HAS#TAG

High Accuracy Service Harnessed Trusted Application and Governance

WP2: REQUIREMENTS

D2.2: Use Cases

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Document Information

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List of abbreviations

AMS – Area Monitoring System
CAP – Common Agricultural Policy
CDSE – Copernicus Data Space Ecosystem
CEADS – Common European Agricultural Data Space
CRCF – Carbon Removals and Carbon Farming
CSRD – Corporate Sustainability Reporting Directive
EC – European Commission
EO – Earth Observation
ESG – Environmental, Social and Governance
FMS – Farm Management System
GDPR – General Data Protection Regulation
GNSS – Global Navigation Satellite System
HAS – High Accuracy Service
MFI – Micro Finance Institution
NDVI – Normalized Difference Vegetation Index
OSNMA – Open Signal Navigation Message Authentication
PA – Paying Agency
PNT – Positioning, Navigation and Timing
PVT – Position Velocity Time
UC – Use Case
WP – Work Package

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Executive summary

The *HASHTAG* (*High Accuracy Service Harnessed Trusted Application and Governance*) project focuses on enhancing data provenance, traceability, and integrity in Earth Observation (EO) and Global Navigation Satellite System (GNSS) data for agriculture. The *D2.2 Use Cases* report outlines how trusted space-based data can support precision farming, regulatory compliance, and financial services by ensuring data authenticity.

In the project a number of principles and technologies are addressed:

- Data Provenance & Lineage: Ensuring EO and GNSS data is traceable and tamper-proof, addressing concerns in agriculture, finance, and regulation;
- Precision Agriculture: The project aims to improve prescription maps, task maps, and as-applied maps, which guide and document farming operations;
- Regulatory Compliance: Ensuring CAP, CSRD, and sustainability (ESG) reporting requirements are met through verifiable data;
- Independent Performance Monitoring: Using EO data for automated compliance monitoring, such as in the EU's Area Monitoring System (AMS);
- Technology Integration: Leveraging Galileo's HAS (High Accuracy Service) and OSNMA (Navigation Message Authentication) to validate GNSS positioning for farming operations.

In this report, five use cases are described:
UC1 - Spinach in baby food: Food industry checks whether a vegetable crop is compliant with standards related to baby food production.
UC2 - Microfinance risk reduction: MFI supporting a farmer with loan, prescribing crop management practices and requiring evidence
UC3 - Certified manure application by contractor: Contractor applying manure collects evidence related to location, application rate and timing based on obligations specified in contract.
UC4 - Targeted soil herbicide application: Optimize the timing, dosage, and location of soil herbicide application in onion farming by using high-resolution Earth Observation data
UC5 - Proof of compliance to CAP eco-scheme regulation: Farmer submits logged machine data as proof of compliance to Paying Agency.

This report is a living document. The abovementioned use cases are expected to cover the diverse applications in the ecosystem adequately, but additions and refinements are still possible based on advancing insights during development. Further refinement of requirements to align user needs with technical capabilities will also take place, and the project will pursue integration of HASHTAG solutions into the agriculture and finance ecosystem, exploring global applicability.

The HASHTAG project aims to establish trusted digital infrastructure that connects farmers, regulators, insurers, and financial institutions, enabling secure, transparent, and efficient agricultural data management.

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1 Introduction

1.1 Data provenance and lineage in space data

The definition of data provenance is the historical record of data that details data's origins by capturing its metadata as it moves through various processes and transformations. Data provenance is primarily concerned with authenticity, providing details such as who created the data, the history of modifications and who made those changes[1]. So, data provenance focuses on the **what, why and who** in the history of data processing and transformations throughout data lifecycle, from generation, evolution to releasing and application. In addition, data lineage provides insights in the **when, where and how** data are changed. Introducing these concepts to data flows will help to improve data quality, credibility, security, reliability and other respects. For GNSS it is relevant to look at integrity of the space signal. Today, the Open Signal Navigation Message Authentication (OSNMA) is an important tool in this respect. For EO data efforts have been undertaken to include lineage (derivation history of a product) to meta-data. Also, initiatives to include a generated hash code have been developed, but less in the context of provenance. The quality assurance of the base data, and of the derivation process is not well covered. The growing complexity of modern data systems and pipelines makes it difficult to track data lineage. Businesses lack complete visibility into how data is transformed and moved across various systems, creating a blind spot for potential issues.

"Since the processes used to extract information presented as evidence from raw EO or GNSS data are very complex and usually beyond the competence of judges or juries, expert witnesses must educate them during their testimony. This situation is complicated by the lack of protocols and standardised methodologies accepted by the courts. Satellite data are processed, filtered, enhanced and interpreted for release by people who may or may not bring their own biases to bear." (EUSPA, 2024)[2]

In agriculture for both the i) "**license to produce**" in the value chain, including performance reporting on ESG subjects, and the ii) "**license to operate**" towards governments, administrations, neighbours, NGOs, etc. including reporting on local impacts, (sharing of) high quality data is required. This might ultimately be used in courts too.

"There is lack of certifications about service accuracy and reliability by a third party different from the vendor." (UCP Agriculture, 2023)

Data provenance and data lineage empower organisations to understand how the data flows and is potentially modified through their systems and through systems of their service providers, by documenting the origin, transformations, and exchanges of data. This transparency allows for proactive identification of potential issues and prevents misinterpretation of data.

1.2 Space data for agricultural transformation

The growing introduction of automated or even autonomous machinery on farms makes the need for good quality data more critical. Moreover, the demand is increasing to log the outputs of those machines for analysis, documentation and compliance. However, current datafiles sent to (task maps), or retrieved from (as-applied maps) machinery lack quality standards on data lineage and data provenance. They cannot be certified because any guarantee on the integrity of the used data and workflow is missing. This is relevant as decision support and performance analyses tools are more and more empowered by AI, requiring trusted and harmonised data sets. HASHTAG is therefore leveraging space assets and services to set up provenance to safeguard the reliability of data ensuring trusted application and governance.

[1] https://www.ibm.com/think/topics/data-provenance

[2] page 197.

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1.2.1 Field operations maps

In precision agriculture field operations, prescription maps, task maps, and as-applied maps represent different stages of the process of planning, executing, and documenting field operations:

1. **Prescription map**

A prescription map is a planning tool that provides variable-rate recommendations based on field-specific data. It defines how much input (e.g., fertiliser, seeds, water, or pesticides) should be applied to different zones of a field based on agronomic analysis. The purpose of a prescription map is to optimise input use for better yield, cost efficiency, or soil quality. Prescription maps are typically presented as geographic information (e.g., shapefiles, GeoJSON, or geoTIFF).

2. **Task map**

A task map is derived from a prescription map but is formatted and adjusted for a specific machine or field operation. It includes technical parameters to ensure compatibility with the machinery being used. The purpose of making a task map is to translate the prescription map into machine-readable instructions. So besides a prescription map, the task map integrates machine settings and operational constraints (e.g., implement width, field boundaries / buffer zones etc.). Task maps are in machine-compatible file formats (e.g., ISOXML, shapefiles tailored to specific systems).

3. **As-applied map**

An as-applied map is a record of what was actually done in the field, capturing real-time application data during operations. Its purpose is to document inputs applied, variations in application rates, and areas covered. It normally consists of data from GNSS-enabled machinery sensors, operational monitors, and real-time system feedback from implements. Format: Geospatial data recorded by the equipment. As-applied maps can also be called 'as-planted map'.

Figure 1 provides a schematic data flow of the three different maps.

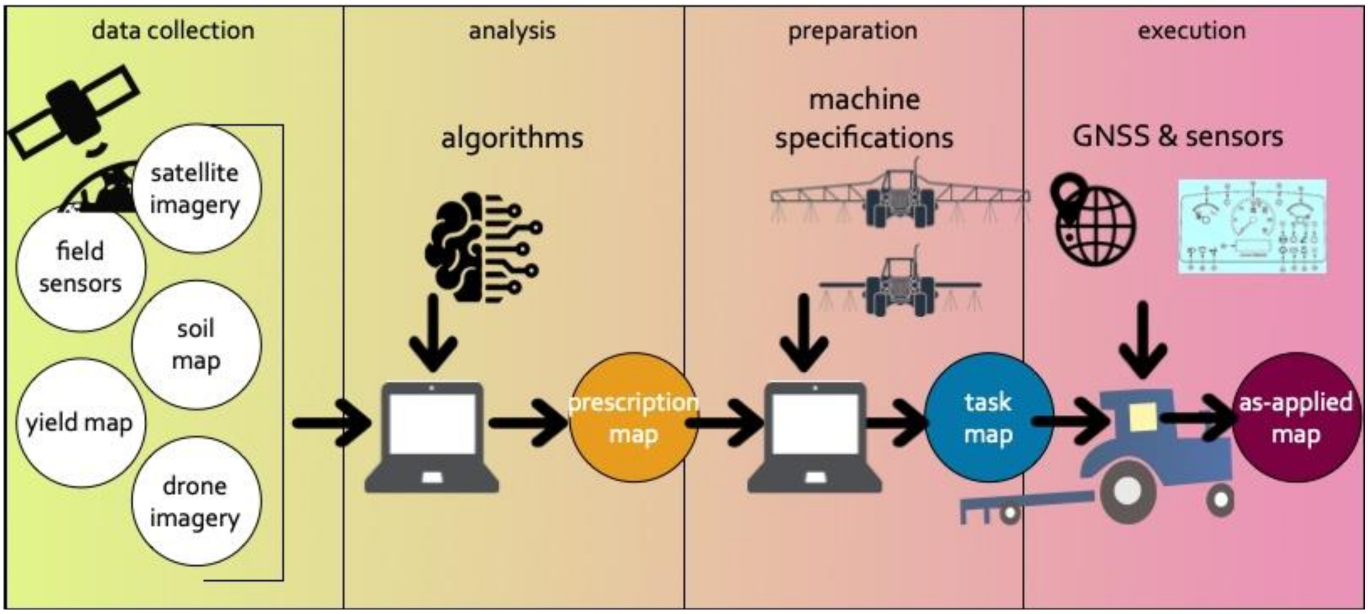

Figure 1: Schematic overview of field operation maps, explaining difference between prescription-, task-, and as-applied map.

The relevance for HASHTAG is that the as-applied map is more and more considered as proof of when, where and how an application is performed[3]. As-applied maps are basically logfiles from machinery

[3]See e.g. https://potatoworld.eu/magazine/01-2023/new-market-for-as-applied-maps/

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including a position and time from the GNSS. Depending on the file format, either proprietary (published formats or not) or open, this can be further processed and visualised as a map in either proprietary software or universal data processing tools. These logfiles, as-applied files, are the connection between field machinery and the office. Therefore, a trustworthy GNSS reading is required-. Also, this as-applied map is executing a prescription map, and it is therefore relevant to record where this prescription map is coming from, which is often a combination of an input source data (e.g. satellite imagery) and algorithms that are based on (scientific) knowledge that represent the translation of the measured values in the input source to an application.

1.2.2 Independent performance monitoring

A second relevant aspect where satellite data needs to be reliable is the independent monitoring of agricultural activity. This is more and more performed with satellite Remote Sensing. It is first of all part of the obligatory Area Monitoring System (AMS) as part of the European Common Agricultural Policy (CAP). Secondly, with the rise of other European initiatives such as the Corporate Sustainability Reporting Directive (CSRD) and Carbon Removals and Carbon Farming Certification (CRCF) Regulation, satellite Remote Sensing becomes more and more an independent source of truth.

1.3 Project overview

The HASHTAG project introduces data provenance and lineage concepts to strengthen how the cutting-edge space technology will revolutionise agriculture. By integrating advanced data provenance concepts to Earth Observation (EO) data from Copernicus satellites and the high-accuracy positioning capabilities of Galileo, HASHTAG aims to empower sustainable, efficient, and precise farming practices worldwide.

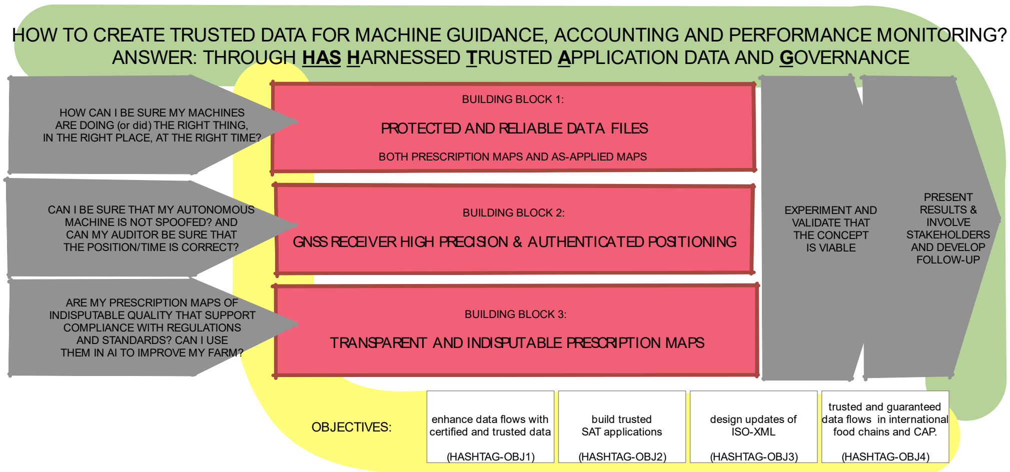

Figure 2: overview of the project, with building blocks and objectives (source: HASHTAG project plan)

The project develops three building blocks:

- **Trusted machinery data flow**: provenance metadata on prescription-, task-, and as-applied maps in end-user data repositories, to have protected and reliable data files;
- **Authenticated and accurate navigational components**: registering HAS and OSNMA in as-applied maps so to have high precision and authenticated position from the GNSS receiver;
- **Certified processing of Earth Observation (EO)**: verify and certify the processing of satellite data towards prescription maps, to assure transparency and indisputable inputs.

Integrating these components will result in a workflow capable of generating a transparent and authenticated data chain of EO data to as-applied maps and maintaining these quality assurance aspects in its downstream processing. This is relevant for current reality, where food production and processing

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are international businesses with ingredients from around the world, governed by food standards and environmental regulations.

1.3.1 Goals

The goals of HASHTAG are:

1. Enhance Data Integrity: Establish trusted, certified data flows between agricultural machinery and data systems, ensuring provenance, lineage, accuracy, transparency, and compliance;
2. Develop Innovative Applications: Utilise Galileo's High Accuracy Service (HAS) and Navigation Message Authentication (OSNMA) to support precise navigation and decision-making in autonomous farming systems;
3. Standardise Practices: Design and promote standardised protocols for creating and validating task and as-applied maps, ensuring uniformity across regions and technologies;
4. Expand Global Impact: Demonstrate the benefits of space-enabled agriculture in diverse contexts, including countries with limited existing navigation infrastructure, such as Serbia, Brazil, and Ukraine.

1.3.2 Expected outcomes

1. Improved Precision Agriculture: Development of task-specific maps for optimized field operations, such as variable-rate seeding and fertilizing, tailored to local conditions and verified for compliance.
2. Trusted Agricultural Ecosystem: Certification systems for data integrity that ensure transparency for regulatory reporting, farm management, and stakeholder accountability.
3. Wider Adoption of Space Technology: Increased use of Galileo and Copernicus programs in agriculture, creating new opportunities for startups, researchers, and policymakers.
4. International Collaboration: Engagement with global stakeholders to create a blueprint for sustainable farming practices driven by space technology.

1.3.3 Impact

HASHTAG addresses critical challenges facing modern agriculture, including sustainability, productivity, and transparency. By fostering the adoption of trusted space data, it will:

- Reduce environmental impacts through precise resource management;
- Support compliance with regulations, such as the EU's Common Agricultural Policy (CAP);
- Promote digitalisation and automation in farming, benefiting both smallholders and large-scale operations;
- Enhance food security and traceability within global supply chains.

By uniting space technology with agriculture, HASHTAG not only innovates but also inspires a future where farming is smarter, more efficient, and environmentally responsible.

1.3.4 Connecting HASHTAG to global data integrity efforts

HASHTAG will seek collaborations with initiatives in European data space development, such as the European partnership "Agriculture of Data" and the Common European Agricultural data space (CEADS), the developments in the Copernicus Data Space Ecosystem (CDSE), projects on data provenance, integrity, and certification, such as the **Sen4CAP project** for agricultural EO validation, **SPACE4GREEN** on OSNMA usage and many others, as well as initiatives around **ISOXML standards, like AgIN initiative from the AEF (Agricultural Industry Electronics Foundation) and the ISO working group on Smart Farming** for data interoperability in farm machinery. By building on existing frameworks, HASHTAG ensures its outcomes are compatible with these ecosystems and sets new benchmarks for trusted data flows in agriculture. Furthermore, the project complements the EU's Green Deal objectives by enabling transparent data governance across supply chains, making it easier for farmers and stakeholders to meet sustainability and reporting obligations. Through this alignment, HASHTAG not only strengthens its impact but also contributes to a cohesive global approach to agricultural innovation.

1.4 Purpose

The purpose of this document "Use Cases" is to describe different situations how users interact with a system to record provenance and lineage of space data. The Use Cases represent real needs of the involved users and describe how a system can be used to accomplish specific goals or tasks. A Use Case describes the interactions between users or actors and the system to achieve a specific outcome.

The growing dependency on data in general, and space data in particular, either EO or SATNAV, introduces new risks that can be mitigated by introducing state-of-the-art data concepts. Organisations that rely on space data must be confirmed in their trust, and organisations that provide services must deliver this trust and/or support the provenance and lineage concepts.

The uses cases as described in this report together with the user requirements are a starting point for dialogue between (potential) users and data and services providers to come to a set of requirements that fulfil this need. It is most likely that this document will be followed by updates after consultation of stakeholders.

1.5 Target audience

This version of the Use Cases report is meant for internal use within the project. The target audience is composed of members of the consortium. The report is considered sensitive and is not publicly available. After validation with users an improved version will be made publicly available.

1.6 Version

In this first version the use cases will be described based on the first version of the persona and user stories (user requirements). The report is considered a living document, so during the project, this document may be further updated and expanded, if needed.

1.7 Related documents

This deliverable is associated with the project plan, annexed to the grant agreement of the HASHTAG project.

1.8 Reader guidance

- Chapter 1 gives an introduction to the HASHTAG project and explains the relation of this use cases document with other project activities and deliverables.
- Chapter 2 describes the methodology and steps taken to derive use cases from the user needs as described in the User Requirements report. It gives an overview of the components of a use case, as background to the HASHTAG use cases as described in the next chapter.
- Chapter 3 includes the HASHTAG use cases. Five use cases have been included, covering the various parts of the area within the system boundary and based on the main categories of actors.
- Chapter 4 gives a brief listing of conclusions and expected next steps

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2 Methodology

2.1 Analysis of user information needs

HASHTAG develops a new concept, with no existing users to interview. The user information needs are derived indirectly and step by step. The analysis is based on the "jobs-to-be-done" theory[4], as explained in the User Requirements report. The 'jobs' various actors need to get done have been analysed through user stories, constructed for several selected relevant personas (stereotyped users).

The use cases are a follow-up of the needs and requirements analysis, however it inverses the 'dialogue' as there is now apparently a 'system' that can be used.

The stakeholder analysis was the starting point for the user needs assessment as it identified relevant stakeholders in the ecosystem. From a holistic point of view, the stakeholders in the ecosystem can be classified in three groups:

- Affected Parties: organisations and stakeholders that would suffer from unknown quality and can potentially be threatened by misinformation;
- Affecting Parties: organisations and stakeholders that can actually do something about the quality assurance;
- Data services providers: the whole value chain of data handling.

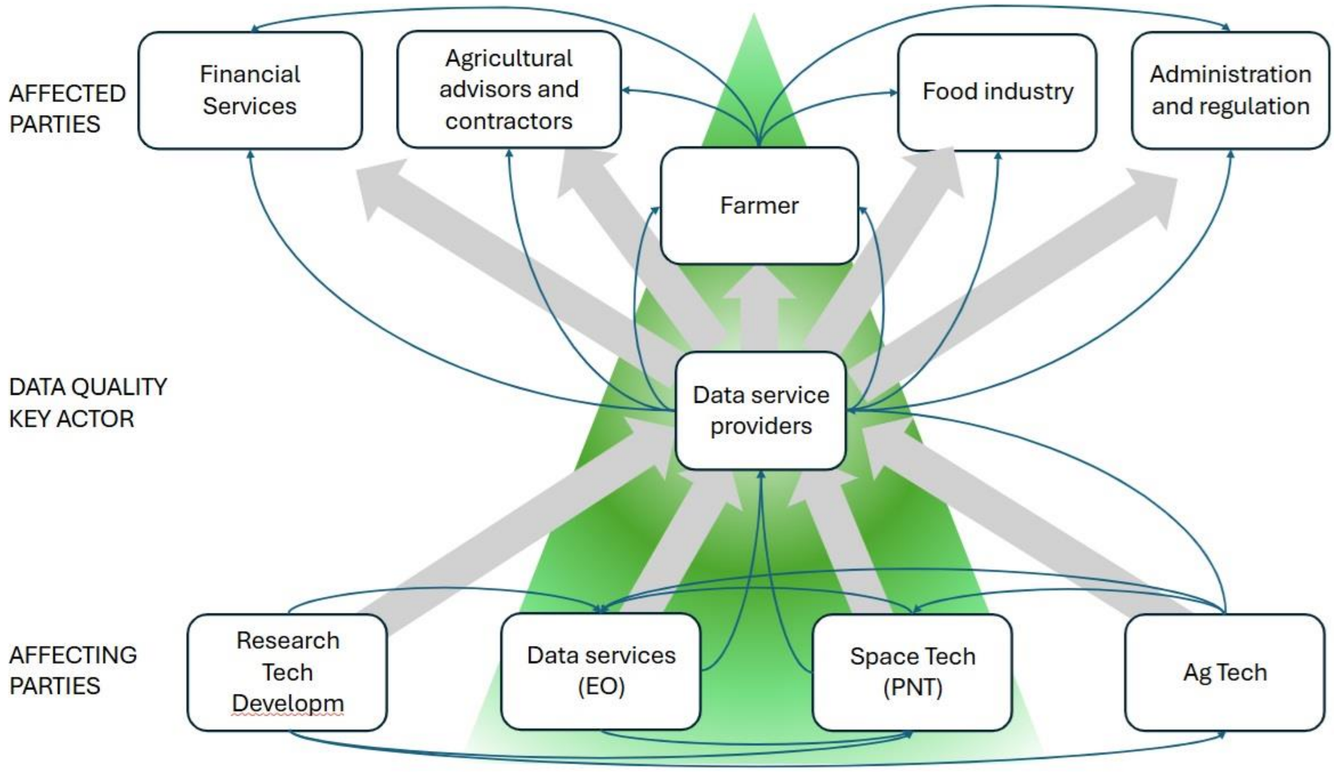

Figure 3: Schematic overview of ecosystem with stakeholders

Affected parties

1. Financial services: for example insurers and banks
2. Agricultural advisors and contractors: external support to farmer, from agronomy to technology and market to operational work, often with specialised equipment.
3. Food industry: post-harvest (downstream) food chain, from traders to processors and retail.

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[4] https://jobs-to-be-done.com/jobs-to-be-done-a-framework-for-customer-needs-c883cbf61c90

4. Administration and regulation: mainly governmental organisations, administering, monitoring and controlling the different agricultural and environmental policies and regulations. Including CAP Paying Agencies.
5. Farmer: the primary production organisations and as the managers of agricultural land, also the primary affected party if something is wrong with the data quality. Depicted in the overview as an intermediate party, as other 'affected parties' may receive their data via the farmer.

Data service providers

6. Various intermediaries in data value chain. Some examples can be found in the EUSPA market report (key companies involved in GNSS and EO).

Affecting parties

7. Research & tech development: universities, research organisations and startups, all playing a role as major change agents
8. Data services (EO): public and private entities that supply satellite data
9. Space Technology (PNT): the 'upstream' segment of the satellite domain, comprising all activities needed to get satellites in place, including their instruments and systems for operating these satellites.
10. Ag Tech: companies that develop agricultural equipment, from machinery to smart devices.

With these groups of stakeholders, different use cases will be developed.

2.2 Development of use cases

2.2.1 From user needs to use cases

Where descriptions of user needs focus on the user from different angles, for example in persona descriptions, user stories, functional and non-functional requirements, use cases focus on the interaction between the user and a system. In a typical description of a use case, a use case diagram shows a process or a few steps in a process. It is often used in software development, although some agile methods prefer to go straight from user stories to code. In HASHTAG, use cases are considered to be helpful in translating 'descriptive' user needs into tangible technical design improvements.

2.2.2 System boundary

As a use case focuses on the interaction between user and system, it is necessary to define the boundaries of this system. Persona descriptions and user stories provide context. When translated into user requirements, there is more focus on specific needs. Use cases are a further step towards the essence.

As HASHTAG is relevant to multiple use cases, the 'system' is not necessarily the same for all use cases. A previous version of this document included a few detailed use cases and a few very general ones. This has been changed into five uses cases covering all 'corners' of the area within a general system boundary. For HASHTAG, this overall system boundary can be broadly defined by the data flow: trusted and certified information to and from agricultural field machinery, and from there to 'affected parties'. Based on trusted data sources and through trusted applications.

HASHTAG will contribute to the use of space data in the agriculture value chain and precision farming. However, it does not address all aspects of 'precision farming' and related technology, policies and applications. It specifically zooms in on data provenance and certified quality.

Each use case covers a part of the overall system. The use cases include a GNSS receiver with HAS and OSNMA capability used for compliance checks, a GNSS receiver used for reduction of risk and cost, GNSS

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and EO-based sensing of manure, EO data for targeted soil herbicide application, and logged machine data as proof of compliance to Paying Agency.

2.2.3 Use case components

As mentioned, a use case is typically visualised in a use case diagram. As a convention, process steps are depicted as oval shapes, and actors and depicted as stick figures.

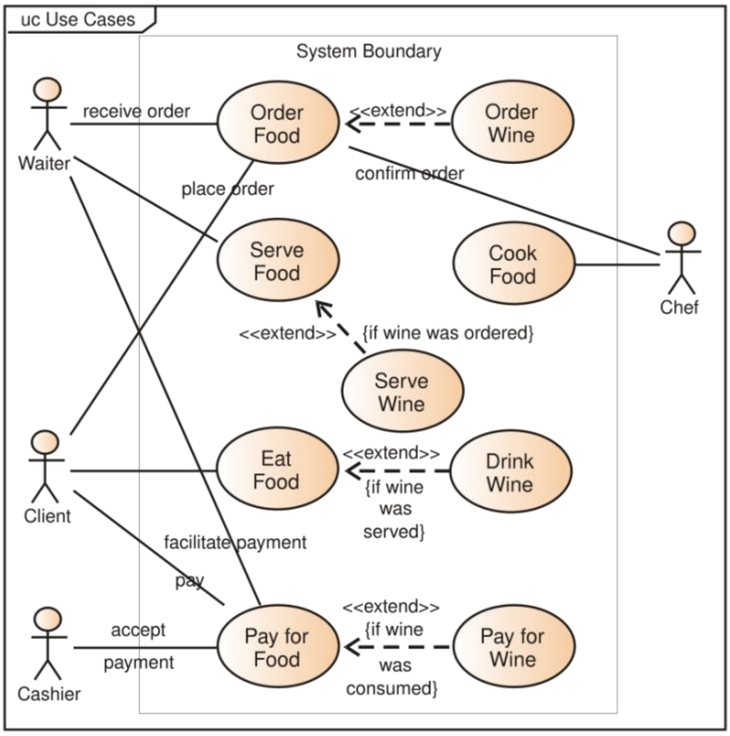

Figure 4: Example of a use case diagram 'customer in a restaurant' (source: Wikipedia)

For a use case description, many preferences and templates exist, but these converge towards the following components:

- Use case name;
- Use case number;
- System: the product or service with defined functionality;
- Stakeholders/actors: anything exhibiting behaviour that interacts with a system, such as a single user, a team, or another piece of software. Identify primary actor (the actor who initiates a system's function to reach a goal), secondary actors and stakeholders (someone with a stake or interest in a system's performance: not necessarily an actor);
- Use case goal: the outcome actors want from a system. Sometimes an actor has more than one objective;
- Precondition: assertions or realities regarding what must occur prior to and following the use case;
- Basic flow: also known as the fundamental flow or main success scenario. A use case that operates flawlessly and exactly as intended with no exceptions or mistakes in the run;
- Alternative flows: deviations from the primary success scenario. This typically manifests when a system-level error occurs. Listed here are the most probable or noteworthy exceptions an actor might make.

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3 HASHTAG Use Cases

For HASHTAG, five use cases have been developed, together covering the various areas within the system boundary:

- UC1 - Spinach in baby food: Food industry checks whether a vegetable crop is compliant with standards related to baby food production.
- UC2 - Microfinance risk reduction: MFI supporting a farmer with loan, prescribing crop management practices and requiring evidence
- UC3 - Certified manure application by contractor: Contractor applying manure collects evidence related to location, application rate and timing based on obligations specified in contract.
- UC4 - Targeted soil herbicide application: Optimize the timing, dosage, and location of soil herbicide application in onion farming by using high-resolution Earth Observation data
- UC5 - Proof of compliance to CAP eco-scheme regulation: Farmer submits logged machine data as proof of compliance to Paying Agency.

In the overall use case diagram on the next page, the main affected parties and affecting parties are included, connected via actions or functions. For the sake of clarity the stakeholders from figure 3 have been reduced to a smaller number of 'actors' in the use case diagrams.

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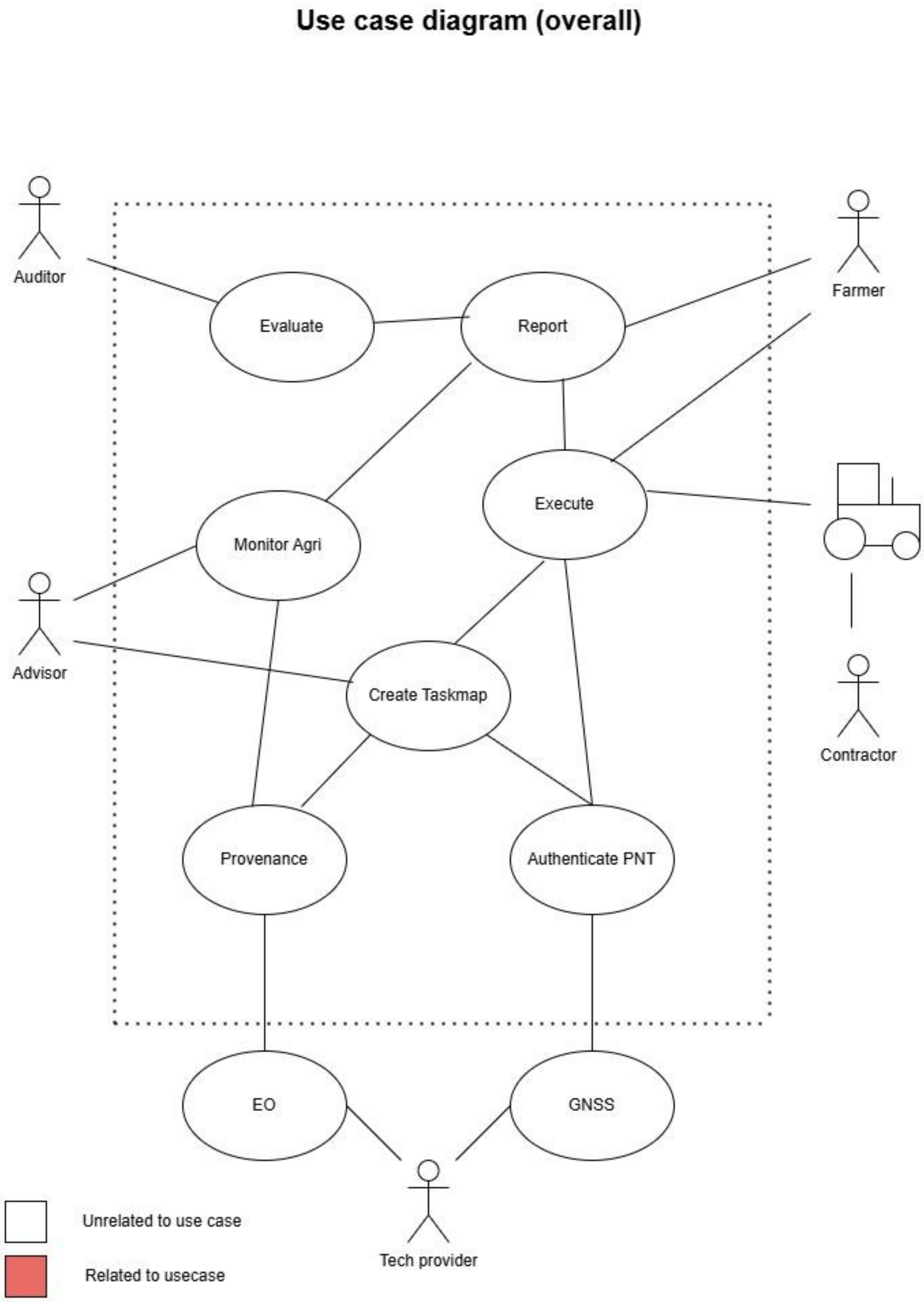

Figure 5: Overall use case diagram

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3.1 Use case 1

Use case nr Use case name	UC1 - Spinach in baby food
System	GNSS receiver with Galileo HAS and OSNMA processing capability
Stakeholders/actors	1. Farmer, spinach grower 2. Food industry, Baby food processor
Use case goal	Baby food production needs to adhere to the highest of standards. The goal of this use case is to provide a food processor the assurance that a farmer has applied a sufficient 'pre-harvest interval' after applying a plant protection product.
Preconditions	1. The farmer grows spinach for baby food production. 2. The baby food processor has an agricultural supply contract with the spinach grower. This includes certification requirements.
Basic flow	• Farmer is compliant and certified as set in the contract • Farmer gives the baby food processor access to the farm management system • Farmer grows its crop and administers accordingly in a farm management system manually. • Farmer links up farming equipment to a farm management system • Farm equipment generates and uploads As Applied maps to the farm management system • Farmer applies spraying schedule as prescribed, and this will be authenticated and logged using OSNMA data and GNSS logged location and timing. • Farmer is compliant and receives a premium for producing spinach according to the contract.
Alternative flows	An alternative flow can for example be that the farmer has a standalone farm management system and shares as applied maps on request to the baby food processor. However, the same authentication principle using OSNMA and GNSS logging applies as will be demanded by the processor.

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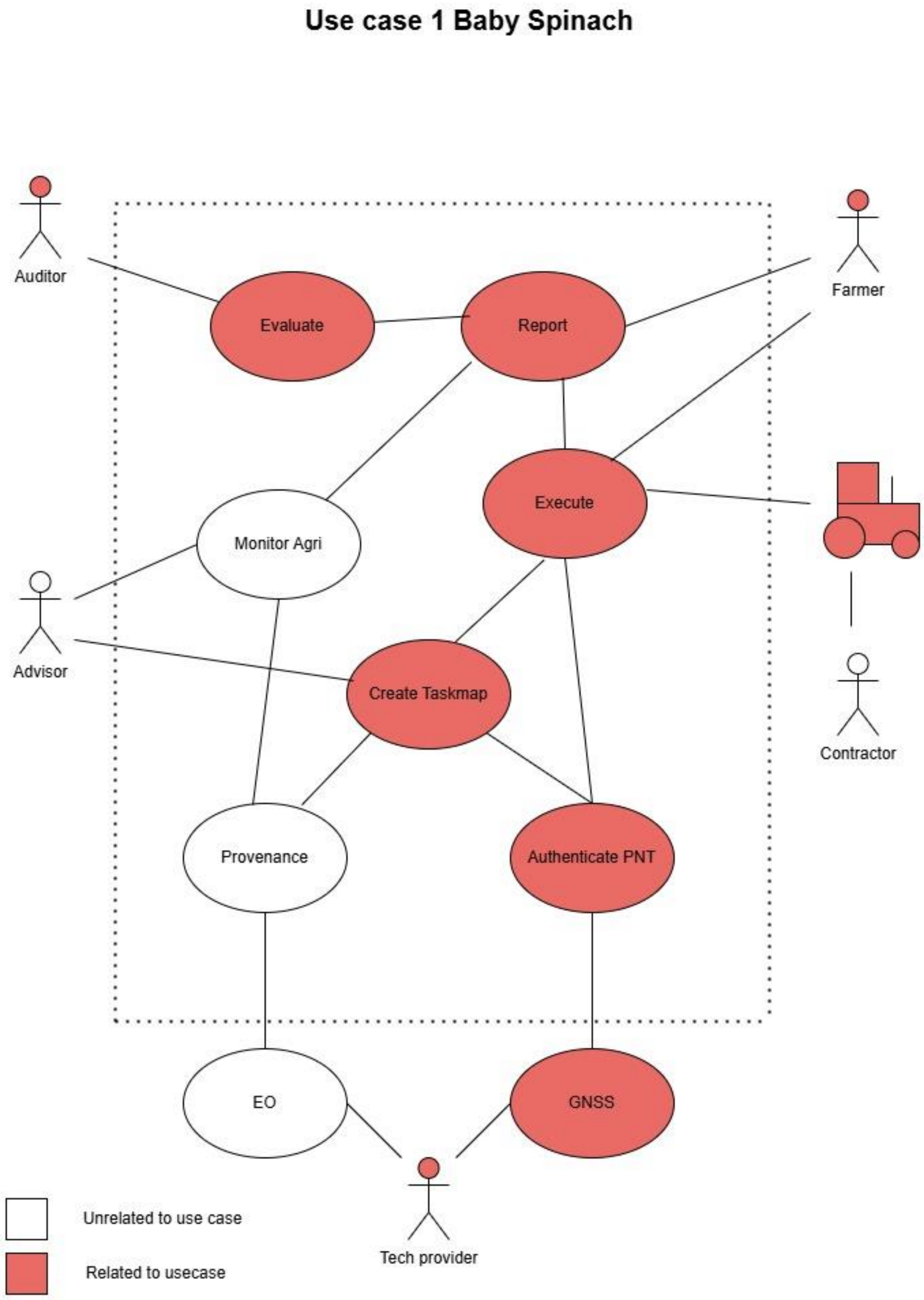

Figure 6: Use case 1 diagram

3.2 Use case 2

Use case nr Use case name	**UC2 - Microfinance risk reduction**
System	GNSS receiver with Galileo HAS and OSNMA processing capability
Stakeholders/actors	1. Small scale farmers 2. Micro Finance Institutions (MFIs)
Use case goal	The goal for the MFI is to reduce the risk of wrongful allocation of funds or defaulting on a loan by farmers. And additionally to provide authenticated crop management advice. This helps an MFI to supply small scale farmers with necessary funding with reduced risk and cost.
Preconditions	1. Farmers in need of financing 2. Micro Finance Institution (or company) having a system in place to be able to either operate or monitor a crop management system sending out instructions to farmers on how to manage their crops. 3. Micro Finance Institution having a system in place to validate field boundaries of what is financed (and insured).
Basic flow	• A farmer is in need of financing and applies for a loan at an MFI. • The MFI requests validated parcels by supplying field boundaries. • The MFI makes a risk analysis by checking the field conditions by earth observations. • The MFI approves the loan (based on e.g. collateral and other parameters) and prescribes certain crop management practices *(e.g. late blight management according to an alert service that they run in-house.)* • The farmer adheres to the crop management practices as prescribed by the MFI and this will be authenticated and logged using OSNMA data and GNSS logged location and timing. • The farmer now runs a substantial lower risk of crop failure due to application of best practices) and hence lowers the risk of defaulting on the loan. • This reduces the overall default rate which lowers the overall interest rate required to make the micro-finance business profitable which in turn is a win-win for both farmers and MFIs.
Alternative flows	Alternative flow can include external providers of crop management solutions used by farmers that can be audited by the MFI. The external service providers would need to adhere to the authentication procedure as described above to qualify for the MFI to be used.

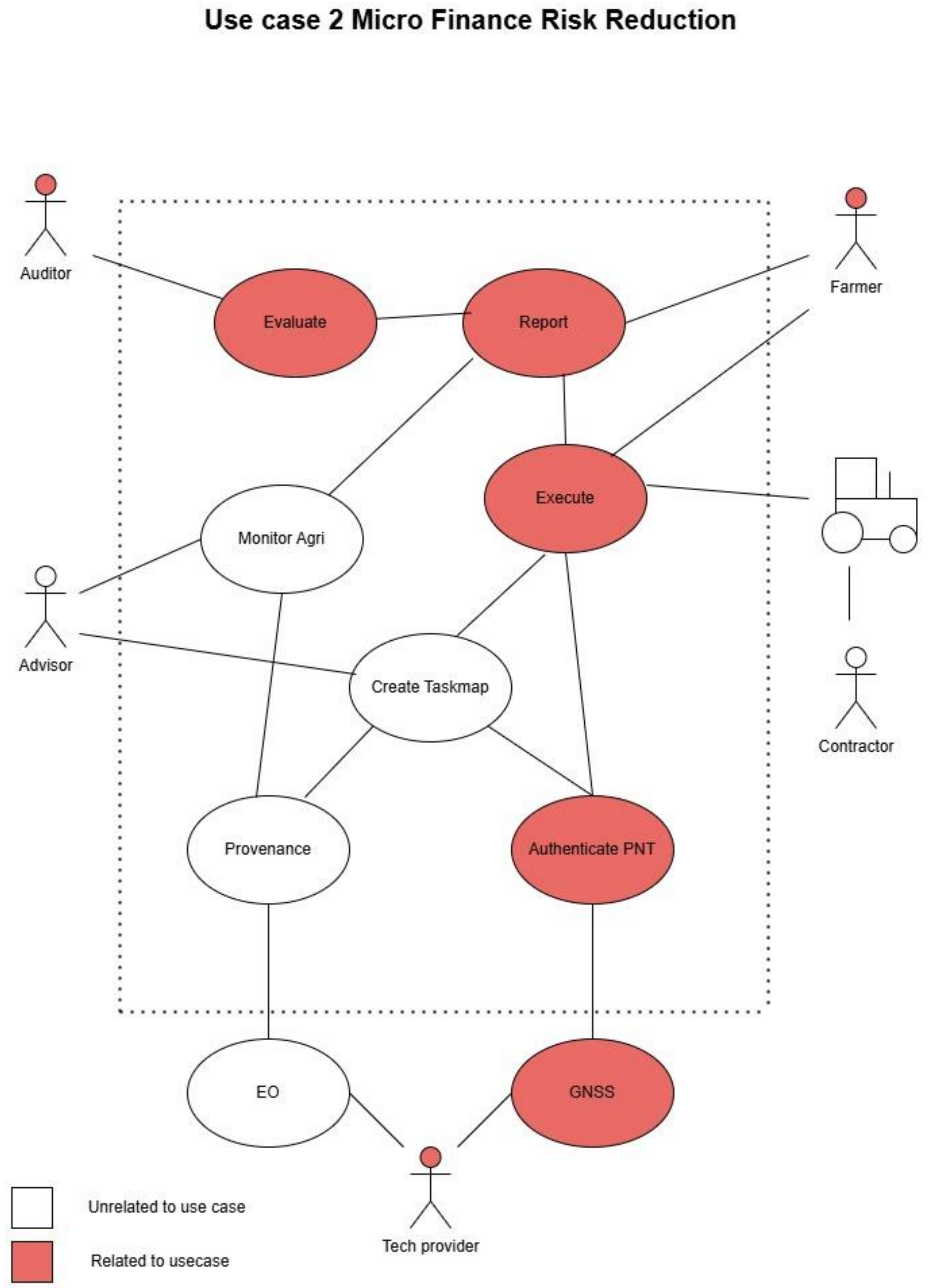

Figure 7: Use case 2 diagram

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3.3 Use case 3

Use case nr Use case name	UC3 - Certified manure application by contractors
System	GNSS-based and EO-supported sensing of manure, soil and leaf nitrogen with OSNMA authentication for a nutrient compliance system
Stakeholders/actors	• Agricultural Contractors (manure and fertilizer spreading service providers) • Farmers (landowners receiving manure application) • Environmental and Agricultural Regulatory Authorities • Manure Producers (e.g., livestock farms) • Insurance Companies and Auditors
Use case goal	Manure quantity and quality has a huge impact on a succesful crop harvest. Misallocation can lead to spillage in the environment. To ensure transparent, traceable, and compliant manure application by contractors, authenticated data is needed. This requires both GNSS data (e.g., OSNMA) and EO-based verification, thereby supporting environmental regulations (Water Framework Directive, other emission limits, nutrient management plans.
Preconditions	• Contracts and national and internation regulations require more and more verifiable evidence of application location, timing, and rate of manure and fertilizer. • Contractors operate GNSS-equipped manure sensors and application machinery with authenticated location tracking. • EO data platforms (e.g., Sentinel-2, commercial satellites, or drones) are used to monitor field and crop conditions pre- and post-application. Manure transport and nutrient documentation requirements are in place (e.g., nitrogen balance rules, nitrate directives).
Basic flow	• A farmer enters into a contract with a certified agricultural contractor for the application of manure and/or fertilizer, under obligations set by national and EU regulations (e.g., nitrate directive, nutrient management rules). • The contractor plans the operation using digital field boundaries and a nutrient application plan aligned with legal nitrogen and phosphorus limits. • GNSS-equipped application machinery (e.g., slurry tanks or spreaders with authenticated GNSS and sensor systems) is used to execute the application. • The system logs timestamped, authenticated GNSS data including precise location, application rate, and operation start/stop times. • Manure transport documentation (origin, quantity, nutrient content) is integrated into the digital record, ensuring traceability from source to field. Earth Observation (EO) data is collected before and after application using Sentinel-2, commercial satellites, or drone imagery to: • Asses soil nitrogen and in future also phosphate • Measure crop nitrogen • Verify field accessibility and soil conditions (e.g., moisture content)

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	• Detect crop/soil response (e.g., NDVI change, greening) • Monitor adherence to buffer zones, slopes, or no-application areas All GNSS and EO data are synchronized in a secure, certified platform that generates a verifiable application compliance report, detailing: • Application zones and rates • Timing in relation to legal spreading windows • Confirmation of adherence to regulatory and contractual obligations
Alternative flows	• Manual Override: The farmer or agronomist may choose to adjust manure applications based on field scouting if EO data is insufficient (e.g., due to cloud cover). • Automated Application: Integration with automated spraying systems using variable-rate application maps generated directly from EO analytics. • Adverse Conditions Detected: If high soil moisture or unexpected vegetation index shifts are detected, manure application is postponed to prevent leaching or crop stress.

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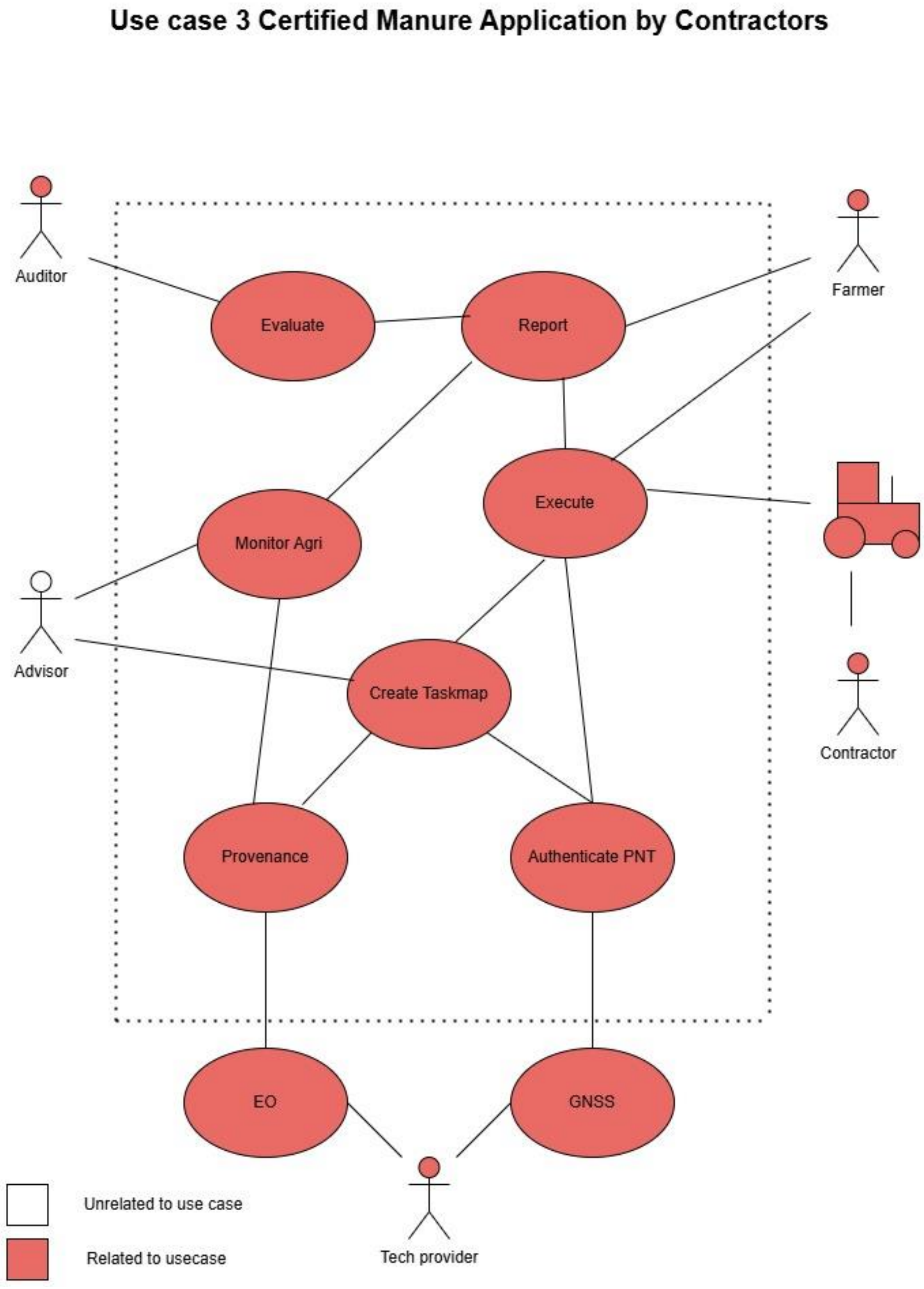

Figure 8: Use case 3 diagram

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3.4 Use case 4

Use case nr Use case name	**UC4 - Targeted Soil Herbicide Application**
System	Earth Observation (EO) data integration platform with crop-specific indices and localized herbicide application advice
Stakeholders/actors	• Agricultural Advisor / Agronomists • Farmers (Onion Growers) • Remote Sensing Data Providers • Input Providers (Herbicide Suppliers) • Environmental Monitoring Authorities
Use case goal	The goal of this use case is to optimize the timing, dosage, and location of soil herbicide application in onion farming by using high-resolution Earth Observation data to reduce costs, environmental impact, and crop damage while increasing weed control effectiveness.
	• Farmers are growing onions in open field conditions. • Access to high-resolution EO data (e.g. Sentinel-2, PlanetScope, or drone imagery) and vegetation indices (e.g., NDVI, soil moisture, bare soil maps). • Availability of advisory services (public or private) capable of interpreting EO data and issuing localized recommendations. • Local herbicide usage guidelines are digitized and tailored for onion crops.
Basic flow	• An onion farmer subscribes to a satellite-based crop advisory service or collaborates with an agronomist using EO data. • EO data is collected at regular intervals, providing surface reflectance, soil exposure, and moisture content information. • The system analyzes weed growth probability based on EO-derived indicators like vegetation cover, bare soil fraction, and soil moisture anomalies. • A targeted herbicide recommendation is issued—suggesting specific zones in the field where application is needed, including timing and dosage. • The farmer applies soil herbicide accordingly, either manually or using GNSS-enabled precision sprayers. • Post-treatment imagery verifies the impact of the intervention and updates the weed pressure model for the rest of the season. • The process helps avoid overuse or underuse of herbicides, improving crop health and ensuring compliance with environmental standards.
Alternative flows	• **Manual Override**: The farmer or agronomist may choose to adjust herbicide applications based on field scouting if EO data is insufficient (e.g., due to cloud cover). • **Automated Application**: Integration with automated spraying systems using variable-rate application maps generated directly from EO analytics. • **Adverse Conditions Detected**: If high soil moisture or unexpected vegetation index shifts are detected, herbicide application is postponed to prevent leaching or crop stress.

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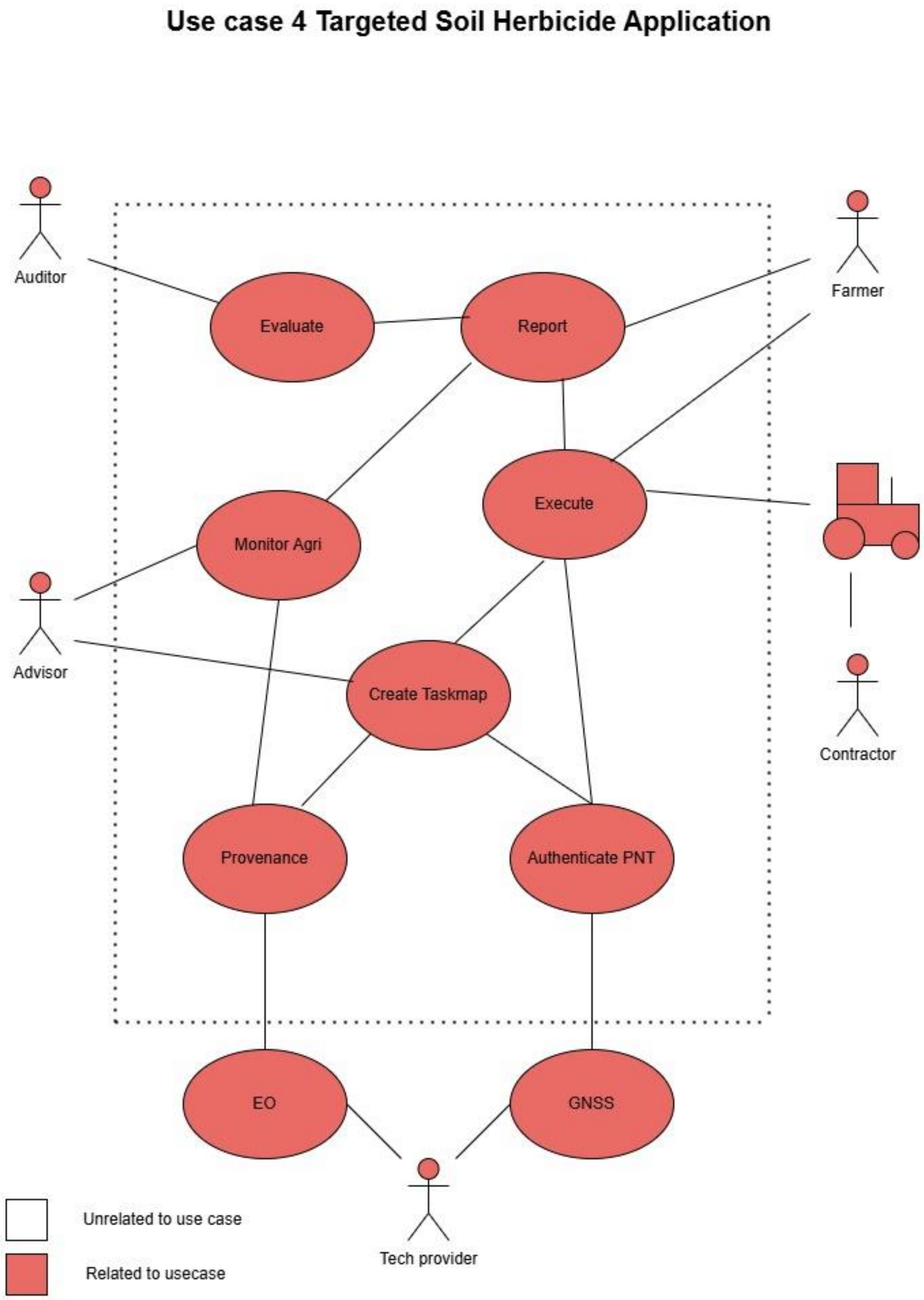

Figure 9: Use case 4 diagram

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3.5 Use case 5

Use case nr Use case name	**UC5 - Proof of compliance to CAP eco-scheme regulation**
System	Farmer submits logged machine data as proof of compliance to Paying Agency, in this case for sowing a catch crop on time.
Stakeholders/actors	1. Farmer (primary actor)
	2. Paying Agency (PA) (CAP payments)
Use case goal	As part of Europe's Common Agricultural Policy (CAP), farmers can get a performance dependent income support. The performance is nationally differentiated, and more and more countries include so-called eco-schemes as an optional measure farmers can take. One of those eco-schemes is the timely sowing of a catch crop after harvest, to avoid losses of nutrients to the environment during the uncropped period. This use case explores and applies the use of data from farm machines, as a new data source for proofing compliance. This use case has two benefits: First of all, it leads to a decrease of administrative burden for the farmer as it may be a logical building block in the embraced improvements to the control systems towards a seamless claim. Secondly, the direct capture of data at machine level can ensure increase in quality (applicability, trustworthiness) when augmented with farmer data (e.g. sowing seed – e.g. barcode from seed bags). Some measures in current CAP (e.g. mixed seed catch crop) are difficult to control and are therefore laborious and costly or even not considered by paying agencies. Thus, using such machine data could lead to a further reduction of the administrative costs and reduction of possibilities for errors for the PA, and hence contribute to sustainable, regenerative and climate-smart farming practices.
Preconditions	HAS and OSNMA capable GNSS receiver
	FMIS that can manage secure GNSS data
	HAS and OSNMA capable prescription map (optional)
	PA Portal that can ingest secure GNSS data

Basic flow	• The farmer selects the field designated for a catch crop following harvest and prepares the sowing equipment.
	• The seed lot barcode is scanned for traceability (e.g., species mix, seed certification).
	• The farmer verifies GNSS equipment is operating with active OSNMA/HAS signals, confirming secure positioning.
	• Sowing operation begins, and machine sensors log:
	    o GNSS-tracked time and location
	    o Seeder parameters: spreading width, seed density, speed, and direction
	    o As-applied data that confirms coverage and dose
	• Data are stored and processed in the FMIS, which calculates total area served and identifies any gaps or anomalies in OSNMA authentication.
	• Upon completion, the farmer submits the as-applied map and metadata (seed type, time, area) to the Paying Agency's digital portal.
	• The Paying Agency reviews the claim, validates the spatial-temporal compliance (e.g., sowing window met, field boundaries respected), and approves the eco-scheme payment.

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Alternative flows	1. GNSS Authentication Gaps**:** If OSNMA/HAS signal is temporarily lost, the FMIS flags unauthenticated segments. The PA may choose to request clarification or accept partial evidence based on risk-based control models.
	2. The seeding operation can be executed by a sowing drone such as the DJI AGRAS T50. This then will involve a drone operator.

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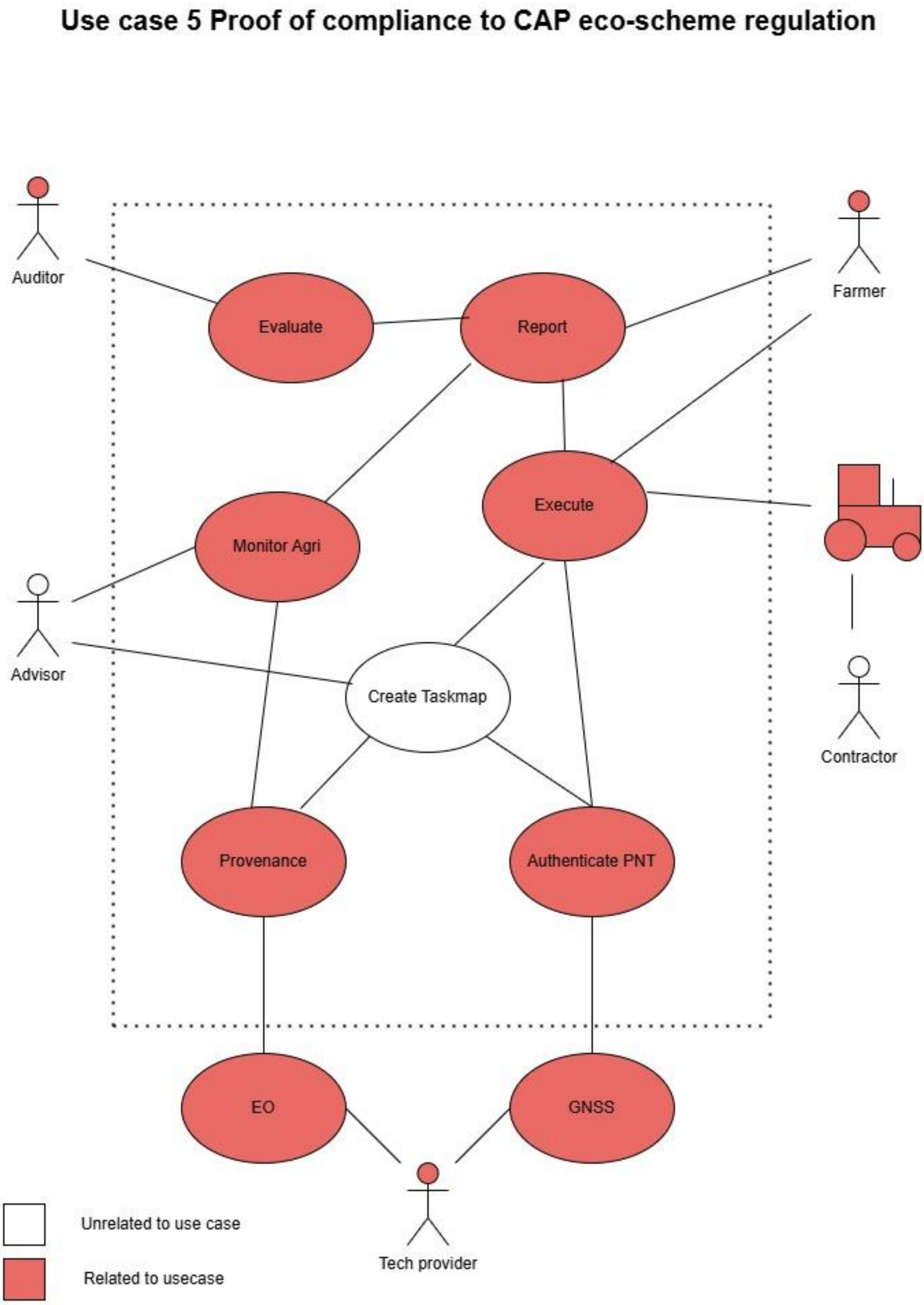

Figure 10: Use case 5 diagram

4 Conclusions and next steps

Translation of user stories into requirements and use cases is not always straightforward. For a complex topic such as HASHTAG, multiple iterations are needed before there is a solid basis for further elaboration of the design.

An important result of the first couple of months of HASHTAG has been the stakeholder analysis. Many of the subsequent steps, such as the persona descriptions and user stories, depend on a thorough understanding of the ecosystem and of the scope of the project. In HASHTAG, a system will be created that does not exist yet. The needs of the relevant actors are in most cases not yet explicitly available. This makes the identification of relevant actors an important first step.

At the start HASHTAG, it was expected that some of the actors would not yet be fully aware of the data quality aspects and the possible implications of using data that is not trustworthy. This meant that some of the user requirements and use cases initially needed to be based on desk study, while simultaneously starting engagement with actors in the ecosystem to proceed with refinement and validation.

A major step towards refinement of the user requirements and use cases has been the execution of interviews. These were organised and executed in the second project quarter, as described in D2.1 User Requirements. Even though a lack of awareness of provenance and authenticity issues was confirmed for many of the stakeholders, the interviews gave a clearer picture of the 'jobs to be done', leading to numerous adjustments in the needs analysis and use cases.

This Use Cases document may be further refined in the course of the project. Large overhauls are not foreseen, since the use cases already cover the various parts of the system. New insights may lead to small adjustments, for example while continuing the interactions with stakeholders in the course of the project, or when translating requirements to specs.

End of Document

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