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Framework Contract for Expert Advisory support to the European Space Policy and Programmes – ENTR/341/PP/2013/FC

Feasibility Study for joint Space-Agriculture Solutions on Nutrient Management

Final Review

23/01/2019

European Commission DG AGRI

pwc

Agenda of the final review meeting

Overview of the NMP feasibility study	11:00 – 12:15

- Project objectives and rationale
- Project overview and deliverables
- Run-through of the working demonstrator

Conclusion, comments and discussion	12:15 – 13:00

Presentation of the project

1

The overall aim for the study was to assess the feasibility of the FaST initiative

The primary objective of the feasibility study was to evaluate the wider business case of a Farm Sustainability Tool, considering an institutional perspective, as well as analysing different options in terms of technical tool scope and associated governance. It focused on the challenges, complexity and points of attention that could arise in the development of this tool, and hence need to be addressed under the implementation of the FaST.

Note: from a geographical scope perspective, it was assumed that the EU28 (i.e. including the UK) are in scope for the assessment of existing solutions and as potential recipients of the options ultimately proposed.

Objectives

Propose and analyse **options for the tool scope in technical terms**	In parallel, **iterate on the expected technical requirements** for the implementation of the tool	**Produce a technical dummy prototype of the proposed technical solution** to be used as demonstrator for communication and outreach

The overall objective of the study was to analyse the feasibility of an initiative devoted to delivering a Nutrient Management/Farm Sustainability Planning tool for Europe, looking at the wider business case from an institutional perspective, and at different options in terms of tool scope.

FaST supports the improvement of farm management from both an environmental and economic perspective

What is FaST?

FaST is the **Fa**rm **S**ustainability **T**ool for nutrients. It will be a digital tool to help individual farmers improve both the agronomic and environmental performance of their farms, by supporting them in the development of an accurate Nutrient Plan Management.

What Fast is not

The FaST is not a tool for authorities to ensure compliance of farmers and their input levels.

What is Nutrient Management?

Nutrient Management Planning is the process of ensuring a farm utilizes its crop nutrients as efficiently as possible, in order to optimize crop yield and quality, whilst also protecting the environment by not having an excess of nutrients.

FaST: a win-win solution for farmers and the environment

In order to address citizens' increasing expectations concerning food quality as well as the environment and the climate, the transition towards a fully-sustainable agricultural sector must be supported by public policies. Buy-in and environmental gains would see an improvement, since FaST will provide clear and timely information that is beneficial for farmers from both an economic and environmental perspective. Farm competitiveness and resilience is increased through enhanced decision support to farmers, who will be able to optimise their nutrient use to improve their incomes, whilst higher environmental and climate benefits are delivered through better access to relevant farm data and including environmental sustainability considerations in the overall farm management decisions.

The legal framework: the GAEC 5

According to GAEC 5 and article 12(3), Member States will establish a system to provide the FaST for nutrients to individual farmers, who in return will be obliged to activate the tool and input the information necessary for the tool to be operational. Minimum elements and functionalities of the tool have been defined. The possibility of adding other electronic on-farm and e-governance applications is embedded in the tool design thanks to modularity. The Commission may support Member States with the design of the FaST, the data storage and processing services required.

Objectives

- Increases **farm competitiveness and resilience** by providing improved decision support to farmers.
- Bolster on-farm environmental care and climate action by **incorporating environmental sustainability considerations** in farm management decisions.
- Strengthens the socio-economic landscape of rural areas by supporting **large-scale digitalisation** of the farming sector.

The study was performed over three main phases, going from research and consultation to a functioning demonstrator

Characterization phase

User journey identification and demonstrator development phase

Synthesis phase

Literature review and desk research:

- Background/context
- State-of-play: overall landscape, existing initiatives
- Definition of NMP scope in terms of main elements and functionalities
- Identification of user communities
- Technical investigation, identification of capacities

User consultation

Identification of user requirements and personas

User stories

Minimum Viable Product (MVP)

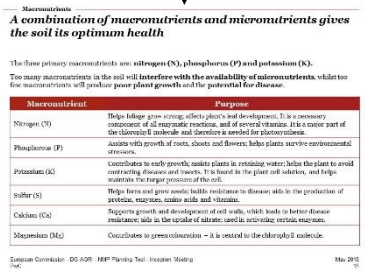
High level impacts

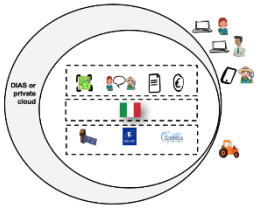
Costing

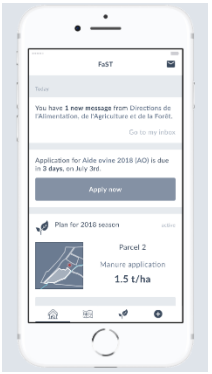
Tool architecture option definition

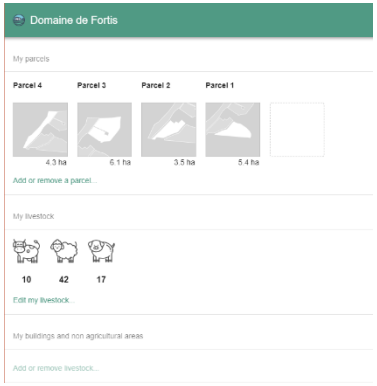
Mock-up development

Demonstrator









A comparative analysis was performed to study possible synergies and understand the landscape

More than 40 products and services from public and private actors in Europe identified

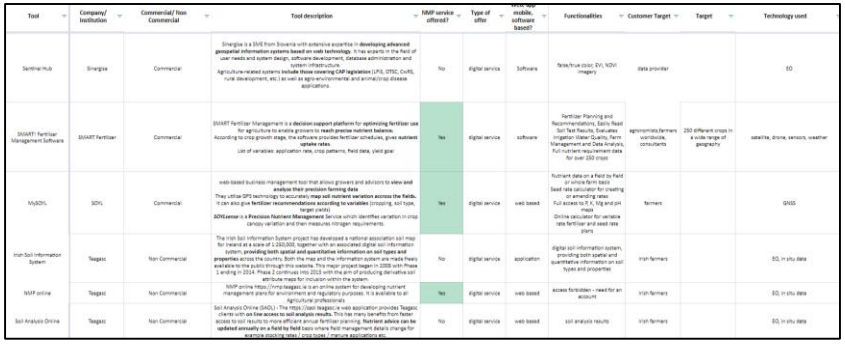
In-depth profiles conducted

2 H2020 projects, 1 ESA project and 3 MS institutional initiatives

3 private initiatives

An excel database of public and private initiatives was compiled in order to give an extensive overview of the European NMP market. Different data were recorded, from the **functionalities** and **customer targets**, to the **data source/technology utilized** and **maturity** of the product.

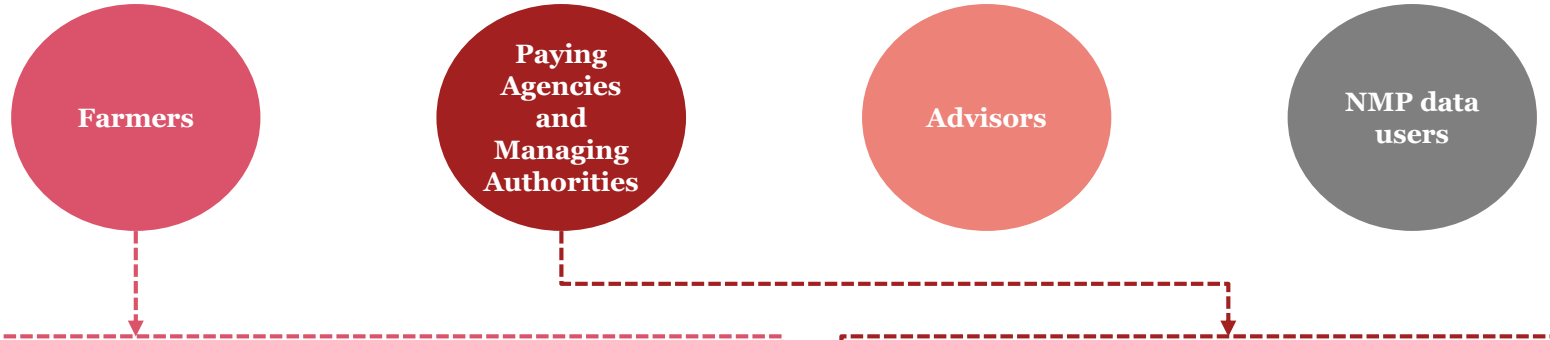
Several of these were then selected to perform further analysis on, especially to help determine the 'lessons learnt' and possible synergies.



Tool	Company/ Institution	Commercial/ Non Commercial	Tool description	NMP service offered?	Type of offer	Mobile app/ mobile, software based?	Functionalities	Customer Target	Target	Technology used
Sentinel Hub	Sinergise	Commercial	Sinergise is a SME from Slovenia with extensive expertise in developing advanced geospatial information systems based on web technology. It has experts in the field of user needs and system design, software development, database administration and system infrastructure. Agriculture-related systems include those covering CAP legislation (LPIS, OTSC, CwRS, rural development, etc.) as well as agro-environmental and animal/crop disease applications.	No	digital service	Software	Tiles/true color, SVI, NDVI imagery	data provider		EO
SMART Fertilizer Management Software	SMART Fertilizer	Commercial	SMART Fertilizer Management is a decision support platform for optimizing fertilizer use for agriculture to enable farmers to reach precise nutrient balance. According to crop growth stage, the software provides fertilizer schedules, gives nutrient uptake rates. List of variables: application rate, crop patterns, field data, yield goal.	Yes	digital service	software	Fertilizer Planning and Recommendations, Easily Read Soil Test Results, Evaluates Irrigation Water Quality, Farm Management and Data Analysis, Full nutrient requirement data for over 200 crops	agronomists,farmers worldwide, consultants	250 different crops in a wide range of geography	satellite, drone, sensors, weather
MySOYL	SOYL	Commercial	web-based business management tool that allows growers and advisors to view and analyse their precision farming data. They utilize GPS technology to accurately map soil nutrient variation across the fields. It can also give fertilizer recommendations according to variables (cropping, soil type, target yields). SOYLeaner is a Precision Nutrient Management Service which identifies variation in crop canopy variation and then measures nitrogen requirements.	Yes	digital service	web based	Nutrient data on a field by field or whole farm basis. Seed rate calculator for creating or amending rates. Full access to Y, L, Vg and pH maps. Online calculator for variable rate fertiliser and seed rate plans	farmers		GNSS
Irish Soil Information System	Teagasc	Non Commercial	The Irish Soil Information System project has developed a national association soil map for Ireland at a scale of 1:250,000, together with an associated digital soil information system, providing both spatial and quantitative information on soil types and properties across the country. Both the map and the information system are made freely available to the public through this website. This major project began in 2008 with Phase 1 ending in 2014. Phase 2 continues into 2019 with the aim of producing derivative soil attribute maps for inclusion within the system.	No	digital service	application	digital soil information system, providing both spatial and quantitative information on soil types and properties	Irish farmers		EO, in situ data
NMP online	Teagasc	Non Commercial	NMP online https://nmp.teagasc.ie is an online system for developing nutrient management plans for environment and regulatory purposes. It is available to all agricultural professionals.	Yes	digital service	web based	access forbidden - need for an account	Irish farmers		EO, in situ data
Soil Analysis Online	Teagasc	Non Commercial	Soil Analysis Online (SAOL) - The https://saol.teagasc.ie web application provides Teagasc clients with an free access to soil analysis results. This has many benefits from faster access to soil results to more efficient annual fertiliser planning. Nutrient advice can be updated annually on a field by field basis where field management details change for example stocking rates / crop types / manure applications etc.	No	digital service	web based	soil analysis results	Irish farmers		EO, in situ data

The landscape within Europe is **fragmented**, especially as there is no EU-wide tool. Some MS are far **more advanced** than others in what tools are available, both on the commercial market and from institutional initiatives, and there are MSs who **lack mature solutions**. Beyond this, some farmers are **more confident in utilizing digital tools** than others.

Pain points for users were identified through stakeholder consultation and research



- **Administration**: Bureaucracy burden, regulations are hard to understand, no alerts/notifications received if risks of non compliance
- **Farm**: Lack of information on crop needs (nutrient and water), lack of access to land, soil degradation, N groundwater pollution, poor water quality, waste of resources (water, fertilizers), lack of future yields visibility
- **Finance/economic**: Significant part of farm cost dedicated to fertilizers, most precision ag tools available are costly, yield potential not unattained
- **Country**: High influence from the country and the government/PA willingness to modernize agriculture
- **Management**: Homogeneous application of fertilizers, poor agriculture decisions taken, current solutions are complex to use, hard to find agronomists with the right skill to manage nitrogen application map development

- **Complexity and administrative burden** when seeking to ensure compliance of farmers to regulations
- **Costly** and **no global On-the-Spot Checks** (OTSC)
- **Lack of information** on the farmers management practices: nutrient, water, manure…

Key Findings

- Objective: offer an overall picture of users, their pains and their requirements
- To reach such goal, need to classify different user communities
- The literature review, the state-of-play as well as the stakeholder consultation help to enhance the understanding of the pains and requirements to design a useful tool for them

FaST Personas are representations of a user for the tool, which establish goals, motivations and pain points of user

Cost Conscious Farmer
Goals :
- Earn while being more cost effective
- Have a more efficient management of inputs while protecting water quality and cutting greenhouse gas emissions
- Generate an easy to use NMP plan and achieve yield objectives

Informed Farmer
Goals:
- Be able to communicate easily with the paying agency
- Decrease the need to master regulation details
- Decreased administrative burden
- Knowing that privacy is respected and only relevant data is communicated via the application/platform to third parties (MS/PA/Advisors)

Technology Minimalist
Goals:
- Clear, simple and timely tool so they can spend the minimum amount of time necessary in the tool
- Not waste time on data input duplication
- Be able to work in the tool for one or a few parcels and their single crop through simple visualisations
- Positioning, camera and geolocation features are enough

Happy Member States and Paying Agencies
Goals:
- Compliance with new CAP legislation
- Easy two-way communication with farmer base, directly to the farmer's device
- Impact beyond nutrients management
- Flexibility to develop/customise/localise the tool for their needs
- Control and comprehension of implementation options and roll out means

Data Enthusiast
Goals:
- Access to consolidated anonymized information in some accessible data format
- Optimisation of IT resources, data volume and data treatment chains through a modular architecture
- Deployed on any DIAS or their own infrastructure

User stories were mapped out based on each Persona's journey within the tool

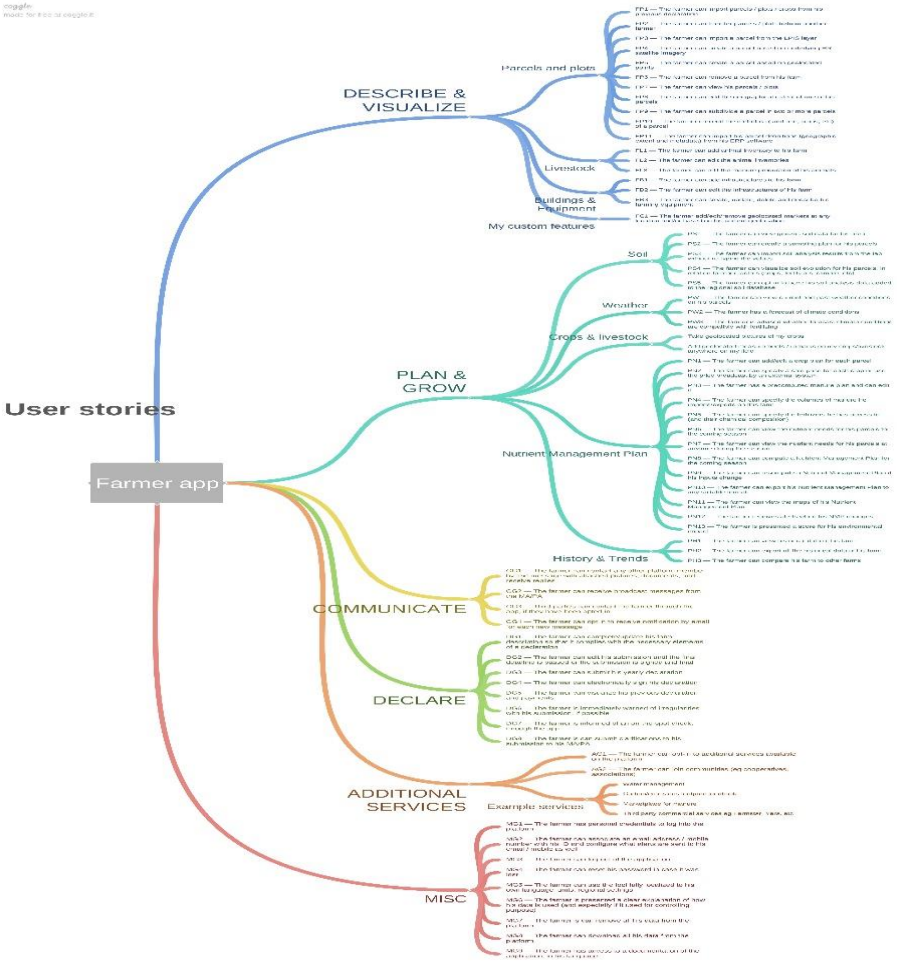
"**User stories**" were on how each **User Persona** interacted with the tool in order to have a desired business outcome or goal.

These user stories were grouped into "**Epics**", which evolved into menu items represented in the User Interface of the farmer application.

Defining these allowed for the development of a first draft architecture for deployment of the tool.

Examples of "Epics" include:

- Describe and Visualize – parcels and plots, livestock, buildings and equipment
- Plan and Grow – soil, weather, nutrient management plan, history and trends
- Communicate
- Additional Services – payment schemes and compliance, farm advisors
- Miscellaneous



The post-2020 CAP regulation lays out the minimum elements and functionalities the tool should possess

Copernicus Data and Information Access Services (DIAS)

Legal limits + requirements | **LPIS/IACS** | **Soil sampling** | **Nutrient budget** | **Management practices** | **Crop history** | **Crop yields**

Data security and privacy

Automated integration of data where possible

Minimum requirements

Core NMP tool

Two-way messaging system *Farmer - Paying Agency*

•••

Modularity (e.g. water and emissions management) and tailoring at national level

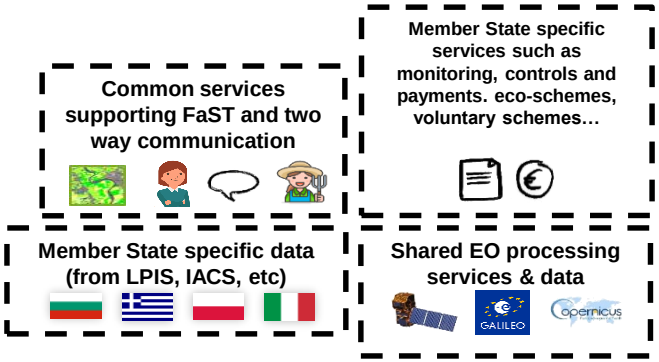
Add-ons developed by private companies

Advice for the farmer including:

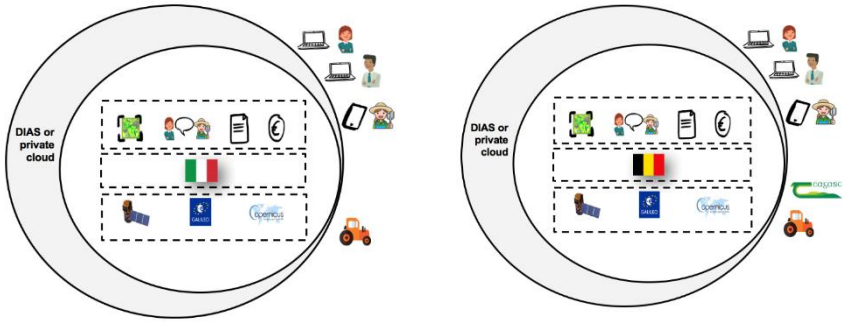
- *What to apply*
- *When*
- *Where*
- *How much*
- ➢ *To achieve yield goals whilst remaining compliant*

Anonymization of some data for use by EC, researchers, etc.

Several deployment options for the FaST were considered

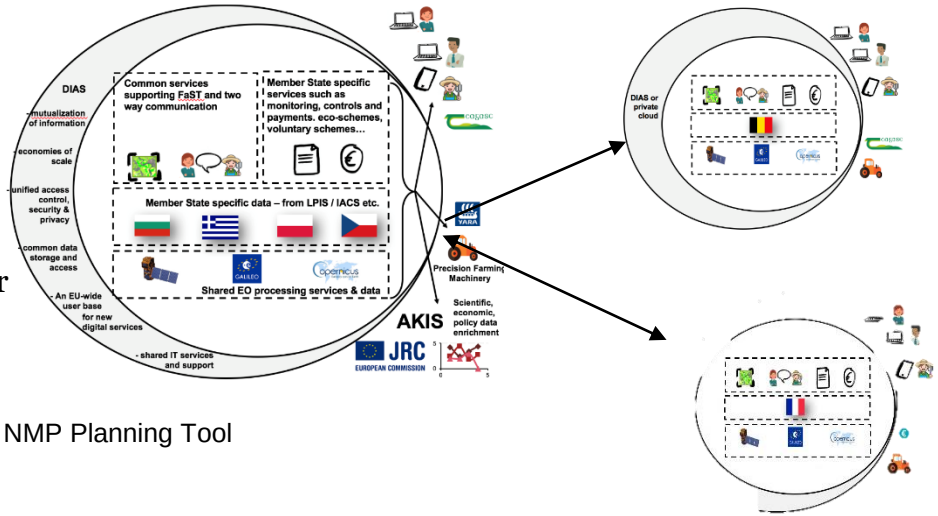


Deployment Option 1: One platform, with required localizations for each Member State. External services connect to a single common platform.



Deployment Option 2: Each Member State installs and maintains its own platform on a DIAS or other cloud. External services have to connect to each and every platform.

Deployment Option 3: A mixed option allows Member States to adapt and deploy the FaST solution according to their own needs or opt-in to a shared platform.



Farmers can benefit from the FaST in a variety of ways

Farmers

Economic Benefits

By using an NMP plan, the farmer knows the correct rate of application for fertilizers. This will lead to an increase in crop yield, and hence increasing the farmer's revenue, whilst decreasing the use of chemical nutrient required and thus reducing the costs for the farmer.

Regulatory compliance

The FaST will not produce or allow any NMP that is not in line with the regulation (environmental, sustainable practices, etc.); hence, if the farmer follows their personalized plan, they know they have evidence and confirmation of being compliant.

Environmental protection

Improving the management of nutrients will lead to overall benefits for the environment, e.g. by reducing risk of nitrogen leaching. Modularity of the tool means that other applications can be introduced, such as environmental-specific tools.

Time saving

Utilizing a digital tool such as FaST will allow the farmer to simplify tasks and avoid duplicating data entry for different declarations.

Increased communication/collaboration

Warnings regarding problems with a declaration, either from the farmer or the Paying Agency, will be shared faster and more easily. There will also be easier communication with advisors, cooperatives, and potentially even other farmers.

Access to more digital applications

Thanks to its modularity, the platform will provide other services that focus on direct payment schemes, such as environmental services, as well as solutions from the private sector, which are not often available to small farmers due to cost or difficulty of access.

Increased knowledge of own data

The digital tool will keep a record of past data for NMP, thus detecting trends on the farmer's land, and hence become a powerful tool for decision-making.

Level playing field for farmers

It can be a challenge for small farms to have digital tools and personalized nutrient management plans. The FaST will ensure there is a solution for all farmers.

Managing Authorities/Paying Agencies can also enjoy benefits from the FaST

Managing Authorities/Paying Agencies

Environmental monitoring

The FaST will support managing authorities in monitoring certain environmental parameters (e.g. soil quality, air pollution, nitrogen rate, water quality, etc.). It will be especially useful in protected areas (e.g. Nitrate Vulnerable Zones).

Increased two-way communication

The two-way communication between the farmer and the Paying Agency/Managing Authority means that warnings regarding problems with a declaration, or changes in policies, etc., can be shared fast and more easily. Farmers can also inform the MA/PAs if there are mistakes in their personal data.

Compliance

The FaST will allow easier compliance by the farmer, by providing advice that is always within the parameters of limitations set by the CAP. Therefore, if the farmer follows this advice, there will be a higher level of compliance, as well as a record showing it as such.

Economics of scale

There will be a larger number of Member States providing resources to add value to the FaST and its users, and there will be a pooling of resources to maintain the platform infrastructure (IT, data protection, access, etc.).

Digitalization

The FaST will support rural development by building the foundation of digitalization, above all for small farms, which do not utilize technology as much as larger farms. The platform will act as a one-stop shop for farmers, providing a portfolio of digital services including from advisors and commercial actors.

Other actors who can benefits from the introduction of the FaST include policy makers, advisors, and private actors

Other actors

European Commission/Policymakers

New knowledge gained from the trends shown via the FaST could be utilized in policy-making. Beyond this, the FaST platform will allow economy of scale within the EU-28.

Advisors

Advisors will be able to offer their services directly to the farmers. The one-stop shop approach will also build a rich benchmark knowledge base, strengthening the farm advisory services with this additional knowledge.

Researchers

The platform could act as a valuable tool for research data, including: specific technical agriculture knowledge, farming strategies, financial skill building, management skill building, networking, resource, nutrient and environment management, statistical model building.

Cooperatives

Cooperatives would be able to use the FaST platform environment to offer members their own services or private services bought through the cooperative. It would also provide a useful way for communication with and amongst members.

Private actors

The FaST will not infringe on the more sophisticated commercial decision support tools provided by the private sector. However, with its modularity and platform-based environment, it could provide the environment for a one-stop shop with all services gathered together. Commercial actors could offer their services as additional solutions to download. It is a challenge for private actors to access small farmers especially, so this will open up a new customer base.

The final deliverables were provided at the beginning of January 2019

The feasibility study concluded at the beginning of January 2019. The following deliverables were hence delivered by the end of the project:

- A final **feasibility report**;
- **Visual support material** for the tool architecture, the deployment options, the demonstrator mock-up, and an overall visualisation of the platform;
- The preliminary live **demonstrator mock-up**, available at the following link:
  https://rebrand.ly/fast-demonstrator
- An **operational prototype of FaST**

Today's meeting will focus on demonstrating the operational prototype of the FaST

Farmer application demonstration and discussion

2

Farm Sustainability Platform

European Commission concrete support for the implementation of the Farm Sustainability Tool for nutrients (FaST)

Farmers

Improve agronomic performance while reducing fertilizer cost and environmental impact

mobile app, web portal, bridges to tractors, etc.

Managing authorities and paying agencies

Register compliance with GAEC 5,
possibly further SMRs and GAECs

Support for further environmental commitments

Gather consolidated data

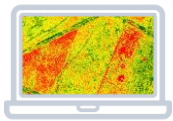
2-way communication

web portal

Advisors

Assist farmers in developing an efficient and compliant NMP

web portal



Institutional & private partners

Propose innovative and relevant services to the extensive FaST user community

integrate through APIs and opt-in service marketplace

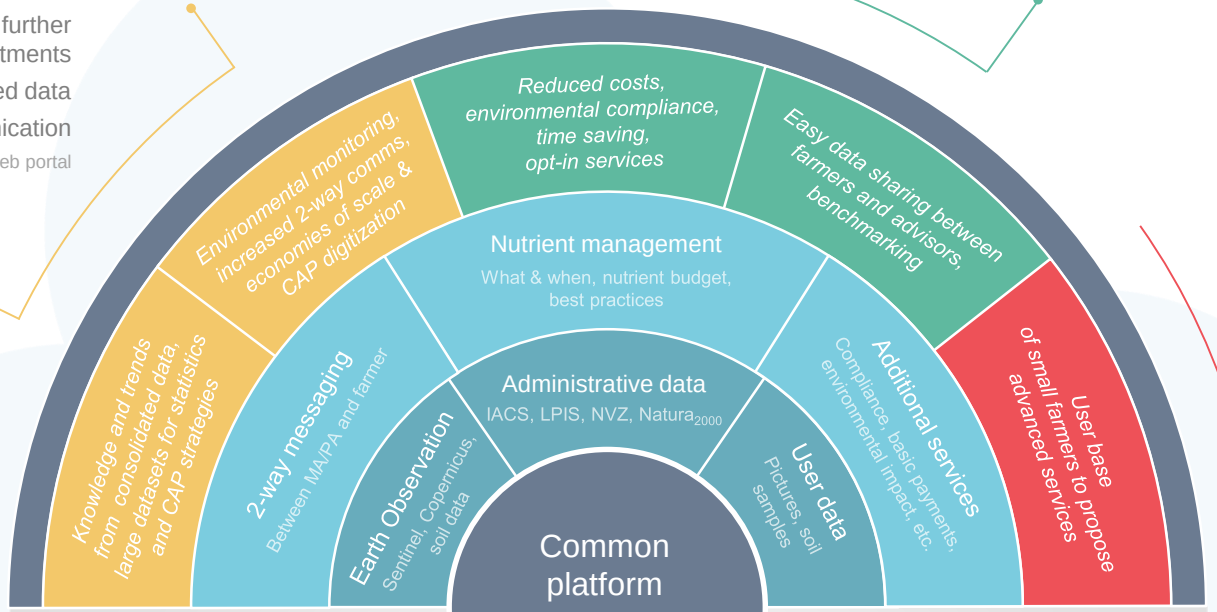
Policy-makers & researchers

Develop innovative solutions to optimize the use of inputs in agriculture

Ensure data security, privacy and anonymization

web portal, APIs

API



Data security & privacy (GDPR)
Modular design ⇢ extensible
Builds on past EU projects (e.g. H2020)

Adapts to local specificities (administrative, agricultural, regulatory)
Interfaces with existing systems
Economies of scale for participating MS

European Commission

Copernicus Europe's eyes on Earth

GALILEO

Farm Sustainability Platform

European Commission concrete support for the implementation of the Farm Sustainability Tool for nutrients (FaST)

pwc included in prototype

Services

Farm edition	Add / remove parcel from LPIS layer View parcel soil data and proximity to water bodies, Natura2000 areas Edit farm livestock and parcel crops
2-way messaging	Basic messaging between platform users Add / remove users' contacts
Nutrient management planning	Data input journey implemented but plan calculations are not real/accurate Create multiple plans, activate / deactivate them
Additional services	Sample services included for demo, only Sobloo Sentinel imagery is actually connected
Weather	Weather forecast and historical data for farm

Data

Agricultural parcels (LPIS)	LPIS (France & Spain / Castilla y Leon)
Terrain	Hydrological network (France & Spain / CyL)
Environment	Natura2000 areas (Europe)
Soil	LUCAS Topsoil & Organic Carbon Content (Europe)
Satellite Imagery	Sentinel-2 True color layer (as served by Sobloo DIAS)
External APIs	Weather / geocoding (free accounts on commercial services)
Livestock & crop species	As extracted from EU regulations / websites

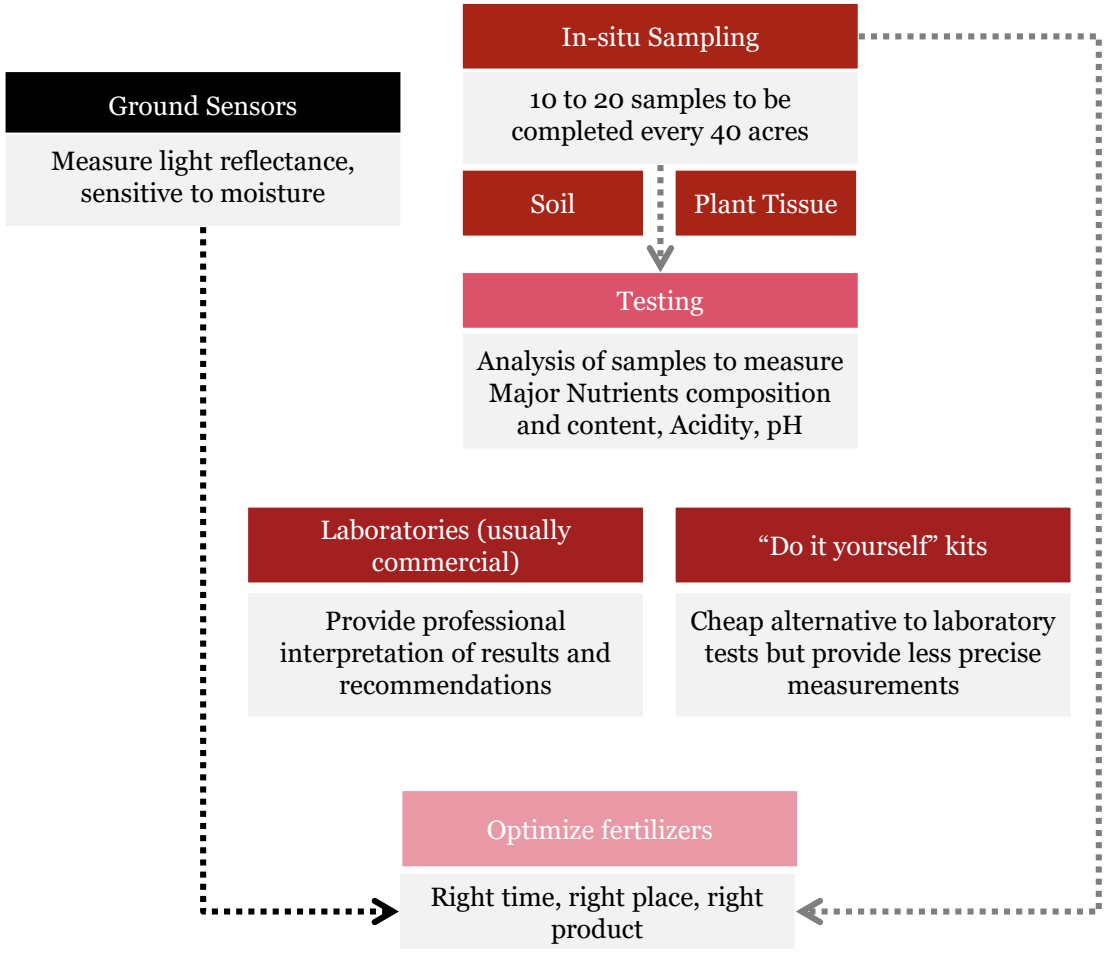
Annex

3

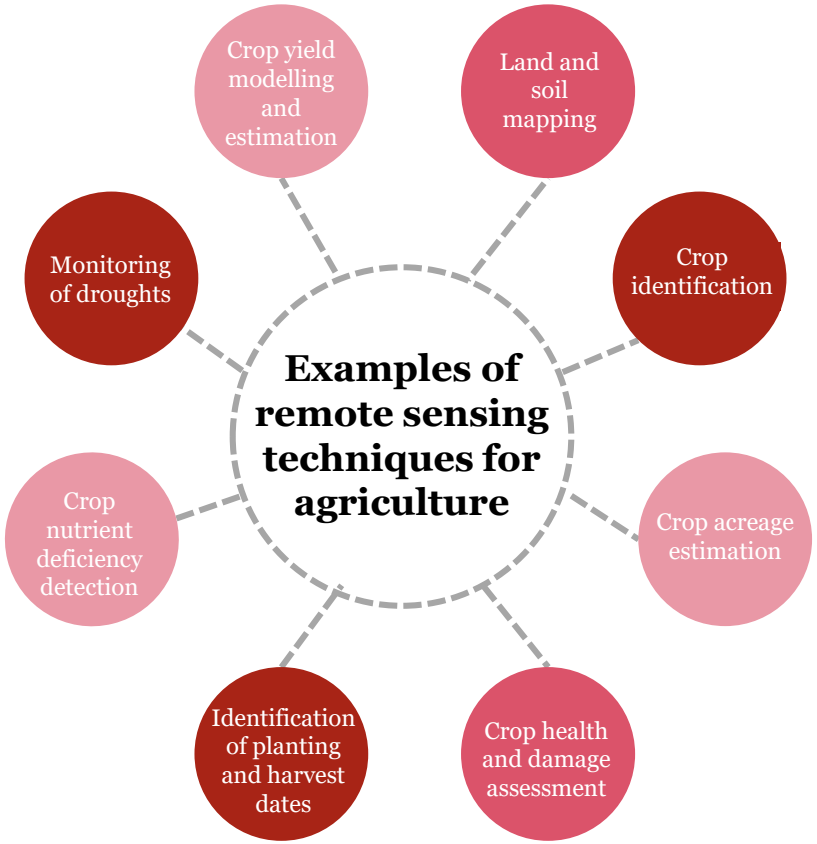
Traditionally, in-situ sampling/testing have been used for measuring the soil/plant available nutrients

Analysis

- **Soil testing** is more suitable when growing crops in slow-release composts and manures. Soil tests are commonly performed before planting.
- **Plant tissue testing** is a complementary analysis (physiology) for fine-tuning of fertilizers. Difficulties that growers are encountering:
  - Takes time for the grower to dry the samples
  - Commercial tests **cost the grower a fee** and usually take **2 weeks to complete**
  - ➔ Results may not be received by the grower until after the ideal time to take action and the interpretation is not always correct
- **Ground sensors** use remote-sensing technologies similar to aerial and satellites. Sensors can be installed in the field or on machinery such as tractors.



Today, remote sensing techniques are becoming more widely used to support agriculture and agronomy



Key Findings

- The advent of **GIS** (geographical information systems) has made remote sensing increasingly popular by delivering actionable intelligence related to specific locations on a map (e.g. a field).
- **Ground sensors** (e.g. handheld or mounted on tractors) and aerial **sensors** (e.g. on UAVs or aircraft) can both be used for applications such as evaluating nutrient levels, or estimating plant population count.
- However, **satellite imagery provides coverage of large land areas**, and is especially useful for monitoring crops status, conducting yield assessments and calculating crop loss.
- Information of crop health can be gleaned by observing **differences** in **reflectance** along sections of the electromagnetic (EM) spectrum.
- The **NDVI** (Normalized Difference Vegetation Index) measures the difference between near-infrared (NIR) and red light and is a way of determining healthy vegetation. **Healthy plants reflect more NIR and green light**, but absorbs more red and blue light – hence the vegetation having the appearance of green. NDVI ranges from -1 to +1.
- Remote sensing can be used both as a tool for agronomy as well as aiding the farmer and regulatory bodies to perform compliance monitoring.

Agriculture is one of the largest sectors addressed by the Copernicus programme

Copernicus-enabled revenues for European GIS intermediate users for precision farming was estimated at **13.7 M€** in 2015*, with a projected increase to **78.2 M€** by 2020 (for service providers only, not including end users revenues).

Copernicus has six thematic services: **land, marine, atmosphere, climate, emergency and security**. The **Copernicus Global Land Service (CGLS)** provides products for vegetation including:

- Leaf Area Index
- Normalized Difference Vegetation Index
- Vegetation Condition Index
- Vegetation Productivity Index
- Dry Matter productivity
- Soil Water Index
- Surface Soil Moisture
- Top of Canopy Reflectances

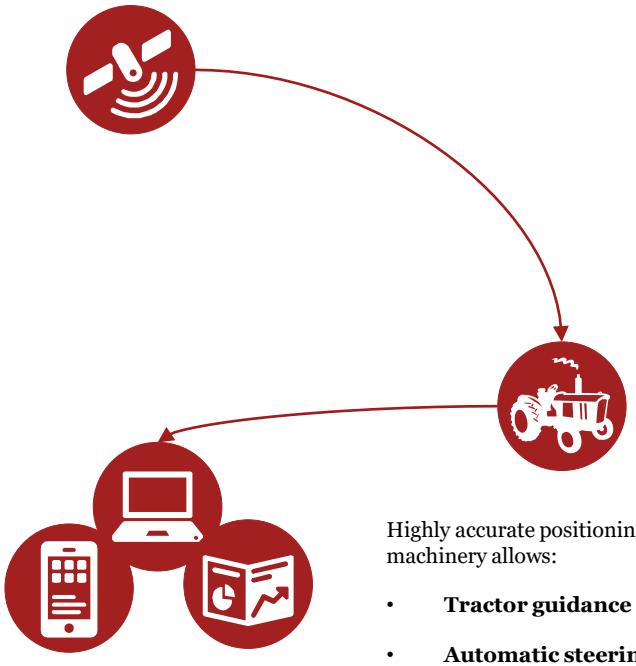
The **Trophic State Index** for lake water quality (expected 2018) will indirectly reflect the **eutrophication** status of a water body.

There is huge potential and opportunities arising from Copernicus for agriculture, especially thanks to the **technical quality of the Sentinel sensors**, the **'Full, Free and Open' data policy**/licensing scheme, and the **global coverage** of land with **guaranteed continuity** of observation over years.

There are several EU-level projects, led by the European Commission and ESA, which explore how the Sentinel satellites can support agriculture and farmers' compliance with the CAP, including: **Sen2-AGRI System, G4CAP, RE.CAP, Sen4CAP, FATIMA,** and more…

**Source: Copernicus Market report 2016, PwC*

GNSS (Galileo and EGNOS) is a key enabler for agriculture applications



Highly accurate positioning of machinery allows:

- **Tractor guidance**
- **Automatic steering**
- **Variable Rate Application**

GNSS also allows:

LPIS and OTSC's geo-referencing

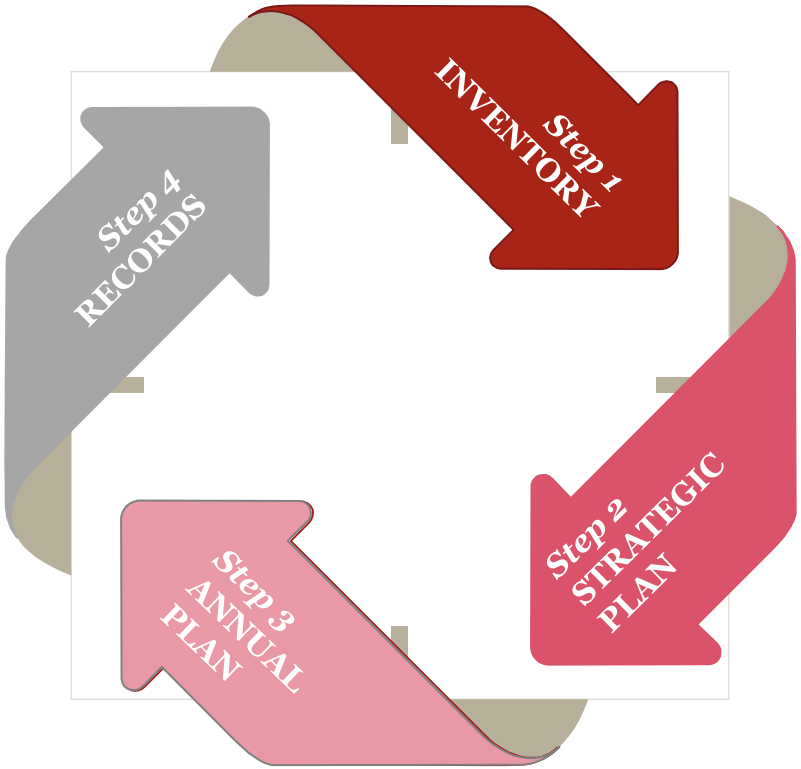
Key Findings

- GNSS applications are used to enable the **integrated farm management concept and support agriculture and farm innovations**.
- GNSS is useful for operations such as: tractors and harvesters' **autonomous driving** and **automatic steering** and **variable rate application**. Other applications include the monitoring of yield and biomass, location-tagging of soil samples, livestock tracking, virtual fencing and field boundary definition.
- Galileo/EGNOS are also useful for **LPIS and OTSC purposes** including the creation of additional map layers and geo-referencing of interest points.
- Key GNSS user requirements in agriculture include: **accuracy** (sub-metre) **availability, continuity, connectivity, interoperability and traceability** for precision agriculture enablers such as receivers, maps and navigation software.
- Key trends:
  - Currently **80%* of automated tractors use EGNOS**.
  - In 2017, about half of the drone's commercial market was coming from agriculture and the association for UVS International forecast that farms will represent 80%* share of this market.
  - Agriculture represents 1,3%* of GNSS global cumulative revenue (2015-2025)
  - The market entry of a dual-frequency chipset in 2017 increased GNSS accuracy from 2.5* meters (single frequency Galileo) to 20-30 cm* path-to path. (GSA, 2017)

*Source: GSA, 2017

There are four general steps within an NMP

Inventory of internal resources (soil and farm) and procedures
Farmers must understand the context: what fertilizers can they use? What type of soil do they have? What historical data?



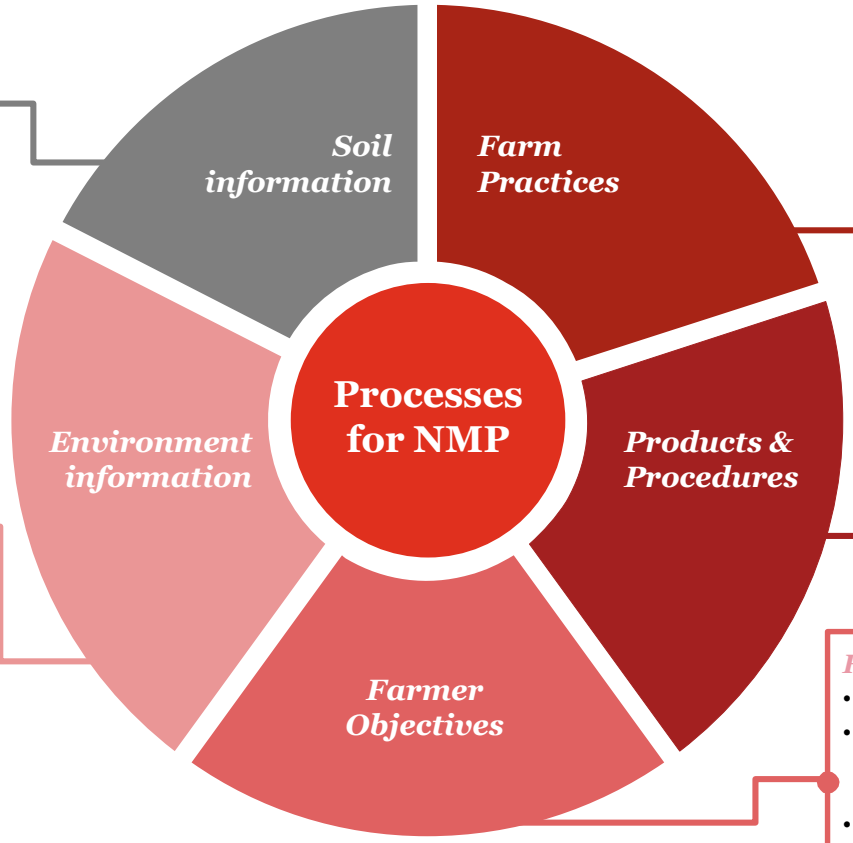
Records are mostly performed in situ. They can be cross-checked with other data like space imagery. The Nutrient Budget is studied. Nutrient checks should be done every 3 to 5 years.

Strategic Plan is a multi-year, long-term vision of NMP. The strategic plan provides guidelines to follow. It should be reviewed on an as needed basis.

Review of the annual plan should be performed prior to each cropping season

Annual Plan defines field specific application rates for fertilizers and manure. The Nutrient Budget is done at that moment. Monitoring long term trends provide better information than a single test. The farmers shall note: rate method and timing of all nutrient applications, but also the source of the nutrients (purchased fertilizers, manure…)

There are certain basic elements that all Nutrient Management Plans should seek to contain



Soil Information

- Inventory of crops/crop rotations by field or by crop groups and expected yields;
- On site tests, e.g. soil sampling, manure sampling
- Inventory of all nutrient sources, e.g. manure, crop residues

Farm Practices

- Historical data - assessing past management practices;
- Techniques - determining preferred application techniques;

Products & Procedures

- When, how to apply manure to maximize economic benefit/minimize environmental impact
- Handling and storage procedures for minimizing the potential for nutrient loss around the barnyard.

Environment Information

- Regulations - Ensuring the nutrient management plan meets legal and industry requirements;
- Environment - Minimizing risk of damage to the environment

Farmer Objectives

- Setting realistic yield goals;
- Nutrient Budget (including a nutrient budget to compare nutrient inputs from all sources with all nutrient outputs;
- The expected yield and type of the crop also will affect the amount of nutrient required

An NMP can be implemented by simple record-keeping or via a complex computer-based tool

01 ***Paper record keeping:*** forms to be filled out for record-keeping and ensure compliance with legislation. It is not necessarily an advisory tool.

02 ***Computer-based tools*** accessible via web-based portals, mobile phone applications, software, etc.

Farmer inputs

Farmers use many cloud-based applications on which they record their data. Aggregated data from farmers creates new opportunities for knowledge-sharing and dissemination

Data libraries

Several international organizations publish data libraries on soils and their properties; some digital-agri companies create proprietary data libraries of crop nutrient requirements, yields and soils, based on data-analytics.

Imagery from satellites, aerial and UAVs

Remote-sensing technologies provide data that can be used for nitrogen optimization. Different spectral indices are utilised, such as NDVI ((Normalized Difference Vegetation Index), CCCI (Canopy Chlorophyll Content Index) and CNI (Canopy Nitrogen Index)

Weather Data coming from satellites

Accurate weather forecasts can be important for decision-making, including timing of planting and fertilizer applications.

In-situ data with soil sampling and field sensors

Soil and plant sampling consist of analysis in laboratories the amount of nutrients

Sensors to measure nutrients can be installed in the field or on machinery such as tractors

Environmental objectives, evaluation methods and progress measures differ among various MS

Countries with regional paying agencies

Paying agencies in MS contribute to implement efficiently European policies such as the Common Agricultural Policy (CAP), they carry out both, **the direct payments (**European Agricultural Guarantee Fund, **EAGF**) and **rural development funds** (European Agricultural Fund for Rural Development, **EAFRD**).

The implementation of the Nitrates Directive (91/676/EC) is mainly based on the delimitation of the designated nitrate-vulnerable zones (NVZ's) where the mitigation measures are applied. **NVZs are designated either for the whole country or for a specific territory.**

National programmes of action are established either following 1) the **Nitrates directive and mandatory codes of good agricultural practice** or 2) as **an integral framework** of action following **the Nitrates Directive and the EU Water Directive (2000/60/EC).**

Monitoring programs evaluating the effectiveness of the mitigation measures remain **highly heterogeneous among MS regions** (sample's geographical localisation, frequency and analysis). (Gault et al., 2015). **N and P thresholds and strategies also differ**, for instance, the Netherlands obtained a derogation for N input threshold and agreed a Phosphorous threshold (Hans et al., 2016).

Down-selection of samples of both H2020 projects and private initiatives to study possible synergies

More than 40 products and services from public and private actors in Europe identified

Downselect according to the solution maturity

2 H2020 projects, 1 ESA project and 3 MS institutional initiatives

- H2020/ESA projects exploit to the utmost the European space capabilities (EO, weather and increasingly GNSS)
- H2020/ESA projects select pilot countries to test their project by ensuring highest diversity of cases (agri practices, climate…)
- Pilot countries differ in their maturity of adopting such solutions. This shows the high heterogeneity inside Europe for agriculture modernization. For example, historically Spain, Italy or Ireland are more inclined to deploy digital tools, compared to a MS such as the Czech Republic.

3 private initiatives

- Private offers mostly rely on remote sensing, do not offer regulatory advice and main objectives are mostly to increase yield rather than reduce environmental impact
- Type of offers are primarily digital services (web-based, applications on tablets, smartphones). Paper-based are more for records and regulatory compliance.
- Historically, customers of mature solutions are large farms and consortiums, but companies are increasingly targeting smaller farms with simpler solutions.

The landscape within Europe is **fragmented**, especially as there is no EU-wide tool. Some MS are far **more advanced** than others in what tools are available, both on the commercial market and from institutional initiatives, and there are MSs who **lack mature solutions**. Beyond this, some farmers are **more confident in utilizing digital tools** than others.

Deployment Option 1:

One platform, with required localizations for each Member State. External services connect to a single common platform.

BENEFITS

sharing of information

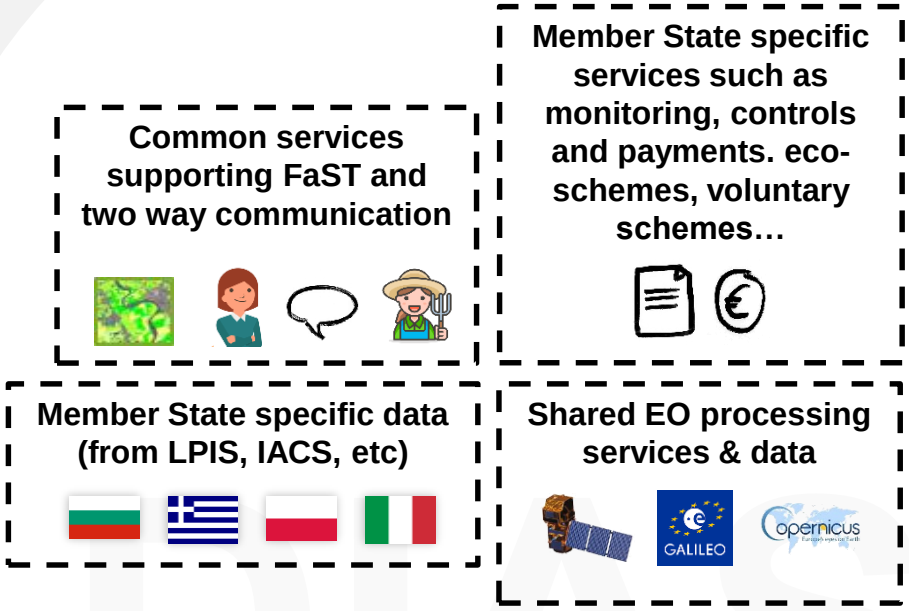
economies of scale

unified access control, security & privacy

common data storage and access

EU-wide user base for new digital services

shared IT services and support



ACTORS & STAKEHOLDERS

Farmer

CAP Managing Authority

Paying Agency

External services:
- advisory
- commercial
- research

Precision Farming

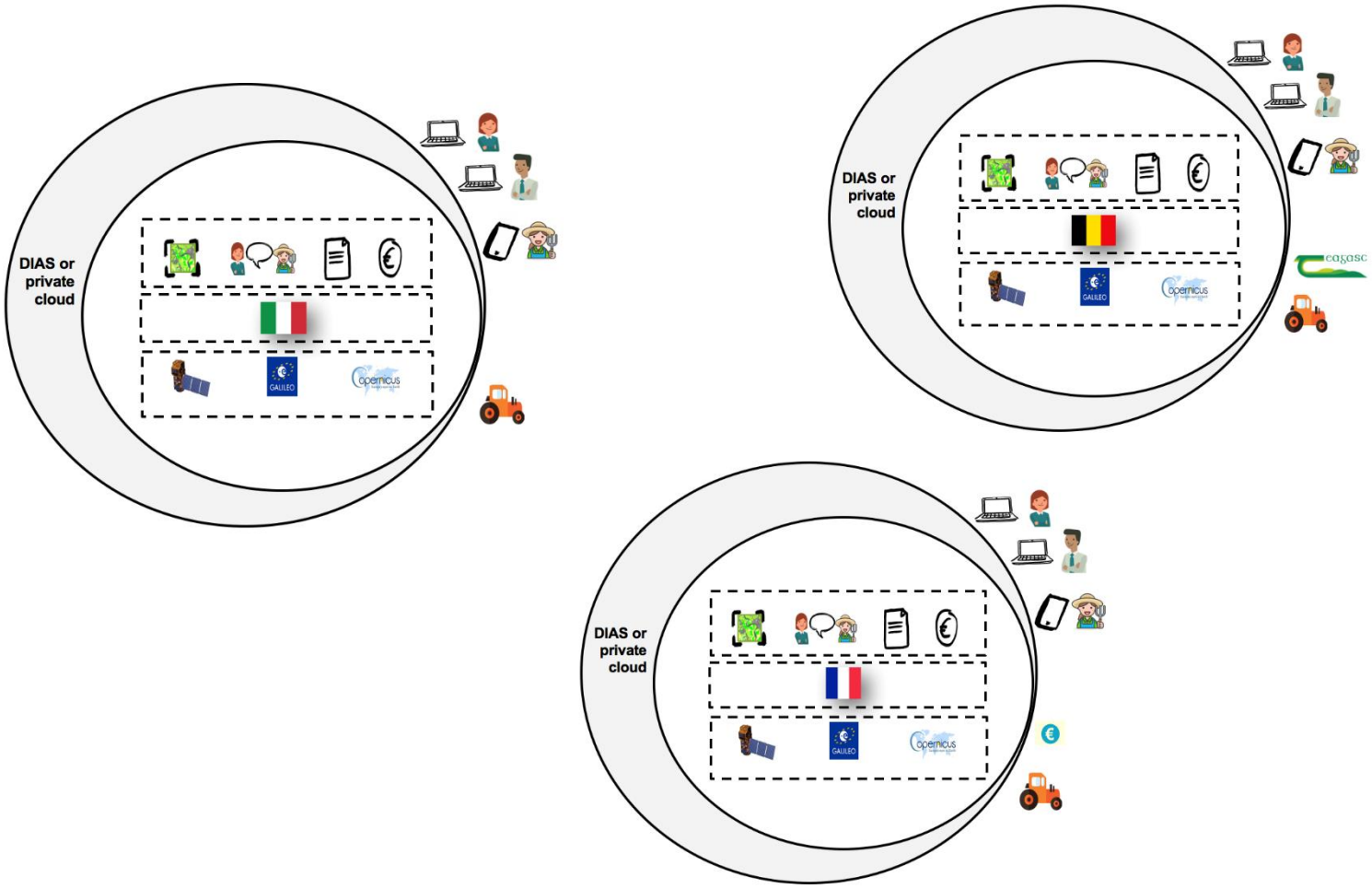
AKIS

JRC EUROPEAN COMMISSION

Scientific, economic, policy data enrichment

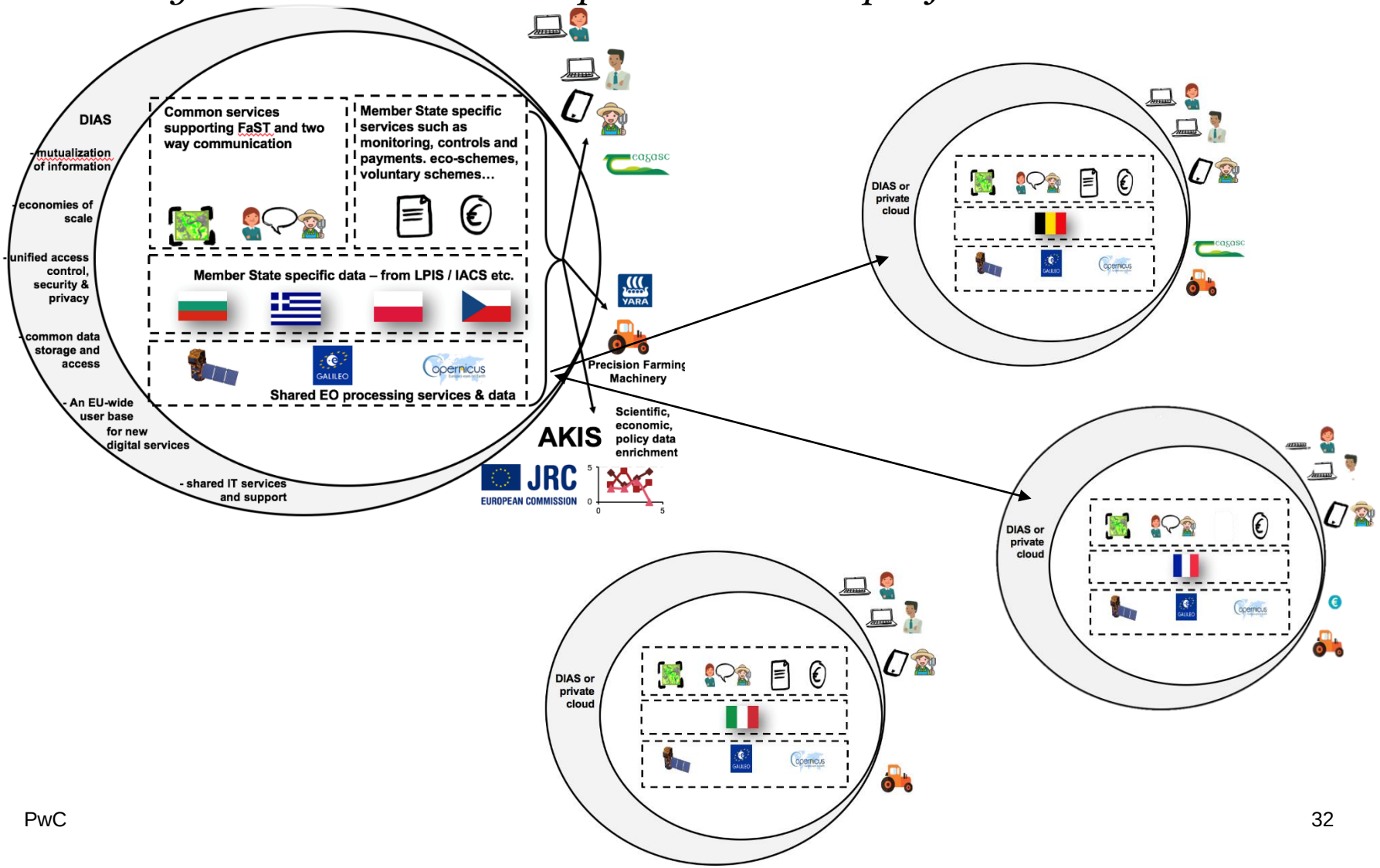
Deployment Option 2:

Each Member State installs and maintains its own platform on a DIAS or other cloud. External services have to connect to each and every platform.



Deployment Option 3:

A mixed option allows Member States to adapt and deploy the FaST solution according to their own needs or opt-in to a shared platform.



Architecture diagram #1 – A FaST platform operated on a DIAS environment

Why microservices? Why containers? Why a container orchestrator?

The prime motivation is to design a platform that **takes advantage of cloud environments** and specifically compatible with all the DIASs.

The platform must by design aim at maximum optimization of the resources it consumes (in other words, deploy only necessary resources as a function of consumption). To do this, the platform is designed to ensure **dynamic scalability** and **deploy/decommission** on-the-fly all the services it is composed of according to their level of use, so as to optimize resources while maintaining quality of service.

The diagram shows all the components involved in the deployment of a module of the NMP/Farm Sustainability tool from the cloud infrastructure to the services' containers.

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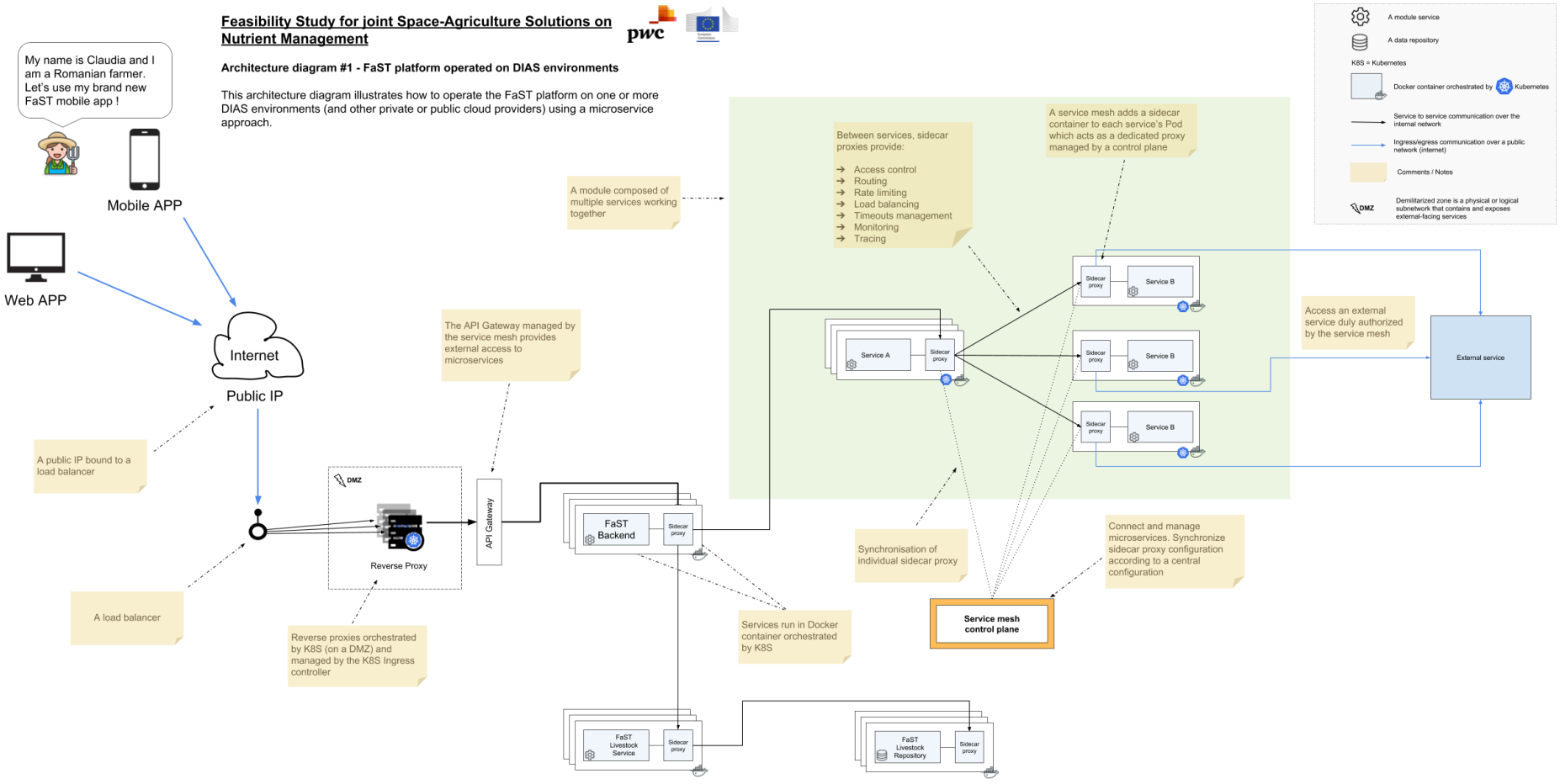
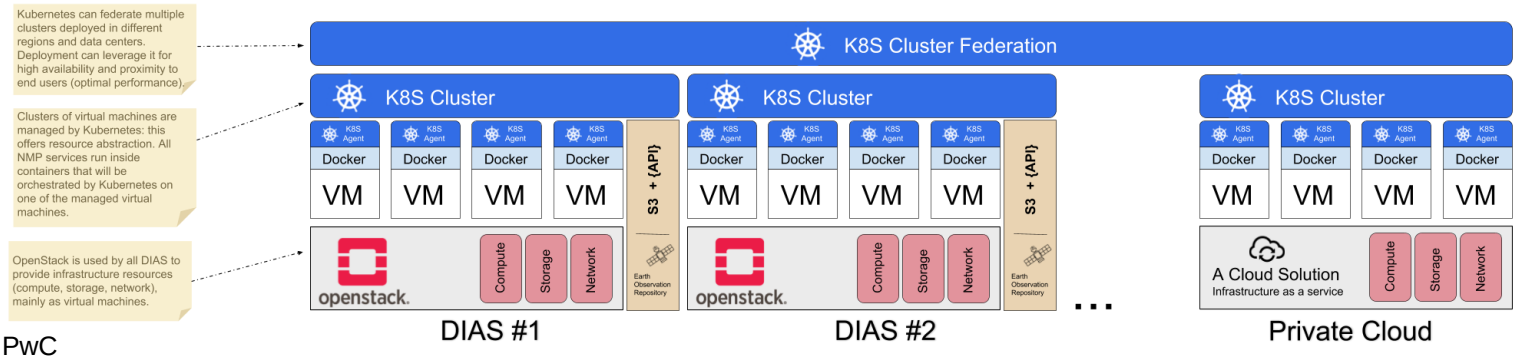
Architecture diagram #1 - FaST platform operated on DIAS environments

This architecture diagram illustrates how to operate the FaST platform on one or more DIAS environments (and other private or public cloud providers) using a microservice approach.





Architecture diagram #2 - Adapting to Member States' specificities

The modularity inherent to a microservice approach makes it easy to adapt the tool to the **specificities of the Member States**. For each of them, a dedicated (micro)service can be deployed and operated.

Depending on the nature of the microservices involved, whether or not it is inherently possible to respect a maximum latency delay for seamless use of the application, it is imperative to keep a synchronous perception of the navigation actions in the application.

If mechanically the processing time is greater than a fixed maximum delay, the synchronous call on the front-end side can be mixed with an asynchronous task.

For instance, ensuring rapid requests of LPIS sources for each member state is not achievable as the diversity of systems and SLAs is varied. To remedy this, an asynchronous task will perform continuous ingestion of LPIS data to a central repository (with on the fly conversion according to each member state’s specificities). The central repository can then be requested synchronously.

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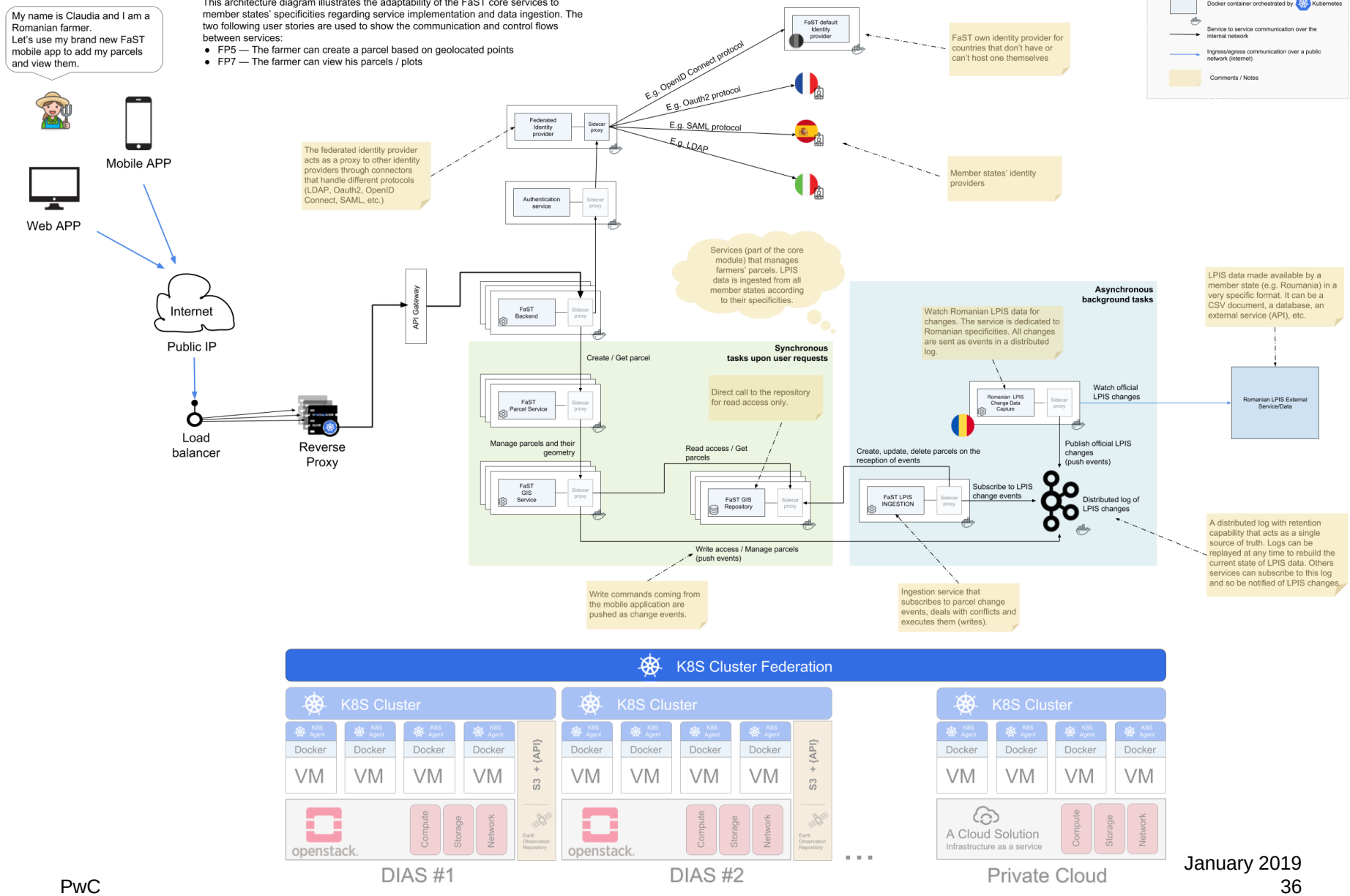
Architecture diagram #2 - Adaptability to member states' specificities

This architecture diagram illustrates the adaptability of the FaST core services to member states' specificities regarding service implementation and data ingestion. The two following user stories are used to show the communication and control flows between services:

- FP5 — The farmer can create a parcel based on geolocated points
- FP7 — The farmer can view his parcels / plots



Architecture diagram #3 - Integration of new modules and external services

The addition of new modules results in the integration of a **set of new (micro)services** to those already existing. The evolving nature of the tool is thus guaranteed.

The diagram shows the integration of two new modules covering water management and weather forecasting. Functionalities managed by one or a set of modules can be exposed to external third-party services (additional services) on behalf of a user (e.g. AgriTask and Teagasc). These same additional services can be used by an internal module to perform outsourceable tasks (e.g. Meteo France as a French weather forecast external service).

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Architecture diagram #3 - Integration of new modules and external services

This architecture diagram shows how the FaST platform can integrate new modules and third party services also called additional services. The following user story is used as illustration:

- AG1 — The farmer can opt-in to additional services available on the platform