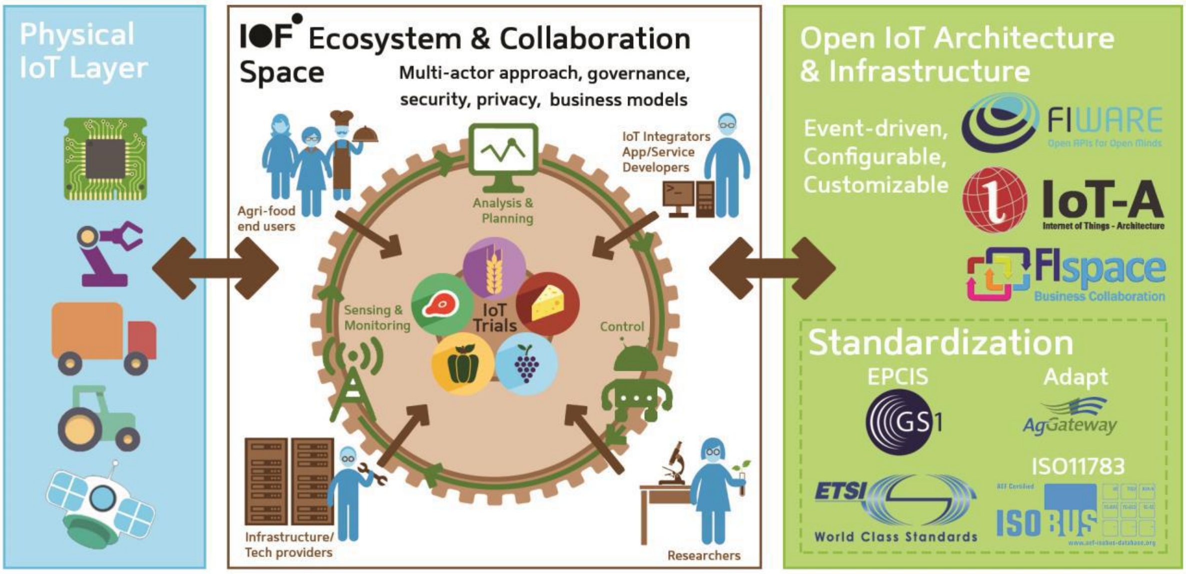

Figure 1: Overall concept of IoF2020

Within IoF2020, Work Package 3 (WP3) aims at supporting the project's use cases in leveraging existing IoT technologies, approaches, and solutions, and facilitate collaboration between use cases. WP3 has been developing work to provide a horizontal perspective of the 19 use cases, divided into five trials. This work has the purpose of identifying reusable components, gathering validation results and lessons learnt from the use cases. Therefore, this deliverable on policy recommendations was assigned to WP3 within the project work plan.

As IoT seems to be mainly a technical task, also non-technical aspects need to be taken into account, to have sustainable implementation and support the aim to play a leading role in innovation and create the future of farming. This document and the resulting policy recommendations is based on the results of IoF2020 and related use cases at this point in time. They are based on the conclusions and barriers identified in relation to the IoT architecture layers. It should serve as guidance for public policy makers and regulators, but as well other stakeholders in the agri-food domain and stakeholders from other business domains to identify potential cross-sector synergies.

IoF2020 gives the following Policy Recommendations:

Recommendation 1: Enhance Digital Infrastructure

The necessary mobile communication infrastructure is pre-requisite for IoT application, especially in rural areas the adequate coverage must be ensured. This includes fibre-optic networks and 5G mobile networks, but also networks dedicated to IoT, like LPWA (Low-Power Wide-Area Wireless Technology).

Recommendation 2: Facilitate Access to Public and Open Data

Having access to public data, e.g. weather, environment, geographic data or other relevant public sources must be made available in an easy-to-use, machine-readable way in order to integrate it into IoT applications and receive full benefit of this technology.

Recommendation 3: Clear Rules on Data Ownership and Usage of Shared Data

In IoT, data is very important; data is created, shared and needs to be protected. The right framework must be provided and full control of the data owner ensured.

Recommendation 4: Ensure and Facilitate Data Protection and Privacy

Data protection and privacy is a key issue identified by the use cases of IoF2020. Clear rules and understandable guidance must be given to famers and other stakeholders in the agricultural chain.

Recommendation 5: Support Reusability of IoT Components

In order to support implementation of IoT in the agricultural domain, double work should be avoided and the use of reusable IoT components should be encouraged.

Recommendation 6: Foster Standardisation

Standards allow implementation in cost-saving way and protecting investments, not being dependent on specific vendor solutions. IoF2020 suggests that policy makers encourage voluntary standardisation, making it a crucial element within activities and ensure that they are freely available and can be used without additional cost.

Recommendation 7: Reduce Administrative Burdens and Support Adoption

Digitalisation is currently changing the way we work and life; this transformation needs to be supported and managed. It is essential for the agricultural sector to support adoption of new technologies, as there are big differences between farmers and other stakeholders regarding their openness and knowledge on the usage of digital technologies. Additionally also consumer needs need to be in focus here, bringing farmers and consumers closer together through transparency.

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LIST OF ACRONYMS

ADAPT	AgData Application Programming Tool
AEF	Agricultural Industry Electronics Foundation
AIOTI	Alliance for the Internet of Things Innovation
API	Application Programming Interface
CBV	EPCIS Core Business Vocabulary
CEMA	European Agricultural Machinery Association
CEN	European Committee for Standardization (Comité Européen de Normalisation)
DSM	Digital Single Market
DSS	Decision Support System
EPC	Electronic Product Code
EPCIS	Electronic Product Code Information Services
ERP	Enterprise Resource Planning
ETSI	European Telecommunications Standards Institute
FMIS	Farm Management Information System
GDPR	General Data Protection Regulation
GPS	Global Positioning System
GSMA	GSM Association
ICT	Information and communications technology
IoF2020	Internet of Food and Farm 2020
IOP	Interoperability Point
IoT	Internet of Things
ISO	International Standards Organization
ISOBUS	Common name of agricultural databus application in conformance with ISO 11783
GS1	Global Standards One
LSP	Large-Scale Pilot Programme

LPWA	Low-Power Wide-Area Wireless Technology
LPWAN	Low-Power Wide-Area Network
M2M	Machine to Machine
NGSI	Next Generation Service Interface
RFID	Radio Frequency Identification
SME	Small and medium enterprise
UC	Use Case
WP	Work Package

1. INTRODUCTION

1.1. WHY POLICY RECOMMENDATIONS?

Work Package 3 of IoF2020 deals with IoT integration and capabilities; it compiles the findings and solutions of the use cases and at the same time supports and facilitates the use cases in using the latest technology standards and architecture. Within this framework, Task 3.2 addresses specifically IoT standardisation, which in its origin is a voluntary effort of interested parties. As IoT is a crucial technology of the future of the agricultural sector, also public policy makers need to provide the right framework to ensure Europe´s leadership in this area and provide access to this technology to all stakeholders, especially to SMEs and farmers. Therefore a specific deliverable on policy recommendations was demanded within the IoF2020 Project.

IoF2020 aims at compiling key policy requirements, establishing a regulatory influence towards the post project exploitation phase. This compilation of policy requirements should enable different stakeholder groups to take full advantage of the IoF2020 validation and demonstration results.

When setting up policy recommendation for IoT in food and farm area, all IoT activities, also in other sectors, like technical industries, smart cities/buildings/electricity or supply chain, need to be taken into account as many components are used for other implementations as well and count on the same infrastructure. Within this context, agricultural-specific requirements need to be addressed and reflected in policy recommendations.

Implementation of IoT technologies in the agricultural sector still stays behind in relation to other sectors. This fact is owed to infrastructural parameters, e.g. internet availability in rural areas as well as cultural parameters, not regarding agriculture as “high-tech sector”. Additionally many SMEs, which need to maintain their competitiveness, are present in the agricultural sector.

The sustainability of the results of the IoF2020 project and further implementation of IoT technologies in agriculture highly depends on the existence of the right policy actions on European and national level. This document on policy recommendations is therefore expected to have a valuable contribution to this.

1.2. THE IOF2020 PROJECT AND POLICY

IoF2020 needs to take into account many developments in an emerging technology like IoT, as many developments are going on in parallel and the agricultural sector needs to find its place here. The results need to be scalable and transferable. Without recommendations and directions given to the market, the developments will go into different directions, leading to higher costs and dependency on specific systems. The policy recommendations canalise the experiences and learnings in the project for a future-proof development.

IoF2020 needs to connect to the other European and national projects in this area, as well as global initiatives. Related to the stakeholders, also ethical aspects need to be taken into account e.g. in the context of ownership of data, transparency throughout the entire supply chain, labour conditions or empowerment of smallholders such as farmers or startup companies. Although WP3 and this policy recommendation deal with technological aspects, there is often a relationship between them. Ethical aspects are specifically addressed in the new Work Package 6 of IoF2020 and will be compiled in Deliverable 6.1.

2. APPROACH AND METHODOLOGY

All 19 use case in IoF2020 are realising IoT based solutions that relate to a specific application scenario of the 5 trial areas (i.e. arable, dairy, fruits, vegetables and meat). The following *Figure 2* presents the overall approach applied in the IoF2020 project, which supports a use case driven approach. Based on the use case requirements, the 19 use case teams are developing specific solutions, while Work Package 3 (WP3) analyses and supports this work from an IoT perspective.

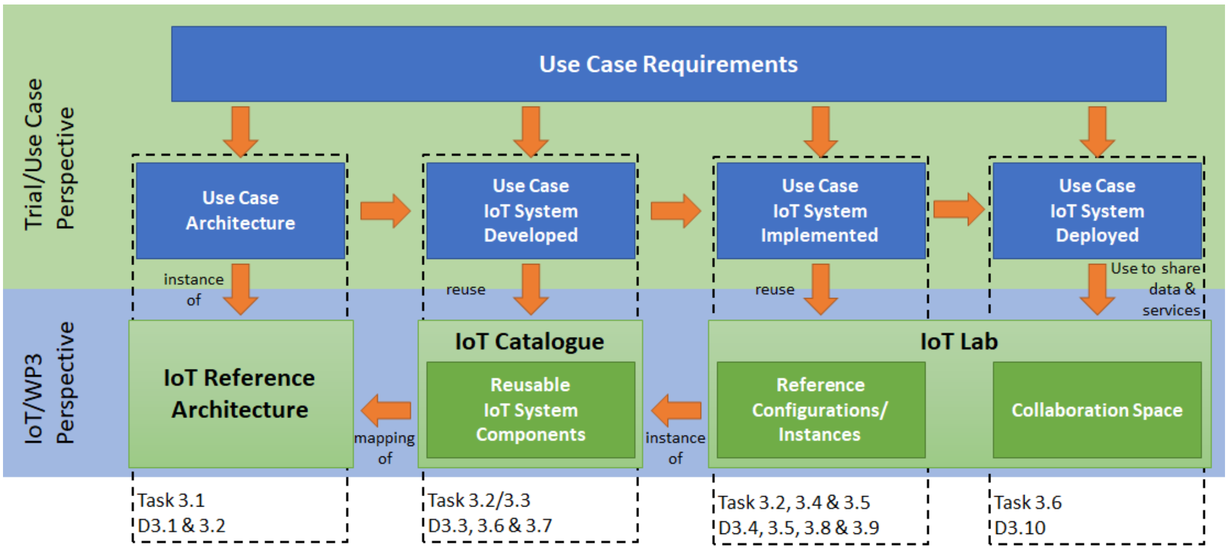

Figure 2: IoF2020 architectural process to ensure reuse and interoperability of use case IoT systems (IoF2020 D3.7).

WP3 generally aims at providing technological IoT support to the use cases in the IoF2020 project. This is implemented through a series of tasks. WP3 is structured in six tasks that complement each other along the realisation of the IoT based solutions in the 19 use cases:

- Task 3.1 developed an approach to analyse and describe the use cases from a technical perspective. Different views were used (i.e. based on an IoT reference architecture) to present the IoT based solutions in a harmonised way. This approach is presented in deliverable D3.1 and the use cases are presented in deliverable D3.2 that are publicly available.
- Task 3.2 is an accompanying task with a focus on IoT related standardisation activities. It analyses the current landscape relevant for IoF2020 related stakeholders. This has produced deliverable D3.3, with an analysis of interoperability points in a reference architecture and an overview of relevant technologies and standards relevant for implementation of IoT solutions in the agri-food domain.

- Task 3.3 aims at identifying reusable components to realise IoT based systems. This includes developing an approach to present project results in a web-based IoT catalogue and develop certain enablers considered as highly reusable and promising to facilitate the offering of IoT based solutions also after the end of the IoF2020 project. Hence, aiming at a long-term sustainability of the project results. This work has produced D3.7 with an analysis of use case requirements in terms of IoT reusable components.

- Task 3.4 will host specific components reusable within IoF2020 as well as a larger stakeholder audience to facilitate the solution development and speed up the implementation and deployment process.

- Task 3.5 analyses synergies of use cases to facilitate collaboration and provide input for the IoF2020 open call on which type of solutions might add key value to the realisation of the IoT based solutions. Deliverable D3.9 produced a detailed analysis of synergies among the 19 use cases of the project, in terms of technology and functionality.

- Task 3.6 is developing additional components required for IoT based solutions and facilitate the collaboration with and in between the additional teams that will be involved via the IoF2020 open call.

One of the specific objectives of the work package is to promote usage and integration of existing IoT, relevant to agri-food and other applicable standards of interest for implementation of project use cases. The current deliverable aims at providing a set of recommendations to facilitate and accelerate the adoption of IoT in the agri-food domain. This work has built on previous results of WP3, and additional sources, and aims at providing inputs for the use cases in WP2, the development of reusable components in WP3, and a wider discussion on IoT standardisation in the agri-food domain. The following *Figure 3* presents the inputs and outputs for the current work.

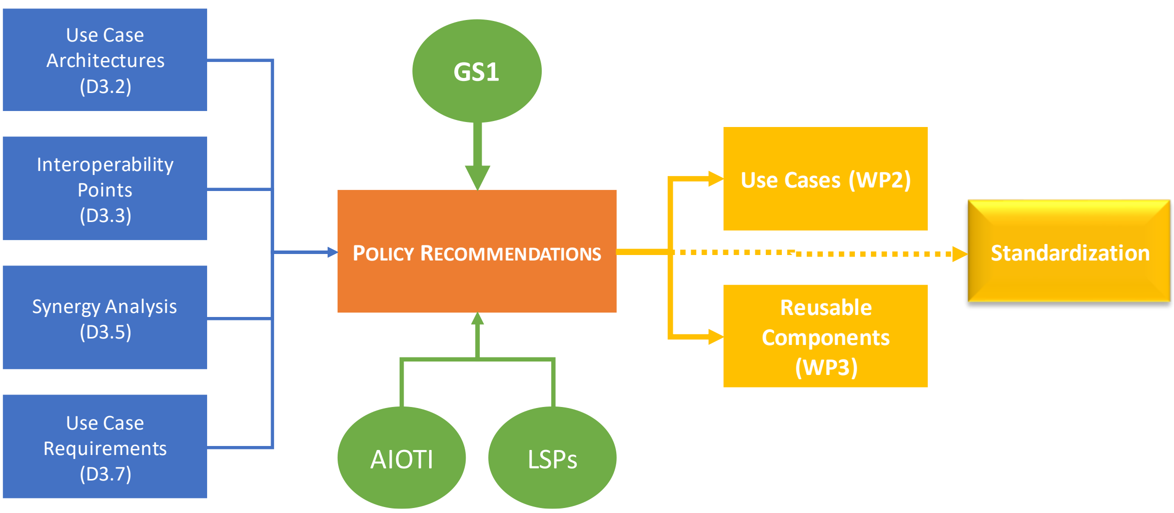

Figure 3: Inputs and outputs of policy recommendations.

The conclusions and policy recommendations present in this document are based on the findings within the use cases and overarching activities of IoF2020. The work was based on analysis of the 19 use cases within IoF2020, a set of IoT reusable components being developed to support the use cases, and wider standardisation activities developed by the lead partner GS1, AIOTI and the IoT LSPs. Some of the main inputs for the current work previous results within WP3, namely the following deliverables:

- **D3.9 Progress Report on Synergy Analysis, Decision and Coordination of Work.** This deliverable provided an analysis based on the architectures that each use case drafted and published in D3.2. The architectures were studied from both a logical and a technological perspective, capturing what functionality the use cases realised using IoT technology, and what technological choices were made in realising that functionality. The results have been validated by the use cases afterwards.
- **D3.2 The IoF2020 Use Case Architectures and Overview of the related IoT Systems.** This work established a common architectural view, for each of the UCs, which can be used as a "common ground" to establish IoT-enabled synergies and new added-value services. Each use case was described in terms of domain model, deployment view, functional view, business process hierarchy, information model, also highlighting the main identified interoperability end-points and assets identified for re-use, as well as gaps to be filled with future activities, as well as through the introduction of IoT developments.
- **D3.3 Opportunities and Barriers in the present regulatory situation for system development.** This deliverable identifies relevant technologies and standards in several IT architectural layers, analyses gaps and adoption barriers and describes how they are adopted in the use cases and trials within the IoF2020 project. The technologies and associated standards address different layers of a seven-layer reference architecture adopted. The analysis resulted in the identification of eight interoperability points between the layers, describing associated challenges and identifying relevant technologies and standards.
- **D3.7 Compilation of Use Case Requirements.** This deliverable provided a harmonised overview of all the components being developed in the 19 use cases of the project, categorizing their reusability potential. In addition, the deliverable identifies a set of IoT reusable components that will be developed in the scope of WP3 to provide a horizontal IoT support to the use cases. These components include an IoT catalogue, security and privacy guidelines, security enhancing enablers, context information management, service monetization and data marketplace.

However, providing policy recommendations is a wide task, and to enable a relevant impact, it is essential to consider work being developed outside IoF2020. Three main additional sources were considered, which are not specific documents, but entities with very prominent roles in standardisation, the agri-food and technology domains.

This deliverable was led by GS1, which is a global, neutral, non-profit standards organisation that brings efficiency and transparency to the supply chain. GS1 has created a set of barcode and technology tools to provide a common foundation to identify, capture and share vital information about products, locations and assets. This work is very aligned with GS1's main interest in standardisation and specific activities in the agri-food domain. GS1 has provided their own vast experience and expertise and will continue to disseminate and elaborate on the results achieved.

The Alliance for Internet of Things Innovation (AIOTI) was initiated by the European Commission in 2015, with the aim to strengthen the dialogue and interaction among Internet of Things (IoT) players in Europe, and to contribute to the creation of a dynamic European IoT ecosystem to speed up the take up of IoT. Other objectives of the Alliance include: fostering experimentation, replication, and deployment of IoT and supporting convergence and interoperability of IoT standards; gathering evidence on market obstacles for IoT deployment; and mapping and bridging global, EU, and member states' IoT innovation activities. AIOTI has produced several documents that have been a constant source of information for IoF2020.

The EU-funded IoT Large-Scale Pilots Programme (LSP) comprises a total of eight innovation consortia, working hand in hand to foster the take up of Internet of Things (IoT) in industrial sectors in Europe and beyond. By addressing both societal and industrial challenges through IoT, the LSP seeks to improve the competitiveness of Europe at the global level, while increasing the quality of life of its citizens. IoF2020 is part of the LSP and collaborates closely with its sister projects to achieving the programme's objectives.

These policy recommendations will be first provided to the use cases within IoF2020. Not only the 19 use cases that started in the beginning of the project, but also the ones resulting from the recent open call. In addition, the recommendations will also be considered within WP3, in the ongoing development of the reusable components that provide an IoT horizontal support to the use cases in the project.

In addition, there is a wider aim of trying to provide some contributions to standardisation. This is done, first of all, through the work of GS1 and IoT LSPs. GS1 will take the recommendations internally in their work. IoF2020 will present these recommendations in the IoT LSPs, in the scope of ongoing working group activities and discuss synergies and a wider dissemination of these results.

The aim is that towards the end phase of IoF2020, the recommendations from this deliverable D3.4 and the project results and impacts are be continuously distributed and integrated into the political environment as well as into horizontal activities like Coordination & Support Actions (CSA) and other domains like Ambient Assisted Living, wearables, smart cities and connected cars. In parallel results and findings shall be harmonised and coordinated with other large-scale projects. Closely supported by agri-food related representatives, relevant standardisation bodies such as ISO, CEN or GS1, facilitate the harmonisation and coordination with domain specific standardisation needs. In WP3 IoF2020 provides a certain series of deliverables as a kind of pathway building upon each other.

3. STATUS OF IOT IN EUROPE

3.1. EUROPE'S IOT POLICY

Background

The European Union aims with the Digital Single Market (European Commission n.d.) strategy to open up digital opportunities for people and business and enhance Europe's position as a world leader in the digital economy (Commission, A Digital Single Market Strategy for Europe 2015). With this strategy the European Union aims to prepare companies, administrations and consumers for the next steps in digitalisation. These steps are covered by the key areas of the strategy.

The Digital Single Market strategy counts on nine key areas, with one of them being "Investing in network technologies". Within this research area, technology and innovation initiatives are supported to enable future technologies in Europe. 5G, the fifth generation of mobile networks, cloud computing and the Internet of Things (IoT) are seen as drivers of the Next Generation Internet. Horizon 2020 (European Commission n.d.) is the biggest research and innovation programme of the EU, supporting the goals of the EU in this area.

In the area of IoT, the European Union is supporting this technology not only by the above mentioned actions, but also through policy actions in order to provide a proper framework here. For the EU, IoT is "a system that merges physical and virtual worlds, creating smart environments for the benefit of European citizens and businesses." (Commission, Digital Single Market, The Internet of Things 2018)

Regarding policy action in the IoT area, the European Commission has been cooperating with industry and stakeholder organisations as well as EU Member States and other countries to bring forward the usage of IoT and to create the framework for this.

IoT Policy of the European Union

The IoT Policy of the European Commission made major developments in 2015 to accelerate the take-up of IoT (European Commission 2018). In 2016, the Alliance for Internet of Things Innovation (AIOTI) was founded in order to support an industry-driven European ecosystem for IoT (Commission, Digital Single Market, The Alliance for Internet of Things Innovation (AIOTI) 2018). The European Commission wants, with help of AIOTI, to work towards a competitive European IoT market and foster new business models. In 2018, AIOTI is the largest European IoT Association with more than 170 members from industry and other stakeholders, making it Europe´s largest IoT association with global relevance.

In addition, the above mentioned Digital Single Market (DSM) Strategy was adopted in May 2015. This strategy includes the support of IoT developments with the aim to avoid fragmentation of the market and support interoperability.

The DSM strategy includes elements which should lead Europe a step further in accelerating developments on Internet of Things. In particular, the strategy underlines the need to avoid fragmentation and to foster interoperability for IoT to reach its potential. In April 2016, the European Commission staff working document "Advancing the Internet of Things in Europe" was published (Commission, Advancing the Internet of Things in Europe 2016), being a part of the "Digitising European Industry (DEI)" initiative the document specifies the EU's IoT vision. It is based on three pillars:

- **a thriving IoT ecosystem**
- **a human-centred IoT approach**
- **a single market for IoT**

The EU identified potential obstacles for a single market for IoT as there is a large diversity and an immense volume of IoT devices that need to be identified and connected. It was proposed by the EU to promote an interoperable IoT numbering space for a universal object identification, as well as an open system for object identification and authentication.

Also in the 2017 proposed "European data economy initiative" IoT topics were addressed (European Commission 2019). This initiative proposes policy and legal solutions concerning the free flow of data in the EU, and liability issues in environments like IoT.

Supporting the policy initiatives the EU has set up concrete IoT research and innovation objectives in the ongoing Horizon 2020 programme. These objectives are reflected in the Large-Scale Pilots explained below.

3.2. LARGE-SCALE PILOTS (LSP) IN THE AREA OF IOT

The European Union supports its IoT-Policy with a number of Large-Scale Pilot Projects in different areas.

The first area are research and innovation projects in the field of advanced IoT platforms, as the future design of IoT depends strongly in the architecture for smart objects, embedded intelligence and smart networks. Currently IoT applications are mainly focused on sensors and their connections, but in future IoT will be more and more related to actuation and smart behaviour.

In order to support research and innovation in the area of IoT, the European Union promotes the development of open and easy accessible IoT platforms. In 2016 the “IoT European Platform Initiative (IoT-EPI)” (European Platforms Initiative n.d.) was launched, connected to this, currently seven research and innovation IoT projects are funded within the Horizon 2020 programme:

Inter-IoT Aim is to design, implement and test a framework that will allow interoperability among different Internet of Things (IoT) platforms (INTER-IoT n.d.).

BIG IoT Addressing the interoperability gap by defining a generic, unified Web API for smart object platforms (BIG IoT n.d.).

AGILE Building a modular and adaptive gateway for Internet of Things devices (AGILE n.d.).

symbIoTe Devising an interoperability framework across existing and future IoT platforms (symbIoTe n.d.).

TagItSmart! Tracking and monitoring of products (TagItSmart n.d.).

VICINITY Build and demonstrate a platform and ecosystem that provides "interoperability as a service" for infrastructures in the Internet of Things (VICINITY2020 n.d.).

bIoTope Laying the foundation for creating open innovation ecosystems by providing a platform that enables companies to easily create new IoT systems (bIoTope n.d.).

According to the EU, these projects are aimed to develop innovative platform technologies and foster technology adoption through community and business building while creating at the same time a vibrant IoT ecosystem.

The second area is the support of IoT ecosystems, with above mentioned Alliance for Internet of Things Innovation (AIOTI), which was initiated by the European Commission to further support the creation of an innovative and industry-driven European Internet of Things ecosystem. AIOTI builds on the work of the IoT European Research Cluster (IERC), grouping together the IoT projects funded by European Commission.

The third area are IoT Large-Scale Pilots (LSPs) for Testing and Deployment, applying IoT in specific application areas. In this area the IoF2020 project is located. With a budget of € 100 million the following projects are funded:

- **Smart living environments for ageing well (ACTIVAGE)** (ACTIVAGE n.d.)
- **Smart Farming and Food Security (IoF2020)** (IoF2020 n.d.)
- **Wearables for smart ecosystems (MONICA)** (MONICA n.d.)
- **Reference zones in EU cities (SYNCRHONICITY)** (SYNCRHONICITY n.d.)
- **Autonomous vehicles in a connected environment (AUTOPILOT)** (AUTOPILOT n.d.)

As the first results of IoF2020 show, there are lots of communalities among the LSPs, even though the application areas are different. For example, IoT applications need to count on the related networks and sensors that can provide information on locations, temperature, humidity etc. Measuring and providing this parameters can be relevant on fields, in cold-storage (as in IoF2020), but also for machinery or supply chain applications. The same applies to establishing rules for privacy or data ownership. Therefore the European Union has set up two additional projects in order to coordinate and support the above mentioned projects.

These projects are:

U4IoT (User Engagement for Large-Scale Pilots in the Internet of Things) that consists of 9 partners from 5 European countries. The objectives are to develop a toolkit for LSPs end-user engagement and adoption, including online resources, privacy-compliant crowdsourcing tools, guidelines and an innovative privacy game for personal data protection risk assessment and awareness as well as online training modules (U4IoT n.d.).

CREATE-IoT (CRoss fErtilisation through AlignmenT, synchronisation and Exchanges for IoT) brings together 18 partners from 10 European countries. The objectives are to stimulate collaboration between IoT initiatives, foster the take up of IoT in Europe and support the development and growth of IoT ecosystems based on open technologies and platforms (CREATE-IoT n.d.).

The European Union aims with this set of Large-Scale Pilots the acceleration of standards setting across different business sectors and at boosting further the IoT technology. Privacy and security, business models, usability as well as other legal and societal challenges are also important factors which EU's Large-Scale Pilots are trying to tackle. Examples of cross-LSP activities are common privacy guidelines (U4IoT) or the Mapping of Pilot Architectures (CREATE-IoT).

3.3. AGRICULTURAL DOMAIN SPECIFIC STANDARDISATION

Standardisation is a key topic for further development of IoT and due to its complexity by touching "everything", it is hard to bring all related topics under one umbrella.

The Head of the Knowledge Sharing Unit at European Commission DG Connect, Gérald Santucci, states: *"Defining the IoT has been, and remains, a key obstacle to standardisation: IoT is* *<u>not</u>* *a technology but an emerging paradigm that encompasses wireless sensor networks, RFID, Machine-to-Machine and other technologies that all tend to converge to intelligent devices based on the connection of anything at any time from any place to any network. More recently, the U.S. industry has been promoting the concept of Internet of Everything (IoE), which is about expanding Big Data."* (Santucci 2014)

In addition to the standardisation activities addressed within the different technology layers, standardisation in different specific domains also has to be taken into account. As IoT is one of the most promising steps into the future, many domains and sectors are active in this area. Examples are Industry 4.0 in the automotive industry and technical industries, activities in the building industry or tracking & tracing initiatives in the food sector or smart home applications.

In the farming sector, various activities and initiatives were started, which are reflected in the variety of use cases in the IoF2020 project. Examples of such areas in the agricultural machinery sector are AEF (Agricultural Industry Electronics Foundation) and AgGateway who have joined forces to define protocols and data elements for data exchange, making the agro sector future-proof and adapting it to the needs of digital farming. Both create and address new technical approaches and prepare guidelines which may go into the ISO standardisation process supporting ISOBUS (ISO 11783) applications.

Additionally, several activities regarding relevant standards of the agricultural domain and common IoT standards relevant for the agricultural domain are described in Deliverable D3.3. These standards are relevant at the respective interoperability points between the layers.

<u>Relevant Standards:</u>

- **Connectivity Layer** with Low Power Wide Area Wireless Technology (LPWA) networks standards and technologies like:
    - LoRaWAN (Long Range Wide Area Network) of the LoRa Alliance

- Narrowband IoT (NB-IOT)
- LTE-M (Long Term Evolution for Machines)
- Sigfox (proprietary)
- ZigBee

- **IoT Service Layer to Mediation Layer**: Here technologies like MQTT(-SN), CoAP, LWM2M and oneM2M apply.
- In **Agricultural Machinery** the above mentioned ISOBUS standard is used for communication upwards. But also activities regarding agricultural data and supply chain data flow are addressed e.g. by AEF (Agricultural Industry Electronics Foundation) and AgGateway.
- In the **mediation and information management layer** the following standards were regarded as relevant:
    - FIWARE NGSI
    - NGSI-LD as emerging standard by ETSI
    - Web Feature Service (WFS) an interface specified by the Open GIS Consortium (OGC) for geoservices
    - WMS Web Map Service, also for geoservices
- In the area of **data models and vocabularies the** following standards have relevance for the agricultural domain:
    - GSMA IoT Big Data harmonised data model, here also entities relevant for smart agriculture were defined. GSMA is the association of mobile operators worldwide
    - ADAPT by AgGateway with a common reference data model for the documentation of precision farming field operations, open source plug-ins and a framework for the development of proprietary plug-ins.
    - GS1 Standards
        - GS1 Keys for identification like GLN (Global Location Number) for entities and locations, GTIN (Global Trade Item Number) for product identification and the GRAI (Global Returnable Asset Identifier) for the identification of returnable assets.
        - GPC (Global Product Classification) for identifying product groups like tomatoes or apples, but also crops or animals.

- GS1 Core Business Vocabulary (CBV) and EPCIS
  The CBV standard specifies various vocabulary elements and their values for use in conjunction with the EPCIS standard. EPCIS (Electronic Product Code Information is an interface standard of GS1 for capturing and sharing of event data and plays an important role in IoT contexts.

3.4. IOF2020: FIVE TRIALS WITH 19 USE CASES

The IoF2020 is aimed to establish and support IoT application in the farming and food area. Therefore 5 trial areas with a total of 19 use cases were set up in the project. These use case activities are supported in the IoF2020 project by a variety of activities for interaction, integration, consolidation, ecosystem development and business support. The trials are aimed to reflect the different application areas, regions and demands on the Internet of Things (IoT) in this area.

The five trial areas in IoF2020 are defined as follows:

The Internet of Arable Farming (Trial 1)

The trial aims to integrate operations across the whole arable cropping cycle by combining IoT technologies focusing on data acquisition (soil, crop, climate) in growing and storage of key arable crops such as potatoes, wheat and soya beans. These will be linked to existing sensor networks, earth observation systems, crop growth models and yield gap analysis tools and external databases (e.g. on economic or environmental impact) and translated into farm management systems. This will result in increasing yields, less environmental impact, easier cross-compliance and product traceability and more use of technology by farmers. The trial consists of a coherent approach of three vertical use cases (1.1-1.3) and a horizontal one (1.4):

- Use Case 1.1 Within-field management zoning; defines specific field management zones by developing and linking sensing- and actuating devices with external data.
- Use Case 1.2 Precision Crop Management, deals with smart wheat crop management by sensors data embedded in a low-power, long-range network infrastructure.
- Use Case 1.3 Soya Protein Management; aims to improve protein production by combining sensor data and translate them into effective machine task operations.
- Use Case 1.4 Farm Machine Interoperability; focuses on data exchange between field machinery and farm management.

The Internet of Dairy Farming (Trial 2)

The trial aims to implement, experience and demonstrate the use of real-time sensor data (e.g. neck collar) together with GPS location data to create value in the dairy chain from ‘grass to glass’. This will result in more efficient use of resources and production of quality foods, combined with a better animal health, welfare and environment implementation. The focus is on feeding and reproduction of cows through early warning systems and quality data that can be used for remote calibration and validation of sensors. The platform 365Farmnet will be used in all use cases to ensure seamless exchange of IoT data and services. The trial consists of 4 coherent use cases:

- Use Case 2.1 Grazing Cow Monitor; dealing with monitoring and managing the outdoor grazing of cows by GPS tracking within ultra-narrow band communication networks.
- Use Case 2.2 Happy Cow; aims to improve dairy farm productivity through 3D cow activity sensing and cloud machine learning technologies.
- Use Case 2.3 Silent Herdsman; is a herd alert management by a high node count distributed sensor network and a cloud-based platform for decision-making.
- Use Case 2.4 Remote Milk Quality; works on remote quality assurance of accurate instruments and analysis and pro-active control in the dairy chain.

The Internet of Fruits (Trial 3)

The trial especially aims to demonstrate IoT technology that is integrated throughout the whole supply chain from the field, logistics, processing to the retailer. Sensors in orchards and vineyards (incl. weather stations, multispectral/thermal cameras) will be connected in the cloud and used for monitoring, early warning of pests and diseases and control (e.g. variable rate spraying, selective harvesting). Traceability devices (incl. RFID, multidimensional barcodes) and smart packaging allows for condition monitoring during storage, processing, transportation and on the shelves. Big data analyses will further optimize all processes in the whole chain. This will result in reduced pre- and post-harvest losses, less inputs, higher (fresh) quality and better traceable products (incl. protected designation of origin, PDO). The trial consists of 4 coherent use cases:

- Use Case 3.1 Fresh table grapes chain; implements a real-time monitoring and control of water supply and crop protection of table grapes and predicting shelf life.

- Use Case 3.2 Big wine optimization; aims to optimize cultivation and processing of wine by sensor-actuator networks and big data analysis within a cloud framework.
- Use Case 3.3 Automated olive chain; works on automated field control, product segmentation, processing and commercialisation of olives and olive oil.
- Use Case 3.4 Intelligent fruit logistics; piloting fresh fruit logistics through virtualization of fruit products by intelligent trays within a low-power long-range network infrastructure.

The Internet of Vegetables (Trial 4)

The trial focuses on a combination of environmental control levels: full-controlled indoor growing with an artificial lighting system, semi-controlled greenhouse production and non-regulated ambient conditions in open-air cultivation of vegetables. Besides there is special attention for organic growing for which weeding is a specific challenge. Attention is also paid to intelligent analysis of data that is generated in the whole supply chain to enhance trust, data integrity and simplification of certification systems. It aims at demonstrating the automatic execution of growth recipes by the intelligent combination of sensors that measure crop conditions and control processes (incl. lighting, climate, irrigation and logistics) and analysis of big data that is collected through these sensors and advanced visioning systems with location specification. This will result in improved production control and better communication throughout the supply chain (incl. harvest prediction, consumer information). The trial consists of 4 coherent use cases:

- Use Case 4.1 City farming leafy vegetables; is a value chain innovation for leafy vegetables in convenience foods by integrated indoor climate control and logistics.
- Use Case 4.2 Chain-integrated greenhouse production; works on integrating the value chain and quality innovation by developing a full sensor-actuator-based system in tomato greenhouses.
- Use Case 4.3 Added value weeding data; aims to boost the value chain by harvesting weeding data of organic vegetables obtained by advanced visioning systems.
- Use Case 4.4 Enhanced quality certification system; deals with enhancing trust and simplification of quality certification systems by use of sensors, RFID tags and intelligent chain analyses.

The Internet of Meat (Trial 5)

The trial aims to demonstrate how the growth of animals (incl. individual and group level) can be optimized and communication throughout the whole supply chain can be improved based on automated monitoring and control of advanced sensor-actuator systems. The data generated by events will also be used for early warning (e.g. on health status) and improve the transparency and traceability of meat throughout the whole supply chain. This will assure meat quality, reduce mortality, optimize labour and improve animal health and welfare leading to reduction of antibiotics. The trial consists of 3 coherent use cases:

- Use Case 5.1 Pig farm management; aims to optimize pig production management by interoperable on-farm sensors and slaughter house data.
- Use Case 5.2 Poultry chain management; works on optimizing production, transport and processing of poultry meat by automated ambient monitoring & control and data analyses.
- Use Case 5.3 Meat Transparency and Traceability; focuses on supporting proactive auditing and enhancing transparency and traceability of meat, based on monitored chain event data in an EPCIS-infrastructure.

3.5. CURRENT FINDINGS

A compilation of use case requirements was elaborated by Work Package 3 (WP3) in September 2018 (Deliverable D3.7). The main purpose of this deliverable was to provide requirements for IoT enablers and hosting to support the IoF2020 use cases. It contains an analysis of the functional architectures and components of the use cases, identifies synergies between the use cases in terms of platforms, components and technologies, introduces interoperability points, and classifies the components in order to define whether they are commercial, individual to the use case or reusable. Additionally challenges regarding reusability of IoT components are defined and specified to support the realisation of the IoT based solutions in the IoF2020 use cases.

Although use case requirements mainly focus on implementation with IoF2020, already some findings can be addressed from this perspective, e.g. the need for reusability of components and the lack of standardisation.

Therefore, the results from a use case perspective are reflected in the policy recommendation and are enhanced by a more general view. Examples are the usage of LPWAN- technologies by various use cases or farm management and machinery systems by use cases related to arable framing (Trial1).

Additionally all use cases follow the same basic architecture, which will be explained in the next chapter, showing reusable components and commonalities.

4. GAPS AND ADOPTION BARRIERS ON DIFFERENT LAYERS

4.1. GENERAL OVERVIEW

Whereas the deliverable on opportunities and barriers in the present regulatory situation for system development (D3.3) shows a generalised view on the main layers of the architecture of the IoF2020 solutions, this chapter aims at identifying the gaps and barriers which hamper the usage standards and having interoperability on the different layers identified (see figure below):

- **Physical Device Layer** – different IoT devices and agricultural machinery generating data
- **Connectivity Layer** – enabling the transmission of data produced to upper layers and back
- **IoT Service Layer** – offers interfaces that allow to communicate with management systems
- **Mediation Layer** – transforms and aggregates raw data to be directly exposed to applications
- **Information Management Layer** – is mainly a data hub for publication, consumption and subscription of all the information
- **Application Layer** – applications used by stakeholders, farmers like Decision Support Systems (DSS), Farm Management Information Systems (FMIS), Dashboards or ERPs
- **Additionally, as cross-cutting layer** the following capabilities are integrated in the view:
    - **Security and Privacy Capabilities**, aiming at guaranteeing Security and Privacy during access to information and devices
    - **Management Capabilities,** aiming at guaranteeing Security and Privacy during access to information and devices, often covered by enabling platforms.

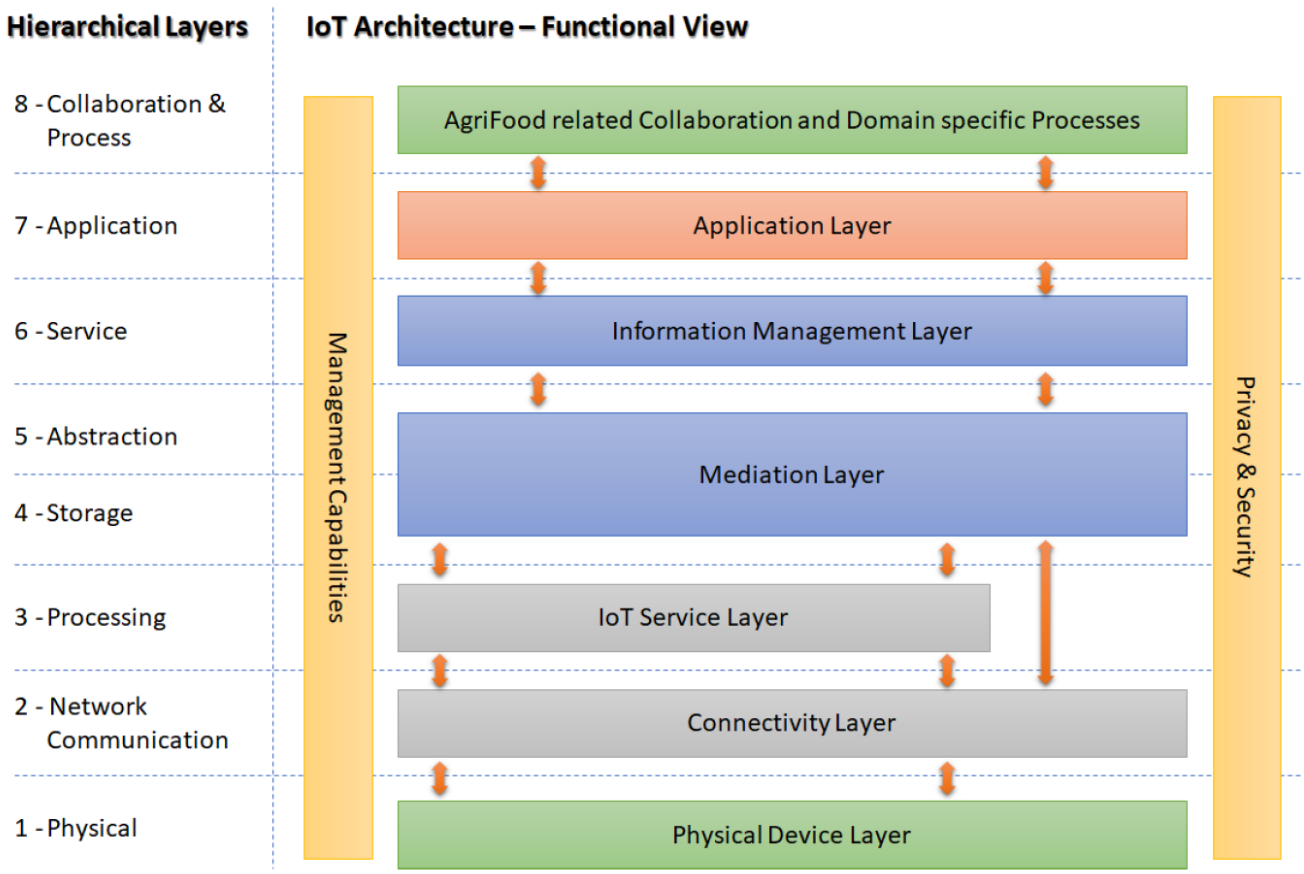

Figure 4: IoT Architecture Reference Model – Functional View. (IoF2020 D3.3)

In addition to this the following external entities were identified in D3.3 as relevant:

- Open Data providers. These could be incarnated, for instance, by databases offering open data in the agricultural domain (pests, disease, historical weather data, ...) or services publishing certain contextual data such as weather forecasts, weather alerts or weather observations. Satellite data/image publication platforms or geo-services which provide geospatial data are also under this scope.
- Harmonised information models. They define the structure and representation of the information to be managed. The final aim is that the different smart farming trials share common information models with a view to enabling interoperability and portability of solutions in a wider ecosystem.
- Public GeoServices. They offer public geospatial data related to agricultural assets (for instance parcels), frequently coming from geo-information systems owned by the public authorities.

In D3.3 also the relevant Interoperability Points (IOP) between the layers were identified. As some barriers relate to the interoperability points and not directly to the layers itself, these are mentioned separately.

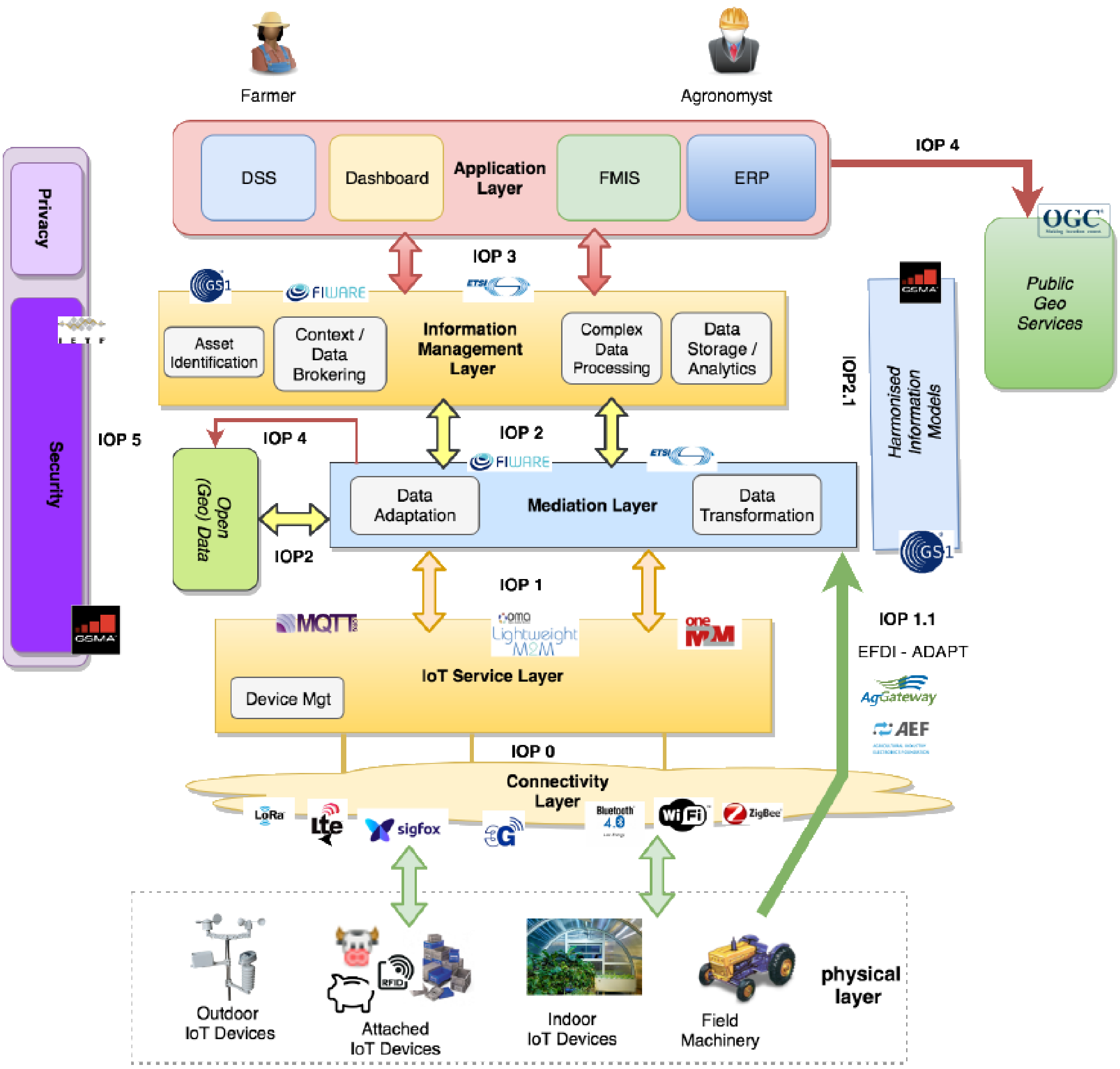

Figure 5: Overview of IoF2020 Use Cases and its relationship to standards. (IoF2020 D3.3)

4.2. PHYSICAL DEVICE LAYER

Starting with the base, IoT devices e.g. agricultural machines (devices in general) generate data which have to be transferred to higher layers (uplink) to give added value to the user (farmer and other stakeholders along the information chain).

Conclusion and main barriers:

No specific barriers were identified for the physical device layer in D3.3. From the use cases, specifically UC 1.1 and UC 3.4 reported, that not everything is off-the-shelf technology. As IoT is relatively new technology also the relevant physical devices, i.e. sensors, need adaption to the specific usage scenario. Issues observed are related to connectivity, configuration and battery life, information dashboards, data ownership and business models. On the long run IoT devices must be standard components at low price in contrast to customized solutions, which are only possible for large-scale implementations.

4.3. IOT CONNECTIVITY LAYER

Once data have been produced by devices, communication to data gathering platforms starts focussing on three main technologies:

- Short Range Communications like WiFi, Bluetooth and IEEE 802.15.4 (ZigBee) is where the digitalisation in farming with the radio-based machine-to-machine communication will take place first.
- Cellular like telco-operated 3G, 4G or 5G networks are not likely to be the solution for agriculture machinery. They are mostly used in areas with low population density and therefore bad cellular coverage. The coverage is only around 30% – even less with 3G or beyond – and will not help to solve problems.
- Long range like low power, low bandwidth technologies (LPWA) have many advantages in wireless sensors networks including Sigfox, NB-IoT, LTE-M, LoRa and ZigBee.

A great part of the barriers among these technologies result from the broad variety of data usage in agriculture and its competitive requirements – direct control oriented on machines versus huge amounts of data to be analysed in the office. Added complexity derives from the mix of different brands of agricultural machines.

Conclusion and main barriers:

- Worldwide availability of technology and radio frequency is crucial. The focus is on the one hand related to new technologies like 5G or other technologies able to cope with a high bandwidth for great amounts of data (e.g. for drone pictures), but also a robust coverage with technologies that allow only small amounts of data must be taken into account, as this is often enough for the specific application (e.g. temperature and location by sensors).
- A wireless direct machine-to-machine communication for agricultural in field usage is lacking.
- Lack of seamless connectivity and data exchange by industry cooperation and by acceptance.
- Insufficient implementation of Industry Standards for communication.

- Depending on the solution there are different coverages in the respective countries and roaming issues.
- Missing ‘open mind’ to connectivity with domain competitors and IT suppliers.

4.4. IOT SERVICE LAYER

The technologies for IoT Services considered as the most relevant for smart farming are:

- MQ Telemetry Transport (MQTT) which is standardised by OASIS now in version 5 under the declaration 'ISO/IEC 20922' and MQTT-SN especially for wireless communication.
- OMA LWM2M means “Lightweight Machine-to-Machine” which is mainly used for resource constrained devices, thus often combined with the Constrained Application Protocol (CoAP).
- OneM2M is the result of a global consortium of renowned members acting as a horizontal IoT/M2M platform providing abstracted APIs for common functions of different vertical domains.

Conclusions and main barriers:

- In this layer a single standard technology is lacking while different technology stacks based on different message exchange paradigms, protocols and data encoding formats are promoted. This causes additional efforts for all parties: implementers, device manufacturers and users, because generic IoT components are provided to each of them in accordance to their specific infrastructure.
- Additionally, there is no standardisation in the format of messages or in the data types or units used by devices

4.5. AGRICULTURAL MACHINERY COMMUNICATION

These area relates to Interoperability point 1.1, between machinery and the mediation layer. Here on the long history of collaboration in standards for electronics and data exchange in the Agricultural Industry between different machines as well as between machine and software gave input to the standard ISO-11783 (ISOBUS, including ISO-XML).

Conclusions and main barriers:

- As conclusion in D3.3 the activities of AEF and AgGateway regarding ISO-11783 are seen as relevant and important and the standards fulfil their purpose.

- Implementation of complex standards like ISOBUS may lead to different interpretation and hamper interoperability. Also changes of actions on short-notice are impossible; as a consequence real-time mediation with defined protocols and data elements for data exchange is lacking. Even common data sets still allow different interpretations and thus lead to various malfunctions, frustration and additional costs.
- Further cooperation within the agricultural domain and with organisations like ISO or ETSI are necessary.

4.6. INFORMATION MANAGEMENT AND MEDIATION LAYER

This is where data adaption and data transformation, harmonisation and publication, as context information, of harmonised data coming from IoT Devices, agricultural machinery or other sources of information take place.

Conclusions and main barriers:

- The main adoption barrier in the Mediation and Information Management Layer is the proliferation of proprietary APIs and incompatible data models, which causes isolated information silos avoiding interchanges. Cooperation of working system seamlessly through data sharing is prevented. One example is in the area of M2M the lack of interoperability between data format of devices and platforms.
- An additional adoption barrier is the proliferation of multiple vocabularies and data models from many organisations with different levels of detail which finally are not able to scale or adapt to increasing complexities.
- It is proposed in D3.3 to expose a common information management layer, based on harmonised APIs and data models. ADAPT, GS1 Core Business Vocabulary and GSMA IoT Big Data are seen good starting points to fill the current gaps and help to eliminate the adoption barriers, but more harmonisation effort is necessary.
- The activities of FIWARE NGSI and its components play an important role here (FIWARE Foundation n.d.) (Giaffreda n.d.).
- One additional aspect addressed in this area is the usage of geodata and, in some cases related to other layers, the usage of various kinds of public data. One issue is the free availability of public data (open data) and standardised and structured availability of this kind of data.

4.7. APPLICATION LAYER

Reaching to the top of the IoT-layers one gets aware of certain parallels to the basement. Both have in common that individuals expect their particular solution to serve and benefit from different layers of IoT. But here data is no longer simply generated or shared from different sources. Here we are near the sink where it is now the aim to query the right data and transform them into sophisticated information for high value-added services.

That is where the user (farmer and other stakeholders along the information chain) come into play and require individual provision and processing of data. By nature there are many different aspects to be surveyed or questions to be answered but here on the highest layer all stakeholders have to agree on a common understanding which combination and thus interpretation of data is reasonable and acceptable. Therefore a guideline on which data to use and how to analyse them is missing and hampering the expansion of IoT-based services.

Conclusions and main barriers:

- As with other upcoming new technologies adoption barriers need to addressed, especially having the farmer in focus here. Usability and interoperability are key topics here.
- Related to the application layer it clearly shows that the whole system needs to work seamlessly, as e.g. in some cases sensor data was not able to display in farm management systems.
- A crucial aspect is also data ownership, security and privacy, which is addressed separately in the subsequent chapter.

4.8. SECURITY AND PRIVACY

Experiences from the use cases show that security and privacy topics in every use case are of high relevance. Collection, exchange and usage of data is essential for digitalisation of the agri-food industry. Examples are livestock data, land and agronomic data, climate data, machine data, financial data and compliance data. Questions arise on privacy, data protection, intellectual property, data attribution (ownership), relationships of trust/power, storage, conservation, usability and security.

Main sources in this area are General Data Protection Regulation (GDPR) in the European Union and additionally the “Code of Conduct on agricultural data sharing signing“ (EU Code of conduct on agricultural data sharing by contractual agreement n.d.) by coalition of associations from the EU agri-food chain.

Areas to be tackled are:

- Data Protection
- Data Ownership
- Data Access
- Security of IoT infrastructure
- Security on Platform

Conclusions and main barriers:

Whereas some areas, especially on security and data access can be resolved on technical level – with adaption for IoT environment, some areas need special attention. These areas are:

- Lack of simple and clear guidelines (addressed within IoF2020)
- GDPR Compliance
- Data Ownership, as with the increasing dependency and amounts of data, more and more questions arise in this area, especially in the context of a growing number of parties involved. Key questions are: “What is the motivation to share data” and “Who benefits from the data?”.

5. RECOMMENDATIONS

As a result from the previous chapter the following policy recommendations for IoF2020 were elaborated by Work Package 3. IoF2020 advocates to different stakeholders and policy makers to foster the use of digital services in the agro sector. Concluding the current results of the 19 use cases in five trials/domains, it is clear that all partners are committed to a transparent value chain starting at the farm level without information discontinuity. Setting the use of digital technology as the main focus of funding is therefore the right path for the continuous development of digital technologies in agriculture. It is suggested that the investment in agricultural programmes is enlarged and intensified.

Digitalisation in agriculture aims at a more efficient usage of resources, at acting in a more sustainable way, enhancing transparency in the chain and responding to growing demands of the consumer. Europe should play a leading role in innovation here. This can only be achieved by a harmonised and coordinated joint effort of all stakeholders, not limited to agriculture as it includes other players in the IoT area.

Below every specific recommendations are provided referring to the respective architecture layers from chapter 4.

5.1. ENHANCE DIGITAL INFRASTRUCTURE

In order to enable adoption of IoT technology in the agricultural sector, the main prerequisite is the existence of the necessary digital infrastructure. In general, but especially in rural areas there are lacks which need to be addressed. The areas are:

- Fast Fibre Optic Networks in order to provide high-speed internet access for actors in rural areas, to allow the usage of state-of-the-art technology. This also supports the implementation of Short Range Communications like WiFi, Bluetooth etc.
- Implementation of 5G mobile networks with a broad coverage for mobile internet applications, e.g. in farm management systems, where high amounts of data need to be transmitted.
- Setting special focus on IoT networks, as for many IoT-applications only small bandwidth is necessary, as LPWAN (Low Paper Wide Area Networks) technologies play a crucial role in adoption of IoT.

IoF2020 calls upon the European Commission to promote the development and implementation of a strategy for digitisation in agriculture at the national level - in all member countries. This requires a joint and coordinated approach by the Commission and the different EU-nations. In that context IoF2020 calls upon the different General Directions of the EU to: A nationwide supply of rural areas with fast fibre optic networks to be ensured in every Member State. In planning the expansion, governments must act in a cross-border coordinated manner in order to avoid friction losses. In parallel, it has to be taken into account that the usage of digital agriculture takes place in the agricultural areas and especially in stables where wireless fast internet connections are needed. This high-performance internet access has to be accomplished by glass fibre cables as a backbone of the development. State-of-the-art digital systems and software help farmers to save costs, to use resources more efficiently and thus to protect the environment.

Mobile Internet access would directly support digital agriculture through targeted information availability on agricultural land. The online availability of information on the field over a fast mobile network enhances innovative applications, e.g. it saves the time-consuming and error-prone offline synchronization of ICT on agricultural machines before they are used, as accumulated data can be transmitted immediately to the fleet control and be evaluated there. Fixed network connections with bandwidths of min. 50 Mbps are only available in perhaps about one third of rural areas. In order to ensure European-wide fast Internet connections in rural areas, the public sector is in demand where economic expansion by companies is not feasible in the future. In parallel, the private-sector has to strengthen its ambition as much as possible and be incentivised in the same field to generate a European-wide implementation of 5G and a future-proof telecommunications infrastructure like LPWAN.

Related architecture layers:

- IoT Physical Device Layer
- IoT Connectivity Layer

5.2. FACILITATE ACCESS TO PUBLIC AND OPEN DATA

IoF2020 encourages open and easy-to-use specific information that is relevant for digital agriculture. Digital, easy-to-use content must be a digital infrastructure service provided by the EU and national governments. This includes in particular uniform data formats and interfaces, information (metadata) on the timeliness of the data and reliable availability. The European earth observation programs such as Copernicus, as well as digital information systems of specialised agencies make a significant contribution to digital agriculture.

Free access to and widespread use of data is an important pillar for the digitisation of the economy and society. With the participation of all socially relevant groups in data-driven innovations, overarching effects are achieved so that both society and economy of the EU member states can master the challenges of digitisation. Open data in politics and business as well as the free flow of data in public authorities and companies will promote the necessary development in all areas of digitisation. IoF2020 is therefore committed to a further expansion and use of open data. Non-personal data should be available by default as current as well as open, machine-readable and commercially usable data.

Many digital solutions for agriculture require up-to-date and accurate geodata, which are already being collected by the Member States. The providers of systems, as well as farmers, rely on them to be made available in a unified machine-readable and open data format free of charge and in real-time. All geodata collected by public agencies and authorities, from the municipality to the European level, should be made freely accessible. An agricultural geodata portal should be set up. This includes not only the relevant geospatial data, but also geodata services and API (Application Programming Interfaces), allowing easy integration of information into software environments.

The INSPIRE Directive, establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment plays also a key role here.

One consequence is that various services of the spatial data infrastructure and the Open Data movement should be used to promote sustainability (environmental and species protection) of digital agriculture and to continuously digitally monitor it. Required data stocks are, for example, weather data, Natura 2000 areas, groundwater protection areas, land sections, impact cadastral data. By these means, next to financial supports, also infrastructural supports have their positive impact to farmers in Europe.

Related architecture layers:

- IoT Information Management and Mediation Layer
- Application Layer
- Security and Privacy (Data Ownership)

5.3. CLEAR RULES ON DATA OWNERSHIP AND USAGE OF SHARED DATA

Data Ownership is a key issue in the adoption of IoT in the agricultural domain. In an interview, Anthony van der Ley, President of CEMA (European Agricultural Machinery Association), states (Kloosterman 2018):

“Farmers must remain the owners of their own data before others start using it and farmers lose their right to exist. I believe it is unethical to take possession of farmers’ data. I don’t think farmers know exactly what the implications are of digitalisation of agriculture.“

This means that implementation of IoT technology depends on clear rules on data ownership that the relevant stakeholders have full control on data shared. Data monopolies should be avoided. It is in the interest of the farmer only to share data, if he benefits from sharing and gains additional information. The originator of the data needs to have full control what is happening with the data in subsequent steps.

Business models of the stakeholders must be set-up and the relevant legal framework must ensure a competitive environment.

Related architecture layers:

- IoT Information Management and Mediation Layer
- Application Layer
- Security and Privacy (Data Ownership)

5.4. ENSURE AND FACILITATE DATA PROTECTION AND PRIVACY

Data protection and privacy is a key issue identified by the use cases of IoF2020. Clear and understandable guidance must be given to famers and other stakeholders in the agricultural chain. Furthermore the rules must be extended not only to cover personal data, but also to any data, e.g. production data, machinery data or commercial data to protect the business of farmers.

Data protection must always be traceable and verifiable for users of digital applications in agriculture. If personal data are generated in networked agriculture, the legal requirements for transparency, disclosure requirements and data security must be observed.

The EU General Data Protection Regulation (GDPR) applies to commercial farmers as well as to agricultural machinery and service providers when processing personal data. Among other things, the GDPR enshrines the principle of "data protection through technology design", which requires providers of data processing products and systems to design them in such a way to allow data protection-friendly data processing. One aspect here is to enable the user to see which data is included in the analysis and, if applicable, the possibility of deciding whether and by whom they may be used.

Related architecture layers:

- IoT Connevtivity Layer
- IoT Service Layer
- Agricultural Machinery Communication
- IoT Information Management and Mediation Layer
- Application Layer
- Security and Privacy (Data Ownership)

5.5. SUPPORT REUSABILITY OF IOT COMPONENTS

In order to support implementation of IoT in the agricultural domain, double work should be avoided and the use of reusable IoT components must be encouraged. Reusability of IoT components is also a key topic within the IoF2020 project and use cases are encouraged to provide components that can be reused in other similar contexts.

With Deliverable D3.7, IoF2020 has compiled a set of reusable IoT components that are being developed to provide an appropriate IoT infrastructure. These components should be promoted by officials and multipliers to enhance the progress of IoT in agriculture; they are as follows:

- An IoT catalogue of IoF2020 provides access to the results for a broad audience which enables connection between end users and solution providers
- Security and privacy guidelines of IoF2020 describe to improve security by implementing the right processes and selecting suitable technologies
- Security enhancing enablers for authentication and authorization management as threat mitigation
- The FIWARE context broker and NGSI support exchange of data, unidirectional collection of data from sensors and systems and bidirectional exchange among components and systems
- A service for replicability and reuse provides a solution for business collaboration between end-users, service providers and developers
- The Connect API in 365FarmNet-FMIS supports creation, acquisition, exchange and visualization of data to this system
- Open data marketplace and configurable dashboards support in having access and getting the most of all the data collected by new IoT solutions and devices

Related architecture layers:

- IoT Service Layer
- IoT Information Management and Mediation Layer
- Agricultural Machinery Communication
- Application Layer
- Security and Privacy

5.6. FOSTER STANDARDISATION

As Task 3.2 of WP 3 addresses the IoT Standardisation objectives of IoF2020, the portfolio of resulting recommendations derive from a heterogeneous field of technological interactions like:

- Business-domain unspecific technology for communication and devices themselves resulting in IoT driven standards
- Integrated and interoperable solutions at reasonable costs demanding for new enabling technology related standards, not limited to IoT-related solutions
- Agri-food domain specific guidelines for food security and consumers' health, deployed in a wide range of IT-applications, hence asking for consolidated standards, implementation and expansion
- Standards for data exchange like Electronic Data Interchange (EDI), barcodes and EPCIS as well as semantics related de-facto standards, to enable dynamic (e.g. weather and season driven) sourcing, specific communication in complex food networks operating on a global and national scale. Those standards are specifically relevant for the application, collaboration and process layer, but need also be incorporated on the processing, storage and service layer for an efficient and effective system design.

The importance and necessity of standards was clearly stated by all stakeholders. As policy recommendation IoF2020 suggests that policy makers encourage voluntary standardisation, making it a crucial element within activities and ensure that they are freely available and can be used without additional cost.

As there are several actors in standardisation, involved in or even managing formal or de-facto standardisation groups, active on national, European, global or sector specific level, cooperation should be encouraged to avoid duplication of work and competition of standards and solutions. Additionally the agricultural domain should adopt existing IoT standards proven in other sectors and the cooperation with supply chain and or other sector standardisation should be encouraged. Examples are the adoption of EPCIS or LPWAN in the agricultural domain.

As mentioned before, public open data and resources subject to authorization, such as varieties, plant protection products and veterinary medicinal products, these databases should provide information for the use in machine-readable and practicable form. This also includes the use of established standards for vocabularies and ontologies to allow processing of machine-readable data in automated processes. The data should be ubiquitously accessible and decentrally provided by the institution responsible for the authorization.

Related architecture layers:

- All layers are addresses here

5.7. REDUCE ADMINISTRATIVE BURDENS AND SUPPORT ADOPTION

Compared to other industries, agriculture shows a significant difference, as it is dealing with living plants and animals and is depending on factors like climate and weather. Digitalisation is already integral part of agricultural production processes, e.g. in precision farming or milking robots. Sensors are essential part of this digitalisation and IoT technologies are driving digitalisation further.

It is essential for the agricultural sector to support adoption of new technologies as there are big differences between farmers in different countries of Europe as well as within countries itself regarding their openness and knowledge on the usage of digital technologies. These aspects need to be addressed and additionally also consumer needs need to be in focus here - bringing farmers and consumers closer together through transparency.

Transparency through the chain

IoF2020 shares the idea of using digitalisation which offer the consumer a corresponding variety and choice. It is recommended to initiate a digital food chain management system so that the origin of the food can be traced back by every consumer. IoF2020 is also committed to a transparent value chain without media breaks along the entire value chain of food. Digital technologies like Blockchain, Smart Contracts and integrated sensor technologies enable product authenticity and product safety to be fully traced, both nationally and internationally. Furthermore, IoF2020 supports the approach of digitalised agriculture and platform economy to facilitate market access for farmers and facilitate direct sales. Short transport distances not only reduce CO_2 emissions, but also promote local food supply and rural development. Concrete examples of this include regional platforms, green vegetable crates, so-called crowd-butching providers, online shops, solidarity agriculture networks.

Education

In order to prepare farmers and other stakeholders and support adoption, education is a key topic. Digitalisation, the related opportunities and obstacles must be known to them.

Demand for experimental fields

Increasing digitisation in agriculture requires more suitable testing and experimentation environments for new digital and digital applications. Through interdisciplinary and transdisciplinary approaches in experimental fields, innovative technical systems and new business models can be tested. Start-ups, in agricultural, technical and research, as well as the validation of the innovation potential of research results are thus promoted. The concept of experimental fields offers all participants great opportunities to test very concrete scenarios and applications and to implement them with partners. IoF2020 therefore expressly welcomes the establishment of experimental fields in agriculture especially with the aim of testing IoT applications. They are able to contribute to the sustainability of domestic agriculture as well as, through the targeted promotion of European agribusiness companies, to increase sustainability worldwide. EU farmers have good preconditions for becoming a global hotspot for digitisation in agriculture.

Drones and Robots

Drones and robots are becoming more and more reality on the fields. Policy makers should take into account that their usage is different from usage in private environments and is daily business. Administrative burdens, like ascent permissions for drones, should be avoided by giving a general ascent permission to farmers on their agricultural areas, once providing their proof of knowledge.

Related architecture layers:

- Mainly Application Layer

6. SUMMARY AND CONCLUSIONS

In order to achieve a leading role in innovation and implementation of IoT in the agricultural sector and along the agri-food supply chain a joint and coordinated effort of the relevant stakeholders and policy makers is necessary.

There is no clear line on prioritisation of the recommendations as the different elements of the policy recommendations and cannot be seen as stand-alone-measures. What is more important is to distinguish between general measures to foster IoT in Europe and measures that are applicable for the agricultural domain, fulfilling their needs.

Overall, the pillars of the policy recommendations of IoF2020 are:

- Digital Infrastructure and Public Data (Recommendation 1 & 2)
- Data Ownership, Data Protection, Data Sharing and Privacy (Recommendation 3 & 4)
- Standardisation and Reusability (Recommendation 5 & 6)
- Implementation & Adoption (Recommendation 7)

The IoF2020 Policy Recommendations can be summarised as follows:

Digital Infrastructure and Public Data (Rec. 1 & 2)

Problem Statement:
Without the adequate digital infrastructure, whether physical, i.e. landline and mobile networks, or the usage of available public resources, like public geodata, implementation of IoT in agricultural sector is not possible. These resources are the core of IoT and the relevant infrastructure needs to be provided.

Relevant Stakeholders to address this topic:
Mainly public policy makers on European and national level in cooperation with industry.

Data Ownership, Data Protection, Data Sharing and Privacy (Rec. 3 & 4)

Problem Statement:
In IoT data is very important, data is created, shared and needs to be protected. The right framework must be provided.

Relevant Stakeholders to address this topic:
Mainly public policy makers on European and national level.

Standardisation and Reusability (Rec. 5 & 6)

Problem Statement:
The IoT ecosystem counts on the usage of different technologies, applied on different layers. Double work and proliferation of standards needs to be avoided to make solutions affordable and future-proof.

Relevant Stakeholders to address this topic:
Stakeholders in the different areas, standardisation bodies and industry consortia and associations, public policy makers in supportive function.

Implementation & Adoption (Rec. 7)

Problem Statement:
Digitalisation is currently changing the way we work and live, this transformation needs to be supported and managed.

Relevant Stakeholders to address this topic:
Public Policy Makers, stakeholders and associations.

In the following two sections the relationship of the recommendations to IoT Layers and the relevance of recommendations to Trials of the IoF2020 project is shown.

6.1. RELEVANCE OF THE RECOMMENDATIONS TO IOT LAYERS

The following table gives an overview on the policy recommendations and the related IoT Layers identified in chapter 4:

	Rec. No. 1 Enhance Digital Infrastruc-ture	Rec. No. 2 Facilitate Access to Public and Open Data	Rec. No. 3 Clear rules on Data Ownership and Usage of Shared Data	Rec. No. 4 Ensure & Facilitate Data Protection and Privacy	Rec. No. 5 Support Reusability of IoT Compo-nents	Rec. No. 6 Foster Standardi-sation	Rec. No.7 Reduce Adminis-trative Burdens & Support Adoption
Physical Device Layer	X					X	
IoT Con-nectivity Layer	X			X		X	
IoT Service Layer				X	X	X	
Agricultural Machinery Communi-cation				X	X	X	

	Rec. No. 1 Enhance Digital Infrastruc -ture	Rec. No. 2 Facilitate Access to Public and Open Data	Rec. No. 3 Clear rules on Data Ownershi p and Usage of Shared Data	Rec. No. 4 Ensure & Facilitate Data Protectio n and Privacy	Rec. No. 5 Support Reusabilit y of IoT Compo-nents	Rec. No. 6 Foster Standardi -sation	Rec. No.7 Reduce Adminis-trative Burdens & Support Adoption
Information Manage-ment and Mediation Layer		X	X	X	X	X	
Application Layer		X	X	X	X	X	X
Security/ Privacy		X	X	X	X	X	(X)

6.2. RELEVANCE OF THE RECOMMENDATION TO THE TRIALS OF IOF2020

The following matrix shows the relevance of the recommendations to the different trials of IoF2020:

	Rec. No. 1 Enhance Digital Infrastruc-ture	Rec. No. 2 Facilitate Access to Public and Open Data	Rec. No. 3 Clear rules on Data Ownershi p and Usage of Shared Data	Rec. No. 4 Ensure & Facilitate Data Protection and Privacy	Rec. No. 5 Support Reusabilit y of IoT Compo-nents	Rec. No. 6 Foster Standardi-sation	Rec. No.7 Reduce Adminis-trative Burdens & Support Adoption
Internet of Arable Farming (Trial 1)	++	++	++	+	+	+	+
Internet of Dairy Farming (Trial 2)	++	+	++	+	+	+	+
Internet of Fruits (Trial 3)	++	+	++	+	+	+	+
Internet of Vege-tables (Trial 4)	++	+	++	+	+	+	+
Internet of Meat (Trial 5)	++	+	++	+	+	+	++

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- Project Proposal IoF2020
  (internal, Proposal number: 731884)
- IoF2020 Deliverables (https://www.iof2020.eu/about/deliverables)
    - D1.3: Detailed Work Plan
    - D1.4: Data Management Plan
    - D3.2: The IoF2020 Use-Case Architectures and overview of the related IoT Systems
    - D3.3: Opportunities and Barriers in the present regulatory situation for system development
    - D3.7: Compilation of Use-Case Requirements
    - D3.9: Progress Report on Synergy Analysis, Decisions and Coordination of Work
    - D4.2: Methodology to assess market outlook and social impact for each use-case;
    - D4.3: Taxonomy of business models relevant to IoT applications
    - D5.3: Ecosystem building strategy;

7.2. EXTERNAL

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