ReMAP

Real-time Condition-based Maintenance for Adaptive Aircraft Maintenance Planning

D2.2 - IT Platform Public Requirements

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Glossary

Term	Type	Meaning
Algorithm	Definition	Set of steps that will be performed to create a Model using Machine Learning techniques.
API	Abbreviation	Application Programming Interface
Approved Model	Definition	A Model that was inspected and approved by an Aircraft Engineer and that can be used in the context of the airline for the intended purpose.
CBM	Abbreviation	Condition-Based Maintenance
Data Source	Definition	In the context of the ReMAP project, a Data Source is any server, API, database or file, external to the ReMAP platform, that contains data of interest to ReMAP.
Dataset	Definition	Collection of data from one or more system from one or more aircraft. Can be created by a Model Builder.
EASA	Abbreviation	European Aviation Safety Agency
FAA	Abbreviation	Federal Aviation Administration
Flight Data	Definition	Data related with the operations of an aircraft. Includes sensors' readings from the aircraft systems and structures, aircraft utilization metrics such as flight cycles or flight hours, and data related with the performed flight, such as city pairs and weather and pollution data.
IFHM	Abbreviation	Integrated Fleet Health Management
Inspection with negative result	Definition	A mechanic is requested to make a physical inspection on a suspect system or component and finds no evidence of defect. This is different from NFF, as parts are not removed from the aircraft.
Launched Model	Definition	A Model that was launched by the Airline IT Staff and that is ready to be used by the airline to apply CBM.
Model	Definition	A model can be described as a set of coefficients, that produces an output accordingly to a given input. It produces an output by calculating the result of the input and the coefficients. In the context of ReMAP, these models can be of three types: data-based models, which are models developed by a Model Builder exclusively by analysing the data and not knowing the physical systems of the aircraft; physics-based models, which are models built by a Model Builder that knows how a certain physical system of the aircraft works; and hybrid models, which are built taking into account the physical system of the aircraft and the information gathered by the analysis of the data. The possible states of a Model are: Trained, Validated, Approved and Launched in an airline.
Maintenance Data	Definition	Data related with the maintenance operations performed in the airline's fleet. Includes logs of the operations, the removals of systems from the aircraft, and shop reports.
Maintenance Planning	Definition	Actions related with the scheduling of the various interventions to be performed in a certain aircraft.
MRO	Abbreviation	Maintenance Repair & Overhaul
NFF	Definition	No-Fault-Found Situation in which a component is removed from an aircraft, and, after inspection in shop-floor, no fault is found. Sometimes the symptom is detected in the removed component, but the defect is caused by another system or component. One of the goals of ReMAP is to reduce NFFs.
OEM	Abbreviation	Original Equipment Manufacturer

Term	Type	Meaning
Planned Maintenance	Definition	Interventions planned 10 or more days in advance. When suggesting interventions, the primary goal of ReMAP is to provide them with 10 or more days in advance, as they will be fed to the normal planning process.
Planning Data	Definition	Data related with the planning of the maintenance of the airline's fleet. Includes the descriptions of the maintenance tasks, its organization in blocks of tasks and the schedules.
Regulation Body	Definition	Responsible for approval of the Maintenance Program and audits of maintenance execution to check if performed as expected. ReMAP must provide evidence that the algorithms work as expected and provide means for regulators to oversee the system.
ReMAP platform	Definition	The IT platform to be developed within the ReMAP project, and all of its components.
RUL	Abbreviation	Remaining Useful Life Remaining Useful Life is used to predict life-span of aircraft components (systems and structures) with the purpose of minimising failure events.
Trained Model	Definition	Model that was trained and tested by the Model Builder and needs to be validated.
UML	Abbreviation	Unified Modelling Language
Validated Model	Definition	Model that was inspected and validated by a Model Builder, using datasets independent of the ones used to train and test the model. The person(s) that validate a model must be independent from the person(s) that developed the model.

1 Executive Summary

ReMAP aims to develop an innovative Integrated Fleet Health Management (IFHM) solution that replaces fixed-interval inspections with adaptive condition-based interventions. This solution highly benefits European aviation as it decreases maintenance costs, reduces unscheduled aircraft maintenance events and increases aircraft availability.

The present document contains the requirements specification for the IT platform developed within the ReMAP project. The requirements are specified using three key concepts from the software development process: use cases, quality attributes and constraints. The objective of this document is to report the high-level requirements of the platform. They describe the main goals of the project, as well as the main actors and use cases. Lower-level requirements are out of the scope of this document and reported in confidential deliverables only available for consortium partners.

2 Document structure

This section presents the document structure and provides background information for the aspects addressed in the IT platform requirements. Section 3 (Cloud level requirements: Very high-level goals of the project) provides an individual description of ReMAP's very high-level requirements. Section 4 (Kite level requirements: High-level goals of the platform) providers a similar description but this time for high level requirements. Section 5 (Conclusion) summarizes the main objectives of this document.

The diagrams presented in this document follow the Unified Modelling Language (UML) 2.0 notation. They provide a visual representation of the interactions between the actors and use cases.

Following, we introduce the requirement levels covered by this report. The types of elements used to define the requirements are also described.

2.1 Requirement levels

The requirements are grouped into 5 levels (Cloud, Kite, Sea, Fish and Clam), as proposed by Alistair Cockburn[1]. The highest levels provide strategic views of the project, whereas the lowest levels provide more detailed specification. Table 1 maps each level with the criteria used in ReMAP to assign requirements to levels.

Table 1 - Requirement Levels

Level	ReMAP assignment rationale
Very high (Cloud level)	Strategic view of the project.
High (Kite level)	High-level definition of use-cases, specifying business processes that may involve more than one actor, or may take several days or interactions to accomplish, or may involve multiple work packages.
User goals (Sea level)	Specifies functionalities that actors can use to achieve specific goals and that may be common to multiple work packages.
Work package (Fish level)	Use cases that are specific to a ReMAP work package.
Detailed specification (Clam level)	Specifies particular aspects of the ReMAP IT platform that must be captured and may have an impact on the architecture.

[1] Alistair Cockburn, *Writing Effective Use Cases*, (Pearson Education, 2000)

The purpose of having multiple levels is to manage complexity in terms of specification validation. When relevant, quality attributes scenarios and constraints may also be refined at different levels using identical criteria.

It is important to notice that each level elaborates on the levels above. The descriptions may reference or refine elements in higher levels but, in principle, should not use information expressed in lower levels of specification. As mentioned before, this document covers the first levels, cloud and kite. The remaining levels contain confidential information that is only available for consortium partners. Thus, they are not addressed in this document.

2.2 Requirement elements

The requirements are specified using elements that express the multiple aspects of the ReMAP IT Platform. Table 2 provides a short explanation of those elements.

Table 2 - Requirement Elements

Element	Short description
Actor	A person or system that has an interaction with the software system under development, with the intention of executing an action.
Use case	An action (or group of actions) that an actor expects to execute in the software system.
Quality attribute	A need of the stakeholders that the software system should satisfy. Usually specified using a scenario that defines the expected answer of the system for a specific stimulus and operating conditions.
Constraint	A non-negotiable need of the stakeholders that the software system must comply.

The following sections contain the requirements specification of ReMAP IT Platform. The requirements are specified using three key concepts from the software development process: use-cases, quality attribute scenarios and constraints (c.f,, Table 2). Use-cases define actors and functionalities expected from the ReMAP platform. Quality attribute scenarios define expected answers of the software system for specific stimulus and operating conditions. Constraints are grouped in business and technical domains and define mandatory properties of the ReMAP platform.

This specification is based on information obtained from discussions with ReMap stakeholders. These stakeholders include partners directly involved with the project, as well as airline staff responsible for aircraft management and maintenance operations.

3 Cloud level requirements: Very high-level goals of the project

Very high-level goals are the main objectives of the ReMAP platform, and they align with the strategic view of the ReMAP project. Every requirement specified in lower levels must have one or more of these objectives as the justification for its existence.

3.1 Very high-level goals diagram

The following diagram contains the very high-level goals of the ReMAP project and the relations between them.

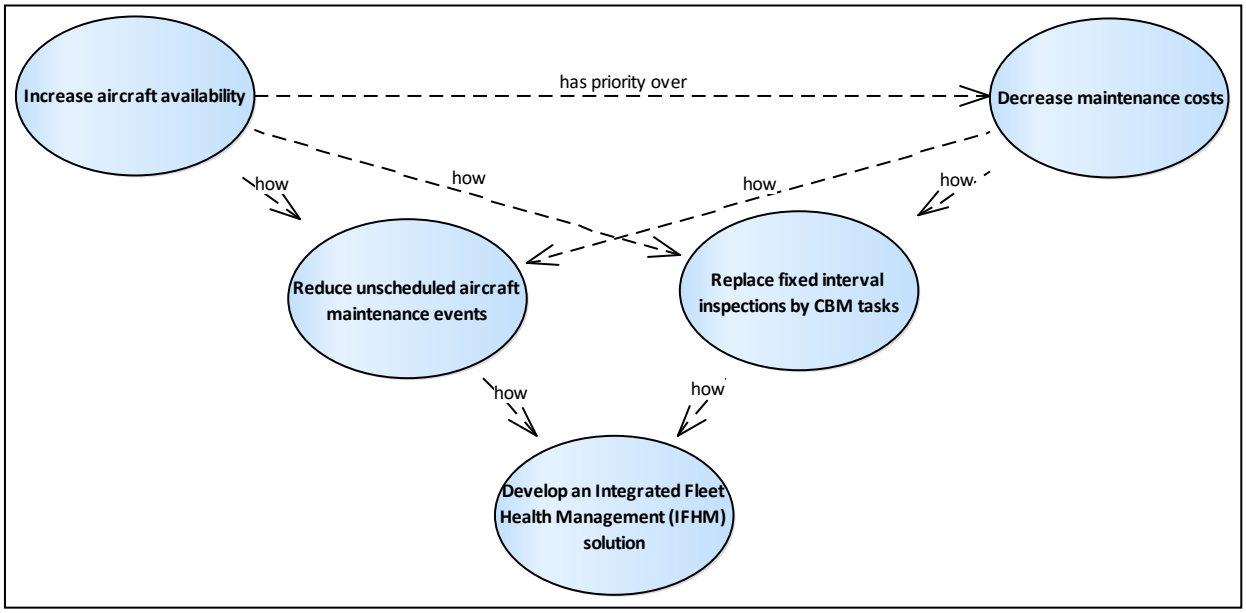

Figure 1 - Cloud level: Very high-level goals diagram

3.2 Very high-level goals descriptions

Table 3 lists and describes ReMAP's very high-level goals.

Table 3 - Very high-level goals

Name	Description
Reduce unscheduled aircraft maintenance events	ReMAP aims to reduce the occurrence of unscheduled maintenance events by monitoring current - and forecasting the future - health state of

Name	Description
	aircraft systems and structures, triggering maintenance alerts before a component fails or identifying the root causes of a detected failure. By avoiding an unscheduled maintenance event and improving fault isolation, the impact on airline operations is reduced, increasing aircraft availability. By reducing unscheduled aircraft maintenance events and false alarm rates, ReMAP is also contributing to the reduction of maintenance costs. Unscheduled events can lead to flight delays or cancellations, which impacts airline operations. The delays and cancellations can also involve a cost related to the compensation and accommodation of the passengers. Additionally, unscheduled events can also lead to high priority component orders, which may be costlier than lower priority orders. Depending on the severity of the unscheduled events, the aircraft can be prevented from flying, becoming grounded away from the airline's maintenance base. These cases require the airline to seek help from local maintenance providers or ferry the required components and personnel to the place where the aircraft is, which might lead to an additional increase in maintenance costs. ReMAP contributes with early identification of a maintenance need, such that it can be planned and executed during a convenient time slot for the airline.
Increase aircraft availability	The ReMAP project aims to increase the airline's aircraft availability. This aligns with the objectives of the airline, which is to maximize the usage of its fleet. This can be achieved by minimizing the volume of both scheduled and unscheduled maintenance.
Decrease maintenance costs	The ReMAP project enables a decrease in maintenance costs, by optimising maintenance operations, and efficiently exploiting the life of each aircraft component. Despite being an objective of the project, it may conflict with the goal of increasing aircraft availability. The objective of the airline is to maximize the usage of its fleet, even if in some cases it means an increase in

Name	Description
	maintenance costs. This is because the cost related to having an aircraft grounded due to an unexpected failure is usually higher than the maintenance cost that might avoid such failure. Thus, airlines prioritize the increase of aircraft availability over the decrease of maintenance costs.
Replace fixed interval inspections by CBM	ReMAP contributes to the replacement of the current interval-based maintenance paradigm by a Condition-Based Maintenance (CBM) one. In the application of the CBM paradigm, fixed interval tasks may be relaxed. These tasks, associated with efficient planning of the maintenance tasks, may even be replaced by health monitoring of the aircraft components and estimation of their remaining useful life (RUL). By current regulations, an aircraft is subject to mandatory fixed interval tasks. These tasks include inspection, servicing and replacement of aircraft components. In some cases, maintenance actions are not imperative, as the maintained components are still in good condition. With the continuous monitoring of the condition of aircraft components, ReMAP enables the usage of components to be extended closer to the end of their useful life, thus reducing the amount of aircraft maintenance interventions and increasing aircraft availability. By maximizing the usage of the parts in an aircraft and scheduling maintenance events according to the RUL of an aircraft's part, ReMAP helps reducing airline's maintenance costs.
Develop an Integrated Fleet Health Management (IFHM) solution	The Integrated Fleet Health Management (IFHM) solution to be developed within the project aims to be an open IT ecosystem of cloud services for aeronautic stakeholders. These cloud services include but are not restricted to algorithms for health monitoring, diagnostics and prognostics of aircraft systems and structures; maintenance scheduling optimisers; and systems for aeronautic governance and maintenance support. The cloud services will be integrated and operationalised using an IT platform, turning ReMAP into a part of the IFHM solution. With this platform, health diagnostics and prognostics from various aircraft systems and structures are used to create real-time adaptive maintenance plans, following appropriate regulations.

Name	Description
	By being able to monitor the condition of aircraft systems and structures, the airline can schedule a maintenance event before the part becomes defective, preventing the occurrence of an unscheduled maintenance event. Having the ability to know the RUL of aircraft systems and structures, the airline can replace the fixed interval inspections, only performing maintenance to the aircraft when it is necessary. By integrating cloud services of various aeronautic stakeholders, the platform enables the usage of data from multiple airlines to train models for diagnostics, prognostics and planning. With access to various silos of data from various stakeholders, the results produced by the models are of greater relevance than the ones built with data from a single provider. By applying a distributed approach, the platform also respects the constraints regarding the privacy and security of the provided data.

4 Kite level requirements: High-level goals of the platform

High-level goals are defined with Actors, Use Cases, Quality Attributes and Constraints. Actors and Use Cases describe high-level goals associated with business processes that may involve more than one actor, may take several days or interactions to accomplish or may involve multiple work packages. Quality Attributes describe properties the software system should have. Constraints describe the must-have properties of the software system.

From an architecture perspective, we consider two partitions of the ReMAP platform. The first, a central component named Core, is dedicated to platform management and model distribution (e.g., data-based, physics-based and hybrid models for prognostics and health management of aircraft systems and components). The second, a client component named Node, intended for the processing of the airline data, is hosted in each airline data centre. These partitions are considered in the requirements specification.

For the sake of simplicity, when using the term "airline", we refer to the airline itself and to other entities related to aircraft maintenance, such as, for example, a Maintenance, Repair and Overhaul (MRO) organization.

4.1 High-level goals diagram

A diagram of the high-level goals of the ReMAP project, with the actors and its use cases, is shown in Figure 2.

For the sake of visibility, we chose to represent only the primary users (i.e., the ones that initiate the flow of events). The exceptions are the representation of Airline Data Sources and Aircraft Structures Data as secondary actors, since they clarify how ReMAP gets data from external data sources.

Also, to ease the interpretation of the diagram, some of the lines establishing relations between actors and use cases have a different colour.

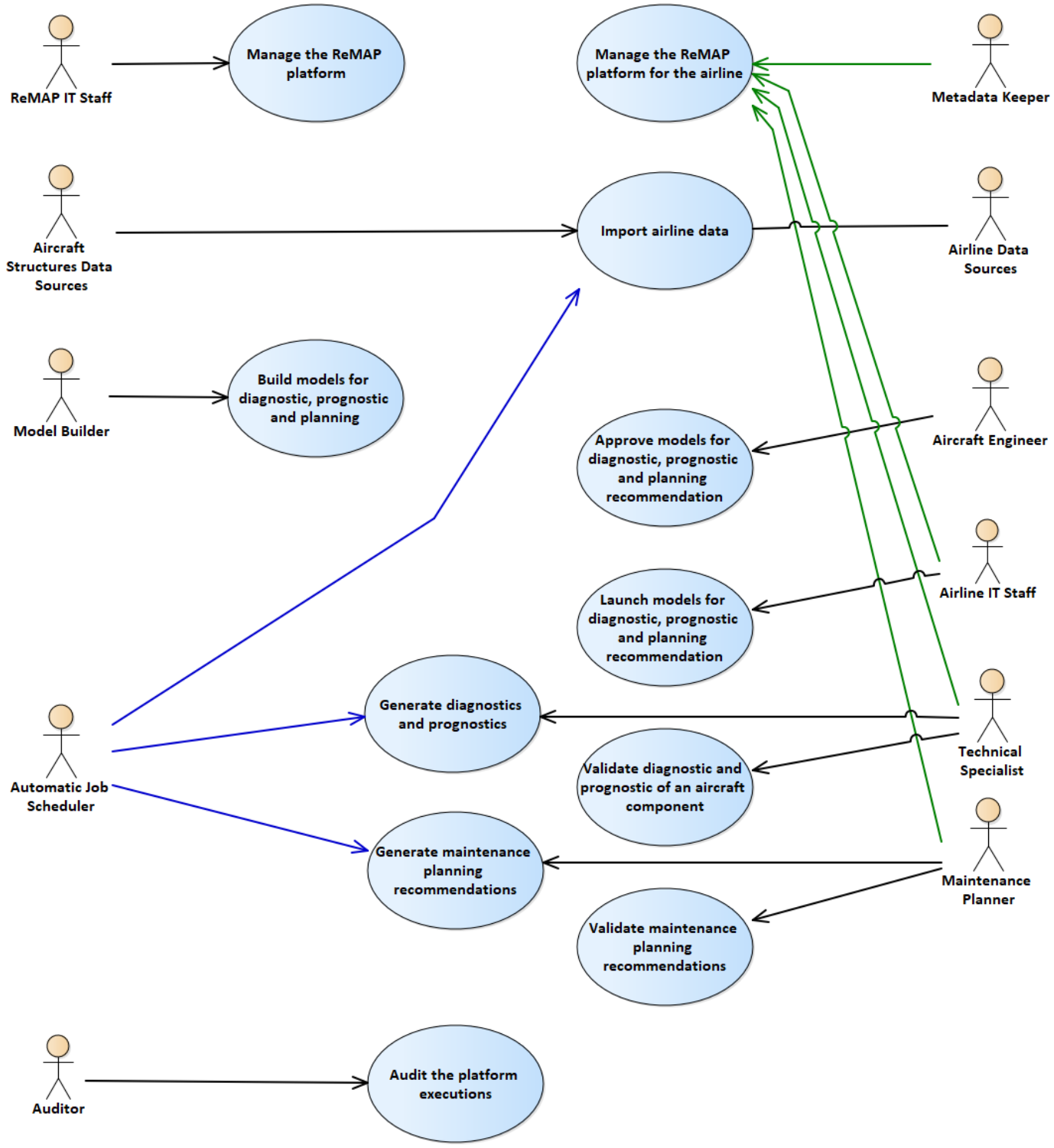

Figure 2 - Kite level - High-level goals diagram

4.2 High-level goals descriptions

The high-level goals of the ReMAP IT Platform are presented next.

4.2.1 Actors

This section describes the actors that will interact in the IT ecosystem of the ReMAP project. There are three major scopes where an actor resides: 1) the scope of the ReMAP platform, for actors that know ReMAP platform's inner processes data model, and that can make changes to it; 2) the scope of the airlines, for actors that belong to an airline (or MRO) and want to make use of the platform for CBM; and 3) the scope of external entities, for actors that belong to entities that want to build Machine Learning models distributed and used through the platform, or entities that audit the platform.

The following table indicates the scope of each actor in the ReMAP platform.

Table 4 - Actors' Scope

Actor	Scope
ReMAP IT Staff	ReMAP
Automatic Job Scheduler	ReMAP
Airline IT Staff	Airline
Metadata Keeper	Airline
Aircraft Engineer	Airline
Technical Specialist	Airline
Maintenance Planner	Airline
Airline Data Sources	Airline
Model Builder	External
Auditor	External
Aircraft Structures Data Sources	External

Table 5 lists the actors of the ReMAP IT Platform, identified for the Kite level.

Table 5 - Kite Level Actors

Name	Description
Airline Data Sources	This actor represents data sources belonging to the airlines, which provide data to the ReMAP platform. The data provided by this actor can include sensor readings from the aircraft systems; information regarding the operations of the fleet (such as routes, locations and schedules); information regarding the maintenance operations of the airline (such as task descriptions, resource availability, and maintenance history); weather history and forecast; and pollution information. This actor resides in the scope of the airline.
Aircraft Structures Data Sources	Within the scope of the ReMAP project, there is a dedicated development of technologies to be applied in the health management of aircraft structures. These technologies enable the diagnostic of the aircraft structures and the estimation of their RUL. This dedicated development involves the generation of data in a laboratory environment, to be used in a demonstration that will simulate the application of CBM to aircraft structures. Due to the work planned for this development depending on laboratory tests, and to decouple research in this topic from the development of the ReMAP platform, all data pertaining to structures is treated as an external source. Thus, this actor will be responsible for providing the diagnostics of aircraft structures and the RUL estimations, obtained through laboratory simulations executed by ReMAP partners. In future evolutions of the platform, this actor will cease to exist, as the diagnostics and RUL estimations will no longer be calculated based on simulated data.
ReMAP IT Staff	This actor represents the technical staff from ReMAP, which is responsible for the internal configuration and management of the IT Platform and for providing the necessary support to the other actors. This actor must have the required knowledge (or access to documentation) to configure and manage the communications within the ReMAP platform.

Name	Description
	It should also configure and manage the access and permission details of the other actors. This actor resides in the scope of the ReMAP platform.
Automatic Job Scheduler	This automated actor is responsible for the automatic triggering of tasks in the ReMAP platform. The triggered tasks are configured and scheduled by the Airline IT Staff actor. This actor resides in the scope of the ReMAP platform.
Model Builder	This actor represents the engineers, physicists or data scientists that develop data-based, physics-based and hybrid models to be used in the ReMAP platform. Should ideally have expertise in techniques to build models and knowledge of the aeronautics domain (e.g., the behaviour of the aircraft structures and systems or aircraft maintenance operations). This knowledge might be obtained from cooperation with aircraft engineers (this is a procedural issue external to the ReMAP platform). A Model Builder will not have direct access to the complete raw data, only to metrics and calculated values about the data, as the mean, maximum and minimum value of a sensor reading. Samples of data may be made available under contractual obligations or non-disclosure agreements. The Model Builder will also have access to the configuration of datasets to be used in the development and validation of the models. This actor resides in the scope of the external entities and may belong to an airline, a university, an aircraft or equipment manufacturer, or other kinds of external entity that wants to develop and distribute models through the ReMAP platform.
Airline IT Staff	This actor represents the technical staff (generic IT staff) from the airline, which configures and manages the ReMAP platform within the scope of the airline. This actor must have the required knowledge (or access to documentation) at the level of the IT infrastructure, to configure the communications and interactions between the airline's systems and personnel and the ReMAP platform.

Name	Description
	Regarding the airline, this actor must be aware of details about the data sources of the airline (e.g., how to communicate with them) and details about the personnel that interacts with the ReMAP platform (e.g., who can access it and what permissions should be assigned to each user). Regarding the ReMAP platform, this actor must also be aware of details about the configuration operations to be performed in the platform, for instance, setting up the communications with data sources and automatic tasks. This actor resides in the scope of the airline.
Metadata Keeper	This actor represents a user that configures the linkage between the data from the airline and the data model of the ReMAP platform, including the needed data transformations. This actor must know about the airline domains (e.g., what data the airline has available, its meaning or formats) and knowledge about the data model provided by the ReMAP platform (e.g., its data structures, formats or types). Although this actor knows the data model of the ReMAP platform, it resides in the scope of the airline. This happens since this actor is the one with knowledge regarding the data model in use in its airline. This role might be combined with the Airline IT Staff.
Aircraft Engineer	This actor represents domain specialists such as System Engineers, Structures Engineers, Big Data Engineers, Avionics Engineers, or Maintenance Programme Engineer. This actor uses the platform to approve models (e.g., data-based, physics-based and hybrid models), enabling its usage by an airline. This is only an internal (airline) approval of the models. This actor resides in the scope of the airline.

Name	Description
Technical Specialist	This actor represents a Technical Specialist from the airline. The Technical Specialist has a specific set of aircrafts, assigned to handle and has specific knowledge of the aircraft structures and systems. This actor uses the platform to obtain diagnostics and RUL estimations of aircraft structures and systems and must know how to interpret this information. This actor resides in the scope of the airline.
Maintenance Planner	This actor represents a Maintenance Planner from the airline, who is responsible for its maintenance planning. The Maintenance Planner has a group of aircraft under its responsibility. When planning the maintenance, the actor must consider the whole aircraft group. This actor uses the platform to obtain recommendations of maintenance tasks such as when and where they can be performed. It is its responsibility to apply or discard these recommendations. This actor resides in the scope of the airline.
Auditor	This actor represents an external entity that wants to access the ReMAP platform to audit it and obtain information regarding its data processing. This actor resides in the scope of the external entities and belongs to an entity such as a regulator.

4.2.2 Use cases

This section describes the use cases that the actors identified will perform through the ReMAP platform.

Table 6 - Uses Cases

Name	Description
Manage the ReMAP platform	The ReMAP IT Staff manages the Core component of the ReMAP platform by configuring its execution environments (such as platform nodes), communications and access permissions. It enables the actor to manage and control how the central partition of the platform behaves. The ReMAP IT Staff configures how the airlines access and communicate with the platform to use it for CBM, and how the external entities access and communicate with the platform to build and distribute ML models. The ReMAP IT Staff also configures how the platform executes its routines and how the overall ReMAP staff accesses its various parts. The configuration of the import process of aircraft structures data is also the responsibility of the ReMAP IT Staff.
Manage the ReMAP platform for the airline	The airline personnel (i.e., Airline IT Staff, Metadata Keeper, Technical Specialist and Maintenance Planner) configures the ReMAP platform by defining access permissions, fleet characteristics, maintenance, airline communications, and execution of automatic actions. This use case enables these actors to manage and control how the platform interacts with the airline. The Airline IT Staff is responsible for configuring airline personnel' access to the platform (within the airline node); configuring how the platform accesses and imports data from the airline systems; configuring the airline's fleet details, specifying the aircraft characteristics (such as aircraft makers and models, systems configurations and tail numbers) and the user responsible for the aircraft; and configuring the details of the maintenance to be performed within the airline. The Metadata Keeper configures the linkage between the airline data model and the platform's internal data model.

Name	Description
	The Aircraft Engineer configures how the platform executes the automatic tasks that generate diagnostics and prognostics by defining which model is used for each component. The Maintenance Planner configures how the platform executes the automatic tasks that generate maintenance planning recommendations by defining which model is used for the generation. The configurations defined by these actors will be used by the Automatic Job Scheduler for the execution of automatic tasks such as data import the generation of diagnostics, prognostics and maintenance planning recommendations.
Import airline data	The Automatic Job Scheduler automatically triggers the importation of data from the Airline Data Sources and the Aircraft Structures to make the airline and structures data available within the ReMAP platform. For the Airline Data Sources, the Automatic Job Scheduler checks what new data is available in different Airline Data Sources. Then, it executes import routines defined by the Airline IT Staff to obtain data from the Airline Data Sources and applies the necessary data transformations (defined by the Metadata Keeper). The transformed data is then stored in the Airline's Node of the ReMAP IT Platform. Upon conclusion, airline data becomes available to be used by the platform in that specific Node. For the Aircraft Structures Data Sources, the Automatic Job Scheduler checks what new data is available in the different Aircraft Structures Data Sources. Then, it executes import routines to obtain the data from the Aircraft Structures Data Sources, applies the necessary data transformations, and stores the transformed data. The import routines, data transformations and storage locations are defined by the ReMAP IT Staff. Upon conclusion, the structures data becomes available to be used by the platform in that specific Node.
Build models for diagnostic, prognostic and planning	The Model Builder builds data-based, physics-based and hybrid models with the data provided by multiple airlines and makes them available

Name	Description
	through the ReMAP platform, to enable its usage by the airlines to apply CBM. The Model Builder performs exploratory actions in the data provided by the airlines through the ReMAP platform to obtain information necessary to build models focused on a particular aircraft component. The Model Builder may download a data sample (whenever made available by the airline) for the initial steps of building a model, outside of the ReMAP platform. Later, the Model Builder submits a model to be trained and tested within the platform. The train and test steps are executed using data and specifications defined by the Model Builder. The data to be used will be provided by the various airlines using the ReMAP platform, improving the performance of the models to be built. After trained and tested, the model is validated by another Model Builder, using a different set of data. After validation, the model is published on the platform, with a report documenting its characteristics (such as accuracy and confidence levels). It becomes available (through the models' catalogue) for airlines to approve and use in CBM-related tasks. Additionally, the model can be downloaded and used from the Nodes. The models to diagnose and calculate prognostics can be generic or specific for an aircraft component. The Model Builder needs to identify what components can be evaluated with the provided model. The Model Build should also be able to access feedback, such as model execution statistics.
Approve models for diagnostic, prognostic and planning recommendation	The Aircraft Engineer approves models so they can be applied by the airline for CBM. The Aircraft Engineer performs the final step related to the approval of a model as the full formal approval might require many steps and involve many entities, such as the regulatory bodies or OEMs. For a model to be approved, the Aircraft Engineer verifies the ML models that are pending approval. Upon selecting a model, the Aircraft Engineer

Name	Description
	examines the model details. Such details include, among others, model creator, insertion date and validation results (e.g., false-positive rate). The analysis of model details allows the Aircraft Engineer to mark the model as approved if all necessary conditions are met. The platform enables the execution of tests and other actions that support the full approval of a model. However, the formal process must take place outside the platform. Depending on factors such as airline, country or system, the models' characteristics might need to adhere to strict specifications (e.g., critical systems) where the number of false negatives needs to be very low. On the other hand (e.g., non-critical systems), the models' characteristics might be more focused on economic requirements and provide increased error rates of the models' performance.
Launch models for diagnostic, prognostic and planning recommendation	The Airline IT Staff launches models so that they become ready to be used by the airline to generate diagnostics, prognostics and planning recommendations. The Airline IT Staff launches a model by selecting it from those approved by the Aircraft Engineer and defining the execution environment, the type of data it uses as input, and the storage location of its outputs. After being launched, the model becomes ready to be used by the airline.
Generate diagnostics and prognostics	The Automatic Job Scheduler triggers the generation of diagnostics and prognostics after new data from an airline is imported to the platform. The Technical Specialist can also trigger this action at any time. This action enables the analysis of the current health state of the aircraft's components and the estimation of the RUL of such components. The Automatic Job Scheduler triggers the generation of a diagnostic and a prognostic for previously configured components on each of the airline's aircraft. The automatic generation is executed every time new data is available, according to configurations defined by the Aircraft Engineer. These configurations consider the model to use, as well as its inputs. In cases where the Aircraft Engineer modifies the algorithm's parameters, the generation of diagnostics and prognostics must be manually triggered. The

Name	Description
	resulting diagnostics and prognostics are stored according to the storage location defined by the Airline IT Staff. After all components of an aircraft are analysed, the platform notifies the Technical Specialist responsible for that aircraft. In cases where the diagnostic and prognostic identify that an intervention is necessary, a maintenance task must be proposed.
Validate diagnostic and prognostic of an aircraft component	The Technical Specialist validates the diagnostic and prognostic (of an aircraft component) generated by the ReMAP platform. That enables the Technical Specialist to propose a maintenance task to be used in the generation of maintenance planning recommendations. The Technical Specialist accesses the details of the generated diagnostic and prognostic of an aircraft component and assesses the validity of the information presented in the platform, concerning a specific aircraft component. The actor validates a new maintenance task if the newly provided information is deemed appropriate. Otherwise, the actor ignores and does nothing. The platform then stores the information related to the decision of the Technical Specialist. When the components of an aircraft are analysed and new maintenance tasks need to be executed, the platform must generate new maintenance planning recommendations with that information.
Generate maintenance planning recommendations	The Automatic Job Scheduler triggers the generation of maintenance planning recommendations after the Technical Specialist specifies that a new maintenance task is to be executed on an aircraft. The Maintenance Planner can also trigger the generation of maintenance planning recommendations at any time. It enables the identification of maintenance opportunities in the maintenance planning of the airline fleet to execute the maintenance tasks. The Automatic Job Scheduler triggers the generation of planning recommendations for an aircraft. The generation must be executed according to configurations set by the Maintenance Planner, considering the type of data to be used as input and the scheduling model to use. The

Name	Description
	resulting maintenance planning recommendations are stored according to the storage location defined by the Airline IT Staff. After maintenance planning recommendations are generated, the platform notifies the Maintenance Planner that new maintenance planning recommendations have been generated.
Validate maintenance planning recommendations	The Maintenance Planner validates and adjusts the maintenance planning recommendations that were automatically generated, so they can be applied in the maintenance plan of the airline fleet. The Maintenance Planner accesses the list of maintenance planning recommendations generated by the ReMAP platform, selects a recommendation and asserts the validity of its information. The Maintenance Planner can accept the maintenance planning recommendation by marking it as valid. The Maintenance Planner can also adjust the proposed planning recommendation. Once the adjustments are complete, the Maintenance Planner can mark the updated recommendation as a valid maintenance plan. Ultimately, the Maintenance planner can refuse a maintenance planning recommendation, marking it as invalid. When the recommendation is considered valid, the platform communicates the recommendation to the airline maintenance systems, applying it to the maintenance plan of the aircraft. The information regarding the validity of a maintenance planning recommendation must be stored in a log file so it can be used in the future for retraining the ML models. Specifically, the initial and last version of the recommendations should be stored. Intermediate versions shall be stored for usability purposes, such as rollback to previous versions.
Audit the platform executions	The auditor examines what data the platform has used and how it has been processed, to ensure that it conforms to rules and regulations. The auditor needs to have access to the IT platform process, including the ML models used and data shared during the period under audit.

4.2.3 Quality attributes

The quality attributes described in Table 7 refer only to the ReMAP software platform. It does not reflect the properties of the whole ecosystem nor specific modules developed in different work packages.

Table 7 - Quality Attributes

Name	Description
Extensibility	Extending the ReMAP platform to use a new machine learning algorithm or to account for a new aircraft component should be possible and would take from 160 to 300 hours, in 80% of the cases, excluding the required conception and scientific research.
Performance	Aircraft data should be imported to the ReMAP platform and made available to the machine learning algorithms in a timely manner. Assuming data sizes of 1GB, the data import operation should be completed in under 10 minutes.
Stability	Given sufficient computational resources, the platform's performance does not degrade in face of simultaneous execution of various tasks such as model training or data imports.

4.2.4 Constraints

This section describes (in Table 8) the constraints that ReMAP platform must respect.

Table 8 - Constraints

Name	Description
Availability of the airline data doesn't follow a well-defined schedule	The availability of the airline's data might not follow a well-defined schedule. Some aircraft, due to their technical configuration or due to their flight schedule, store batches of data from multiple flights. All the content of these batches is communicated to the airline's infrastructure at once, making it also available at once.

Name	Description
	The ReMAP platform must be able to deal with this irregular availability of data and with data from multiple flights of an aircraft at once and generate accurate RUL prognostics and maintenance planning recommendations for each aircraft.
When an aircraft has an accident, the access to data is restrained	Whenever an accident occurs with an aircraft, authorities can restrain or cease access to data related to that aircraft. When such a case occurs, data cannot be considered for usage in the platform. The data to be restrained - and respective retention time - is defined by the authorities.
Airworthiness regulations must be considered	To allow the usage of the ReMAP platform in a production environment, the platform might need to be approved by certification authorities such as EASA and FAA and comply with airworthiness regulations such as DO-178C (Software Considerations in Airborne Systems and Equipment Certification). Due to the TRL of the project aiming at a proof of concept, compliance with regulation is not mandatory. Nevertheless, the regulatory requirements should be considered during the development of the platform.
The ReMAP platform must adapt to data formats and communication protocols of external systems	The ReMAP platform interacts with different external systems that provide different kinds of data. Each system might specify a certain protocol or follow a certain standard for communications and/or data structures. These external systems will belong to the airlines that want to make use of the ReMAP platform in its maintenance processes. The ReMAP platform must be able to obtain data from these systems, complying with the restrictions imposed by owners, such as security restrictions.
Executions of the operations must be auditable	The ReMAP platform must allow the auditing and traceability of diagnostics, prognostics, planning recommendations and decisions. This allows an auditor to observe if the defined procedures are correctly followed and what data and actors were involved.
Processing of the operational data must preserve privacy constrains	The airline needs to comply with regulations and agreements regarding the sharing, access and processing of data. Regulations may enforce that the data cannot be stored or be shared outside the European Union, outside the country of origin and/or outside the airline itself. Agreements with

Name	Description
	specific entities, such as pilots' unions, impose constraints regarding the processing of data, prohibiting the traceability and profiling of the aircraft crew. The data is of great intellectual value for the airline, thus access by non-authorized parties must be assured by the airline so that full control and privacy are ensured.
The ReMAP platform must support multiple Machine Learning techniques	The ReMAP platform must support multiple Machine Learning techniques to deal with algorithms and models developed and built by different entities.
Confidentiality of the results related with diagnostics, prognostics and maintenance planning of an airline must be ensured	The results related to the diagnostics, prognostics and maintenance planning of an airline are of great importance and value for the airline. Thus, the confidentiality and full control of that information by the airline must be ensured, preventing access by someone not authorized by the airline.
Risk level of the maintenance process cannot be increased with the usage of the platform	The risk level associated with the current maintenance process cannot be increased by the introduction and usage of the ReMAP platform. Possible hazards associated with the introduction and usage of the platform in the maintenance process must be identified, and the platform must address and deal with those hazards to tackle the risks associated with them.

5 Conclusion

This document described the requirements specification for the IT platform developed within the ReMAP project. The requirements were specified using three key concepts from the software development process, namely, use cases, quality attributes and constraints.

The objective of this document was to report the upper-level requirements of the platform (cloud and kite levels). They described the main goals of the project as well as the platform’s main actors and use cases.

After the completion of the platform development, the next step is the integration and testing phase, where the platform's performance will be evaluated. Furthermore, all the requirements described in this document will be assessed during the process.