# Report on User Needs and Requirements

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**Date: 27/09/2022**

**The current version of the Report on User Needs and Requirements is an extract of the Draft document focusing on the user requirements analysis.**

| | Change Log: | | | |
|---|---|---|---|---|
| | 1.0 | Preparatory document to the User Consultation Platform (UCP) 2022.<br><br>Extract of Chapter on User Requirements Analysis | VVA | 27/09/2022 |

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# 1 User Requirements Analysis

This chapter aims at providing a detailed analysis of user needs and requirements pertaining to Insurance and Finance applications introduced before, describing the different roles and needs covered by GNSS and EO and, ultimately, identifying the corresponding requirements from a user perspective.

Table 5-1 below depicts the main applications making use of GNSS and/or EO technologies in Insurance and Finance. The list of applications is non-exhaustive and is expected to potentially grow and adapt according to the expected adoption of space technologies in the coming years and the innovations that should come with it. The current report being the first version of the Insurance and Finance report on User Needs and Requirements relevant to EO in addition to GNSS, it is a living and evolving document that will periodically be updated and expanded by EUSPA in its next releases.

While each one of the applications addressed in this document can benefit from GNSS and/or EO, the current issue of this report does not cover in detail the needs and requirements for all of these applications. A categorisation was performed prioritising some applications based on their maturity level and relevance to the market trends and drivers. Other applications are foreseen to be covered in more detail in future versions of this RUR.

The following applications categorisation reflects the depth of information available in section 5:

● **Application Type A:** these applications correspond to those for which an in-depth investigation is presented, and for which needs and requirements relevant to GNSS and EO have been identified and validated with Insurance and Finance user community at the UCP.

◐ **Application Type B:** these applications correspond to those not selected for in-depth investigation in the current version of the RUR, for which a partial specification of needs and requirements is provided, limited at this stage to the ones relevant to GNSS.

○ **Application Type C:** these applications correspond to EO-based applications, not selected for in-depth investigation in the current version of the document. A high-level description of the application is included considering that they will be further analysed and developed in next versions of the RURs.

Currently, no type C application is part of the analysis. The table below maps the **6** Insurance and Finance related applications to the three above-mentioned types. **The following** list of **applications and their** categorisation are **expected to evolve in the next versions of the document.**

**Legend**

EO only application

GNSS only application

The table for consumer solutions, giving an overview of its subsegments, their applications and categorisations is presented below:

**Table 1-1: Applications and level of investigation**

| Sub-segments | Applications | Types of Application/ Level of Investigation | |
|---|---|---|---|
| **Insurance** | Event footprint | A | ● |
| | Index production | A | ● |
| | Risk modelling1 | A | ● |
| **Finance** | Commodities trading | A | ● |
| | Risk assessment | A | ● |
| | Timing and synchronisation for finance | B | ◐ |

The following section 5.1 first addresses "type A" applications, followed by "type B" applications and finally "type C" applications, for which the level of provided information is currently the less developed. Further investigations will be carried out and the section expanded and completed in the next releases of the RUR.

Each EO-based "Type A" application will cover the needs and requirements for potentially several operational scenarios. For each scenario, a table summarises the EO related needs and requirements. The table template is illustrated below in Table 5-2 and explains the various inputs.

**Table 1-2: Description of needs and requirements relevant to EO table[1]**

| | |
|---|---|
| **ID** | Identifier |
| **Application** | Application covered. |
| **Users** | Common users of the product/service. |
| **User Needs** | |
| **Operational scenario** | **Describes the operational scenario faced by the user, which requires a solution.** |
| **Size of area of interest** | Describes the area of interest (e.g. an agro insurer is interested in a crowd of fields spanning 10 to 100 $km^2$). |
| **Scale** | Describes the scale of interest |
| **Frequency of information** | How often the user requires the information. |
| **Other (if applicable)** | Other user needs such as contextual information (weather data) or file formatting requirements. |
| **Service Provider Offer** | |
| **What the service does** | Description of the service that satisfies the user's needs. |
| **How does the service work** | (Technical) description of how the service works. |
| **Service Provider Satellite EO Requirements** | |
| **Spatial resolution** | Spatial resolution of the satellite imagery/data required by the service provider to realise the service. |

[1] See key EO performance parameters (detailed) definition in annex A1.2.

| | |
|---|---|
| **Temporal resolution** | Frequency of satellite data (revisit time) over the area of interest. |
| **Data type / Spectral range** | Type of data (e.g. RGB, SAR) and spectral range (if relevant). |
| **Other (if applicable)** | Other data requirements. |
| **Service Inputs** | |
| **Satellite data sources** | Type of required data and examples of operational satellites that can provide these data. |
| **Other data sources** | Other sources of data that the service provider uses to realise the service. |

**Disclaimer:** The EO-related requirements presented in the next section should be considered as "work-in-progress". They must be seen as a first attempt to specify requirements relevant to EO and are likely to evolve throughout the UCP process. Current GNSS/EO use and requirements per application

### 1.1.1 Event footprint

**What is Event Footprint?**

Event footprint involves comparing the claims received from insured clients with the actual material damages that occurred in the field in order to determine the amount of compensation that should be paid.

Claim management starts with a formal request by the insured person or organisation to the insurance to be reimbursed for money, goods, or services after incurring a loss. A claims examiner checks that they have complete information and compares it to the policy to verify the loss is actually covered. This usually involves also persons in the field visiting the occurred damage (e.g. taking pictures, talking to the persons). Then, a claims adjuster digs deeper into the specifics of the claim to determine whether or not the insurance company will pay. Overall, it is a time/effort consuming and costly process.

There are two types of observations of relevance:

1. the first one is a monitoring service that allows for continuous change detection of the relevant assets and/or geographical locations (e.g. changes in forest areas).
2. The second one contributes to the in-depth analysis after an event (man-made or natural). This involves information (imagery) before the event (establishing a baseline status) as well as during/after the event, preferably at the point of time of maximum impact/damage. E.g. forest areas can be insured against forest fires and storm breaks (e.g. wind, ice, storm). As forests usually cover large areas and are uninhabited, the happening of such events can go by unnoticed. Therefore, continuous / regular monitoring of the insured areas is necessary. As soon as a relevant event is detected, the extent of the damage needs to be assessed.

Other events (e.g. flooding, landslides, avalanches, hurricanes, earthquakes) and their impact occurring in populated areas can be usually clearly identified at the time of occurrence, as concerned people will report the damage. In such cases, images collected before and during/after an event are required to support the claim management process. Such information may be already sufficient to conclude the claim management process, not requiring evidence collected in the field. E.g. the geographical location of a house in a flooded area may be already sufficient proof. Related processes can be automated increasing the speed and efficiency of the process.

**The use of EO in Event Footprint**

EO data can be used in two ways:

1) When a loss is observable from space and does not need in-field verification, **damages can be evaluated remotely**. This only applies when large-scale, covariate risks such as natural disasters or hazards, such as extensive flooding or fire damage, materialise.
2) Using free satellite imaging, **resources for in-field assessment may be best utilised** (in terms of where to examine first, etc.).

Table 1-3: EO requirements - ID UR-INFIN-001

| **ID** | **UR-INFIN-001** |
|---|---|
| **Application** | **Event footprint** |
| **Users** | Reinsurers, insurers, brokers, insured people and organisations, local authorities, disaster relief organisations, humanitarian organisations |
| **User needs** | |
| **Operational scenario** | • Forests insured against forest fire events and storm breaks<br>• Personal assets insured against damaged by natural events such as flooding, landslides, avalanches, hurricanes and earthquakes).<br>• Agricultural crops insured against damaged by natural events. |
| **Size of Area of Interest** | 1 km$^2$ to > 100 km$^2$ |
| **Scale** | *Pending UCP feedback* |
| **Frequency of information** | There are two frequencies for data capture:<br>1. **Periodically**: An updated view of the baseline situation may be required periodically. Most likely annually when insurance contracts are renewed. (a few times a year)<br>2. **Ad hoc trigger**: Once the natural disaster occurs, information needs to be captured and made available as soon as possible. Multiple captures over time will be required to get a sense of both the maximum damage extent and how/when the situation might improve (e.g. flood waters retreating). |
| **Other if applicable** | Data are usually provided in form of web services. |
| **Service Provider Offering** | |
| **What the Service does** | Provide damage assessment in conformity with the type of insurance, based on EO data are collected from the area of relevance in regular time intervals before during and after an event. |
| **How the Service works** | When an event strikes, geographical delineation maps based on EO are created indicating the impact zone of the event. This information is fed into the insurance claims management process either with direct interface or via web based services. |
| **Service Provider Satellite EO Requirements** | |
| **Spatial Resolution** | • Sub-meter range (e.g. residential properties);<br>• meter range (e.g. assessment of infrastructure);<br>• 10-100 m (e.g. assessing larger events). |
| **Temporal resolution** | Daily to weekly. |
| **Data type / Spectral range** | Different data types or spectral ranges relevant for different types of disasters. E.g. SAR imagery for flooding extent; optical imagery for storm or wind damage; near-infrared (NIR) imagery for damage to vegetation or natural assets |
| **Other if applicable (e.g. non-functional, latency,** | • Reliability of information |

| | |
|---|---|
| **availability of historical data, reanalysis, pre-processing, etc.)** | • Historical imagery before the event to compare the situation with the present |
| **Service inputs** | |
| **Satellite data sources** | • Public: Sentinel-1, Sentinel-2, Sentinel-3, MSG/METOP<br>• Commercial imagery coming from Very High (VHR) and High (HR) resolution optical satellites. Hyperspectral satellites. SAR satellites<br>• GNSS supported ground-based information to confirm the space-based observations complements the data. |
| **Other data sources** | • Weather data for the monitoring of weather effects (e.g. storms, rainfall)<br>• In-situ measurements (e.g. flood depth),<br>• imagery collected from UAVs |

***NOTE:*** *In the case of event footprint, no GNSS requirements will be presented since this is an EO-only application.*

### 1.1.2 Parametric (or index based) insurance

**What is parametric (or index based) insurance?**

The application refers to index-based insurance products. The principle is to exploit satellite images to measure observable and quantifiable parameters and to compute an index from these parameters. The aim is not to measure the risks or impacts of precise natural events.

Used mainly in agriculture, it serves to pay out indemnities based on indexes for potential losses resulting from natural events such as storms, earthquakes, draughts, floods and other events causing crop damage. Thus, index products can be sold by insurers as a protection against various natural disasters.

The insurance then provides pre-specified pay-outs based upon a trigger event where the calculated index reaches the threshold value and "triggers" a pay-out. Typical representatives of such insurances are floods and crop production. Related services are based either on event triggered monitoring (floods) or on continuous change detection (agriculture). In case of flooding, an insured person whose estate is flooded, files a claim to his/her insurance company. In case of agricultural insurances, a continuous monitoring of the relevant area/region is done. If certain environmental conditions are met (e.g. drought, flood, other events), then the pay-out is triggered. As this type of insurances reduces significantly the cost of claim management and the overhead cost of insurances (insurance transaction cost), such insurances become also an attractive means for micro-insurances to smallholders in developing countries.

**The use of EO in Index Production**

EO contributes to calculate indexes such as **soil moisture** and **vegetation growth** used in insurance products covering potential damage coming from mainly **natural disasters** such as floods and droughts and other weather events. The assessment of the satellite images and the determination of the trigger event are usually supported either by AI and ML or by personal assessments.

**Table 1-4: EO requirements - ID UR-INFIN-002**

| | |
|---|---|
| **ID** | **UR-INFIN-002** |
| **Application** | **Parametric (or index based) insurance** |
| **Users** | Reinsurers, insurers, brokers, insured people and organisations, local authorities, disaster relief organisations, humanitarian organisations |
| **User needs** | |
| **Operational scenario** | • Farmers insuring their crops against potential damage caused by weather events<br>• Companies insuring against business interruption exposures stemming from earthquakes.<br>• Private properties insured against damage from hurricanes ensuring fast pay-outs |
| **Size of Area of Interest** | > 100 km² |
| **Scale** | *Pending UCP feedback* |
| **Frequency of information** | Continuous monitoring (daily to weekly). |
| **Other if applicable (e.g. non-functional, data format, contextual information, etc.)** | *Pending UCP feedback* |
| **Service Provider Offering** | |
| **What the Service does** | Index production insurance covers potential losses incurred by natural disasters and pay-outs are quick after a trigger. Compared to traditional insurance products, there is no loss assessment. |
| **How the Service works** | EO data are then translated e.g. into geographical demarcation of an event, or directly into a calculated index/parameter. The policy pays out a lump sum if an event occurs within a predefined geographic area surrounding/affecting the insured asset and the trigger threshold is met. |
| **Service Provider Satellite EO Requirements** | |
| **Spatial Resolution** | 10 m |
| **Temporal resolution** | Daily to weekly |
| **Data type / Spectral range** | SAR imagery for flooding extent; multispectral imagery for damage to vegetation or vegetation stresses (e.g. droughts) |
| **Other if applicable (e.g. non-functional, latency, availability of historical data, reanalysis, pre-processing, etc.)** | • Reliability of information<br>• Historical data is also valuable to understand past trends of the insured event. Particularly in areas where no/limited other historical data is available (e.g. from weather stations). |
| **Service inputs** | |
| **Satellite data sources** | • Sentinel-1, Sentinel-2, MSG/METOP<br>• GNSS based ground-based information to confirm the space-based observations |
| **Other data sources** | *Pending UCP feedback* |

***<u>NOTE:</u>*** *In the case of index production, no GNSS requirements will be presented since this is an EO-only application.*

### 1.1.3 Risk modelling

**What is risk modelling?**

The insurance industry relies heavily on **models for risk assessment**, capital allocation or projecting financial market trends. These models have been built generally relying mostly on historical data. If an asset was insured or what the related insurance premium was, was decided on the location of such an asset and the probability of certain events to hit this asset.

In view of present- and future-day uncertainties introduced by factors such as climate change, interest rates and inflation, among many others, insurers need to debias their risk assessment models and make them also forward looking. Modelled risks need to reflect both past experience, and present and likely future developments. The range of forward-looking variables to consider for insured risks is wide, and different by line of business. E.g. climate change is impacting insurers' assets and liabilities. Rising global temperatures are leading to increased intensity of severe storms and increasing losses when an extreme weather strikes areas of high population and economic value. By far the biggest risk driver remains the rapid increase of assets in exposed areas, mainly through urbanisation. As an example, systematic indices and heatmaps for local, industry and sector situations are enabling improved risk scenario analysis.

The type of events that affect more people around the world than any other is flooding, and it is a rising threat. Urbanisation, economic growth, and changing precipitation patterns are all contributing to increased flood losses. Fast-growing cities are often located on coastlines or near rivers that are increasingly prone to flooding. On top of that, development of flood infrastructures, such as sea walls, dams and levees, often lags the expansion of cities and is not keeping pace with the climate trend. Flood is also a complex peril to model. The influence and interplay of various factors such as 'soil sealing,' ageing infrastructure, and climate change create additional challenges compared to other natural catastrophes.

**The use of EO for risk modelling**

Earth Observation via satellites is able to contribute to many of aspects of risk modelling, by including historical data providing imagery of natural events and damages hitting certain geographical areas in the past and supporting the creation of risk maps. These time series of imagery and data on parameters influencing the future risks, allow foresight on future trends introduced by climate change.

The EO requirements for Risk modelling are presented in the table below:

Table 1-5: EO requirements - ID UR-INFIN-003

| **ID** | **UR-INFIN-003** |
|---|---|
| **Application** | **Risk modelling** |
| **Users** | Reinsurers, insurers, brokers, catastrophe modelling companies, |
| **User needs** | |
| **Operational scenario** | • Predict environmental risks from forest fires.<br>• Forecast upcoming crop and climate conditions |
| **Size of Area of Interest** | 100 $m^2$ - > 100 $km^2$ |
| **Scale** | *Pending UCP feedback* |
| **Frequency of information** | **Continuous / regular monitoring** will be required to be able to predict occurring risks as soon as possible as some models only predict for a limited |

| | |
|---|---|
| | time in the future. However, most insurance products are re-evaluated and re-priced **annually**. |
| **Other if applicable (e.g. non-functional, data format, contextual information, etc.)** | Ancillary data from local databases are required to complete the analyses. |
| **Service Provider Offering** | |
| **What the Service does** | The service provides either the most recent information on the current status of the aspects of interest to the insurer (e.g. infrastructure), or time series of historical imagery and data on relevant aspects (e.g. location, extension and impact of an event).<br>Where available, foresight into future trends can be provided, e.g. extension of arid zones, increased drought/flooding risk, rise of ocean water levels, expansion of cities, change of land cover and characteristics. |
| **How the Service works** | Risk modelling companies develop their models that rely on large volumes of data, including EO, to model and predict natural catastrophes. These models are then purchased by insurers and underwriters to develop their insurance products to sell. |
| **Service Provider Satellite EO Requirements** | |
| **Spatial Resolution** | 1 m to 1 km |
| **Temporal resolution** | A few days to a few weeks |
| **Data type / Spectral range** | Optical/SAR |
| **Other if applicable (e.g. non-functional, latency, availability of historical data, reanalysis, pre-processing, etc.)** | There are no specific requirements under this category when it comes to time series of data (either they exist or not).<br>When it comes to foresight of impact of climate change, it should be clear that such foresight is tainted with uncertainty (e.g. with respect to the timeline, intensity, geographical coverage, etc.). |
| **Service inputs** | |
| **Satellite data sources** | Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P, GNSS/Galileo, MSG/METOP |
| **Other data sources** | Depending on the type of risk subject to modelling, a variety of data sources are relevant, especially archived data:<br>• SAR imagery data for infrastructure determination, flooding extensions, subsidence, water level;<br>• Optical imagery for aspects like heatmaps, vegetation, soil and plant parameters, affects and impact of weather events and natural disasters (e.g. cyclones, landslides, earthquakes, volcano eruptions)<br>• Meteorological information for weather related aspects (e.g. floods, droughts, extreme weather events.<br>• Where available and relevant, GNSS supported ground based historic data to complement the space-based data.<br>• Drone based remote sensing data that provides high resolution imagery<br>• Vulnerability data is required (which is asset specific information about its ability to withstand shocks, financial value, rebuilding value, etc.) which can typically not be derived from satellite data and would have to be provided by the insurer or the insured. |

***NOTE:*** *In the case of risk modelling, no GNSS requirements will be presented since this is an EO-only application.*

### 1.1.4 Commodities trading

**What is commodities trading?**

A commodity is a basic good that is used in trade and may be exchanged for other commodities of the same kind. Oil and metal products (such as ore and petroleum) are examples of hard commodities, whereas agricultural products are typically considered soft commodities (e.g. potatoes, wheat, cotton, coffee, sugar, soybeans). To make better and quicker decisions and to have an advantage over their competition in trading on the trading market, users in any commodity market are interested in increasing transparency and knowledge about the current and future availability versus the current and future demand. This is expected to lead to financial gains.

Regarding hard commodities, the users are usually interested in information covering the whole process from production to sale to identify supply demand balance changes. On the example of oil trading, information is required how much oil is stored in storage tanks at the production sites, ports and other large distribution infrastructure and how much oil is extracted (representing the potential supply), how much oil is stored in storage tanks at the buyer sites, how much oil is in the shipping process towards these sites (e.g. with oil tankers), and what is the rate of consumption (representing the potential demand). Such information is then fed into trading models.

Regarding soft commodities (agricultural products), the users are usually interested to get predictions on the yield rates of the next harvest as early as possible in the growing cycle. Knowing as early as possible if there is a crop shortfall in one region will allow them to secure crop orders in another region.. The consequences of climate change with varying impact in different regions worldwide are especially noticeable in soft commodities (e.g. regions with more droughts, regions with more floods) leading in the future to a stronger imbalance between offering (reduced yields) and demand (growing world population).

While there is an increasing understanding of sustainability impacts (e.g. deforestation, pollution of air, soil, water) of various internationally traded commodities. information on these issues is generally more relevant to longer term investment, financing or purchasing decision making. (e.g. risk management in equity investment, reputation risk management linked to loans, selecting suppliers). And less relevant for short term commodity trading decisions based on derivative financial instruments. Where sustainability issues become pertinent for commodity traders is when one off event cause disruption of supply (e.g. hurricanes, oil spills causing seize of operations). The broader financial and reputational impacts from one off (pollution) events will be priced in a (polluting) company's stock price rather than the price of the commodity being produced.



**The use of EO for commodities trading**

Earth Observation is able to provide information on a number of the above-mentioned aspects, e.g. with high resolution SAR imagery the filling status of storage tanks can be observed, with optical imagery the activities at the production sites can be monitored and the rate of oil extraction assessed, transport activities (e.g. truck traffic, loading of ships) can be monitored, with AIS data ship transports can be monitored (e.g. ETA). Other data to complete the modelling process (e.g. oil consumption) are usually available to the traders. For soft commodities, information inputs such as EO, help generate predictions on yield rates and crop shortfalls in certain regions or include information during the sowing period (which type of crop, the total area of a specific crop) and a few times during the growing phase (status of the crops, what is the level of irrigation or fertilisation, are there droughts or floods) ahead of the harvest. Information inputs can be created from optical EO imagery (e.g. NDVI, irrigation). Other commodities like renewable energy requires information on environmental parameters (e.g. solar radiation for PV plants, wind speed and direction for wind power parks, water availability for hydro power). Nowadays more and more information on green/sustainable behaviour is required, as the finance industry is becoming more and more susceptible (image, reputation). Pollution of air, soil, water can be monitored from space

**Table 1-6: User requirements - ID UR-INFIN-004**

| **ID** | **UR-INFIN-004** |
|---|---|
| **Application** | **Commodities trading** |
| **Users** | Traders, banks, hedge funds, commodity producers, commodity buyers, commodity speculators |
| **User needs** | |
| **Operational scenarios** | Traders are aided by EO by providing critical information production, inventories and supply chains. A few examples are:<br>• Traders can predict annual yield estimations and price projections of certain crops;<br>• Estimations of crude oil in storage tanks;<br>• Estimations of amounts of raw material extracted by measuring the size of stacks at mining sites. |
| **Size of Area of Interest** | • **Hard commodities**: 1-100 km$^2$<br>• **Soft commodities**: 100-10,000 km$^2$ |
| **Scale** | *Pending UCP feedback* |
| **Frequency of information** | For **hard commodities**, daily to weekly updates are sufficient (depending on the type of commodity).<br>For **soft commodities** only, few updates (monthly / 2-monthly updates) during the crop growth period are required at specific points of the growth cycle (depending on the crop). If there are significant events (e.g. weather-related events such as flood, drought, storms) influencing the expected harvest result, these have to be reported immediately / as soon as possible. |
| **Other if applicable (e.g. non-functional, data format, contextual information, etc.)** | Pure production and consumption insights will typically be combined with other socio-economic data points that could indicate future demand/supply issues (e.g. policy, economic growth and consumer spending, crises in upstream markets) Information has to be provided in a format that is capable of being integrated easily in existing models of the users. |
| **Service Provider Offering** | |
| **What the Service does** | For **hard commodities** this includes monitoring of ongoing production activities (e.g. oil production, mining), on amount of produced goods, on transport activities, on pollutions (green/sustainable misbehaviour).<br>**Renewable energy commodities** rely on environmental conditions (e.g. weather, wind sunshine, water levels). For these commodities related predictions are provided and fed into existing models.<br>For **soft commodities** observations during the growing cycle are provided and fed into growing models to allow predictions regarding the potential harvest yields. |
| **How the Service works** | Traders extract business intelligence insights from EO data using basic algorithms such as object counting, vegetation indexes, change detection and volumetric measurements. These are then often combined with more advanced image analytics algorithms and Deep Learning models. Some traders might develop their own algorithms and ingest raw EO data and other traders rely on derived ready to use products. |
| **Service Provider Satellite EO Requirements** | |
| **Spatial Resolution** | • **Hard commodities**: < 1 m to 100 m.<br>• **Soft commodities:** *Pending UCP feedback* |
| **Temporal resolution** | Daily (e.g. renewable energy) to weekly (yield predictions). |

| | |
|---|---|
| **Data type / Spectral range** | Multispectral, optical and radar can all be relevant. |
| **Other if applicable (e.g. non-functional, latency, availability of historical data, reanalysis, pre-processing, etc.)** | Information has to be available in time and reliable. If the EO data used or the system used is not reliable, this can result in immediately in financial losses, and are detrimental to any service. |
| **Service inputs** | |
| **Satellite data sources** | Sentinel-1, Sentinel-2, GNSS/Galileo, MSG/METOP as well as commercial satellite data. |
| **Other data sources** | Depending on the type of commodity observed, a variety of data sources are relevant:<br>• Where available, ground based information to confirm/verify the space-based observations.<br>• Non-geospatial information would include pricing and transaction data, regional/national economic output or consumption statistics etc. |

***NOTE:*** *In the case of commodities trading, no GNSS requirements will be presented since this is an EO-only application*

### 1.1.5 Risk assessment

**What is risk assessment?**

Risk assessment for finance is the process of analysing potential events that may result in the loss of (financial) value of an asset, loan, or investment and is one element of risk management. It usually includes an analysis of the history and assessment of the current physical situation.

- Offshore wind parks: assessing the location and complexity to build and operate the park (influences e.g. CAPEX/OPEX), the environmental threats (e.g. regular storms, high waves) and the expected wind yield (influences profit);
- Infrastructure such as airports, power plants, bridges, mines or housing: assessing the situation of the ground (stable vs. subsidence), the risk of natural disasters (e.g. earthquake, flood, landslide) and whether the ground is polluted. As well as the effect to the environment/people, in case of pollutions caused by the infrastructure (e.g. air, water, ground);
- Agriculture/forestry operational risk analysis: assessing the past crop yields and the weather-related risks (e.g. flood, drought) Assessing the risk of infestations/diseases or pollutions affecting the quality of the harvest (e.g. ground, water, air); and
- Biodiversity risk analysis: to assess the clients/investee company's current or proposed activities in high biodiversity areas. Assess the risk to cause land use changes or pollution impacts in these areas as well as assessing the risk of breaching the bank/investor's policies on biodiversity.
- Assessments on country level of natural events like flooding, fire, earthquake, volcano, etc. in order to define counteracting measures or implement rescue plans on regional/country level.

**The use of EO for risk assessment**

Earth Observation can contribute to the determination of physical various risks associated with a current or future investment. While EO data was historically most relevant to understand immediate physical risks associated with financial assets, there is now a broader set of risks that mainstream financial institutions are interested in understanding as their understanding of climate change and sustainability related issues increases (i.e. the exponential growth of green/sustainable finance). The four major types of sustainability related risks include:

a) **Transition risks**: e.g. Power station operational costs increasing as carbon prices go up and being outcompeted by cleaner technology power production
b) **Physical risks**: e.g. Heavy industry assets facing operational disruptions due to increased flooding or drought events, leading to loss of revenues
c) **Liability risks**: e.g. Extractives company paying millions or billions in fines for environmental damages caused by their operations such as BP's Gulf of Mexico oil spills, or Vale's Bruhmadinho disaster
d) **Reputational risks**: e.g. Bank's clients moving their savings after finding out the bank has been providing loans to companies responsible for deforestation in the Amazon

This is based on the processing of large data series of satellite images for the generation of images, statistics and indicators describing the past situation over a specific area. To ultimately understand trends and potential future evolutions.

If climatic aspects are of importance, such historic analyses may be complemented by climatic change analyses providing foresight on future climatic threats / increased risks. The following table provides an overview of the User Requirements:

**Table 1-7: EO requirements - ID UR-INFIN-005**

| **ID** | **UR-INFIN-005** |
|---|---|
| **Application** | **Risk Assessment** |
| **Users** | Investors (asset owners, asset managers), financiers (banks), companies, individual persons, authorities/governments |
| **User needs** | |
| **Operational scenario** | • Offshore wind parks<br>• Infrastructure<br>• Agriculture/forestry<br>• Biodiversity risk analysis<br>• Assessments on country level |
| **Size of Area of Interest** | • For offshore wind parks the area of interest includes all oceanic area able to impact the construction and operation of the wind park up to shore (for any transport activities); the area of interest will be in the range of 100 km².<br>• The smallest area of interest is related to specific infrastructure (except for linear infrastructure like roads, railways, power/gas/water pipelines) such as buildings, bridges, houses, etc. with coverage areas of hectares up to few km².<br>• For agricultural or forestry areas covering larger land areas in the size of few to max 1000 km².<br>• Risk assessment on country level: 100 to 10,000 km². |
| **Scale** | *Pending UCP feedback* |

| | |
|---|---|
| **Frequency of information** | Typically two frequencies:<br>1. **Ad hoc** when taking an investment decision<br>2. **Annually** for updated risk management or reporting purposes |
| **Other if applicable (e.g. non-functional, data format, contextual information, etc.)** | Coverage of archived imagery and data has to be available for the asset and region under investigation. As well as ancillary data from local databases are required to complete the analyses such as asset-level data (information about a company's assets e.g. their location and operational characteristics) is required to make geospatial datasets relevant and attribute these insights to the company level. |
| **Service Provider Offering** | |
| **What the Service does** | EO based data and insights can be provided directly to the financial institution. E.g. the service collects data from the various data sources and processes the data into easily understandable information. Usually simple maps presenting risk zones (green, yellow, red) are preferred by the users. |
| **How the Service works** | Data and processed information is made available often via web based platforms.<br>EO based data and insights can also be provided indirectly to the financial institution through (financial data/news) intermediaries who combine it with ancillary (financial) datasets. The intermediary will combine geospatial datasets and EO derived indices or risk datasets, asset data and financial information to calculate risk scores (e.g. Value at risk, ESG ratings) at the company level. This allows investors to compare companies and their risk profiles against one another. |
| **Service Provider Satellite EO Requirements** | |
| **Spatial Resolution** | Assets: 10 m or less<br>Weather parameters: > 1 km<br>Air pollution: around 100 m |
| **Temporal resolution** | Weekly |
| **Data type / Spectral range** | *Pending UCP feedback* |
| **Other if applicable (e.g. non-functional, latency, availability of historical data, reanalysis, pre-processing, etc.)** | Historical data is a necessity for the risk models to be as accurate as possible. |
| **Service inputs** | |
| **Satellite data sources** | • Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P<br>• Commercial satellite data for high value or high impact risks or high-risk exposure.<br>• Where available or required, GNSS supported ground base information linking the location and key information to confirm the space-based observations. |
| **Other data sources** | *Pending UCP feedback* |

***NOTE:*** *In the case of risk assessment, no GNSS requirements will be presented since this is an EO-only application.*

### 1.1.6 Timing and synchronisation for finance

Timing and synchronisation are two distinct functions that can be fulfilled using GNSS.

**Timing**: is the marking of an event with respect to a reference origin, usually UTC (Coordinated Universal Time), or more precisely a realization of UTC maintained by a time laboratory, named UTC(k), as UTC does not exist in real time. The precise time user requires the time tagging of events (also called Time stamping). Time stamping refers to the use of an electronic timestamp to provide a temporal order among a set of events.

**Synchronisation**: deals with understanding the temporal ordering of events produced by concurrent processes. Two clocks can be synchronised between them and/or with respect to an absolute time. Synchronisation is particularly important to ensure successful communication between nodes of a network. It is also required in applications in which two events have to be initiated within a specific time frame. In this document, the term “synchronisation” refers to both phase and frequency synchronisation (frequency synchronisation is actually called synchronization).

GNSS can be used to provide both services:

- **Timing**: GNSS provides a direct and accurate access to a prediction of UTC.
- **Synchronisation**: Either synchronisation between receivers at different locations can be established and maintained using GNSS reference time. Or, a master clock synchronized itself using the time provided by GNSS can redistribute this time to the slave clocks disseminated within the systems.

Financial services rely on very powerful IT systems and networks requiring a high level of availability, security and reliability. Due to their influential status within the financial system and upon national economies, banks are highly regulated in most countries. Nevertheless, the current regulation is obsolete and the current timing requirements are no more linked to regulation but to technical needs although this situation is currently evolving.

In the Finance sector, GNSS time is distributed throughout a network to up to several thousands of machines (client). Usually a GPS antenna is deployed on a roof and it is connected to a PTP or NTP server. It is highlighted that PTP is clearly the future (the whole industry works on it) as it provides sub µs accuracy (instead of millisecond for NTP). However, there is a significant issue with the current version of the PTP protocol which suffers from a single point of failure and is therefore not sufficiently reliable [RD29].

Availability of timing information is very important for banks and stock exchanges.

The finance community is increasingly concerned by GNSS threats (interference but primarily spoofing). Up to recently, considering the currently required accuracy (1 ms) unavailability of GNSS timing/synchronisation information in case of open GNSS services denial was managed by alternate solutions (e.g. NTP, local oscillator) even during a long period of time. This situation should rapidly evolve with the increased requirement for more accuracy (towards µs) and resilience.

Moreover, GNSS as a single source with no authentication is not a service answering the requirement for such CIS as recommended by the Network and Information Security Directive and ENISA policy. A complement solution shall be available.

#### *1.1.6.1 Banks*

Banks rely on very powerful IT systems and networks requiring a high level of availability, security and reliability. Critical operations are performed in dedicated data centres.

GNSS equipment is used for Time Stamping functions, to log events in a chronologic manner and therefore be able to recreate causal links. Typical requirement in terms of accuracy is 1ms for most applications but there is an increased trend for more accuracy linked to regulation requirements.

Banks operate centralized networks with much more machines than Stock Exchanges. Current PTP adoption is directly linked to the accuracy requirement.

Within a particular Bank organisation, time distribution for synchronisation applications is obtained by the use of transfer protocols (e.g. NTP, PTP). Today almost all the main European Banks are already equipped with timing and synchronisation equipment using GNSS technology. The number of implemented GNSS equipment is not foreseen to increase for this segment [RD1] [RD2].

#### *1.1.6.2 Stock exchanges*

The individual Stock Exchange servers apply time stamps to the trades they execute and to the quotes they establish (In the United States, the quotes are sent to the Consolidated Quotation System (CQS) which is an electronic service that provides quotation information for stock traded on the American Stock Exchange).

All stock exchanges are equipped with large data centres holding the exchanges' matching engines in racks of interconnected servers using GPS receivers as timing and synchronisation sensors. PTP adoption is underway in this sector.

It is assumed that today almost all of the main Exchanges are already equipped with the synchronisation equipment using GNSS technology. The number of implemented GNSS equipment is not foreseen to increase for this segment. The regulation requires implementing systems providing µs level accuracy.

As an illustration of GNSS use in Stock Exchanges, 10 000 NTP clients are operated by the New-York Stock Exchange (NYSE) fed by around 10 GPS receivers [RD1] [RD2].

## 1.2 Limitations of GNSS and EO

### 1.2.1 GNSS limitations

Even if GNSS is massively used for Timing & Synchronisation there are several constraints that limit its further growth:

- Spoofing threats and the possible remaining after strategies currently developed by the receiver manufacturers to improve the resilience to spoofing
- Low resistance against interference
- Availability issue for Indoor/Urban use
- Receiver power consumption

### 1.2.2 EO limitations

Although EO imagery is undergoing massive improvements in terms of temporal and spatial resolutions with commercial providers expanding their offers quickly, certain technical limitations of EO are still present such as:

- **Latency of signal**

In the EO domain there has been a trend in recent years towards near real time (NRT)data, together with increased resolution and revisit rates. NRT refers to low latency and fast processing of workflows to deliver EO data and analysis rapidly. This serves the needs of certain users in need of fast responses in fields like emergency response, environmental monitoring for agricultural purposes meteorology. Latency will always exist between satellites and ground sensors, as an inherent quality of space communications, but it is in fast processing capabilities and pre-tasked orders, that the industry is becoming more agile in delivering products and services.

- **Spatial resolution and coverage**

The spatial resolution of EO imagery refers to the size of the smallest feature that can be detected by a satellite sensor or displayed in a satellite image, usually expressed in kilometres, metres or centimetres for the highest resolution. The value indicates the size or length of each pixel in a given image. This varies greatly across satellites and has significantly improved in recent years. The spatial coverage is the swath or band that a circling satellite captures at any given moment in time, that is defined by its orbit, orbital plane and technical capabilities. For certain insurance products, insurers need detailed damage information on individual assets which needs high resolution images.

- **Cloud coverage**

One of the most common interferences that especially optical imagery faces when capturing images of the earth's surface is the abundance of clouds at different altitudes; This is also true for some of the sentinels that operate in the multispectral ranges. Insurers are concerned about the continuity and consistency issues cloud coverage can create by interrupting the service. To mitigate the information loss and this the continuity caused by cloud-coverage, complementary technologies such as Synthetic Aperture Radar (SAR), and a series of processing approaches can be used, increasingly ML and AI that extrapolate information and build on historical data.

- **Archive with homogenous historical data**

The Sentinel Hub services supports various data collections, such as Envisat, ESA, Landsat and commercial collections, from the moment that this data became available. The availability of data is not homogeneous trough time and space and researchers might face data gaps in their investigations. For risk models and index insurance products, companies need consistent historical data to make accurate predictions.

- **Angles**

The absolute accuracy of imagery is not normally given, and off-nadir imagery requires some adaptations and processing to convert it into truly accurate 2D maps. Images can be assembled from multiple angles to complete the gaps created by shadows of buildings in the case of urban settings. Although off-nadir imagery can lead to lower spatial resolution it leads to more ground coverage, which might be more important in emergency situations that require NRT information, where any information is better than none.

## 1.3 Prospective use of GNSS and EO

### 1.3.1 Prospective use of GNSS

Prospective use of GNSS in Timing & Synchronisation
The Reports on User Needs and Requirements on surveying (see **Error! Reference source not found.**) identifies prospective uses of GNSS in Finance this is repeated below:

**Future trends**

GNSS spoofing is seen as an increased threat, in particular when high frequency trading is at stake [RD1] [RD2]. However, contrary to Telecom the Finance industry already put in place mitigation measures (e.g. architecture choice) [RD29]. Indeed, GNSS spoofing in an issue for GNSS source not connected with PTP or NTP technologies but network technologies can help identify and mitigate interference from the GNSS source [RD28]. Moreover, there is more awareness on the GNSS spoofing threat even though the Finance industry would welcome a resilient GNSS solution. Traceability is one of the most important requirements as it is now legally required – see section 5.5.2.3 and it is stressed that GPS is not fully traceable to UTC. Another major parameter is Trustability that requires three-time sources to be available [RD29]. Moreover, there is now a legal obligation [RD16] to be accurate at 100 µs (up to now the "legal" requirement was 1 s). This level of accuracy can be achieved with NTP but with a lot of difficulties whereas PTP provides easily this level of accuracy. However, PTP in its current version has an issue of single point of failure which 6 Links to products datasheets are available in [RD2]. 7 Analysis made in 2017 on 260+ GNSS Timing solutions from 30 manufacturers. can be overcome with some solution (which is therefore not the standard solution). A change of the PTP standard should be envisaged in PTPV3 to make it more robust [RD29]. Finally, even if the requirement for a robust GNSS is met, the Finance industry would always prefer to rely on multiple time sources [RD29]. Prospective use of Earth Observation

The benefits of using Earth observation for Insurance and finance-related applications are recognised and the operational use of EO products and services in the market is continuously increasing, there are still some barriers on why not all players are using EO yet. Listed below are a few key elements that limit the uptake of EO in the **insurance** industry:

- **The conservative nature of the Insurance industry** makes insurers to stick to existing systems and techniques. They take caution adopting new ways as it imposes a risk.
- **Some information requirements are already existing and free of charge** such as daily forest fire hazard assessments that are available on the internet to everyone.

- **A lot of effort needed to incorporate EO analysis tools into insurance products** and insurers might there opt out due to high development costs in terms of resources and time.
- **The required skill set is lacking in the insurance industry** to adopt the new EO methods, as insurers are currently limited to just entering location information on risks.
- **Concerns over continuity and reliability are expressed by insurers** as any system adopted requires a low probability of interruption of service.
- **As the insurance industry structure and its systems are inflexible,** the methods of accessing and using EO data sources need to adapt.

In the **finance industry**, the uptake of EO is becoming increasingly important informing in decision making processes often before markets are impacted. However, the use of EO is held back by three data barriers:

- **The lack of reliable asset level data at required granularity and regularity;**
- **Lack of supply chain data at required granularity; and**
- **Poor adaptation of observational climate and environmental data in financial applications.**

Currently, only for a select few major sectors, **asset data**, including the location, ownership information, and other characteristics of particular assets, is commercially accessible. Asset data and the accompanying information on company trees must be significantly upgraded in order to provide insights with a broad enough coverage to satisfy the majority of use cases. Only then, financial assessment with the help of EO can be used efficiently.

Similarly to assets, **supply chains are also lacking granularity** which blocks the use of EO data to create understanding needed for finance.

Finally, **robust climate and environmental datasets are missing** crucial to finance and investment decisions. Up-to-date, high resolution environmental or climate observational datasets encompassing metrics over a large portfolio are required in order to evaluate asset data against in order to acquire superior environmental and climate spatial financial insights. Depending on the application, different datasets will need to be developed at different temporal frequencies. All will ideally need to maintain methodological consistency with other observational datasets utilised, as well as throughout time and using the same base datasets.

## 1.4 Summary of drivers for user requirements

The following table summarises the main drivers in the GNSS Timing & Synchronisation and EO for Insurance & Finance.

**Table 1-8: Main drivers for GNSS in T&S and EO for Insurance and Finance**

| GNSS | EO | |
|---|---|---|
| **T&S for Finance** | **Insurance** | **Finance** |
| Resilience and reliability<br><br>Security<br><br>Traceability<br><br>High availability<br><br>GNSS Authentication<br><br>Low (1ms) /Medium (10 µs) Accuracy for T&S<br><br>Increasing demand for calibration of hardware equipment delays | High resolution imagery<br><br>High availability<br><br>Accessibility of end-users to EO data<br><br>Cost effectiveness of insurance pay-out processes<br><br>Increased climate change effects availability of historical data | High resolution imagery<br><br>High availability<br><br>Prevention of financial losses<br><br>Increased climate change effects availability of historical data<br><br>Regulation requiring transparency |

# 2 Annexes

## A1.1 Definition of key GNSS performance parameters

This Annex provides a definition of the most commonly used GNSS performance parameters, based on [RD10] and is not specifically focusing on the Insurance and Finance community.

**Availability**: the percentage of time the position, navigation or timing solution can be computed by the user. Values vary greatly according to the specific application and services used, but typically range from 95-99.9%. There are two classes of availability:

- System: the percentage of time the system allows the user to compute a position – this is what GNSS Interface Control Documents (ICDs) refer to
- Overall: considers the receiver performance and the user's environment (for example if they are subject to shadowing).

**Accuracy**: the difference between true and computed position (absolute positioning). This is expressed as the value within which a specified proportion of samples would fall if measured. Typical values for accuracy range from tens of metres to centimetres for 95% of samples. Accuracy is typically stated as 2D (horizontal), 3D (horizontal and height) or time.

**Continuity**: ability to provide the required performance during an operation without interruption once the operation has started. Continuity is usually expressed as the risk of a discontinuity and depends entirely on the timeframe of the application (e.g. an application that requires 10 minutes of uninterrupted service has a different continuity figure than one requiring two hours of uninterrupted service, even if using the same receiver and services). A typical value is 1x10-4 over the course of the procedure where the system is in use.

**Integrity**: the measure of trust that can be placed in the correctness of the position or time estimate provided by the receiver. This is usually expressed as the probability of a user being exposed to an error larger than alert limits without warning. The way integrity is ensured and assessed, and the means of delivering integrity related information to the user are highly application dependent. For safety-of-life-critical applications such as passenger transportation, the "integrity concept" is generally mature, and integrity can be described by a set of precisely defined and measurable parameters. This is particularly true for civil aviation. For less critical or emerging applications, however, the situation is different, with an acknowledged need of integrity but no unified way of quantifying or satisfying it. Throughout this report, "integrity" is to be understood at large, i.e. not restricted to safety-critical or civil aviation definitions but also encompassing concepts of quality assurance/quality control as used by other applications and sectors.

**Robustness** to spoofing and jamming: robustness is a qualitative, rather than quantitative, parameter that depends on the type of attack or interference the receiver is capable of mitigating. It can include authentication information to ensure users that the signal comes from a valid source (enabling sensitive applications).

In this document, characterisation of the robustness against GNSS spoofing is made as follows:

1. Identification of the different types of attacks using Humphrey's spoofing threat continuum
2. For each type of attack, assessment of:

- The cost of attack
- The time to put the attack in place
- The capacity needed to implement the attack
- Deduction form the information here above of the possible profile of attackers

Low, Medium, High, Very High susceptibility to spoofing are defined as follows:

Note: for some users, robustness may have a different meaning, such as the ability of the solution to respond following a severe shadowing event. For the purpose of this document, robustness is defined as the ability of the solution to mitigate interference or spoofing.

**Table 2-1: Low, Medium, High and Very High susceptibility to spoofing definitions**

| *Susceptibility to spoofing* | *Types of attacks* | *Cost of attack* | *Time to put in place* | *Capacity* | *Profile of attackers* |
|---|---|---|---|---|---|
| *Low* | *Plug and play* | > €10 | *A few hours* | *Very little* | *End user criminal* |
| *Medium* | *Record and replay (using SDR)* | Several €100s | *Weeks* | *Limited* | *End users criminal* |
| *High* | Non-synchronised attack (can be done with SDR) | Between €1000 and €100 000s | and €100 000s A few months | *Significant* | *Organised crime* |
| *Very high* | Synchronised attack | More than €1000 000 | From 6 months to a year | *Formidable* | *Hostile nations* |

**Indoor penetration**: ability of a signal to penetrate inside buildings (e.g. through windows). Indoor penetration does not have an agreed or typical means for expression. In GNSS, this parameter is dictated by the sensitivity of the receiver, whereas for other positioning technologies there are vastly different factors that determine performance (for example, availability of Wi-Fi base stations for Wi-Fi-based positioning).

**Time To First Fix (TTFF):** a measure of a receiver’s performance covering the time between activation and output of a position within the required accuracy bounds. Activation means subtly different things depending on the status of the data the receiver has access to:

- Cold start: the receiver has no knowledge of the current situation and thus has to systematically search for and identify signals before processing them – a process that typically takes 15 minutes.

- Warm start: the receiver has estimates of the current situation – typically taking 45 seconds.
- Hot start: the receiver knows what the current situation is – typically taking 20 seconds.

**Latency**: the difference between the time the receiver estimates the position and the presentation of the position solution to the end user (i.e. the time taken to process a solution). Latency is usually not considered in positioning, as many applications operate in, effectively, real time. However, it is an important driver in the development of receivers. This is typically accounted for in a receiver, but is a potential problem for integration (fusion) of multiple positioning solutions or for high dynamics mobiles.

**Power consumption**: the amount of power a device uses to provide a position. The power consumption of the positioning technology will vary depending on the available signals and data. For example, GPS chips will use more power when scanning to identify signals (cold start) than when computing position. Typical values are in the order of tens of mW (for smartphone chipsets).

## A1.2 Definition of key EO performance parameters

*In line with the list of key parameters to be covered in section 6.2 (and definitions provided in particular in MR7 annex 3 when relevant).*

This Annex provides a definition of the most commonly used GNSS performance parameters, based on [RD10] and is not specifically focusing on the Insurance and Finance community.

**Spatial resolution** relates to the level of detail that can be retrieved from a scene. In the case of a satellite image, which consists of an array of pixels, it corresponds to the smallest feature that can be detected on the image. A common way of characterising the spatial resolution is to use the Ground Sample Distance (GSD) which corresponds to the distance measured on the ground between the centres of two adjacent pixels. Thus, a spatial resolution of 1 meter means that each pixel corresponds to a 1 by 1 meter area on the ground.

**Temporal resolution** relates to the time elapsed between two consecutive observations of the same area on the ground. The higher the temporal resolution, the shorter the time between the acquisitions of two consecutive observations of the same area. In absolute terms, the temporal resolution of a remote sensing system corresponds to the time elapsed between two consecutive passes of the satellite over the exact same point on the ground (generally referred to as "revisit time" or "orbit cycle"). However, several parameters like the overlap between the swaths of adjacent passes, the agility of the satellites and in case of a constellation, the number of satellites mean that some areas of the Earth can be reimaged more frequently. For a given system, the temporal resolution can therefore be better than the revisit time of the satellite(s).

**Spectral range** refers to the wavelength range of a particular channel or band over in which remote sensing data must be collected.

**Latency** is the difference between the reference time of the satellite measurement and the time the final product is made available to the user (here the service provider).

## A1.3 List of Acronyms

***Pending: to be completedat the end.

| Acronym | Definition |
|---|---|
| | |
| EC | European Commission |
| EGNOS | European Geostationary Navigation Overlay Service |
| EGNSS | European Global Navigation Satellite System |
| EO | Earth Observation |
| ESA | European Space Agency |
| EU | European Union |
| EUSPA | European Agency for the Space Programme |
| GNSS | Global Navigation Satellite System |
| HAS | High Accuracy Service |
| MR | Market Report |
| EUSPA | European Agency for the Space Programme |
| OSNMA | Open Service Navigation Message Authentication |
| PNT | Positioning, Navigation and Timing |
| R&D | Research and development |
| RUR | Report on User needs and Requirements |
| R&I | Research and Innovation |
| SATCOM | Satellite communications |
| SME | Small and Medium-sized Enterprise |
| SoL | Safety of Life Service |
| UCP | User Consultation Platform |
| | |
| | |
| | |
| | |

## A1.4 Reference Documents

**To be discussed with EUSPA**: Which reference documents from previous RUR do we keep in? Mainly those listed as source for the requirements? Any other documents? To be completed at the end.

| Id. | Reference | Title | Date |
|---|---|---|---|
| [RD1] | GSA Lot4 SC1, D1 V2.0 | Market research and quantification of the timing and synchronisation | 19 January 2014 |
| [RD2] | GSA Lot4 SC1, D2.2 V2.0 | Existing and Potential GNSS TS applications and produc | 30 October 2014 |
| [RD3] | Spoofing GNSS Timing Receivers | Spoofing GNSS Timing Receivers, Tim Frost (Calnex) and Guy Buesnel (Spirent), proceedings ITSF 2015 | November 2015 |
| [RD4] | DEMETRA Time Service User Needs Analysis | DEMETRA “Time Service User Needs Analysis” D05 Public abstract | 15 May 2015 |
| [RD5] | Market Report 4 | GSA GNSS Market Report Issue 4 | March 2015 |
| [RD6] | ] Delivering a national timescale using eLORAN | Delivering a national timescale using eLORAN, Chronos | 07 June 2014 |
| [RD7] | Roseline | Revolutionizing how we keep track of time in cyberphysical systems, URL: http://nsf.gov/news/news_summ. jsp?cntn_id=131691 | July 2014 |
| [RD8] | Timing Accuracy Down to Picoseconds | Timing Accuracy Down to Picoseconds, URL: http:// gpsworld.com/timing-accuracy-down-to-picoseconds | 05 October 2015 |
| [RD9] | Market Report 5 | GSA GNSS Market Report Issue 5 | May 2017 |
| [RD10] | Technology Report 1 | GSA GNSS Technology Report Issue 1 | October 2016 |
| [RD11] | Guidelines for GPS Traceability | Guidelines on the Use of GPS Disciplined Oscillators for Frequency or Time Traceability, EURAMET Technical Guide No. 3, Version 1.0 | March 2016 |
| [RD12] | Impact of GNSS lost on UK economy | The economic impact on the UK of a disruption to GNSS, London Economics commissioned by Innovate UK | June 2017 |
| [RD13] | Legal Traceability of Time, NIST | Legal Traceability of Time, NIST: http://tf.nist.gov/ general/pdf/1433.pdf | 2001 |
| [RD14] | Security and resilience | Critical Infrastructure Security and Resilience, International Committee on Global Navigation Satellite Systems | November 2014 |
| [RD15] | 5G the future of mobile communications | 5G the future of mobile communications, Martin Kingston (RAN) and Andy Sutton (Network Strategy) | November 2015 |
| [RD16] | GNSS Security and Robustness | GNSS Security and Robustness, Shankar Achanta (Schweitzer Engineering Laboratories, Inc) | September 2015 |
| [RD17] | Model-Based Evaluation of GPS Spoofing Attacks on Power Grid Sensors | Model-Based Evaluation of GPS Spoofing Attacks on Power Grid Sensors Ilge Akkaya, Edward A. Lee, Patricia Derler University of California at Berkeley | |
| [RD18] | UTC Traceable Time for the Financial Sector using PTP | UTC Traceable Time for the Financial Sector using PTP, NPL Elisabeth Laier, proceedings ITSF 2015 | November 2015 |
| [RD19] | GPS & precision timing’s role in the financial services sector | GPS & precision timing’s role in the financial services sector, Andrew F. Bach (Juniper Networks) | September 2015 |
| [RD20] | RTS25 Draft regulatory technical standards on clock synchronisation | Annex I MiFID II / MiFIR / MiFID/MiFIR Draft Regulatory Technical Standards - RTS25 “Draft regulatory technical standards on clock synchronisation” | 28 September 2015 |

| Id. | Reference | Title | Date |
|---|---|---|---|
| [RD21] | ] FINRA Regulatory Notice Consolidated Audit Trail (CAT) | National Securities Exchanges and FINRA Issue Joint Guidance on Clock Synchronisation and Certification Requirements Under the CAT NMS Plan | March 2017 |
| [RD22] | NPL Time used by UBS and TMX Atrium | UBS and TMX Atrium use new NPL network timing service www.npl.co.uk/news/ubs-and-tmx-atrium-use-new-nplnetwork-timing-service | Sept 2016 |
| [RD23] | 2008/114/EC Directive | 2008/114/EC Directive on the “identification and designation of European critical infrastructures and the assessment of the need to improve their protection” | December 2008 |
| [RD24] | Homeland Security Researching GPS Disruptions, Solutions | Inside GNSS News, Homeland Security Researching GPS Disruptions, Solutions, Latest News, Dee Ann Divis http://insidegnss.com/homeland-security-researchinggps-disruptions-solutions/ | June 10, 2014 |
| [RD25] | Critical Infrastructure Vulnerabilities to GPS Disruptions | Critical Infrastructure Vulnerabilities to GPS Disruptions Sarah Mahmood, Program Manager, Resilient Systems Division Homeland Security Advanced Research Projects Agency Science & Technology Directorate | 4 June 2014 |
| [RD26] | GPS disruptions effort to assess risks to critical infrastructure and coordinate agency actions should be enhanced | “GPS disruptions effort to assess risks to critical infrastructure and coordinate agency actions should be enhanced”, GAO-14-15 | November 2013 |
| [RD27] | Consultation with Mr Jiri Luhan | Consultation report with Mr Jiri Luhan | February 2012 |
| [RD28] | Consultation with Mr Gilles Boime | Consultation report with Mr Gilles Boime (Spectracom) | February 2012 |
| [RD29] | Consultation with Mr Pedro Estrela | Consultation report with Mr Pedro Estrela (IMC Financial Markets) | February 2012 |
| [RD30] | Consultation with Mr Mats Larsson | Consultation report with Mr Mats Larsson (ABB) | February 2012 |
| [RD31] | GSA-MKD-TS-UREQ233690 | Report on Time & Synchronisation User Needs and Requirements | November 2017 |
| [RD32] | GSA-MKD-T-SMOM-246199 | User Consultation Platform 2018 – Minutes of Meeting of the Timing and Synchronisation Pane | 03.12.2018 |
| [RD33] | MIFID2/RTS25 | COMMISSION DELEGATED REGULATION supplementing Directive 2014/65/EU of the European Parliament and of the Council with regard to regulatory technical standards for the level of accuracy of business clocks | 07.06.2016 |
| [RD34] | High Precision Time (White Rabbit) Pilot | https://www.eurexchange.com/exchange-en/resources/ initiatives/technical-changes/high-precision-time-whiterabbit-pilot | 16.07.2018 |
| [RD35] | Market report 7 | EUSPA EO and GNSS Market Report 2022 issue 1 | January 2022 |
| [RD36] | Parametric Insurance: Shaping the Future of Public Sector Resilience with Data and Technology | Parametric Insurance: Shaping the Future of Public Sector Resilience with Data and Technology, Serena Sowers and Aaraon Michel, https://riskcenter.wharton.upenn.edu/lab-notes/parametricinsurance/ | June 8 2022 |

| Id. | Reference | Title | Date |
|---|---|---|---|
| [RD37] | Routes to Market Report: 18 - Satellite Technologies for Insurance Services | Routes to Market Report 18 - Satellite Technologies for Insurance Services, Innovate UK and Catapult Catellite Applicaoints. https://sa.catapult.org.uk/wp-content/uploads/2018/12/18-Insurance-Services1.pdf | |
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