Horizon 2020 - Work Programme 2018-2020 Smart, green and integrated transport
MG-3-6-2020: Towards sustainable urban air mobility

Type of action: Research and Innovation Action

LAIKA

Low Airspace Innovation Key Actions

Technical proposal – Section 1 to 3

Participant no.	Participant organisation name	Country
1 (Coordinator)	PildoLabs (PLD)	Spain
2	Ayalon Highway Company (AHC)	Israel
3	Babcock Mission Critical Services Fleet Management (BMCSFM)	Spain
4	Barcelona Supercomputing Center (BSC)	Spain
5	Correos (CORREOS)	Spain
6	MGROUP Drone Think Do (DTD)	Netherlands
7	European Emergency Number Association (EENA)	Belgium
8	Envisa (ENV)	France
9	FADA-CATEC (FCAT)	Spain
10	Fraunhofer IAO (FH)	Germany
11	Kinéis (KIN)	France
12	Pipistrel Vertical Solutions (PVS)	Slovenia
13	Tecnalia Research & Innovation (TEC)	Spain
14	University of Seville (USE)	Spain
15	University of Stuttgart (USTUTT)	Germany

Table of contents

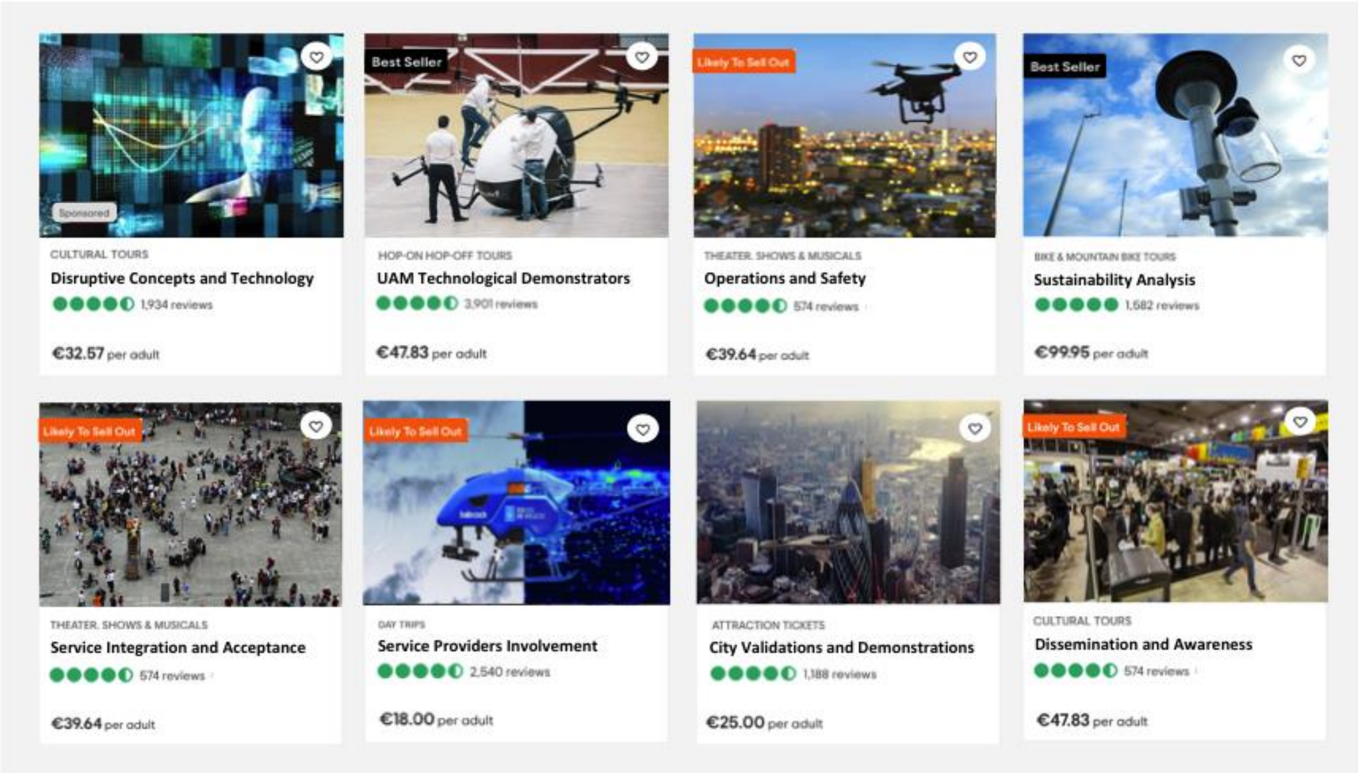
EXECUTIVE SUMMARY

Things to Do in Laika

LAIKA is the capital of Urban Air Mobility. Its name stands for Low Airspace Innovation Key Actions and it was founded as in result of the MG-3-6-2020, "Towards Sustainable Urban Air Mobility" topic, defined within the H2020 Work Programme on Smart, green and integrated transport, published by the European Commission.

Top of the edge research and industry, public authorities and communities live in LAIKA, investing on sustainable Urban Air Mobility solutions, for the benefit of millions of people populating its whole metropolitan area. Widely spoken, Innovation is the official language.

Explore Laika



1 EXCELLENCE

LAIKA (**L**ow **A**irspace **I**nnovation **K**ey **A**ctions) is an initiative coordinated by PildoLabs, with the support and expert participation from:

- City councils and public authorities responsible of urban planning and mobility services;
- Operational arm on innovative and smart transportation for the Ministry of Transport of Israel;
- Technology Corporation leader on developing first air taxi for pilot-less city transport;
- Industrial pioneer of high technology in light aviation and electrification;
- European reference universities in the subject of air robotics and in-flight dynamics control;
- National Research Centre in Advance Aerospace Technologies;
- National Institute for industrial engineering within mobility and innovation systems;
- SME focus on environmental assessments and regulations definition within aviation;
- SME focus on satellite-based technologies within aviation and mobility on-demand services;
- Spin-off from National Space Agency developing disruptive technologies for global connectivity;
- The European Emergency Number Association;
- Worldwide leader on the provision of Emergency aerial services;
- National provider of physical and digital communication and deliveries;
- International think tank on green business with more than 25k+ members, top influencers; and
- European Union Aviation Safety Agency as technical advisor.

1.1 Objectives

The Swiss Re (insurance company) has prognosticated that the global urban population will “grow by about 1.4 billion to 5 billion between 2011 and 2030, with 90% of the increase coming in the emerging markets”. Several disadvantages will appear such as traffic jams, pollution, and decreased productivity and effectiveness caused by delays in the flow of people and goods. City planners find it hard to keep abreast the population growth and the pace of urbanization.

By 2030, 60% of these people will live in urban areas (see Figure 1-1), placing an increasing strain on our mobility infrastructure. As cities get even larger, enabling efficient, sustainable, affordable and effective urban mobility will become a more pressing challenge.

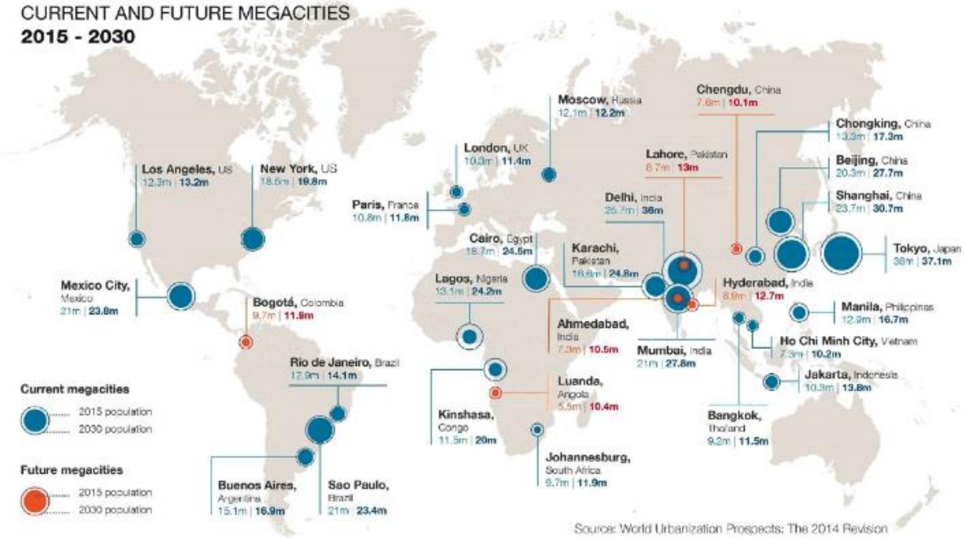


Figure 1-1: Current and future megacities. Source: World Urbanization Prospects

In 2017, more than 3.5 billion passengers travelled by air. That is a 10-fold increase in 30 years. Now, at any given moment, there are over 1 million people airborne around the world. The biggest surprise, though, is that we are just still at the beginning of this revolution. Change is happening faster than anyone imagined, and the digital age is speeding innovation up even more.

Recent developments – in battery capacity, autonomy, and on-board technology – make new kinds of aircraft possible. These vehicles have new shapes, capabilities, and operations, which our current airspace system was not designed to handle. Smaller cargo drones can move packages faster and more efficiently to hospitals, offices, and homes. An emerging class of electric vertical take-off and landing (eVTOL) aircraft can transport people around congested cities in minutes instead of hours. These new vehicles can fly further – and lower – than ever before. And because prices will fall to a fraction of today's air operations, they create the potential for massive, wide-scale use.

The digital age of aviation will change our skies. The number of flights will grow by order of magnitude. The airports of tomorrow will be all around us – in our homes and our workplaces, on the roofs of buildings, on top of delivery vans and fire trucks.

Such dramatic expansion is not straightforward. How can these aircraft be introduced safely? How can they co-exist with each other – and with future uses that have not been invented yet? And how can we make sure that we manage that change? The answers require redesigning airspace in a way that enables innovation while also prioritizing high assurance.

Urban Air Mobility is certainly more than just a vehicle able to fly safely over an urban environment, but actually a complete value chain, that should consider from a multi-disciplinary approach, its efficient integration in urban infrastructure and public acceptance by demonstrating being inclusive (see Figure 1-2). New business schemes might also be required, embracing concepts such as mobility-as-a-service and mobility-on-demand, being considered in the new era of Smart Cities. Ultimately, urban air mobility represents a field of disruptive innovation, not only for aviation but also for mobility systems and urban planning at large.

Figure 1-2: Urban Air Mobility value chain. Source: Airbus

Due to its requirements for vehicle performance, safety, sophisticated operations, infrastructure, operating costs, and system scale and tempo, the use of urban air mobility systems for people transportation is one of the most demanding applications. It is an attractive application once the system capabilities are in place. However, we cannot implement urban air mobility or achieve its vision without first building and gaining experience in other less demanding areas.

Starting today with less challenging and more controlled lower-density locations as test cases for the development of vehicles, control schemes, and networking concepts, should ensure the sustainable deployment of more challenging operations. We need to solve basic issues first, then gradually increase complexity by bringing the fielded solutions into more sub-urban, and then urban environments, where increased population, obstruction density and traffic density create more challenges.

Perform scenario-based studies, to assess societal impacts (privacy, intrusion, public health and welfare, transparency, environmental, inequity, etc) of advanced urban air mobility vehicles and the associated infrastructure (ground, airspace), should help to recommend a path to implementation that prioritizes maximum public benefits.

LAIKA’s (**L**ow **A**irspace **I**nnovation **K**ey **A**ctions) main objective is to develop innovative concepts, technologies and solutions towards the sustainable deployment of urban air mobility services, by conducting scenario-based studies, and integrated demonstrations, of candidate operational concepts that prioritizes maximum public benefits.

In order to achieve that main objective, the following specific objectives are defined:

- Capture early and often the requirements for the deployment of air mobility services, based on the definition of specific case-base studies in representative urban scenarios, and derive recommended practices from real experimentations and showcase demonstrations;
- Work-out with public authorities’ common guidelines on how to integrate Urban Air Mobility within Sustainable Urban Mobility Plans, endorsed not only through theoretical assessments and simulations, but also real measurements like vehicle noise characterization;
- Promulgate results towards a more systemic approach on urban mobility, considering not only mobility within cities (intra-city), but also between cities (inter-city) at shorter ranges, and prioritizing early services in less populated peri-urban and rural areas, without disregarding a cross-border dimension;
- Integrate a series of operational technological demonstrators, to support the development and validation of advanced systems and solutions in representative operational environment, and demonstrate to city stakeholder’s viability of the overall urban air mobility concept and services;
- Define flight procedure and airspace design guidelines, to support safe and secure U-space integration and management, minimize noise footprint, low carbon emissions and visual disturbance, and leverage lessons learned from rotorcraft community in low airspace operations;
- Provide evidences to EASA and National Aviation Authorities, on the safe integration of autonomous and remotely piloted aerial vehicles for specific and certified operations, considering, among others, the European Drone Regulation and the draft opinion of high-level regulatory framework for the U-Space;
- Contribute to EU urban mobility related initiatives (EIT Urban Mobility, EIP-SCC), establish synergies with other EU research programs (e.g. CleanSky, SESAR), and benefit from other activities related to EU satellite-based systems (EGNSS);
- Ensure future exploitation of results and innovative solutions through the engagement of industrial leaders, including unmanned air systems OEM and operators, service providers national and global leaders, end-user communities and public services;
- Develop a communication and dissemination plan at national and international level, engaging recognized topic experts from technological think-tank, user associations and other international partners, assuring adequate promulgation of results, recommendation towards decision makers, and share practices with early adopters.

1.2 Relation to the work programme

The Work Programme and Call-Topic to which LAIKA answers shall promote Research and Innovation Actions (RIA) towards the introduction of sustainable Urban Air Mobility services.

The Horizon 2020 Work Programme 2018-2020, and in particular the Specific Programme on Smart, green and integrated transport, sets out as the overall objective the achievement of a European transport system that is resilient, resource-efficient, climate – and environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.

Urban Air Mobility is a field of disruptive innovation, and an opportunity to reinforce the competitiveness and performance of European transport manufacturing industries and related services on global markets including logistics processes and retain areas of European leadership (e.g. such as aeronautics).

With most of future transport growth occurring outside Europe, access to knowledge and to new markets will become increasingly important. Urban mobility and sustainable electrification, especially in large urban areas from developing and emerging economies, is identified within five international cooperation flagships and research areas specially devoted to international cooperation.

The main challenge of Call-Topic MG-3-6-2020 is to address novel concepts, technologies and solutions beyond the state-of-the-art, to make urban air mobility not only safe, secure, quiet and green but also more accessible, faster, affordable, inclusive and publicly accepted. The companies enabling urban air mobility and the cities and regions embracing it may develop competitive advantages, both in terms of aircraft systems' business and mobility services. The following tables explains in detail how LAIKA addresses the specific challenges and overall scope of this topic.

Topic's specific challenge	How LAIKA will address it
"...a field of disruptive innovation, not only for aviation but also for mobility systems and urban planning at large"	LAIKA proposes the combination of aviation tech (taken from manned helicopters, and from a UAM platform) with robotics perception and conventional mobility concepts (such as transport on demand) to assess the viability, and the best approach, to urban mobility, whilst improving the urban sustainability.
"...urban/suburban and peri-urban/inter-urban level, point-to-point air connection can help overcome the lack or congestion of surface transport, lighten and complement logistic chains whilst saving time and recurrent infrastructure costs.""	Three main activities are proposed within LAIKA to overcome current congestion in urban and peri-urban level: people transport, logistics and emergency services, bringing a drastic reduction of marauding traffic around the city streets and increasing efficiency.
"...develop competitive advantages, both in terms of manned/unmanned aircraft systems' business and in terms of mobility services for people, emergency services and freight"	A multimodal approach is taken in LAIKA with a mobility-as-a-service architecture to improve the mobility services in the three proposed activities, paving the way to interconnecting business activities as never before.

Table 1-1: Relation between LAIKA and topic's specific challenge

Topic's scope	How LAIKA will address it
"...should address novel concepts, technologies and solutions beyond state-of-the-art"	Bleeding edge technologies from many sectors are combined in LAIKA to propose the best approach to a safe and expeditions urban mobility, ranging from novel propulsion and autonomous control to *blockchain* architecture and satellite IoT in various activities.
"Proposals should address all the following research areas:(A). Safety and Security, (B). Sustainability with regard the overall footprint, noise and visual pollution and (C). Public Acceptance, socio-economic modelling and relevant regulatory and organisational aspects of UAM systems"	LAIKA proposes workshops with stakeholders, a deep involvement from aviation authorities (including EASA as active member, and AESA and CAAI as supporting members), and a sustainability approach that takes into account municipalities (involved as supporting members) to bring in the adequate means to enable A, B and C topics.
"In addition, the proposals will also have to address one or more of the following research areas:(D). Services, (E). Operations, (F). Power-plant/propulsion system development and (G). Infrastructure adaptation"	The proposed methodology, backed with a highly specialised consortium, covers the adequate research areas (from D to G) that will enable the seamless integration of aerial platforms for in the urban mobility, logistics and emergency service: from the definition of services based from stakeholders' deep involvement (WP2), and the adaptation of the aerial platforms and their propulsion systems (WP3), to the definition of the concept of operations and operating tools (WP4) and the adaptation of the infrastructure to the city requirements (WP5, WP6).
"Particular emphasis should be addressed to potentially early UAM services (e.g. for air medical services, for safety & security services, for logistics, etc)"	The main operational technology demonstrators proposed within LAIKA aim to cover the basic mobility needs of a city: people, goods and emergencies.

Topic's scope	How LAIKA will address it
"TRL can reach up to level 6"	Based on previous experiences and developments, LAIKA will reach TRL6 for people transport, TRL7 for logistics and TRL9 for emergency.
"Ensure complementarities with the European U-space Demonstrator Network and with SESAR JU U-space activities"	Many participants in the project have been, and still are, involved in SESAR U-space demonstrations where U-space services from U1 to U3 are explored, enabling the concepts and systems proposed in LAIKA to be aligned with U-space architectures. Stakeholders workshops are prepared at the beginning of the project to foster early involvement of U-space service providers.
"...strong commitment for collaboration and communication with local authorities and communities as well as with players from other relevant leading-edge industrial and service sectors..."	LAIKA counts with the explicit support of up to six municipalities (four in Europe and others in Israel and Brazil), ensuring that a wide range of urban typologies, needs and communities are involved early in the project.
"...can leverage synergies with other EU activities such as: EIP-SCC, CIVITAS, EIT-KIC, EU satellite-based systems (EGNOS/Galileo, Copernicus), EU communication/connectivity initiatives"	Within the consortium, Tecnalia manages "The Marketplace of the EIP-SCC", and supporting Ingolstadt leads an EIP-SCC demonstration project, supporting Barcelona city manages the Urban Mobility EIT-KIC, where Tecnalia is also a partner, and many synergies are detected with GSA initiatives fostering EGNOS/Galileo integration (many led by PildoLabs).
"...may include the explicit commitment from the European Aviation Safety Agency (EASA) to assist or to participate in the actions"	EASA is an active member of the proposal, involved as *in-kind* third party.
"International cooperation is encouraged in cases of mutual benefit, such as sharing of practices with early adopters in non-European megacities"	Not only the early involvement of six international cities (two of them in Israel and Brazil) is ensured by annexed letters of interest, but also specific demonstrations are planned in all of them, enabling the dissemination and final assessment of project's outcomes in such different urban ecosystems.

Table 1-2: Relation between LAIKA and topic's scope

1.3 Concept and methodology

1.3.1 Concept

LAIKA seeks to improve urban air mobility safety, and accelerate scalability, trough integrated demonstrations of candidate operations concepts and scenarios. The project will help to identify the service requirements, and define a path to implementation through a series of scenario-based studies, not only from theoretical studies, but also coping with experiences, data measurements from tests and real experimentations.

Data measurements and tests are underpinned by the integration of a series of Unmanned Aerial Systems, so-called **operational technological demonstrators**. By prioritizing experimentation, the technical feasibility of developed solutions could be assessed in operations. In addition, market-based evidence towards local authorities, including decision makers, urban mobility-planners and early adopters, could be provided not only from theoretical assessments but also test-field measurements.

While air-taxi vehicle tests, will principally be dedicated to system integration/validation in a laboratory and more controlled airfield environment, more extensive experimentations will be possible thanks to a couple air-vehicle falling more suited for the specific operations category. Those experimentations will benefit from the participation of Babcock, the European Emergency Number Association (EENA), and the National post-office from Spain (Correos), acting as end-users and operators.

The use of multi-category air vehicles, should allow to best assess first the technical feasibility of the fielded solutions in less challenging operations and more controlled lower-density locations, before gradually increase complexity by bringing them into more sub-urban and urban environments.

UAS specific category, benefitting from the participation of a global leader on aerial emergency service provision and a national post-office as end-users and operators.

The overall concept of the project could be summarized as follows:

- Define with local authorities, end-user communities, operators and service providers, the service requirements and system specifications for the deployment of candidate operational concepts subject to specific scenario-based studies;
- Integrate a series of operational technological demonstrators on the light of defined service and system requirements;
- Deploy an operational framework, so-called Urban Air Mobility Lab, providing the means for entering airspace infrastructure through 4D trajectory-based operations;
- Test, measure and validate the developed solutions through a series of laboratory, test-field experiments and integrated demonstrations;
- Consolidate case-base studies with real measurements from experimentations, provide guidelines and recommendations to local authorities, regulatory agencies and disseminate the results to a larger audience and public.

1.3.1.1 Specific-based studies

Urban air mobility can bring about transformation in a number of industries including transportation, emergency response, and cargo/package logistics. However, it is important to ensure that societal benefits and costs of implementation are well understood using scenario-based analyses to assist, as all the applications will most likely not be evident until deployment is under way and users adapt to new capabilities. Being able to communicate benefits will aid in public acceptance and community outreach.

A series of scenario-based studies will be defined with the participating cities, local authorities, service providers, operators and end-users, from a list of urban air mobility services and candidate operational concepts, which might include:

- **Urban Air-Taxi and Air-Ambulance** (TECNALIA, EENA), being one of the most demanding applications of urban air mobility due to its requirements for vehicle performance, safety, sophisticated operations, infrastructure, operating costs, and system scale and tempo. It is an attractive application once the system capabilities are in place. However, we cannot implement urban air mobility or achieve its vision without first building and gaining experience in other less demanding areas.
- **Urban Emergency Medical Services, First Response and Public Safety** (EENA), new capabilities can trigger missions beyond people transport, so that it might very well include security patrols for safety, rapid response for emergencies and fires, police patrol, and even the delivery of life-saving medicines during emergencies.
- **Peri-Urban Package Delivery** (CORREOS) appears to be one of the visible “initial adopters” of autonomous air vehicle technology and capability for rural domestic cargo operations. This would include “last mile” local package delivery and “middle mile” cargo as one of the first applications fielded by companies.
- **Peri-Urban Emergency Medical Services** (BABCOCK), in less populated areas, are included as those near-term applications among others like first responders, search and rescue, and disaster relief.

The scenarios-based studies will assess societal impacts of advanced urban air mobility vehicles and the associated infrastructure not only through theoretical assessments but also fed with data from simulations, test-field experimentations, validations and integrated demonstrations. For example, airspace design infrastructure for an air-taxi scenario at Barcelona city will consider simulated air-vehicle performance and vehicle noise measurements, while emissions affectation would be modelled from real environmental data.

1.3.1.2 Operational technological demonstrators

To support technology development and practical experience on how to integrate autonomous aerial systems in UAM applications and services, a series of operational technological demonstrators will be integrated in the project. A set of UAS systems, including air-vehicle and ground systems, will be integrated and upgraded with novel systems and solutions, enhancing test and validation in operations. The necessary operational tools to support service provider-operators integrate airspace in a safe and secure manner will also be upgraded and/or developed.

The three in total operational technological demonstrators (see Figure 1-3), aims to support a wider range of systems and operational concepts for both, certified and specific operations categories.

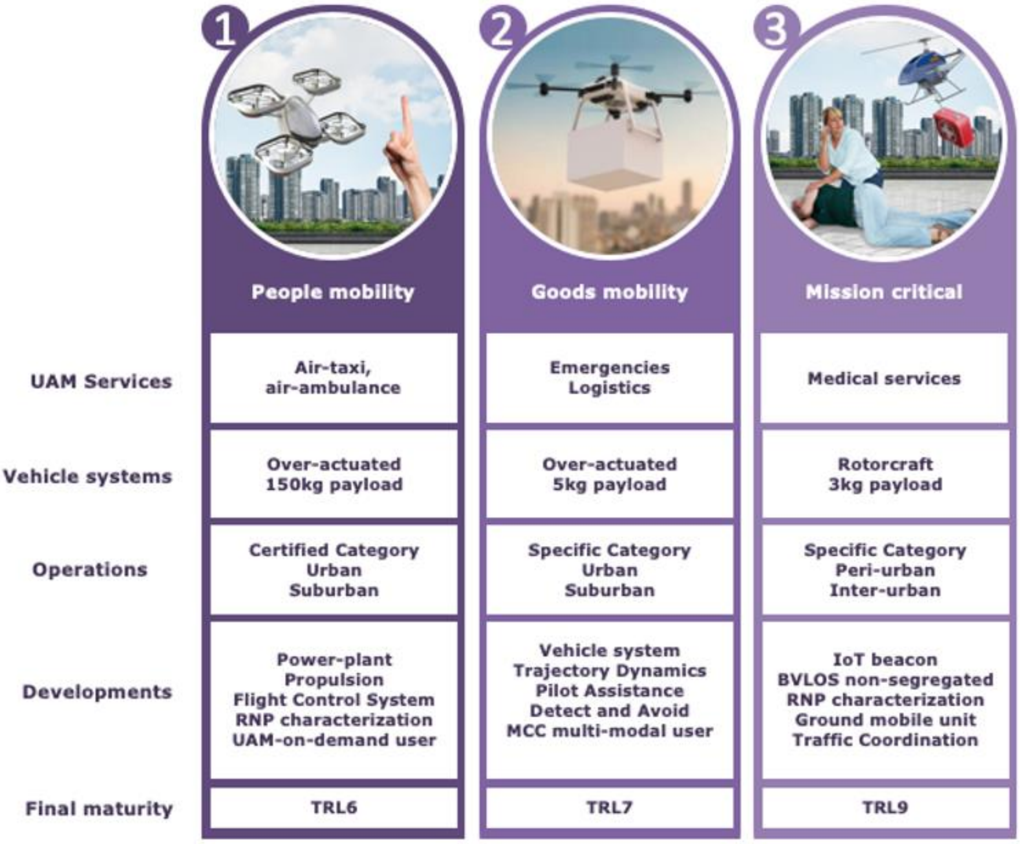


Figure 1-3: LAIKA operational technological demonstrators

1.3.1.2.1 People mobility services: air-taxi, air-ambulance

1.3.1.2.1.1 *Vehicle systems*

With a broad experience in the electrification of aircraft subsystems, TECNALIA has recently revealed its design of an **air-taxi concept** (see Figure 1-4), conceived for the intra-city transport of people. The objective mission of this vehicle is to travel 15 km in 15 minutes, with a maximum load capacity of 150 kg. The vehicle will travel at 90 km/h during journeys, although its architecture could allow speeds of up to 190 km/h, with a cruising height of between 100 and 300 metres, pending the evolution of current legislation.

One of the differentiating characteristics of this design is that it is an over-actuated aircraft, based on four quadrotors joined through universal joints to a central airframe, where the passenger or the payload can be located. This over-actuated nature provides several benefits over traditional multirotor structures, such as increased manoeuvrability and passenger comfort.

A prototype and a control algorithm were developed to study the technical viability of the proposed architecture. Actuators, sensors, and processors are distributed through the aircraft: a central controller computes the desired attitudes of the peripheral quadrotors to follow a given trajectory and four peripheral controllers, each located in the centre of each quadrotor, compute the required angular speed of each motor to reach that attitude. In the framework of this project, TECNALIA's air-taxi prototype will be evolved in several aspects to achieve the required specifications to conduct a demonstration in a real environment.

Figure 1-4: Render of TECNALIA's Air Taxi design (left) and the operational prototype presented in San Sebastian (Spain) in July 2019 (right).

Some of the most notorious updates will be performed in the following systems:

- Advanced flight control: Starting from an available proof-of-concept level (TRL4), flight control will be evolved up to TRL6 aiming to validate the aerial platform in a real environment. This task will be leaded by the University of Stuttgart and the Institute of Flight Mechanics and Controls, who has broad experience in the field of guidance, navigation, and control of aerospace vehicles, with a strong focus on the interface between advanced theoretical methods and practical engineering applications. Recently, they have contributed to the development of flight control algorithms for major actors in the UAM ecosystem, such as Volocopter.
- Power-plant and propulsion system: Prototype’s power-plan and propulsion hardware system is going to be upgraded to improve aircraft operation’s safety and cost effectiveness, while improving environmental impact. Furthermore, this change will improve high power/weight ratio, reduce battery recharge times, increase the level of reliability and fail-safety, reduce level of noise, and maintenance requirements. The development of this novel system will be leaded by Pipistrel, a Slovenian light aircraft manufacturer with a broad experience in fixed-wing electric aircraft and subsystem development.

1.3.1.2.1.2 *Generic concept of operations*

Due to the typology of the UAM vehicle, it is expected that the protection areas for departing, traveling and arriving routes will prevent close proximity to buildings. Therefore, the location of the vertipads will be specified at open areas on ground level (e.g., next to the airport or close to a business park), and on the rooftop of highest skyscrapers. This is convenient, as the UAM is mainly focused to transportation of people, commuting from/to work or departing/arriving at the airport.

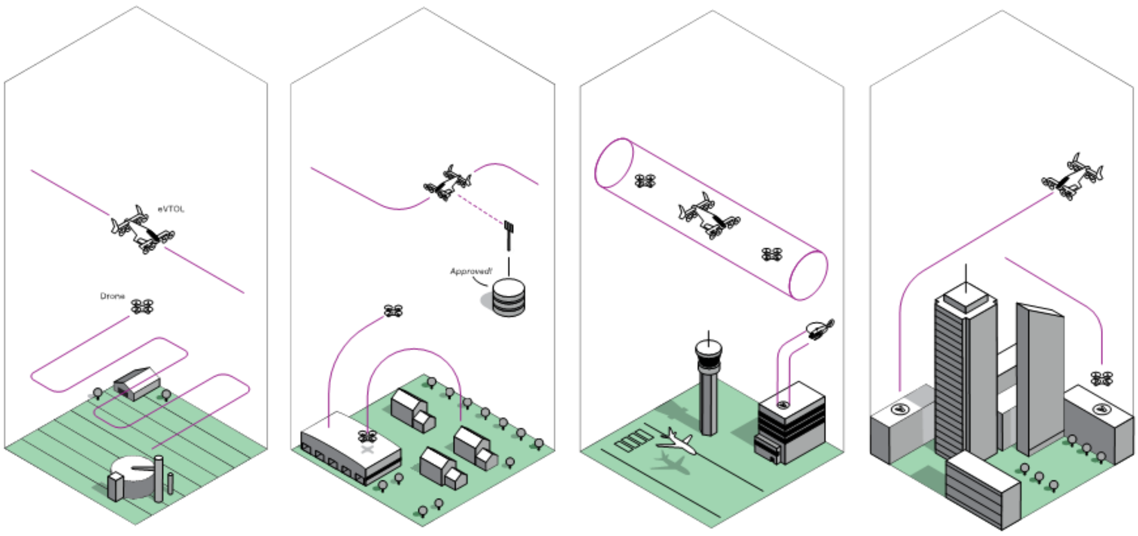


Figure 1-5: Urban Air Mobility concept of operations depiction

Therefore, the UAM routes will be defined from ground level to a vertipad in altitude, and vice versa, as well as ground to ground and rooftop to rooftop. This will enable a complete set of route typologies, as expected for UAM services.

1.3.1.2.1.3 *Transport-on-demand tools*

In order to turn the air-taxi into a viable UAM service, it is crucial to approach the service to potential users through an effective transport-on-demand contracting system. Among others, such system shall provide the user with the means to schedule an air-taxi by defining basic information like: departing location/time, landing location/time, travel cost, number of passengers, etc. On the other side, this system shall provide the required tools to the service operator to establish its operational service by: defining landing/departing locations, presenting predefined routes, and holding algorithms to improve the management and routing of multiple operations/vehicles.

In this framework, LAIKA project will adapt an already existing transport-on-demand system (Ne-mi) to air-taxi operations.

Ne-mi (*nemi.mobi*) is a system developed by PildoLabs which enables the operation of demand-responsive public transport services. It makes mobility in low-density areas feasible by providing a software solution that enables flexible bus routes. Consisting on a system back-end (which hosts the routing algorithm), a mobile user app, a driver app, and a web back-office, it allows citizens to book seats on vehicles which are operating different demand-responsive lines by indicating origin, destination and time of their desired trip. The available options are shaped by the virtual stops and schedule previously defined by the competent public authority.

Ne-mi is totally flexible and adaptable to all types of operating models, designed following public administration's requirements and intended for municipalities, transport authorities and bus operators.

It allows to relax public transport services to make them more efficient, sustainable and inclusive by optimizing kilometres travelled and saving emissions of CO2 and air pollutants.

1.3.1.2.2 Goods mobility services: emergencies and logistics

1.3.1.2.2.1 *Vehicle systems*

Aiming to cover urban and peri-urban emergencies and logistics operations, TECNALIA will lead the development of a **smaller vehicle** with maximum weight of 25kg and a payload of 5kg. Such a vehicle will be designed to achieve greater endurance, by minimizing drag and possibly introducing lift-generating surfaces.

The vehicle will be based on the same concept that TECNALIA’s air-taxi: an over-actuated architecture, with quadrotors attached to the airframe by means of universal joints, offering increased precision and manoeuvrability. Thus, it will be a good testing platform for the more advanced features of autonomy and control algorithms developed along the project which could, in the future, be transferred to the larger platform.

FADA-CATEC will work on the integration of on-board sensors and advanced algorithms for the provision of detect and avoid autonomous functionalities, while University of Seville will support the development of on-board advanced functions for pilot awareness and 3D perception.

1.3.1.2.2.2 *Generic concept of operations*

Delivering packages inside the city, especially at the last-mile, will require a multimodal cooperative service with air and road parts. At this moment, it is unrealistic to require a drone to deliver a package to an apartment in the city centre. Therefore, the goods mobility service will first connect the sub-urban, air-, rail- and road-connected logistic warehouse to micro-hubs spread around the city. Eventually, in more rural or peri-urban areas, a micro-hub could be deployed, on a temporary basis, from current package delivery cars or vans. This will remove the road distribution with mid-trucks that usually follow the congested traffic flows coming into and going out of the city (therefore preventing traffic jams, reducing pollutants, reducing road congestion, etc.) at around the city ring. Instead, the road link will only be used from these micro-hubs to the final customer, all inside the city and involving short distances, enabling clean modes of last-meter delivery (as opposed to last-mile delivery) such as bicycle, scooter or walking.

In this case, the routes will be defined mostly from ground level to ground level, from the central warehouse to the micro-hubs, found spread around the city. Potentially, a vertipad might be located at a building rooftop, if the building is declared a hotspot for deliveries. This could be the case for big office buildings with very high demand of inbound and outbound packages, in which case the last-meter delivery would be done directly inside the building.

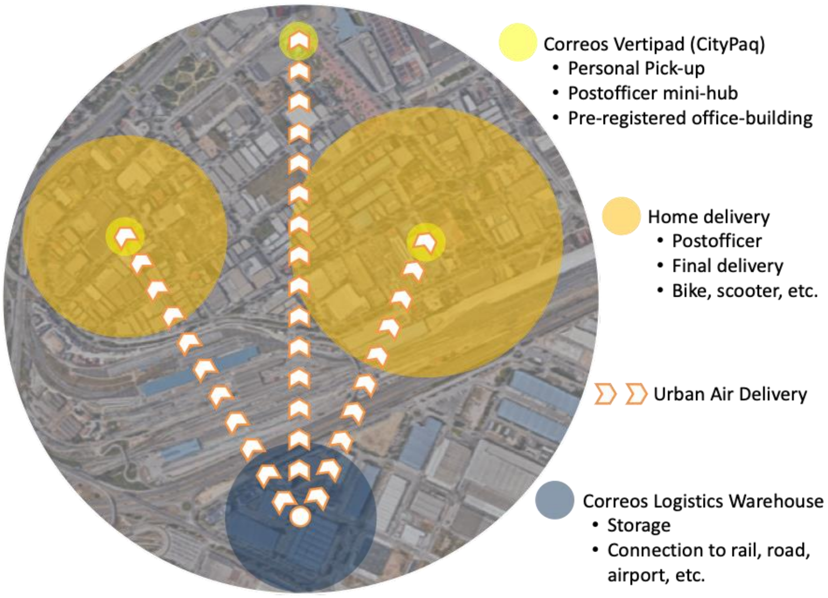


Figure 1-6: Correos Urban Air Delivery concept of operations depiction

This typology of routes, and the nature of medium- to low-sized drones, might require flights close to buildings, maybe even between buildings, following urban corridors and crossing parks and open spaces.

1.3.1.2.2.3 *Mission Coordination Centre*

The Mission Control Centre resides inside Correos' logistics systems and centralises the requests for air/ground deliveries, generating the optimal number of flights and routes considering the operator's CONOPS. This system is integrated into the operator's logistic platform in a way to ensure the correct communication of the services to the designated staff, who effectively carries out the control of the different phases of the delivery mission. Besides, a graphical interface allows the real-time monitorization of the execution of the air- and ground- deliveries, enabling the resolution of issues if they arise. The objective is to create an interface adapted to people who are not experts in the use of UAVs, allowing the drone and van monitorisation during all phases of the mission. The purpose is that the delivery mission is safe, and can be handled by a person who is not an expert (specially the air segment) and thus be able to integrate with the delivery of last mile logistics operations.

This application should be integrated in coordination with other airspace users, requesting the reservation of the required air-corridors to perform the specific flights, notifying the different phases of the flight, and hence, paving the way to business-to-business integrated multimodal commercial services.

This application resides at the operator's side, enabling and optimising its own package delivery operations. The modular architecture of this system will enable further specialisations of the application, which could be created in the future as the operator requirements grow.

1.3.1.2.3 Mission critical services: medical services

1.3.1.2.3.1 *Vehicle systems*

LUA is an unmanned aerial system (see Figure 1-7) based on a rotary wing VTOL aerial platform with an MTOW of 30 Kg specifically designed for firefighting and other mission critical services. In this configuration, the aircraft is capable of carrying up to 3 Kg of payload with a maximum flight time of more than 3 hours. The development started in 2017 under a R&D contract with the Galician regional government in the framework of the Civil UAVs Initiative for the procurement of a complete UAS solution to fulfil the public emergency civil services required by this Spanish administration, and is currently under qualification by the Galician public health administration.

The system has received approvals for operating in BVLOS firefighting and medical emergency missions under the specific category of the current European and Spanish regulations. It is also under certification by the Spanish Agency (AESA).

At the same time, additional system requirements were enforced to meet the tough environmental and operational conditions expected in emergency operations. In particular, an oversized power plant was required to give the aircraft plenty of power to operate with high wind gusts, temperatures and a large range of operating altitudes. The main structure is also oversized to withstand rough conditions and to reduce maintenance requirements.

Figure 1-7: Render of Babcock's LUA (left) and LUA in a fire-fighting operation at Andalucía, Spain (right)

In the framework of LAIKA, LUA surveillance systems will be upgraded by Kineis and PildoLabs, who will work on the integration of an on-board IoT nano-satellite communication system, which will provide a back-up solution to remote pilot situational awareness and surveillance functions. This will derive in new mitigation systems that will ease the acceptance of the concept of operations.

Furthermore, this new system will provide LUA with the capabilities to be positioned based on IoT nano-satellites through triangulation techniques, providing a redundant solution in case of losing primary satellite-navigation (GNSS) function.

1.3.1.2.3.2 *Generic Concept of Operations*

A specific operation for the fast delivery of defibrillators and medical equipment for cardiac arrest emergencies upon reception of calls at the regional health emergency coordination centre (CCUS-061) is used to assess and qualify the proposed traffic coordination solutions. The service is centralized at the CCUS-061, while the LUA UAS is operated from already available health emergency ambulance bases.

The key element in this operation is a quick response to the emergency, which is required to be less than 10 minutes in any point within the covered area, and thus requires prioritizing this traffic and providing a direct route to the emergency location. Because the UAS is operated from a health emergency services base, the departure is usually located within or near urban environment.

The concept involves both predefined routes over the area with UAS service coverage and real-time traffic coordination, flight plan publication and other related tasks. These predefined routes allow to simultaneously start the UAS flight with a known departure route while managing traffic-related tasks at the intended target location: publishing the destination point, diverting any traffic around the area of interest, planning a safe access to the emergency location, etc. In any case, these real-time management activities must also be fast to ensure a prompt access to the target.

This operation is already under qualification by the Galician health emergency agency (061), and will eventually start the service in 2021. These real operations will be used as a pilot scenario to validate and demonstrate enhancements in real-time traffic management, which will be implemented on top of the current, already approved operational system.

1.3.1.2.3.3 *Ground Mobile Unit*

As a complementary part of the aircraft, LUA system is supported by a ground mobile unit, a vehicle prepared to access rough terrains and to transport and deploy the system as required by the target emergency missions, with three operating stations: the UAS pilot control station, the payload operator station and the air traffic coordination station.

The ground segment has been specifically designed for firefighting and medical emergency services, but it is generic in terms of mission, and it can be used without modification for search and rescue off-shore operations among other applications.

The air traffic coordination station provides information and tools to ensure a safe flight within a potentially congested air space. Along with transponder/ADS-B information received by the UAV and relayed to ground, it provides navigation data for all aircrafts involved in the operation, additional alarms and procedures to allow traffic coordination. The station is intentionally installed inside the mobile unit, side by side to the UAS pilot station, in order to allow for faster UAS actions when required.

Even if this information could be enough to ensure air traffic safety in certain operations such as firefighting, there could be other situations in which external traffic, not involved in the operation and potentially non-collaborative, should be expected and handled. For this reason, the ground mobile unit is capable of transporting a mobile primary and secondary radar which feeds data into the air traffic coordination station. The radar is tuned to detect general aviation traffic with a range of more than 20 miles, and small UAVs at several miles of distance.

In the framework of LAIKA, some modifications will be performed over the ground mobile unit in order to manage the new surveillance system integrated on-board the LUA, and to execute the concept of operations related to medical services.

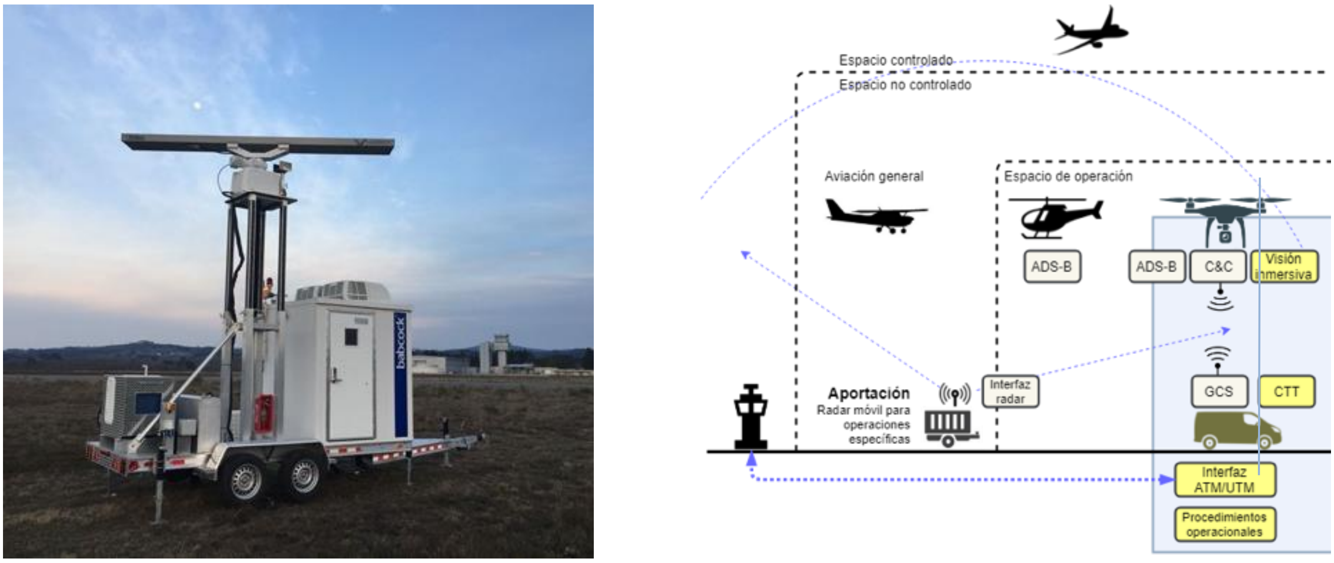


Figure 1-8: LUA Ground Mobile Unit primary and secondary radar (left) and air traffic coordination diagram of LUA system (right)

1.3.1.3 Urban Air Mobility Lab

The **UAM Lab** includes the necessary infrastructure, tools and services for testing and operating the technological demonstrators in a representative operational environment (see Figure 1-9). Through it, UAS operators will integrate the airspace infrastructure in a safe, secure and coordinated manner.

The deployment of the UAM Lab to support each operational scenario gathers several components which can be arranged in four main categories, as described in the following paragraphs and shown in the figure below.

Safety Risk Assessment: to evaluate that drones' operations are well protected by adequate safety levels, a risk assessment must be carried out. Basically, this assessment should ensure on a qualitative and quantitative manner that the probability that something goes wrong is low, and that any mitigation measure is put in place. Drone operations in the EU are subdivided into three categories: open, specific and certified. The specific category are the only ones that requires authorisation by a competent authority, while for the certified category drones will have to comply with standard aviation requirements, and the operational rules are the same as for manned aviation.

RNP characterization: Performance-Based Navigation is based on the possibility of an aircraft to keep the adequate level of performance for the proposed operations in the context of a particular airspace, defined in terms of accuracy, integrity, availability and continuity. Aircraft Required Navigation Performance (RNP) relates to the on-board systems capability to steer a predefined route, and provide the pilot with any warning in case this capability is lost. Adopting the PBN concept within drone industry requires the appropriate characterization of UAS RNP performances.

Airspace design: the design of low-level corridors and routes is based on a statistical error analysis and the definition of obstacle free surfaces, in order to minimize the probability of hitting the terrain or any other artificial obstacle during a flight operation. PBN flight procedure design criteria are based on the RNP defined values for a certain operation and airspace volume. The design of the airspace shall consider the type of operation and applicable flight rules (visual or instrument), the aircraft performance, any existing airspace structures, the take-off and landing locations, among others.

Urban ATM services platform: a modular cloud-based software platform, providing access to a limited set of U-Space services for de-conflicting and manage urban air mobility routes (regarding all types of request, from all operators).

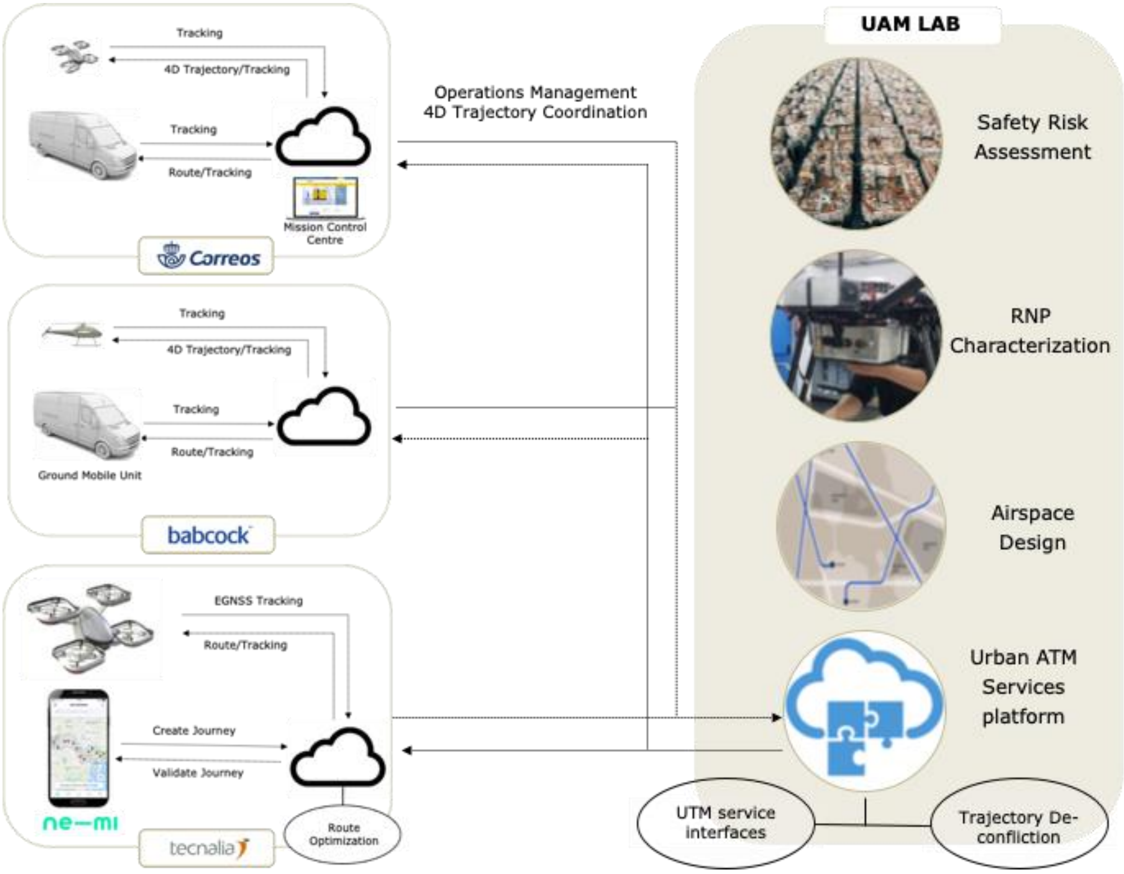


Figure 1-9: Operational framework and interface with technological demonstrators

In the figure above, LAIKA overall operational framework is depicted. The operators (on the left) receive and manage service requests through their own systems and applications. Upon acceptance of the service by the operator, a request for integrating the operation into the airspace is launched. Each service request is converted into an optimized 4D flight trajectory fitting designed or computed low-level-routes. The information is then handed over to a centralized Urban Air Services platform, which ensures de-confliction and coordination between operators through the U-space services.

Interface with the Urban Air Service is implemented on the operational tools from each technological demonstrator, meaning: TECNALIA UAM-on-demand back-end, Correos Mission Coordination Centre and Babcock Ground Mobile Unit.

1.3.1.3.1 Safety Risk Assessment

The deployment of the Urban Air Mobility Lab will need to accommodate the specific requirements for the proposed case-base studies and operational concepts developed. As such, safety risk assessments will need to consider the different concept of operations defined for each technological demonstrator.

In principle, **certified category** operations will need to accommodate standard aviation rules, including visual (VFR) and instrumental (IFR) flight rules. The integration of air-taxi operations, through manned or unmanned systems, is most similar concept as current rotorcraft operations at low-level airspace. Actually, first air-taxi urban mobility on demand services are already being offered by manned rotorcrafts at some city locations, among others: Mexico, Sao Paulo, Dallas or New York (Voom Airbus company, *voom.flights*, or Blade, *flyblade.com*). Those operations are principally conducted under visual conditions and, in case of degraded weather situation, the operation is integrated into ATM infrastructure under IFR rules with other instrumental traffic. The development of specific IFR low-level routes for helicopters are today being early introduced, principally based on GNSS systems. Early adopters are within the provision of Helicopter Emergency Medical Services (HEMS). Although VIP transportation keeps a huge interest on, their implementation over urban areas is quite residual and limited by the authorities. For the risk assessment on the introduction of eVTOL certified type of operations, LAIKA will benefit from the safety guidance material, and gained experience, developed within the FLAG European working group, dedicated to the introduction of low-level IFR helicopter operations (PBN GNSS IFR).

For **specific category** operations, a risk assessment must be carried out for each and every use case, and mitigation measures must be identified and adopted. The outcome of the risk assessment must be authorized by the CAA of the member state. To assess drones operational related risks, a standard methodology has been devised by JARUS (Joint Authority for Rulemaking on Unmanned Systems), a group of experts from National Civil Aviation Authorities worldwide that make recommendations on technical, operational and safety requirements for the safe integration of drones into the manned airspace.

JARUS risk assessment methodology is called the SORA (Specific Operation Risk Assessment) and divides the risk of a drone operation into two distinct classes: **air risk** as collision between the drone and another airspace user; and **ground risk** as collision between the drone with people, animals or objects on the ground.

In order to circumvent the workload on the development of a SORA, the concept of standard scenarios has been put into place. These standard scenarios describe the most common types of drone operations in conjunction with the risk assessment and the mitigation measures. LAIKA will benefit from existing and future standard scenarios on the risk assessments linked to the validation exercises and demonstrations.

1.3.1.3.2 RNP characterization

For safety and operational reasons, instrumental flight procedures have evolved towards the RNP concept in which certain navigation requirements are need to operate each procedure. In this field, IFR aircrafts integrate RNP navigation systems which satisfy certain level of performance through the use of its navigation sensors, system architecture, and modes of operation.

Hence, an RNP 10 procedure can only be operated by aircrafts integrating an RNP 10 navigation system, which means that the position computed by its navigation system shall by contained inside a circle of 10NM radius centred in the real position. This position error is known as total system error (TSE), which is mainly composed by:

- the error on the position computed through the satellite-based navigation system (NSE - Navigation System Error), and
- the error on pilot or auto-pilot follow the computed position over a series of waypoints (FTE - Flight Technical Error).

The NSE that could be measured from a satellite-system in a certain region depends on the system design, and could be obtained from the service documents[1]. Considering the type of operations, and particularities of the urban environment, a downgrade on NSE performance could be measured from satellite signal affectations (multipath, loss of satellites in urban canyons, interferences, among others). In that particular topic, LAIKA will benefit from DELOREAN project results, as introduced later on in section 1.3.3.

Instead, LAIKA will work on the characterization of the FTE, which is fully depending on the systems and solutions tackled by the project research areas. That includes dependencies with aircraft design, power-plant and propulsion system, on-board flight control systems and auto-pilot. Due to the amounts of statistical data required, and different flight conditions to test, in order to contain the overall costs, simulation exercises will be put up-front real flight tests. Even thought, by taking advantage of the flight validation exercises and demonstrations, and thanks to PLATERO flight validation platform, simulations results would be cross-validated with in-flight performance measurements.

[1] *https://www.gsa.europa.eu/newsroom/news/new-egnos-safety-life-service-definition-document-published*

1.3.1.3.2.1 *Air-vehicle simulator for people and goods mobility*

TECNALIA has developed a simulation environment that captures the main dynamic behaviour of their aircraft prototype and enables testing different control strategies in a virtual world. This simulator is based on the equations of motion of the aircraft, which have been analytically developed for simplified flight regimes and are numerically integrated in time. The simplifying assumptions consider quasi-static flight conditions and, even if ground-effect and some sensor noise is considered in the model, most aerodynamic interactions and navigation system errors have been neglected.

Both the dynamic model and the control algorithm are simultaneously simulated, which effectively provides an interface from user inputs to vehicle trajectories. Depending on the chosen controller, the inputs could be desired trajectories (fully automated trajectory tracking) or desired speed references (piloted flight). Apart from the actual simulator, a basic visualization tool has been developed (see Figure 1-10), to ease the understanding of vehicle motion. Currently, the simulator is implemented by means of Matlab/Simulink.

Within LAIKA, the simulator will evolve to compute Flight Technical Error (FTE) and define safety buffers along the desired trajectory.

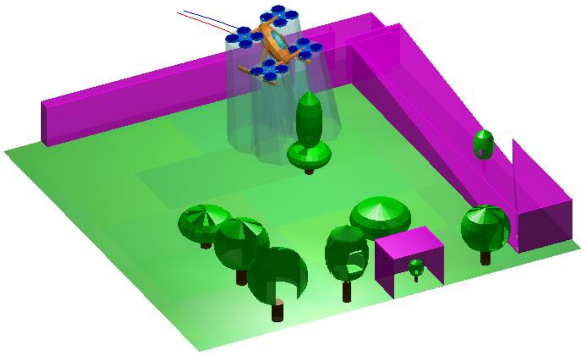


Figure 1-10: TECNALIA's simulation environment visual interface.

1.3.1.3.2.2 *Air-vehicle simulator for mission critical services*

The Quattro simulator is a complete framework for simulating unmanned system flight operations with the autopilot integrated in Babcock's LUA (Quattro autopilot). It includes hardware-in-the-loop (HIL) and software-in-the-loop (SIL) capabilities, and is fully customizable in terms of aircraft modelling and parameterization, with simulation capabilities for both fixed-wing and rotary-wing aircrafts.

The simulator integrates several modules that provide all the simulation functionalities. A physical engine provides the environment dynamics and specifications (pressure, temperature, gravity, wind, etc.), with the ability to control the environment behaviour during simulation sessions. An aircraft engine handles the aircraft model, parameters and actuation systems, including specific aerodynamics for rotary-wing and fixed-wing platforms. This engine includes the autopilot interface, which can work with its software version (SIL) or from the actual autopilot hardware (HIL). Being a standard interface (STANAG 4586), the actual autopilot source used is transparent to the simulation.

The standard interface is also used to communicate the simulator with the ground control station software, which is used to control the simulated system. The UAS operator commands the system with the exact same tool that is used in real flights. The simulator provides the required feedback to the autopilot, and this in turn gives telemetry to ground as usual. Additionally, a specific software interface is available to setup and control the simulation, with the ability to inject specific problems and events (platform hardware problems, for example).

The framework also includes a 3D engine to show a synthetic view of the environment and the aircraft.

The ground control station uses Vigilant Spirit as the ground control software, which uses the same STANAG 4586 protocol for communications. It has the ability to monitor and control several UAVs in flight, and to also monitor other aircrafts (manned or unmanned), with pilot warnings and alarms for several events, including possible conflicts, terrain, geofencing, etc.

Within LAIKA the simulator will be used to characterise the Flight Technical Error (FTE) and define safety buffers along the desired trajectory.

1.3.1.3.2.3 *PLATERO flight validation platform*

PLATERO (*platero.pildo.com*) is the latest generation of flight validation services. A portable system for flight validation and inspections of satellite navigation flight procedures with automatic reporting. It provides validation pilots with all necessary elements to manage the validation flight campaign in a simple, secure and cost-effective manner. The overall system is registered and protected by a European Patent EP3026461. PLATERO has already been used for flight validation of specific drone flight procedures (reference to REAL project within section 1.3.3). The system will be interfaced with the different vehicle systems and used during the validation flights and demonstrations for flight error performance assessment.

1.3.1.3.3 Airspace infrastructure

LAIKA intends to define a new experimental PBN design criteria based on low-level corridors, taking as reference the design criteria developed in related activities, such as REAL and REALITY (see section 1.3.3). Moreover, routes will be sized by taking into consideration the specific RNP values computed through previously described simulations and validation flights. Based on previous experimental flights with COTS mass-market UAS, performance up to **RNP 0.02** could be expected (see Figure 1-11 and Figure 1-12).

Most probably, the operation of low-level corridors through large eVTOL on passenger cargo, will require the integration of a final visual segment. Today exists already a tailored flight procedure defined for rotorcraft operations, so-called Point-in-Space (PinS). An adoption of such concept will be done for Tecnalia prototype, representing the first eVTOL provided with a tailored flight procedure accommodating specific performance.

Smaller vehicles will be able to handle higher trajectory dynamics, and will also be equipped with a higher level of autonomous flight capabilities. Those functionalities will be considered for the adoption of existing experimental flight criteria, in addition to lower expected RNP values.

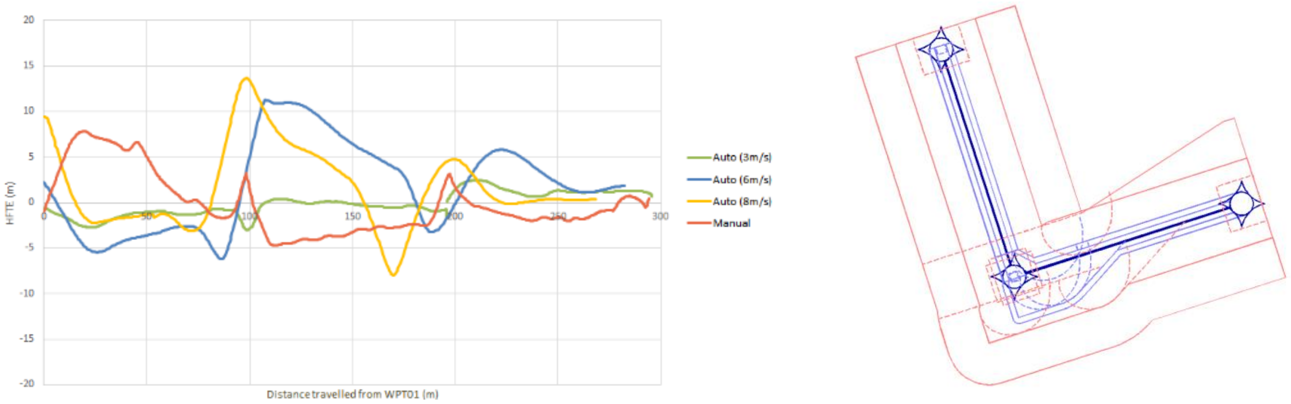


Figure 1-11: Horizontal FTE performance measured (left) and experimental flight design criteria (right) from REAL activity

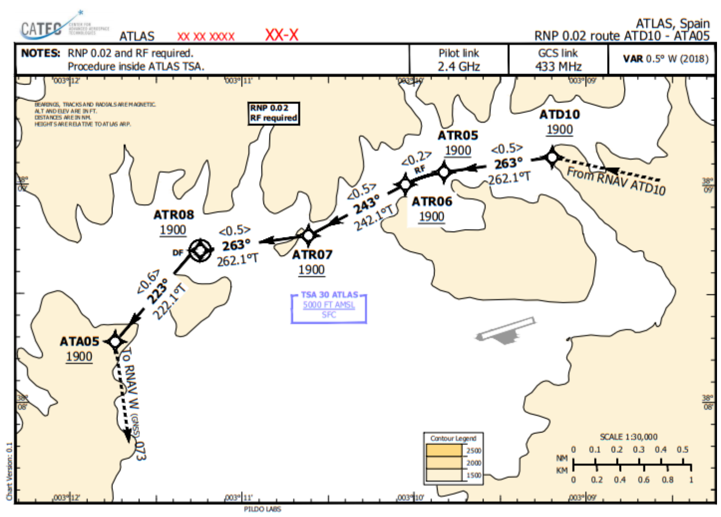


Figure 1-12: RNP 0.02 low-level route at ATLAS test airfield (src: REAL project)

1.3.1.3.4 Urban ATM Services Platform

LAIKA will deploy a set of U-space services through a cloud-based platform aiming to support the technological demonstrators during its validation in real environments.

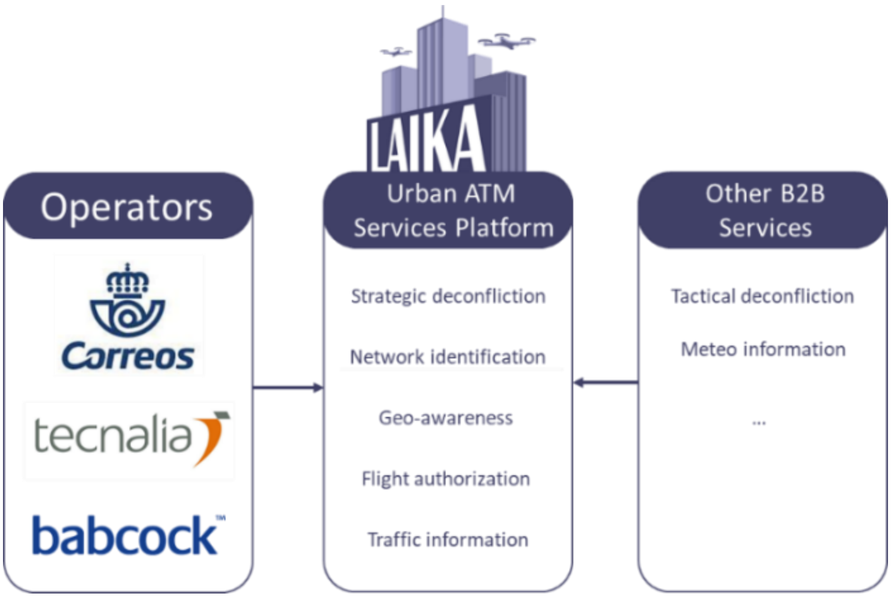


Figure 1-13: Urban ATM Services platform concept diagram

Among others, the present project intends to focus in developing a novel strategic de-confliction service.

- **Strategic de-confliction service**: This service will be interfaced with the operational systems from UAM service operators, to support Urban ATM operator to manage authorization and de-confliction of flights based on: 4D trajectory computation techniques, and 3D trajectory protection from terrain. Those trajectories will be designed following the PBN design criteria described in previous section.

  Once the Urban ATM operator receives the procedure, aside from its authorization, two different tasks will be conducted during the flight duration:
  - trajectory protection from terrain/obstacles; and
  - trajectory deconfliction with other trajectories/traffic.

  Time based trajectory deconfliction will be mainly based on slot allocation, as currently done with commercial aviation. This means that, if a conflict is detected between two trajectories, a traffic times will be adapted (and coordinated with the operator) based on an operations preference system.

A side from the previous service, LAIKA project will deploy those U-space services defined by EASA as mandatory[2]:

- **Network identification service**: This service shall continuously process the remote identification of the drone throughout the whole duration of the flight and provide it to authorized users. At least the following information should be distributed: the UAS operator registration number; the unique physical serial number of the add-on compliant with standard ANSI/CTA-2063; the geographical position of the unmanned aircraft and its height above the surface or take-off point; the route course measured clockwise from true north and the ground speed of the UA; the geographical position of the remote pilot or, if not available, the take-off point; the emergency status of the UAS; and the time at which the messages were generated.
- **Geo-awareness service:** This service shall provide to U-Space users with information related to the operational conditions for drone geographical zones to support the drone geo-awareness system. This shall include the geometry of all airspace with special access rules, any valid times or special airspace rules, and the time of update or a version number.
- **Flight authorization service**: This service shall provide the authorization to the drone operator to enter the U-space airspace under the terms and conditions specified by the USSP in the flight authorization. For this

[2] *See EASA Opinion 01/2020.*

means, the service shall check the request for flight authorizations against airspace restrictions and limitations, and ensure strategic de-confliction from other traffic.

- **Traffic information service**: This service shall provide the drone operator with information on other known or observed air traffic which may be in proximity to the position or intended route of the drone flight to alert and to help the drone operator to avoid a collision. This may include manned and unmanned aircraft.

Other B2B services, such as tactical deconfliction (surveillance) or meteorological information, are available (or planned) in COTS UTM platforms. The modular architecture of Urban ATM Services Platform developed in LAIKA will allow the future integration of such services, leaving commercial exploitation of new B2B services from external actors.

1.3.1.4 Test Flight Centres

LAIKA project will benefit from the right test-field means to perform all necessary integration, test and validation of the systems and solutions developed. A series of test flight centres (see Figure 1-14), either directly managed, or easily accessible to project partners, will provide the right means to perform the integration and test in operations of the different operational technological demonstrators. Those tasks will be essential prior to the final demonstrations at city locations.

Figure 1-14: LAIKA Test Flight Centres

Test site in Flughafen Lahr airport Test site for urban flight is located in Lahr airport (ICAO: EDTL), Germany. To support Urban Air Mobility vehicle testing, an electric charging station is available, as well as a large battery storage. The airport features a large asphalt runway of 3000 m x 45 m and various taxiways and VTOL areas for operations of many types of aircraft on the premises. As the airport is located in an urban environment, operation outside of the airport premises will be close to populated areas and require additional permissions. Another use case might be the test of multimodal traffic concepts in cities.

Test site in Mengen Hohentengen airport Test site for autonomous flight is located in Mengen airport (ICAO: EDTM), Germany. Equipped with various instruments for precise navigation based on RTK solutions, long-range encrypted communication systems, and airspace surveillance performed through primary radar system for drones and passive sensors such as ADS-B and FLARM. The field features two smaller asphalt (1600 m x 30 m) and grass (700 m x 30 m) runways. It is located in a very rural environment and allows flights in a specified BVLOS test volume 2 km from the airfield. Close-by there is a segregated airspace allowing more critical flight tests.

ATLAS Test Flight Centre ATLAS (Air Traffic Laboratory for Advanced unmanned Systems) is a test flight centre located in Villacarrillo, Jaen (Spain), managed by CATEC. It is specially designed for light and small UAS/RPAS operations. It counts with 1000 Km2 of segregated airspace until 5000 ft. available jointly with a main runaway of 600 m and auxiliary one of 400 m. In fact, it has been the test centre for numerous R&D projects, including the only two Spanish U-space demonstration projects (SAFERONE and DOMUS), managed by SESAR JU. Telemetry and primary surveillance radar facilities are available. Along with a suited orography and climatology enabling more than 300 day a year for operations.

CIAR Test Flight Centre CIAR is a UAS Flight Test Centre located in Galicia (Spain). Its activity started in 2015 as a joint initiative of the Galician regional government (Xunta de Galicia), through its Innovation Agency, GAIN, and its Economic Development Institute, IGAPE, and the Spanish Institute for Aerospace Technologies (INTA), which also manages the centre. It provides an airfield of more than 3 square km with a prepared runway of 1200 m, along with the required infrastructure for flight testing: a control centre in the airfield control tower, aeronautical communications systems, real-time field weather stations that include low-height wind and turbulence measurements, and safety systems provided by fixed radar. The centre also provides a wide restricted airspace for flight testing, along with the possibility of extending the testing area to nearby segregated spaces.

1.3.1.5 Cities supporting the action

A series of integrated demonstrations will be performed in close coordination with the different European, and other International cities/regions, supporting the action (see Figure 1-15). Those demonstrations will be performed, to the best possible, and in agreement with local and national authorities, in representative operational environments of the case-based studies and operational concepts.

Figure 1-15: Cities supporting LAIKA (map not to scale)

Barcelona (Spain) Barcelona, the cosmopolitan capital of Spain's Catalonia region, has a population of 1,6 million, for a total of 5,5 million in metropolitan region. The city council is actively participating on the research and development of new urban mobility solutions. Leads and coordinates the EIT Urban Mobility, a body of the European Union with a total co-funding of up to €400 million (2020-2026). The city is the actual Mobile World Capital and also hosting the Smart City World congress.

Ingolstadt (Germany) Ingolstadt is a city in Bavaria, Germany, known for hosting Audi manufacturing. It has a total population of 137,000 people living in a large urban area of 133,35 square kilometers. The city is actively participating within the EIP-SCC initiative, being one of the frontrunners for the UAM Initiative Cities Community, in particular for the research and development of drones to support medical assistance and air-taxi.

Tel Aviv (Israel) Tel Aviv, is the most populous city in the Gush Dan metropolitan area of Israel, with a population of 450k, and being the economic and technological center of the country. Ayalon Highways is a government company charged with promoting the planning and execution of transportation projects, and serves as the operational arm of the Ministry of Transport. Many advances are being done within the urban air mobility arena, which includes the publication of a Request for Proposal (RFP) for initial provision of services.

Sevilla (Spain) Sevilla is the capital and largest city of the Spanish autonomous community of Andalusia, with a rough population of 1,95 million of people. The city plays an important role within the national aerospace industry, and in particular linked to the drone technology development, with dedicated Research Centers and Universities. Fellow of the EIP-SCC urban air mobility initiative, and part of the city's community.

Camino de Santiago (Spain) The Camino de Santiago is a network of pilgrims' ways leading to the shrine of the apostle Saint James the Great in the cathedral of Santiago de Compostela in Galicia, northwestern part of Spain.

Many follow its routes as a form of spiritual path, being also popular within hiking and cycling enthusiasts. An operational area to provide fast-response on cardiac arrest emergencies with drones is already defined. A response time of less than 10 minutes, in any location within Sarria and Palas de Rei 50Km stretch, is targeted.

São Paulo (Brazil) São Paulo, Brazil's vibrant financial centre, is among the world's most populous cities with approximately 12 million inhabitants with the urban area and more than 21,5 million in the metropolitan region. Considered as one of the most important megacities in the world, holds one of the highest rates on daily helicopter movements. City council seeks for improving urban mobility, looking at urban air taxi services as a very promising option. It hosts the Drone Show, most important event in South America related to drone services and technology.

1.3.2 Positioning of the project

Urban air services, especially when unmanned, are still very embryonal. Operators and service providers are exploring the concepts that will modify the way they provide their services today, as a breakthrough towards more efficient and commercially exploitable operations. Therefore, the project lands on the '**idea to application**' phase.

Many of the system parts in the project start at a very low Technology Readiness Level. Exceptions are Babcock's drone LUA, which is involved in Babcock's own operations manual for firefighting missions; and Correos' own logistics software system, used every day for their postal services. A summary of TRLs related to the systems used (integrated), developed or upgraded in the project is found in the following table. This table refers to the TRL at the beginning of the project, as well as the expected outcome TRL at the end of the project.

System	Context	Departing TRL	Objective TRL
Tecnalia's UAM platform	Upgrade	4	6
Babcock's LUA	Integrate	9	NA
Babcock's Safety and Surveillance systems	Upgrade	6	7
Correos' Logistics SW	Integration	9	NA
Correos' Mission Control Centre	Upgrade	6	7
Detect and Avoid	Upgrade	3	5
PildoLabs' ne-mi	Integrate and Develop	4	6
e-identification beacon	Upgrade	4	6
Kinéis satcom IoT	Integrate	9	NA
RNP design criteria	Upgrade	5	6

Table 1-3: List of systems in LAIKA and their departing and objective TRLs

1.3.3 National and international research and innovation activities linked to the project

The following list presents national or international research and innovation activities linked with the project.

1.3.3.1 REAL and REALITY

REAL (RPAS EGNOS Assisted Landings, *real.pildo.com*), a project lead by PildoLabs and funded by European Global Navigation Satellite Systems Agency (GSA), aimed at promoting the use of EGNOS for the safe integration of BVLOS drone operations. A new flight-procedure design-criteria was defined in order to fly a very low-level operation coupled with the drone auto-pilot. By means of an experimental ad-hoc on-board sensor, an RNP0.02 level of performance was measured in-flight, keeping drone trajectory well within the designed obstacle clearance surfaces.

REALITY (RPAS EGNOS Adoption and Liaison with Navigation Integrity) is an on-going project that continuous with REAL objectives, aiming to consolidate those RNP performance based on more statistical data from an intensive flight campaign with mass-market UAS systems.

Both project outcomes are of particular interest to LAIKA, considering the type of performance, and in particular integrity levels, required to safely integrate autonomous urban operations in proximity to building and terrain.

1.3.3.2 ARIOS

REGA, the National Helicopter Emergency Service in Switzerland, is investing on the development of new capabilities to integrate IFR helicopter operations in more restringing and challenging environments. To accommodate Swiss territory orography, PildoLabs developed an ad-hoc RNP-AR helicopter flight design-criteria. In order to conform with the level of performances required (up to RNP0.1), helicopter's avionics require the integration of an additional inertial system. EASA, in coordination with LEONARDO, is in charge of the overall certification process of an AW-169 unit suited for the purpose. Additionally, a Flight Operational Safety Assessment (FOSA) is being developed for the first two scenarios where this design criteria will be applied (already designed): Interlaken and Samedan.

LAIKA will directly benefit from the experience on developing advanced design criteria based on performance, its test and acceptance by National regulation authorities.

1.3.3.3 FLAG

The FLAG (5Lives Advisory Group) was originally established under the 5-Lives project co-funded by GSA within the Horizon 2020 programme with the aim to bring helicopter operators and national aviation authorities together to promote and harmonize the implementation of EGNSS operations for rotorcraft in Europe. The group is now composed of: European helicopter operators and manufacturers, ANSPs, regulatory and national aviation authorities and supported by EUROCONTROL, the GSA and EASA. In collaboration with all stakeholders the group has developed a three-year work programme for implementation and support of satellite-based rotorcraft operations and is acting as a leading European panel for this type of operations. PildoLabs acts as chairman, on behalf of GSA, and technical coordinator of the group.

LAIKA will benefit from all lessons learned, generic safety material and technical guidelines developed within the group, particularly significant for the introduction of urban air mobility low-level operations within the certified category.

1.3.3.4 TRACE

TRACE (Smart Drone EGNOS-based beacon for U-space), an on-going project participated by CATEC and funded by European Global Navigation Satellite Systems Agency (GSA), aims at promoting the use of EGNOS in the drone sector through the development of an EGNOS-based portable smart beacon. Such beacon will enhance the integration of drones at Very Low-Level interfaced with U-space services defined by EASA as mandatory in Opinion 01/2020: network identification, geo-awareness, flight authorization and traffic information. The smart beacon developed will be validated and demonstrated in two operational scenarios (agriculture monitoring and linear infrastructure inspection) by means of a leading U-space platform provided by Unifly.

LAIKA will benefit from TRACE smart beacon developments, which will be taken as the base surveillance system for IoT nano-satellite communications system integration, procuring a solution compliant with U-space services and providing additional features through IoT nano-satellite present and future communication services.

1.3.3.5 DELOREAN

DELOREAN is an on-going project led by PildoLabs, co-funded within the H2020 EGNSS Market Adoption Programme, aiming at the development of EGNSS (EGNOS and Galileo) requirements for the integration of urban air mobility operations. The project is underpinned by operational cases, engaging two main commercial services operators: Airbus and Correos. Present and future services offered by European satellite-navigation systems are tested and demonstrated in the city of Benidorm. The project is based on the use of COTS drones, and experimental avionics with advanced EGNSS receivers.

LAIKA will benefit from, up-to-date, the only project fully dedicated to EGNSS and urban air mobility. Results, and in-flight data collected, will be considered within the definition of system requirements and air-vehicle RNP characterization tasks. In particular considering any possible downgrade on the navigation system error, due to multipath, temporary loss of satellites, interferences or any other signal affectation related to the specific characteristics of an urban environment.

1.3.3.6 POSTLowCIT

The general objective of the POSTLowCIT project is the development of an efficient urban freight delivery service of Correos, Spanish universal postal operator. For that purpose, it holds a feasibility study of an innovative solution that encompass the implementation of a smart fleet and logistics control system that ensures smooth last-mile connections and the deployment of electric vehicles and softer modes in urban areas and of vehicles powered by auto gas for long distance transport between urban nodes. This feasibility study will be held in four main urban nodes within Mediterranean Corridor at Spain, Madrid, Barcelona, Sevilla and Valencia and its inter-urban links. These urban nodes are representatives of different typology of cities along the Mediterranean Corridor, in terms of population size, urban structure, freight delivery volume and demand typology, multimodality, factors that condition urban traffic.

LAIKA will benefit from all the outcomes of this project, which will support the definition of goods mobility technical demonstrator.

1.3.3.7 Galileo Information Centre in Brazil

The Galileo Information Centre in Brazil (*galileoic-brazil.com*), coordinated by PildoLabs, is established in Technology Park at São José dos Campos by the European Commission under the Directorate General Industry and Space (DG DEFIS), to promote international cooperation across technologies and programs of European satellite navigation systems (EGNSS).

The Centre aims on consolidating the European Commission, not only as a GNSS signal provider, but also as a key cooperation partner for Brazilian stakeholders, by providing the adequate instruments to effectively develop GNSS initiatives from different perspectives (policy making, research, industry, etc.), and offering a privileged entry point for European GNSS industry in Brazil.

LAIKA will benefit from the institutional support, and local partners engagement, to promote, demonstrate and establish mutual benefit cooperation based on project activities and results.

1.3.3.8 Civil UAV Initiative

The Civil UAVs Initiative (*www.civiluavsinitiative.com*) is a strategic framework implemented as a pre-commercial procurement processes promoted by the Galician regional government (Xunta de Galicia) and led by the Galician Innovation Agency (GAIN). The Initiative started in 2016 with the goal of promoting the use of UAS for civil applications and, in particular, to improve public services through the use of unmanned systems and through public-private collaboration with research, technological and industrial strategic partners. Babcock, Indra and Boeing lead the three main R&D programs within the CUI framework. In particular, Babcock is leading 20 projects in this program, all of them aimed to implement actual emergency services with UAS for public administrations. One of such projects addresses the qualification and provision of medical emergency services for the Galician Health administration.

LAIKA will benefit from a real-case operational service which is an ideal scenario to assess the proposed traffic solutions for peri-urban operations.

1.3.3.9 Framework Tender for Transporting Cargo via UAV

As it is well-known, recent months have seen the outbreak of the Corona pandemic, infecting hundreds of thousands of people across the globe, subsequently leading the Health Ministry to issue a series of public guidelines, as well as implement Emergency Regulations (The Novel Coronavirus - Limited Activity), 5780-2020 that inter alia, have substantially reduced going out into the public sphere, and imposed restrictions on the use of several means of transport. Against this backdrop, and as part of the ongoing efforts to cope with this situation, Ayalon Highways, in consultation with The Ministry of Transport and Road Safety, the Civil Aviation Authority of Israel and the Israel Innovation Authority, launched a framework tender to locate, examine and contract with suppliers capable of delivering a technological response for transporting cargo via UAV that will serve as a support vehicle for the aerial transport of various cargo.

LAIKA will benefit from the definition of service specifications, also proposing an ideal regulatory framework and case to demonstrate and deploy project results.

1.3.4 Methodology

LAIKA will progress on different research areas that are considered essential for the future deployment of urban air mobility services. Aside from safety, one of the most important barriers to adoption of urban air mobility applications and services, is societal acceptance of this new technology and perception that the benefits it delivers outweigh the impacts is has on bystanders, the environment, and the overall quality of life.

Today we stand at a unique convergence point of several new technologies, such as autonomy, improved batteries and low-cost mass-produced light-weight materials that enable us to move into the third dimension with a new class of urban flying vehicles. All technological elements are in place to make urban air mobility a success, but there is a need on providing more evidence that this is actually possible, and more important that accommodate customer requirements.

Lean innovation methodology is focused on customer experience, allowing to adapt to new information, and help to make decisions based on market-based evidence. With the intention to minimize waste in the product development cycle, the overall process prioritizes experimentation over-elaborated planning, increasing efficiency by capturing customer feedback early and often. The concept is based on three main principles, empathy, experiments and evidence. LAIKA will adapt lean innovation methodology, to develop a research framework providing through experimentations tangible results and evidence on defined requirements.

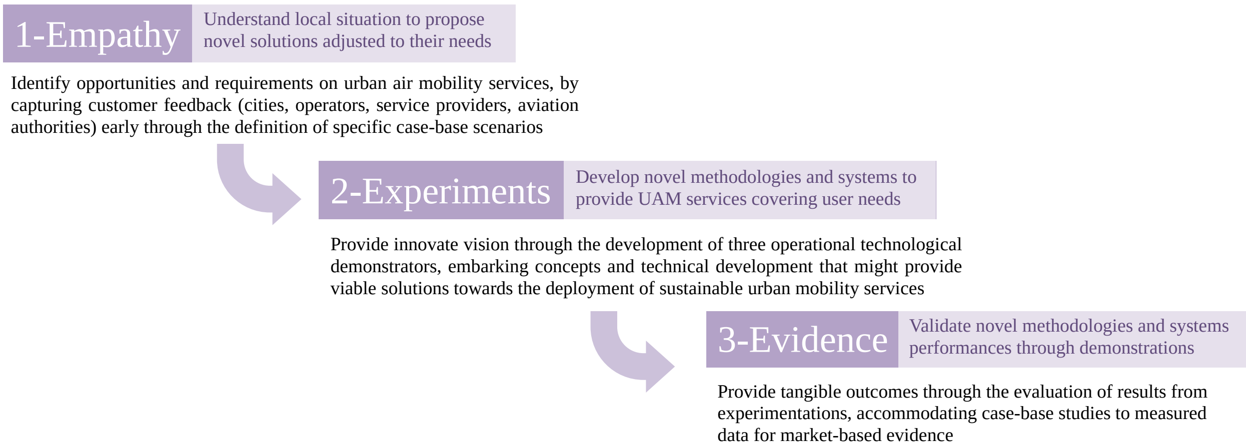


Figure 1-16: LAIKA Lean innovation based methodology

1.4 Ambition

LAIKA will work on innovative concepts, services and functionalities beyond current state-of-the-art, and demonstrate how those can provide a viable solution and contribute to the successful deployment of urban air mobility services. Next sub-sections provide more detail on the innovation potential within key areas of research developed through the project.

1.4.1 New aviation applications; new aircraft systems

Urban Air Mobility term embraces new aviation applications that common aircraft systems are not able to assist. Recent developments – in battery capacity, autonomy, and on-board technology – make new kinds of aircraft possible. These vehicles have new shapes, capabilities, and operations. Smaller cargo drones can move packages faster and more efficiently to hospitals, offices, and homes. An emerging class of electric vertical take-off and landing (eVTOL) aircraft can transport people around congested cities in minutes instead of hours. These new vehicles can fly further – and lower – than ever before.

Leading institutions have recently published several analyses where their vision of future urban airspace is described. The consensus is that different aircraft topologies will coexist, in the same way that a variety of wheeled vehicles share the roads today. Thus, each aircraft architecture is expected to be optimized for a given application, broadly classified as: **small multirotor** vehicles for inspection and surveillance labours, **larger multirotor** for short-range (intra-urban) transport of goods and people and dual-phase, **tilt-wing and fixed-wing** concepts for longer range transport (peri-urban and inter-urban) of goods and people.

Most of these vehicles will make use of Distributed Electric Propulsion (DEP), which drastically reduces local emissions and noise. Besides, the intrinsic simplicity of electric powertrains, in comparison with combustion-based ones, provides fewer modes of failure. The redundancy of distributed systems also contributes to the safe landing of the vehicle when subsystem failure happens.

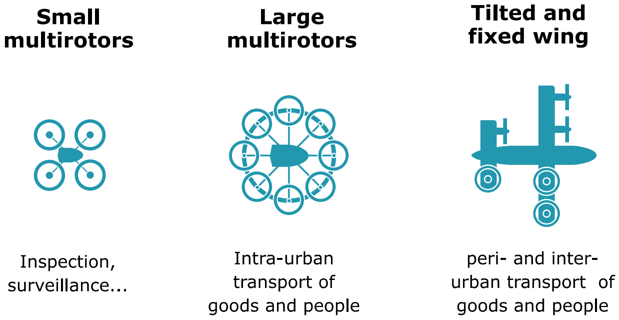


Figure 1-17: Broad classification of the multiple aircraft architectures that will coexist for different UAM applications.

Most urban air vehicles that are currently on development integrates a large number of electrically driven actuators. The over-actuation of aerial vehicles, not only provides higher levels of safety in case of actuators failure, but also provides more stability in the presence of turbulence and wind gusts, which might get intensified in the proximity of high buildings or other aerial vehicles. Indeed, the possibility to independently control the six degrees of freedom of the vehicle's cabin, can enhance more precise landings and stability to the overall operation for a best passenger experience.

Significant advance beyond the state-of-the-art will be done on electric vehicle system architecture, including:

- analysis of different propulsion topologies for the development of two aerial systems that best fits the operational requirements on people mobility or lower-weight goods mobility; and
- investigation on potential over-actuated aircraft architectures, and in particular on actuation control algorithms and allocation strategy, to ensure safety, efficient energetic use, and better user-experience.

1.4.2 Boosting electric propulsion

Traditionally in aviation, the propulsion system was treated and designed almost entirely decoupled from the rest of the systems on board an aircraft. Furthermore, the interface and distinction between the airframe and propulsion system was entirely clear (engine under/on/above the wing, in the nose, or mounted on aft-fuselage pylons), and the notion of flight control association with the propulsion system not existing, apart from the consideration that controllability be possible also in case of propulsion failure. The next wave of flying vehicles, however, in particular distributed-propulsion vertical-take-off-and-landing aircraft, will need to tightly couple the aspects of controllability and trajectory control to the responses and reliability of the propulsion system.

The interaction between the propulsion system and the actuators of the flight control system are key to stabilize the vehicle in flight and best steer the trajectory. Within LAIKA, the possibility to interact directly the flight control system with the propulsion system will be investigated, providing a more stable, redundant fail-safe solution, and reducing the overall costs.

The action will also contribute to advance on electric propulsion component development, with a battery showcasing a pack-level energy density of 170 Wh/kg at a median discharge rate of 4 C, and power controllers with a minimum core power density of 15 kW/kg.

Significant advance beyond the state-of-the-art will be done on critical hardware and propulsion system development, including:

- develop and demonstrate a novel architecture of propulsion system for a much broader solution beyond the needs of multi-copter-like aircraft;
- develop core elements of the propulsion system, including power supply modules (battery and management unit), power controller and associated sensors, suited for the intended operations;
- investigate on the direct integration of propulsion and flight control systems, without no dedicated gateway or single-point interfaces, providing a much redundant and fail-safe architecture;
- research on real-time powertrain performance modelling and forecasting, to flight control computer confidently compute the flight trajectories;

- investigate on modelling techniques of the thermodynamic transient effects, to support autonomous decision-making on trajectory flyability; and
- validate generic architecture, and components performance, though the integration of two operational demonstrators.

1.4.3 Ease and assist complex urban piloting

Analysts predict that initial implementation phases of urban air mobility will be through piloted operations rather than autonomous flights. The need of professional pilots is a strong handicap for the economic viability of urban air mobility services. As such, self-piloting and remote piloting become interesting alternatives, but enhanced systems to better assist them is a critical and necessary.

On a functional level, nominal flying must become intuitive, i.e. a high level of handling qualities must be achieved and in addition, non-nominal critical conditions must be covered by algorithms in such a way that simple piloting, or simple remote control, remains guaranteed even in that case.

A higher level of handling qualities depends on the design of the command filters. Those command filters maps pilot inputs to reference flight states, and are normally designed for each operational mode. Switching between operational modes (e.g from hover to forward flight) requires some transients, that may not be easy to handle.

Similar to the path predicted for the automotive industry, flight automation will begin by a pilot assistance system, which will ensure safety, especially at critical manoeuvres such as: collision avoidance, take-off or landing. Deep reinforcement learning algorithms, combining optimal control algorithms with deep neural networks, has initially demonstrated to provide promising results in the field of aircraft control as in support to high dynamics and agile manoeuvres management. Exist different types of reinforcement learning algorithms, including: actor-only, critic-only and actor-critic. Actor-critic methods combine the advantages of other two, and are being investigated in the control of complex aerial platforms thanks to their good convergence properties.

Flying in urban environments involve flying very close to possible obstacles, and the probability to encounter non-planned situations is much higher than in traditional flights at higher altitudes. It is really important to perceive and automatically understand the environment. Semantic visual analysis supports the task, by providing the means to automatically identify and classify the relevant infrastructure and objects around the vehicle. All relevant methods employ a supervised deep neural network method, that analyses an image to produce a per-pixel semantic label. Within LAIKA the use of deep neural networks for semantic visual analysis will be investigated, devising lightweight and/or fast architectures that could be efficiently executed on-drone equipped with special GP-GPU computing units.

Considering the intrinsic of flying over an urban environment, relevant advance beyond the state-of-the-art will be done to best assist pilots, including:

- develop new command filters for over-actuated systems, with smooth transients between different operational modes, and best assist pilots with handling qualities and easy control;
- investigate the use of reinforcement learning algorithms, principally based on actor-critic methods, to support dynamic stability and energy efficient operations in complex urban environments;
- develop novel mapping techniques to increase situational awareness, combining high-accuracy and large-scale maps based on a multi-resolution approach;
- test and validate semantic visual analysis and reinforcement learning algorithms in relevant operational environments, through the integration of a small air vehicle for goods mobility reaching TRL7; and
- reach TRL6 for people mobility system and obtain a permit to fly to perform remote piloting flight demos.

1.4.4 Towards more autonomous operations

The deployment of urban air mobility services will be gradual, prioritizing less challenging and populated environments. More advanced autonomy functionalities will need to be developed, in order to accommodate the higher safety levels imposed by more complex urban environments. Detecting and avoiding obstacles, and other aerial vehicles, is fundamental to ensure safe autonomous operations in urban complex scenarios.

Urban air vehicles should be able to react to obstacles not previously considered during the flight plan management phase (strategic deconfliction), and situations where trajectory re-planning (tactical de-confliction) is not possible (imminent collision).

Certainly, one relevant aspect of detect and avoid functionality is to solve the real-time planning of avoidance trajectories. Robotics community has worked on real-time trajectory planning approaches for the last four decades (first on industrial and ground robots and lately on aerial robotic systems). LAIKA will build innovative solutions upon the latest development in robotics trajectory planning.

Autonomous functionalities are highly dependent on the precision of the position computed by the on-board navigation system. Primarily this is assured by GNSS systems, which might be precise enough most of the time, but not in more challenging take-off and landing operations. The possibility to use on-board sensors, such as 3D LIDARs, opens the possibility to develop a more robust system to assure precise navigation all over the flight.

New solutions and techniques beyond the state-of-the-art will be investigated towards more autonomous and safe operations, including:

- develop efficient avoidance algorithms that can be implemented on-board UAS, taking into consideration the computational limitations due to limited payload capacity;
- explore new solutions for real-time trajectory planning, based on heuristic algorithms such as Lazy Tectha, or probabilistic ones like Rapidly Exploring Random Tree (RRT)
- combine trajectory optimisation techniques with RRT algorithms for more accurate trajectory planning in obstacle rich environments; and
- investigate the fusion of GNSS with other on-board sensors, through SLAM methods and other localization algorithms, in order to keep precise navigation all over the flight in urban challenging environments.

1.4.5 Design safe and secure airspace

New urban air mobility vehicles can fly higher—and lower—than ever before, and have new shapes, capabilities, and operations, which our current airspace system was not designed to handle. The digital age of aviation will change our skies, and how to integrate future unmanned (vehicle/systems) remains a key challenge to overcome.

Imagine in future millions of autonomous air vehicles, providing autonomous rides at a portion of a price of today's air operations, being massively used at a wide-scale, and contributing to reduce global emissions with ecologically responsible and sustainable aircraft like the eVTOL.

How to integrate such a large amount of future unmanned (vehicles/systems), in coordination with existing ATM traffic and infrastructure in a seamless air traffic flow, remains a key area of research and investigation. Existing air traffic management system is tailored to commercial flights for fixed wing aircraft. It still relies on voice communication, human-centered task execution and radar technology. More autonomous and decentralized traffic management solutions will be required to support operations in urban areas, from helicopters to drones. A key element is unmanned traffic management (UTM), also called U-space in Europe.

While for current low altitude flights, for example with general aviation aircrafts or helicopter, navigation today relies mostly on pilot visual capabilities; this scenario is not a viable solution in future. As such, what today is mostly airspace where a pilot can fly only on visible conditions will turn into airspace where most of the actions will be based on automated decisions from on-board equipment and instruments, in order to avoid any conflict with planned flights. Based on that, new flight procedure design guidelines will need to be defined based on performance-based navigation concepts. More restringing navigation performance will need to be adopted, and possibly create time-based separation between flying trajectories.

The digitization and provision of real time traffic information, will come with stringent cyber-security requirements to secure the overall system. More redundant communication channels will also be required, and the possibility to safely self-navigate in case primary GNSS solution is lost.

New concepts and disruptive technologies beyond state-of-the-art will be evaluated to best organize and manage airspace in a safe and secure manner, including:

- develop flight procedure guidelines, and define experimental flight criteria accommodating the specific required navigation performance of two technological demonstrators;
- evaluate different operational concepts, and interaction schemes between operators, to design and publish a planned trajectory;
- evaluate the possible use of internet-of-things services via nano-satellites in urban air mobility operations, providing a better resilience in contingency management and robustness for Beyond-Visual-Line-of-Sight (BVLOS) operations;
- develop a cloud-based platform to handle flight operations requests through 4D trajectory-based techniques and strategic de-confliction;

- investigate novel concepts and techniques towards autonomous traffic coordination and safe separation of BVLOS operations;
- investigate the use of cryptocurrency blockchain technology to secure the 4D trajectories transactions on a distributed network via a digital ledger; and
- evolve an urban air mobility system to reach TRL9 for urgent medical assistance in non-segregated airspace.

1.4.6 Sustainable deployment and acceptance

Public acceptance of urban air mobility services, particularly noise aspects and its psychological factors, is perhaps one of the biggest challenges along with safety. Failure to address these issues could hinder urban air mobility implementation. Noise from aircraft and other transportation modes is a complex topic spanning acoustics, the physiological way humans experience noise, and the psychological perceptions listeners have of the source of the noise and what it represents of them. A large body of research spanning this area has been conducted over the last century, with learning outcomes relevant to model aviation.

Early operations may start with a less intense acoustical impact on bystanders, for example less frequent operations in rural areas, and with strong positive social impact, such as mission critical services on emergency medical services, search and rescue and disaster relief. These applications can be a valuable test-bed to learn and refine low-noise operations as well as actively shape positive public perception of technology.

The deployment of urban air mobility will also contribute to sustainable electrification in large urban areas and reduce pollution levels and increase air-quality through near to zero emissions vehicles. Quantify the obtained gains, and promote them towards society will ease that urban air mobility services are not only considered quiet but also green, contributing to the global environment endeavour.

Practical experiences will contribute to best assess and quantify main barriers, and benefits obtained, for the deployment or urban air mobility services. Within the action, significant advance will be done beyond the state-of-the-art, in particular to:

- define specific case-base studies to assess the deployment of urban mobility services in concrete scenarios;
- investigate on generic guidelines for urban air mobility service deployment and practically assess them on tree operational technological demonstrators and specific city locations;
- investigate environmental affectations (visual intrusion, energy demand, local pollution, climate change and noise annoyance) and recommend airspace design guidelines for an optimal network of low-level corridors connecting vertipads;
- develop best practices on the implementation of urban air mobility services through operational technological demonstrators, and help public perception through integrated demonstrations in cities; and
- investigate on electric vehicles life cycle and create showcases for environmentally friendly urban air mobile, including end of life and recycling phases.

1.4.7 Integrating a multi-modal ecosystem

Urban design of modern cities considers the transport system of a city as a first order contributor to the overall economic, social and environmental performance. City planning and transport have to be designed concurrently to deliver an ever-evolving optimal system. Introduction of Urban Air Mobility will open a new era in transportation and will, in the long run, reshape cities and how we live and commute.

Urban air mobility is the first truly digital native transport system. Leveraging the power of networks for the transportation system, promoting sharing economies, multifunctional air stations engaging local entrepreneurship and boosting economic development. Sustainable by design, with low environmental footprint and embedded within multi-modal transport systems, urban air mobility opens up a new era in transport.

Another key functional area to investigate is UAM integration with public transport within Mobility as a Service (MaaS) ecosystem (e.g. mobility platforms, seamless mobility, cybersecurity, insurance, legal, transport operations). Ultimately, the provision of a B2C booking platform will be necessary, providing travellers with the ultimate in convenience and reliability at accessible price points.

Airbus' on-demand helicopter booking platform, Voom, already operates at Sao Paulo and Mexico City, providing rides mostly from city heliports to International Airport. In rush hour traffic, that journey can take two hours, compared to 10 minutes flight time on a rotorcraft. Although the service is now discontinued due to COVID-19, it helped to lay the groundwork for Airbus' longer-term vision of urban mobility using electric vertical take-off and landing (eVTOL) vehicles. Voom has proven to be an awesome mechanism to glean key insights into the potential of the on-demand air mobility market and passenger preferences.

While helicopter operation costs are still quite high, it is expected that through eVTOL and automation the overall operational costs will be drastically reduced, opening a window opportunity for democratizing the use of air flights in cities and at the meantime lead to low emission.

To promote the integration of urban air mobility services with other existing transport means, the project ambition beyond the state-of-the-art is:

- evolve a generic transport-on-demand platform to integrate urban air mobility services, and interface with U-space service platform to publish and coordinate flights with other drone and public transport operators;
- develop route optimization algorithms for a multi-user on-demand ride and evaluate them in different operational scenarios including highly populated airspace;
- integrate urban air mobility services, in a multi-modal and seamless manner, within current goods delivery chain, and demonstrate benefits for last mile delivery in rural areas; and
- demonstrate solutions through integrated demonstrations in representative environments, and evaluate key performance indicators on the basis of results.

1.4.8 We are the world, we are the cities

The European Commission is working on improving citizens' quality of life and strengthen the economy by promoting sustainable urban mobility and increased use of clean and energy efficient vehicles.

New political challenges have emerged in recent years. Climate change, energy policy, air quality legislation and the difficulties of tackling congestion are just some examples. The objective now is to enhance mobility while at the same time reducing congestion, accidents and pollution in European cities.

The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) aims to improve urban life through more sustainable integrated solutions and addresses city-specific challenges from different policy areas such as energy, mobility and transport, and information and communication technologies (ICT). It builds on the engagement of the public, industry and other interested groups to develop innovative solutions and participate in city governance.

With most of future transport growth occurring outside Europe, access to knowledge and new markets will become increasingly important. Urban mobility and sustainable electrification in large urban areas, in particular at developing and emerging economies, is identified among five international cooperation flagships defined to build a transport system contributing to a low-carbon and climate resilient future.

Cities like Tel-Aviv has reached such amount of traffic levels that are among world’s five most congested cities (according to navigation app Waze). It takes on average 2.38 minutes to drive one kilometre, and new created solutions for road offloading should be assessed. Urban air mobility provides an alternative “space” worth exploring. City council is working together with aviation authorities, for best understanding the overall requirements and regulations to enhance the gradual deployment of urban air mobility services, probably first through light cargo services in suburban space through authorized routes. Those first experiences should definitely help to best understand how a sustainable deployment plan could be defined.

Engaging urban planners and city stakeholders, together with aviation authorities, is key for best understand how urban air mobility services could be deployed. The current initiative will contribute to the task with some elements beyond the state-of-the-art, among those:

- engage cities on the development of specifications on system and service deployment, together with industrial operators, service providers and public aviation authorities;
- establish a cooperation framework on the urban air mobility topic through international partners, in particular at those areas where early implementation is taking place;
- benefit from well-recognized technological think-tank and service associations to promote results and provide recommendations towards European institutions;
- engagement of National Aviation Authorities, and European Safety Aviation Agency, on the development and test-case of technological demonstrators and operational concepts; and
- promote the amendment of draft regulations based on results from experimentations, at city, regional and national level.

2 IMPACT

2.1 Expected impacts

Since 2016, with the publication of the European Drone Outlook Study, the tremendous potential of VLL operations with drones and autonomous aerial vehicles has been identified as a priority in Europe. Moreover, in the last year, UAM applications have also attract a lot of attention.

UAM can be defined as a safe and efficient system for air passenger and cargo transportation within an urban area, inclusive of small package delivery and other urban Unmanned Aerial Systems (UAS) services, that supports a mix of on-board/ground-piloted and increasingly autonomous operations.

According to studies of urban population growth[3], 68% of the world´s population will live in urban areas in 2050. Rising population in urban centres is limited to the transport systems in our cities: crowded subway, bus, train or tram lines, traffic jams, etc. This situation causes an increase of pollution levels, greater loss of time, and money for worldwide citizens. Moreover, the European Commission estimates that the effect of traffic congestion currently costs almost 100 billion euros a year. By 2030, it could be close to 300 billion euros.

The deployment of UAM services could revolutionize the way that people move and packages are transported within and around cities by shortening commute times, reducing the amount of CO2, by passing ground congestion, enabling point-to-point flights across cities, and reducing traffic accident. To achieve this paradigm, shift is needed to develop systems that allow the safe operation of this type of transport and improve public acceptance. The UAM market is expected to grow from 5,300 to 15,200 million dollars, at a CAGR[4] 11,33% from 2018 to 2030 (see Figure 2-1). Moreover, the integration of autonomous aerial vehicles in urban environments as part of the SmartCities services will allow access to market value at 1.29 billion of euros in 2020, with a potential benefit of 2 billion of euros.

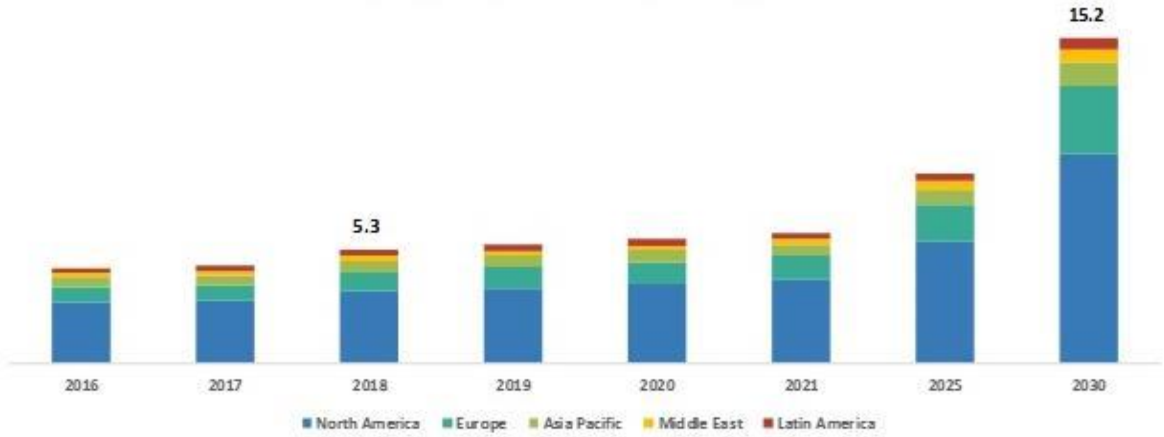


Figure 2-1: Urban air mobility market, by region (USD billion) (src: MarketsandMarkets Analysis)

This high potential is translated also in an important industrial interest, where nowadays there are multiples examples of prototypes for aerial vehicles models for people transportation: Kitty Hawk (US), Lilium (Germany), EHang (China), Volocopter (Germany), CityAirbus (Airbus), etc. Both transport companies (like Uber) and aeronautical companies (like Airbus, Bell or Boeing) are launching projects aimed at developing UAM solutions.

Besides, a market study developed for NASA published relevant information regarding the future viability of UAM services like: last-mile parcel delivery, air metro and air taxi (see Table 2-1).

UAS last-mile delivery	It may have a viable market in 2030. A significant increase of this kind of transport due to e-commerce players. Potential price in 2030: 4.20 $/delivery
Air metro	It may have a viable market in 2028. This option resembles current public transit options such as subways and buses, with pre-determined routes, regular schedules, and set stops in high-traffic areas throughout each city. Potential price in 2030: 30 $/trip

[3] *https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html*

[4] *Compound annual growth rate*

Air taxi	High investment costs make a widespread air taxi market with ubiquitous vertiports unlikely in 2030. Concentrated areas of high net worth individuals and businesses served by air taxi solutions.

Table 2-1: Summary of NASA UAM viability study

Therefore, UAM mobility has become a global trend that aims to reduce the rising pressure on transport infrastructure building transport capacity in the third dimension: the sky. However, in order to become a reality, a number of important challenges need to be overcome (regulation, public-acceptance, battery technology, and also safe integration in the airspace).

LAIKA will design new concepts and technologies that will facilitate the use of autonomous aerial vehicles in future UAM applications and services, while developing public material to support gradual introduction of UAM services. Some of the most notorious impacts foreseen to extract from LAIKA activities are summarised in the following subsections.

2.1.1 Innovative aircraft architectures for smarter cities

Tecnalia has recently revealed its design of an air taxi concept (see section 1.3.1.2.2.1), conceived for the intra-city transport of people. One of the differencing characteristics of this design is that it is an over-actuated aircraft, based on four quadrotors joined through universal joints to a central cabin, where the passenger is located. This over-actuated nature provides several benefits over traditional UAM multirotor structures, such as increased manoeuvrability and passenger comfort.

Through the development tasks performed in LAIKA, it is expected to evolve Tecnalias' vehicle prototype architecture in order to get impact in the following aspects:

- Urban environment integration: Based on its enhanced manoeuvrability and reduced dimensions, it will ease vehicles adequate integration in the urban environment. Furthermore, the vehicle's distributed electric propulsion will contribute to **maintain aviation safety levels** and to **increase the competitiveness and economic growth**, as congestion in cities is detrimental to business reactivity.
- User acceptability: Unlike conventional multi-copters, this vehicle will control the main cabin's attitude regardless of the aircraft speed or while counteracting wind gusts, contributing to **increase the final user experience and acceptability**. Furthermore, this novel architecture seeks to **inspire and engage** new generations of students, engineers, and urban planners and mobility managers.
- Operation performance: By using its tilting rotors and cabin's attitude control, vehicles most aerodynamic position will be maintained obtaining minimum parasitic drag. This will allow to increase travel speed, contributing to the operation performance by **decreasing the time in door-to-door travel, emergency** or **interventions** and to **decrease the overall environmental footprint**.
- Health status monitoring: Interface between power controller module and flight control computer will be developed to interchange information about health status of the vehicle as well as the forecasting of health parameters for the propulsion system components (thermal reserve, power reserve, capacity reserve, etc.). This innovative solution will contribute to best predict possible contingency situations and contribute to minimize operational risks.

LAIKA excellence on aircraft design, will contribute to ease the introduction of air mobility services in cities, with tailored innovations that best accommodate the intrinsic characteristics of an urban environment, and provide seamless operation and user experience as existing transport means and services. Air connected vehicles will interact with other mobility solutions and integrate mobility as a service offer, towards **smarter and more sustainable cities**.

2.1.2 Appraise air vehicle certification and approval

The current aircraft regulatory framework has initially been designed for conventional fixed-wing aircraft, rotorcraft, balloons and sailplanes. Propulsion was mostly provided by a low number of piston or turbine engines using fossil fuels, therefore requiring very high reliability requirements for the powertrain and increasing the final cost. EASA is currently consulting with its Advisory Bodies on new Rulemaking tasks (RMT.0731) to develop rules or amend existing ones, to address new technologies and operational air transport concepts, to be agile and to adapt the regulatory framework.

On 2 July 2019, the European Union Aviation Safety Agency (EASA) released the first building block to enable the safe operation of hybrid and electrical vertical take-off and landing (VTOL) aircraft (Special Condition for VTOL[5]). The final Special Condition published provides the framework for manufacturers to develop innovative VTOL aircraft. It applies to person-carrying VTOL heavier-than-air aircraft in the small category, with lift/thrust units used to generate powered lift and control. The small category covers aircraft with a passenger seating configuration of 9 or less and a maximum certified take-off mass up to 3175 kg.

Two certification categories were introduced in this special condition, namely 'Basic' and 'Enhanced', and are linked to the intended type of operations. A direct relationship between airworthiness and types of operations already exists, for example when certifying for VFR or IFR operations. Introducing this additional link provides greater scalability in setting safety objectives and allows to assign the highest safety levels when flying over congested areas and commercial air transport of passengers.

Following these guidelines from the regulatory framework, LAIKA project provides a methodology and a process of integrating different technologies optimally and efficiently trying to minimize the final cost/reliability ratio obtained, which could be an example for future developments.

- As an example, in the powertrain a redundant motor powertrain is chosen that bases its robustness not on a few very expensive motors with high reliability, but on cheaper motors with long runs and which, due to their high redundancy, may have lower robust requirements and thus lower the cost of the aircraft significantly, accelerating the deployment of this type of urban aircraft.
- Following the same route, for the control development, an open platform that could be used for very different aircraft applications will be used, leading to a hardware solution that could be applied to very different applications and therefore reduce the development cost of future aircraft designs.

With direct support and implication from EASA, LAIKA will contribute to best understand if the solutions developed in the project could well **accommodate and maintain aviation safety levels**. In the meantime, will help to assess the applicability and suitability of current regulatory framework on obtaining a permit to fly. This joint effort, will contribute to **raise the capabilities of public authorities** and provide a better understanding of the overall air-vehicle certification and approval process.

2.1.3 Reduce environmental footprint for climate resilient future

While the benefits of UAM services for EU citizens are clear in terms of mobility and connectivity, the sector represents a challenge for the environment in the years to come. Even if most of unmanned vehicles are electric (avoiding local air pollution), its operational footprint can be divided in two main factors: noise pollution and energy consumption.

Because of UAM services will be provided in populated areas, it is critical to consider the noise pollution caused by eVTOL propulsion systems. Long-term exposure to aircraft noise is linked with a variety of health impacts even at relatively low noise levels, including ischaemic heart disease, sleep disturbance, annoyance and cognitive impairment (see Table 2-2).

On the other side, eVTOL aircraft have a large energy consumption during take-off and climb flight phases. However, during the cruise phase, vehicles can become relatively efficient based on its design and flight conditions. Furthermore, the infrastructure and flight procedure itself (departure/landing points, trajectory, altitude, speed, etc.) may condition aircraft consumption, notably modifying its efficiency, and also optimize the noise footprint.

Health effect	Relationship
Annoyance	Confirmed starting from L_{den} 45 dB (estimate of the magnitude quite reliable).
Sleep disturbance	Confirmed starting from L_{night} 40 dB (estimate of the magnitude quite reliable).
Ischaemic heart disease	Confirmed starting from L_{den} 52 dB (estimate of the magnitude not reliable).
Child cognitive impairment	Confirmed starting from L_{den} 55 dB (estimate of the magnitude reliable).

Table 2-2: Main health effect of aviation noise (src: WHO Europe, 2018)

[5] *https://www.easa.europa.eu/document-library/product-certification-consultations/special-condition-vtol*

Aiming to reduce the environmental impact of UAM services, LAIKA will contribute through the following developments:

- The design of an eVTOL over-actuated aircraft will allow to control the main cabin's attitude regardless of the aircraft speed, keeping the best aerodynamic position of the vehicle during all the flight, and reducing energy consumption. Novel techniques will be used to assess and adjust the downwash airflow of the vehicle to obtain minimization of noise pollution.
- Development of an eVTOL power-plan/propulsion hardware system for safe, economic and environmentally friendly UAM. Characteristics include high power/weight ratio, fast battery recharge, high level of reliability and fail-safety and low level of noise, emissions, and maintenance requirements
- Definition of UAM services CONOPs, providing the methodology to design efficient routes which optimize the eVTOL flight time (reducing the energy consumption) while minimizing visual intrusion and noise pollution over populated areas.

2.1.4 Seeing is believing: provide evidence through practical experiences

LAIKA is based on lean innovation concept, providing early evidence through market-based experimentations, that gradual and sustainable deployment of urban air mobility services is feasible. Getting practical experiences on how to overcome the actual barriers, and build confidence on the solutions and services, should contribute to **reduce the lead time-to-market** and **de-risk** the set-up of urban air mobility services. Success of urban air mobility systems will be dependent on several factors, if they are to be accepted from an economic, social, and regulatory standpoint. LAIKA developments will directly impact on evidence those factors.

Safety	Urban air mobility will have to demonstrate the high safety levels expected by the public for modern air transportation systems. LAIKA contributes to **maintain aviation safety** levels through: • Innovative air vehicles, propulsion and flight control systems • Advanced algorithms for better pilot handling qualities and situational awareness • Advanced systems and algorithms for autonomous detect and avoid • Redundant communications and navigation solutions through precursor satellite systems • Tailored flight procedure design guidelines • Advanced U-space techniques for trajectory deconfliction and traffic coordination
Security	Emerging technologies present new cybersecurity risks and vulnerabilities that will have to be managed. LAIKA contributes to the secure digitization of air transport through: • Cryptocurrency techniques to secure trajectory coordination • U-space network identification
Social Acceptance	New products or services applying aerial mobility must gain the trust and support of the public, taking-into-account multiple factors • Prioritize operational cases that provides higher societal benefits (emergencies) • Showcase solutions in representative cities and operational environments
Resilience	Contingency management, the ability to manage the expected and the capability to recover from the unexpected will be a key of success • Air vehicle health monitor prediction techniques • Advanced real-time trajectory computation algorithms • Redundant CNS capabilities
Environmental impacts	Factors such as noise and visual impact form air vehicles on the environment and nonparticipants, as well as greenhouse gas emissions and any associated air pollutant emissions, will have to be minimized to acceptable levels. • Optimal trajectory computation based on performance characterization • Emissions modelling from real measurements • Vehicle life cycle assessments • Noise characterization and modelling
Regulation	New rules to accommodate the technology as well as to define its integration into the European airspace will have to be created. • Refer to VTOL special conditions • Risk assessments for specific operations • Leverage rotorcraft regulatory material • Further BVLOS operations in non-segregated airspace
Scalability	Any successful approach to urban air mobility will need the capability to scale as the market segments emerge and grow. • Innovative service and business model

	• More efficient and cost-effective solution for 061 cardio arrest
Flexibility	With any disruptive new initiative, flexibility is crucial as new use cases and operations concepts emerge. • Adaptive concept of operations • Transport-on-demand service • Multi-modal operational scenarios

Table 2-3: Evidence on urban air mobility success-dependent factors

2.1.5 Foster outstanding job creation through public-private cooperation

The use of commercial drones in outdoor situations has increased in recent years, and this trend will continue in the future. In Europe, 200,000 commercial drones will be sold in 2025 and 395,000 in 2035. Agriculture sector will be the most relevant one with 150,000 units in 2035; however, Delivery will produce 70,000 units, and Mobility 10,000 by 2050 (see table below).

in EUR	2035 impact				2050 impact			
	Products	Services	Others	Total	Products	Services	Others	Total
Agriculture	800 M€	3 200 M	500 M€	**4 500 M**	600 M	3 200 M	400 M	**4 200 M**
Energy	<100 M	1 600 M	<100 M	**1 600 M**	<100 M	1 600 M	<100 M	**1 600 M**
P.S.S[1]	300 M	800 M	300 M	**1 400 M**	300 M	700 M	200 M	**1 200 M**
Delivery	600 M	800 M	600 M	**2 000 M**	700 M	1 400 M	800 M	**2 900 M**
Mobility	<100 M	<100 M	<100 M	**<100 M**	400 M	2 600 M	600 M	**3 600 M**
Others	200 M	700 M	100 M	**1 000 M**	200 M	800 M	100 M	**1 100 M**

1: Public safety and security

Table 2-4: Summary results of economic impact by industry sectors. Souce SESAR

The development of novel concepts, technologies and solutions proposed in LAIKA, will impact substantially to increase participants ‘competitiveness, know-how and expertise, and allow them develop new business opportunities in the market. Through the engagement of important industrial players, business opportunities turn to job opportunities created, promoting the sustainable **growth of employment** in a very promising sector. The participation of Universities and Research Centres will also represent an opportunity to Master/Bachelor **students and the research engineers** to come into contact with Industry partners that eventually could **engage them** based on acquired knowledge and excellence.

Public-private cooperation, engaging end-user NGO, public authorities and services, with industrial operators and service providers, should also impact on the definition of UAM solutions and business schemes that best suits market demand. Participation of aviation authorities together with city stakeholders will also contribute to understand the different challenges and barriers faced by urban air mobility services, and increase the overall capabilities to assess how to overcome them by keeping adequate safety levels.

Finally, the use of commercial drones is a **global market** that will require high-end European produced vehicles as well as for outstanding know-how. With most of future transport growth occurring outside Europe, access to knowledge and to new markets will become increasingly important. **International cooperation** will have a key role to play for developing new business opportunities. Project impact on that respect will be huge, endorsed by the actual participation of an economically influent third country such as Israel, and a wide network of project partners at non-European megacities and regions, pioneering the implementation of urban air mobility services.

2.1.6 Strength European competitiveness

Air transportation is a key industry in Europe, and it is crucial to evolve it in a safe and secure way towards UAM in order to maintain a dominant position within this market. To carry out this evolution, it must be considered that numerous entities and bodies might get involved, at some point, during UAM services deployment and operation (industrial partners, cities or regions, end-users, regulatory agencies, etc.), and proper coordination and understanding between them is required.

In this field, LAIKA project aims to develop representative UAM solutions and, for this purpose, a high cross-disciplinary consortium has been gathered, together with a group of Advisory board (AB) members that will support project activities (see Figure 2-2).

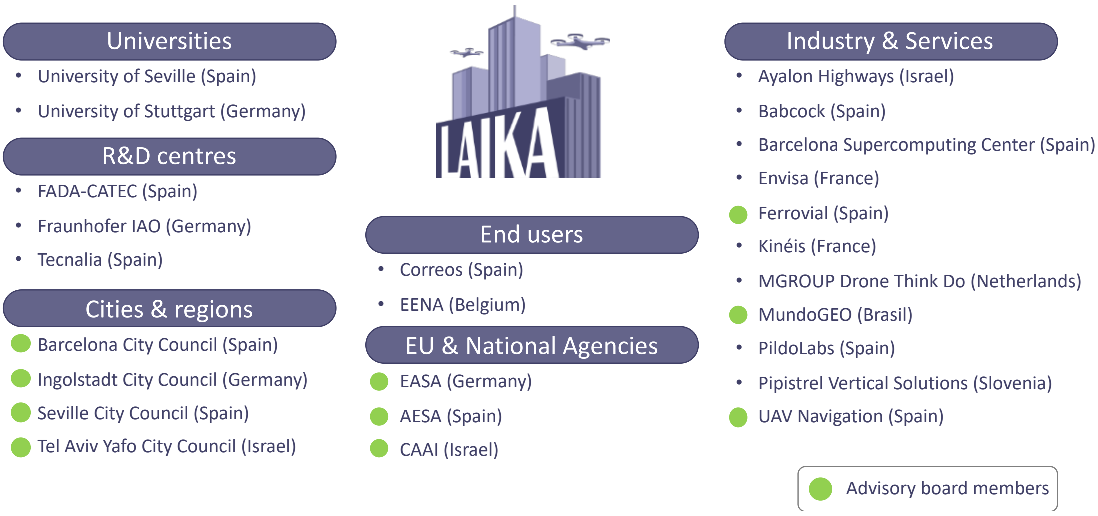


Figure 2-2: LAIKA consortium and advisory board members

Furthermore, the project includes the explicit commitment from National Authorities from Spain and Israel, plus the European Aviation Safety Agency (EASA), to assist in the actions. This is particularly important for the activities related to vehicle systems certification and approval, as well as risk assessments on the operational concepts developed. Aviation authorities participation will also contribute to the development of European and International standards and legislation for urban air mobility, acquiring and sharing knowledge that will allow moving forward from initial seed and segregated implementation to a more ambitious implementation plan.

Links with EUROCONTROL activities, and in particular their active contribution to the JARUS group, will also be assured by establishing synergies on the basis of the FLAG working group activities.

2.1.6.1 Join forces with other EU endeavours

The European Commission is working on improving citizens' quality of life and strengthen the economy by promoting sustainable urban mobility and increased use of clean and energy efficient vehicles. LAIKA will impact and contribute to such enterprise, by establishing close coordination with most relevant initiatives within the urban mobility topic.

The Marketplace of the EIP-SCC

The European Innovation Partnership on Smart Cities and Communities is an EU-backed initiative that aims to bring together the main forces behind the transformation of urban energy in the EU (cities, industry, research, and projects) to increase the impact of the sector throughout Europe. Within this initiative, six Action Clusters (thematic assemblies of partners that commit working on specific issues related to smart cities, sharing knowledge and experience with their peers, giving added value to their national and local experience and identifying gaps to be covered at European level). Tecnalia is part of the consortium that currently manages "The Marketplace of the EIP-SCC" since September 2019.

The work of the EIP-SCC is carried out in six Action Clusters, one of them is *Sustainable Urban Mobility* (SUM), which integrates the UAM initiative, where one of the demonstration projects is led by the German city of Ingolstadt (Advisory board member). In addition, Drone Think Do acts as ambassador to the EIP-SCC UAM initiative, within the network of frontrunners and fellow cities and regions. This network is already participated by some of the cities supporting the action, such Sevilla and Ingolstadt. PildoLabs cooperates with Airbus, leader of the UAM initiative within the EIP-SCC, on the development of rotorcraft and UAM operations.

Urban Mobility EIT-KIC

The Institute of Innovation and Technology is an EU-backed initiative led by Barcelona city council, where Fraunhofer IAO and Barcelona Super-Computing Centre are partners and Tecnalia is a network partner. EIT is a body of the European Union, to become the largest European initiative that transforms urban mobility. Although EIT-KIC activities are still in quite embrionary phase, within its terms of reference the urban air mobility is almost considered. Partners participating in the EIT-KIC will impact that other UAM complementary activities could be co-financed in future.

LAIKA initiative will also establish synergies and leverage results from parallel research frameworks, including: **SESAR** (Single European Sky ATM Research), PildoLabs, FADA-CATEC and Universidad de Sevilla participates in different early research and U-space demonstration projects and **other research activities** related to the exploitation of satellite-based navigation services within the drone sector (EGNOS/Galileo). PildoLabs, Correos, FADA-CATEC cooperates in the topic. Universidad de Sevilla works on U-space related topics.

2.1.7 A practical path to public acceptance

According to a study developed by Airbus, nearly one in two people surveyed are in favour of UAM deployment. In fact, 44% indicate they support, or strongly support, the initiative. The findings also reveal that 41% of participants perceive these aerial vehicles to be safe or very safe. Moreover, safety (55%) ranks as participants' leading concern for UAM implementation in their communities, followed by sound types (49%) and sound volume (48%) generated by the aerial vehicle. In general terms, the study findings are very positive and demonstrate there's growing support.

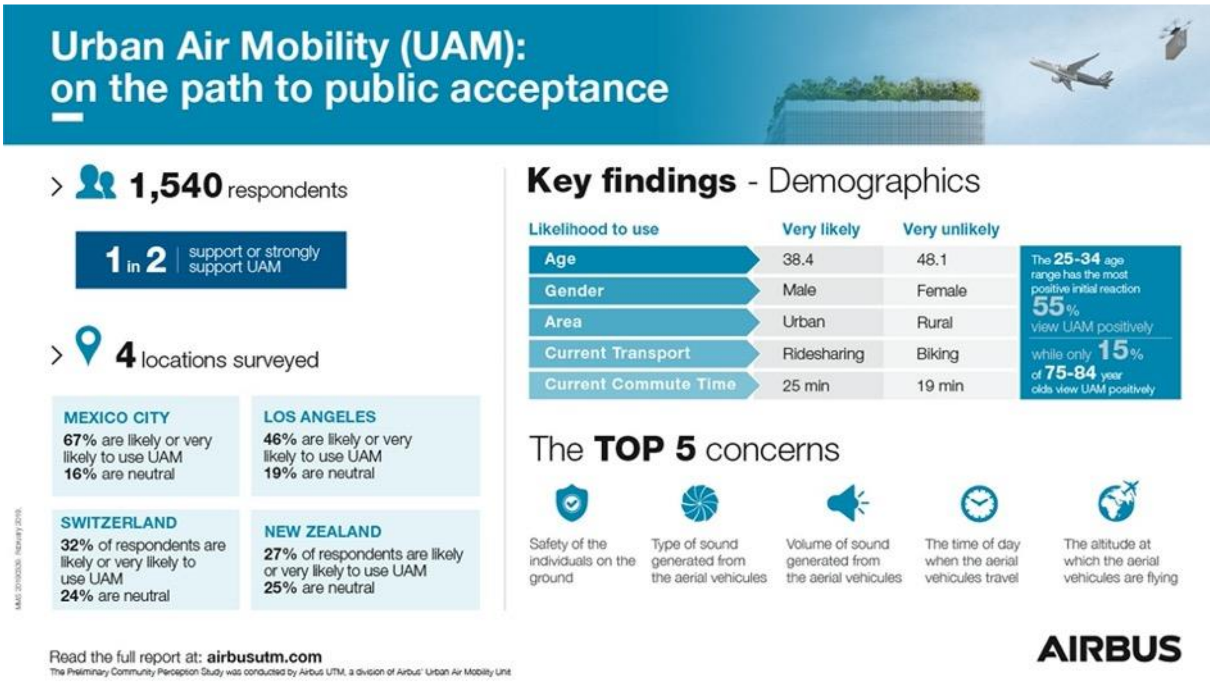


Figure 2-3: Study results on UAM public acceptance. Source: Airbus

From the study, it can be derived that public acceptance of urban air mobility services, particularly noise aspects and its psychological factors, is perhaps one of the biggest challenges along with safety. The study also indicated that people are yet to form opinions with concerns about the miss-use of drones affecting their privacy and security (which is always an important opinion the public withholds when advanced technology is released).

LAIKA will prioritize the development of urban air mobility services in those areas that are less populated, and not disregard those services that are considered essential and eventually saves life. The showcase of eVTOL as in support to air-ambulance should also impact to create a quick-winning case towards people to accept drones infringing their visual area.

Finally, the disposal of different operational technological demonstrators from the project, will open large opportunities in future to showcase in other events or cities, create a positive public acceptance case, and create proximity of society with a much disruptive technology that is not easy accessible or could be seen in the near future as a commodity.

2.2 Measures to maximise impact

2.2.1 Dissemination and exploitation of results

2.2.1.1 Plan for the Dissemination and Exploitation of the Project's Results

The overall objective of LAIKA project is to develop innovative concepts, technologies and solutions towards the sustainable deployment of urban air mobility services. In this line the consortium will disseminate non-confidential results to the Research, Industrial and Public communities. A plan for communication and dissemination of results and a plan for the exploitation of results will be realized and will be updated during the lifetime of the project following the line guides "*Guide on Data Management*" for Horizon 2020 project.

Among others, the results communication and dissemination plan will involve the following activities:

Project webpage Creation of LAIKA's project webpage. It will be used to provide updated information regarding project status and participants.

Advisory group Organisation of two technical meetings with experts in order to discuss the progress and results of the project with European Stakeholders: EASA, AESA; CAAI; European City Councils such as Barcelona, Sevilla, Ingolstadt, etc.

Dissemination workshops These will be organized along the project lifetime. International renowned speakers will be invited, and the outcomes will be published on the website. A technical presentation will be carried out in top level conference. Project targets, aerial demonstrator performance and main technical research lines, as well as future air transport electrification strategies, tendencies and technologies will be presented

Demonstrations Invitations to relevant UAM companies or organizations will be send to attend the final demonstrations will be conducted in three real scenarios. Through these demonstrations, the benefits provided by the novel solutions developed in LAIKA will be presented to interested stakeholders.

European press releases Press releases published in European Commission's webpage and others.

International working groups, meetings and conferences Attendance and active participation in EUROCAE working groups, and a preliminary list of conferences presented further below in this section.

Dissemination material Generation of videos showing the results of the demonstrations. Pictures of the demonstrations campaign to be shown in the meetings. Generation of brochures, flyers and posters to be distributed during the meetings

Interaction with identified European stakeholders Interaction with National level authorities, local level authorities, SME, Universities and other research institutions, etc. will strongly contribute to collect useful context information to improve the project team dissemination and exploitation strategy.

The LAIKA partners will exploit the project and its outcomes for uptake in their internal strategic R&D roadmaps in order to foster new innovative solutions.

Partner	Exploitation actions foreseen
1. PildoLabs	LAIKA represents a great opportunity to adopt and evolve company aviation products and services to the specifics of the urban air mobility industry and operations. Future exploitation of the results include: provide flight procedure design services adapted to urban air mobility performances to operators and UTM providers; capitalise previous investments on drone trajectory management and real time tracking through UAS commercial products; integrate new solutions and concepts in a proprietary cloud-platform towards multi-modal and UAM-on-demand operations; and commercialise B2B micro-services to secure drone operations in U-space
2. Ayalon Highway Company	Extend knowledge to deploy viable urban air mobility (UAM) policy for the following use cases: last mile delivery service, air-metro service, and air-taxi service. Refine its understanding on the economics and the constraints to better evaluate how the UAM can be commercially operated and can finally contribute to diminish traffic and improve transport experience in the streets. Coordinate the sustainability and risk analysis with other members of LAIKA and possibly enlarge this to other trials done in EU. Build operating centres required for the tests, and operate drones. Determine best practices to address UAM public acceptance and establish a clear phased approach to regulate the operational environment.

Partner	Exploitation actions foreseen
3. Babcock Mission Critical Services Fleet Management	LAIKA results will eventually integrate in current and future Babcock operations to enhance their functionalities and efficiency, and thus will directly influence our UAS emergency services, in particular (but not exclusively) the health emergency use case addressed in the project. Research tackled in this project will enhance the knowledge background of Babcock's Research Center on Advanced Autonomous Systems in fields that are key to enable the deployment of future UAM/UAS services. Therefore, the project has also an indirect impact on future projects and advanced services with UAS that Babcock currently considers in its UAS development and service strategy. The project is also an excellent occasion to get an overall picture and a common ground for interactions between commercial and emergency operations in complex environments. Babcock experience in low-level operations and complex air services will both contribute to and benefit from project partners inputs and views, and will eventually result in further work and opportunities.
4. Barcelona Supercomputing Center	Air quality is an issue of major concern in urban areas, due to the high level of emissions from road traffic and unfavourable conditions for the dispersion of contaminants. This project will allow BSC to improve our understanding of emission sources in cities and explore the potential benefits of urban air mobility to improve air quality. BSC manages the Air Quality Forecast System for Spain: CALIOPE (http://www.bsc.es/caliope/?language=en). This work will contribute to improving the emission model in the Barcelona region and related air quality forecasts.
5. Correos	Correos will benefit from LAIKA in order to test and validate its UAV´s operations in remote areas, in addition also to develop systems that will allow the mission to be carried out autonomously, safely and efficiently. This project will allow Correos to make a realistic study of all the different costs of introducing UAV´s in our peri-urban operations and to define a service strategy for the future. Define and realize UAV´s operations with Correos´s own staff and test the necessary requirements.
6. Drone Think Do	Increase awareness about the project and the industry in general amongst the public. Engage and involve key decision makers (public) and high-level industry actors (private) in advanced discussions about the future of the industry. Increase revenue and add potential new services to our repertoire Increase employment with 2 new employees and broadening the base of co-workers. Add to and improve the dissemination and communication tools and materials of our company.
7. European Emergency Number Association	For EENA, this project will help us have a better understanding of how UTM can benefit Emergency Services and what is needed to make it a reality, thanks to field experience and working with industry experts. This experience will become content for EENA's network, to educate first responders about UTM, researchers, industry and also lawmakers to create adequate legal frameworks.
8. Envisa	Envisa will develop a new set of algorithms for UAM environmental impact including noise and emissions modules to the existing aviation models. Envisa will coordinate within its existing on-going projects (EASA Framework contract on Aviation Environment) the regulatory aspects to sustainability issues, and will create a new know-how for the industry before implementation to the cities,
9. FADA-CATEC	For CATEC the project is a great opportunity to develop new technologies related to urban applications with drones and UAS and explore in detail the flying capabilities that it is possible to obtain with GNSS in urban environments. CATEC, as a research centre, is committed to the development of new technologies and applications with UAS and drones. Then, the idea of this project is to increase the TRL of new urban applications with UAS so it can be shown to the industry and end-users, increasing its awareness and creating interest for these new technologies. If industry is interested in a specific application with these new technologies, the plan is to create a new project where we can help the company, with other consortium partners, to develop a pre-commercial prototype and get the technology up to TRL7/8. Finally, this project will increase CATEC visibility in the drone/UAS sector enforcing its capacity building.

Partner	Exploitation actions foreseen
10. Fraunhofer IAO	Thanks to the tasks developed in LAIKA, Fraunhofer will get knowledge and experience in consultations related to the local integration, social acceptation and preference analysis of UAM services, which could be applied in other locations and projects. After the project, further activities might be conducted assessing potential vertiports and routes for UAM in other cities with regard to the impact. Furthermore, other services shall be analysed with regard to their potentials.
11. Kinéis	Validation of the technical constraints and issues of having an added IoT device on a drone, including antenna position, and power supply. Measurement of the potential quality of service that is achievable both in terrestrial and satellite mode, including latency, availability and integrity/accuracy. Assessment of the part of terrestrial vs satellite data link depending on use cases and external parameters (environmental and weather). Validation of pertinent use cases for the IoT on drone technology and the benefits obtained from that. Evaluation of the effective data usage required for these use cases, which is a major driver in cost and adoption
12. Pipistrel Vertical solutions	Specialty power controller modules and battery/battery management systems and their direct, gateway-less, interface with the flight control computers. This model-based real-time health forecasting capability will pave the way for future abilities of autonomous system decision-making related to flight initiation or continuation as a function of the vehicles actual and/or forecast health status both in nominal and off-nominal conditions. Established and applicable methodology to anticipate system-level and component level failure-modes so that the level of criticality is minimized and single-point failure elements completely eliminated. A demonstrated flight-control and propulsion system architecture which is free from single-point failures and as such represents a substantial progress and will have an impact for future low-cost system vehicle propulsion/control systems with high demanded reliability.
13. Tecnalia	Aircraft prototype for air-taxi service: Enhanced manoeuvrability by controlling the main cabin's attitude regardless of the aircraft speed or while counteracting wind gusts. Costs reduction compared with using helicopter ambulances. Aircraft prototype for emergencies/logistics service: Quicker transport of fast expiration medications, in interurban areas in emergencies and difficult access areas. This vehicle presents enhanced manoeuvrability regardless of the aircraft speed or while counteracting wind gusts and offers increased travel speed thanks to the minimum parasitic drag achieved when tilting the rotors in the forward's direction and keeping the cabin in its most aerodynamic position. Higher payload capability with the same energy consumption and better stability. Once TECNALIA's aircraft prototypes reaches TRL6 at the completion of the project (for people and goods mobility), further demonstration actions of technological performances and cost-effectiveness field trials, together with the industrial partners, will be performed, starting at the same time the manufacturability assessment and validation, standardisation and regulatory acceptance activities. During this activities TECNALIA shall get the support of regulatory/ certification partners (e.g. EASA, EUROCONTROL) and final aeronautical or automotive manufacturers (e.g. Airbus, Boeing, Pipistrel, Mercedes, Audi).
14. University of Seville	University of Seville (USE) will benefit from LAIKA in order to apply basic aerial robotics technologies to a new field (UAM operations) with a high academic potential and industrial impact. This project will allow the University of Seville to extend their leadership from aerial robotics to drones in UAM operations that require autonomous functionalities. USE will study the possibilities to apply the developed technologies to urban environments where it is expected that autonomous vehicles will have a major impact in the cities of the future, incrementing more the impact of LAIKA results.
15. University of Stuttgart	At university level, LAIKA will attract students on all levels, due to its challenging and attractive topic, with an attractive set of participants from a student point of view. PhD students will be able to work in a technologically advanced field that is embedded in a systems approach – a rare opportunity in the academic environment.

Table 2-5: Exploitation actions foreseen

The approach to intellectual property rights (IPR) in the project will be governed by the signature of the Consortium Agreement. This will cover the activities related to ownership, exploitation, and dissemination of the project results. As a general principle:

- All Background IPR is and will remain the exclusive property of the Party owning it.
- Results shall belong exclusively to the Party generating such Results.
- In case of joint ownership of Results, each of the joint owners shall be entitled to use their jointly owned results free of charge, and without requiring the prior consent of the other joint owner(s) for their direct exploitation only.
- Each Party may transfer ownership of its Results wholly or in part following the procedures of the Relevant Grant Agreement.

2.2.2 Communication activities

LAIKA communication activities will be organise in such a way that dedicated communication channels tailored for all identified target audiences will be used. This will maximise the impact of the project and create awareness for European collaborative research in general and in particular for novel solutions applied to UAM services.

The activities will be detailed in a dedicated dissemination plan to be prepared in the first months of the project. This plan will be maintained and updated regularly. The target audiences are listed below.

2.2.2.1 General public and communities

Communicating LAIKA research and results to the public will have two major aims: (1) to create awareness for collaborative research in the UAM domain in general, to show the benefits for European society at large and to demonstrate that European tax payers' money is well spent and invested in this research; and (2) to communicate results of LAIKA and their benefits in UAM services implementation. As mobility and logistics is central subject of the general interest influencing people's private and business life, it is expected to be able to achieve some articles covering LAIKA technologies and their impact being published in newspapers and general interest magazines, and as factsheets. LAIKA will utilise the professional communication and public relation departments of the LAIKA partner organisations who have vast experience in preparing ready-made articles, which can be used directly for publishing, therefore needing very little editing effort.

2.2.2.2 Scientific and technical community

LAIKA aims at maximising the dissemination impact in the academic and industrial research communities. The international specific conference (see Table 2-6) offers the perfect way to communicate to a knowledgeable audience the challenges that were overcome during the project and stimulate further research.

<table>
<tr><th colspan="2">Event</th></tr>
<tr><td>Paris International Air Show, Paris, France, (biennial) June 2021
Amsterdam Drone Week, Amsterdam, Netherlands, (annual) December 2020
Farnborough International Air Show, Farnborough, UK, (biennial) July 2022
M2S – Mobility Solutions Show, Toulouse, France, November 2020
International Conference on Robotics and Automation (ICRA), Paris, France, (annual) May 2021
International Conference on Recent Advances in Aerospace Actuation Systems and Components (R3ASC), Toulouse, France, (biennial) November 2020
More Electric Aircraft (MEA), Toulouse, France
Expodrónica, Madrid, Spain, (annual) June 2020</td><td>The Future of Transportation World Conference
(annual)
European Transport Conference (ETC)
Milan, Italy
(annual) September 2020
SESAR Innovation Days (SIDs)
Budapest, Hungary
(annual) December 2020
AIAA Aviation Forum
EEUU
(annual)
Electric Vehicle Symposium (EVS)
Portland
(annual) June 2020</td></tr>
</table>

Event	
International Conference on Intelligent Robots and Systems (IROS), Las Vegas, EEUU, (annual) October 2020	

Table 2-6: Scientific communication events planned

Additionally, the results from this project will be published in scientific journals which are all recognised as the leading international peer-reviewed journals in this area of work and where the project partners already have a strong track record of publication, illustrating their standing in the scientific community. The research will be disseminated through joint publication and attendance at major specialist international conferences and symposia. It is expected that the research will lead to a very consistent publication output. A preliminary list of potential journals is as follows: Aerospace Science and Technology, International Conference on Robotics and Automation, International Conference on Intelligent Robots and Systems, Journal of Air Transport Management, Research in Transportation Business & Management, Transportation Research Part D: Transport and Environment. LAIKA partners will also seek to publish project results in renowned peer-reviewed scientific-technical open access journals.

Additionally, it will be considered scientific and industrial networks in the frame of the **EU initiatives** forums, such as: UAM initiative of the EIP-SCC, Urban Mobility of EIT-KIC, where some members of the Consortium are already partners or members.

2.2.2.3 Policy makers and industry

The above-mentioned events will also be used to liaise with policy makers and industry as they are attending as well. However, the approach will be different:

- For the policy makers, the impact of LAIKA solutions will be presented, their contribution to the overall aims set out in the different road maps, blue prints and white papers.
- For industry, communication will be application-oriented. Of special interest are the optimization part and the aspect related to the costs. Particular attention to the trade-off between all the technological and economical aspects will be taken.

2.2.2.4 Communication means to be used

A dedicated dissemination plan will be prepared in the first months of the project. This plan will be maintained and updated regularly. Initially planned communication activities for the individual target audiences are presented hereafter:

- A common graphical project identity will be developed (logo, colours, standardised templates, etc.) and implemented throughout the project.
- A public website with dedicated sections targeting the different audiences described above. The website will be prepared by Drone Think Do with support and input from all partners, and will be available after 6 months and regularly updated with new content to gain interest.
- LAIKA social media profile via Twitter and a dedicated LinkedIn project page.
- Participation in international events is expected to take place to maximise the impact of the project in the international community
- General communication material, e.g. flyers, brochures, posters, factsheets will be prepared and produced as needed.
- Ready-made articles and press releases will be produced in cooperation with the communication departments of the LAIKA partners exploiting their network and contacts to maximise impact.
- A LAIKA video highlighting the innovative concept and including expert interviews and shootings of important project milestones will be produced and made available via the project website, YouTube, Twitter and LinkedIn to maximise dissemination and allow for further media uptake.

3 IMPLEMENTATION

3.1 Work plan

LAIKA consortium aims at performing the activities in the most efficient way. With this purpose, the work plan has been defined takin into account that, even if it is intended to cover three different UAM services, there are common developments and assessments. Hence, LAIKA work plan groups the different activities in four main phases: services definition, solutions development and test, integration assessment, and validation and promotion.

3.1.1 Overall structure of the work plan

As aforementioned, the proposed work plan is intended to group the tasks in four main phases. The interface between phases and its main tasks, are depicted in the following diagram.

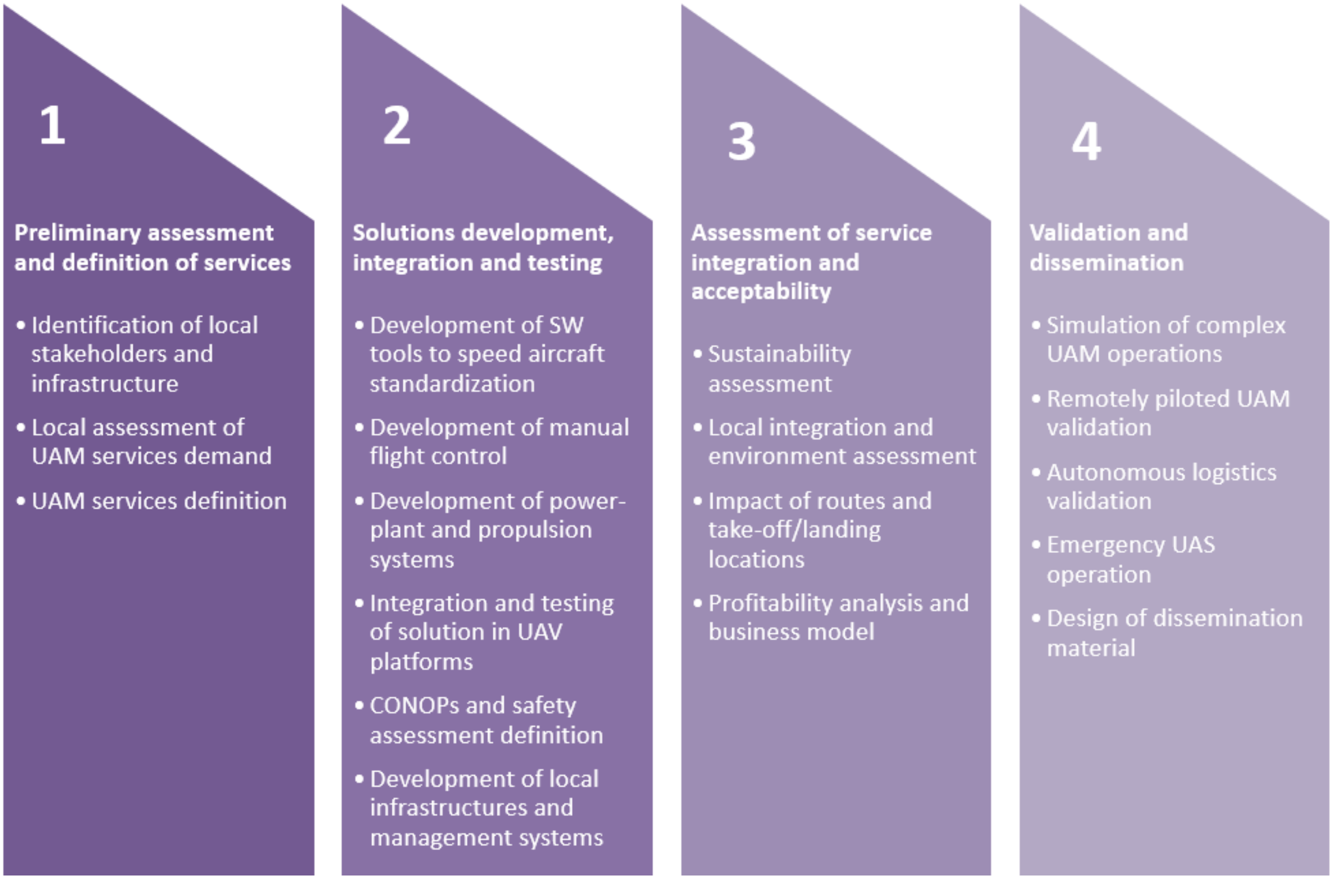


Figure 3-1 - LAIKA project structure

3.1.2 Work Breakdown Structure

The following figure presents the project's work breakdown structure.

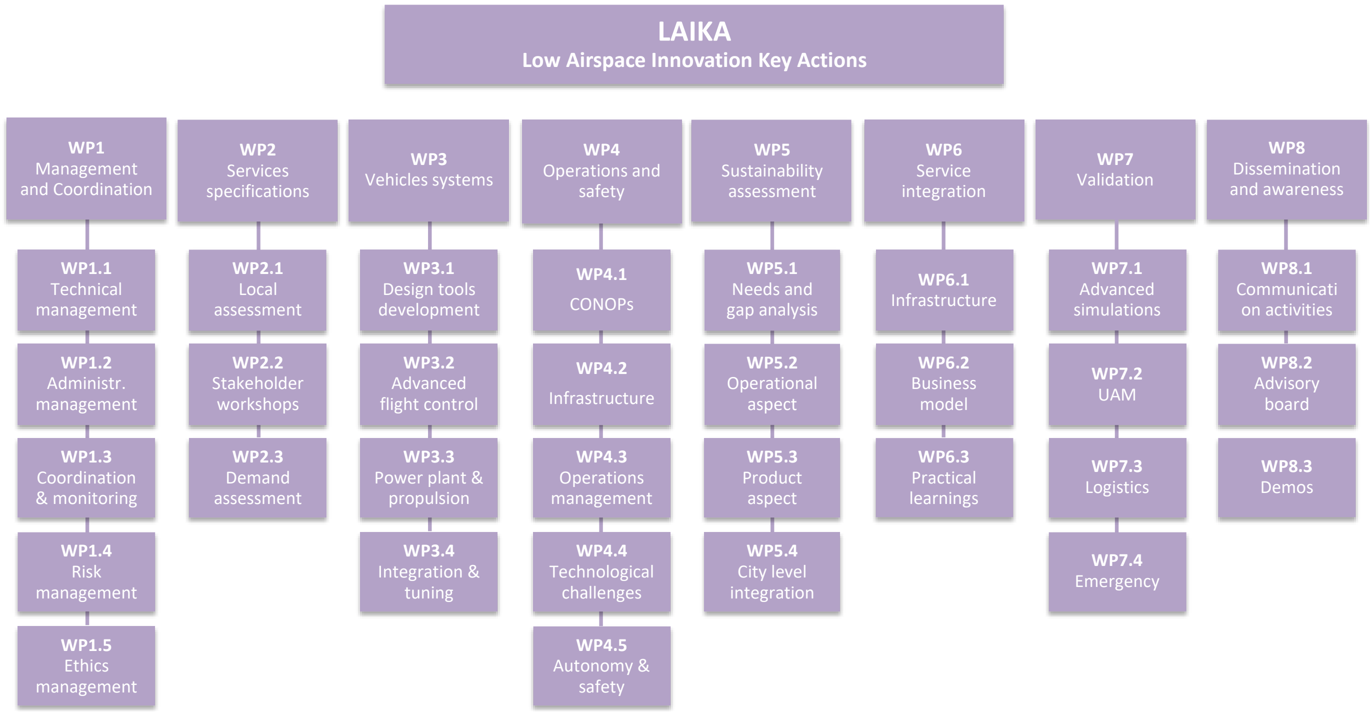


Figure 3-2: LAIKA work breakdown structure

WP No.	WP Title	Lead Participant No.	Lead Participant Short Name	Person-Months	Start Month	End month
1	Management and coordination	1	PLD	39	M1	M30
2	Services specifications	2	AHC	38.5	M1	M10
3	Vehicles systems	13	TEC	190	M3	M20
4	Operations and safety	1	PLD	128	M3	M24
5	Sustainability assessment	8	ENV	58	M6	M27
6	Service integration	10	FH	28	M6	M30
7	Validation	9	FCAT	139	M18	M30
8	Dissemination and awareness	6	DTD	115	M1	M30
				735.5		

Table 3-1: LAIKA work packages list

3.1.2.1 Work Package description

Work package No	1			Lead beneficiary	PildoLabs			Start month	M1		End month	M30			
Work package title	**Management and coordination**														
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	20	1	1	1	1	1	2	1	1	3	1	1	1	3	1

Objectives

The main goal of this WP is to undertake general project management and coordination activities, both at technical and at administrative level, to ensure the project's successful implementation. For this purpose, the following aspects will be covered: technical and administrative management of the project; coordination and communications between project partners and towards external entities; project data and risk management; and quality of deliverables.

Description of work

WP1.1 – Technical management

This task covers the technical management of the project, including the coordination of partners and work packages, progress monitoring (with respect to cost and time), assessment of the quality of the results and, if necessary, corrective actions. It also covers relationships with relevant stakeholders beyond participant organizations (European Commission, manufacturers associations, regulation bodies), as needed by the project. Updated status will be provided inside quarterly reports.

WP1.2 – Administrative management

This task encompasses all legal, financial and administrative activities within the project, both among the partners and with respect to the relationship with the European Commission. The following tasks will be developed: writing and updates of the Project management plan; Grant Agreement management, including requests of amendment; updates of the Consortium Agreement (if needed); writing of quarterly reports, final report and final report executive summary; handling of partners' accession and withdrawal, in collaboration with the Governing Bodies; administration of the EU financial contribution regarding its allocation between partners and activities, in accordance with the grant agreement and the decisions taken by the consortium; day-to-day relationship with the whole consortium to answer queries regarding costs eligibility, financial reporting, official process for fund transfer etc. and payments to the partners without unjustified delay.

WP1.3 – Coordination and monitoring

PildoLabs will set-up, within the first months of the project, a secured collaborative internet platform for project management. It will organize communication between participants of the project and enhance the official communication inside the consortium. Access (login and password) will be provided. The internet platform will allow access to technical and financial project follow-up as well as project archives (project database).

PildoLabs will be the website administrator. Each WP leader will be responsible for updating the project progress data according to the latest developments in order to guarantee the accuracy of the information. A tool kit will be sent to participants including: the "good practices" of resources management will be presented in the administrative and financial implementation manual, emphasising the duties of each partner and setting out the project management procedures; a tool to monitor expenses and common reference documents such as deliverables and milestones list, planning.

Monitoring tools will be set up, in order to be able to gather data from participants, and to provide key indicator at each WP leader. The coordinator will ensure a regular monitoring of the budget consumption, which will be populated by data collected from each partner and updated every two months. Audit on financial statement will be included in this subtask, for those who need to provide one.

WP1.4 – Risk management

Risks will be constantly assessed and evaluated within the whole project duration. The methodology to be followed for risk management consists of four steps: risk identification: areas of potential risk will be identified and classified; risk quantification: the probability of events will be determined, and the consequences associated with their occurrence will be examined; risk response: methods will be produced to reduce or control the risk; risk control and report: lessons learnt will be documented; risk evaluation will be contained inside quarterly reports.

WP1.5 – Ethics management

An Ethics Management Plan will be developed to detail the project ethic aspects including, among others, the approach to be followed regarding the data management life cycle, specifying how data will be collected, processed, monitored, catalogued, and disseminated during the project's lifetime. This document, which will be updated on a regular basis as the project evolves, aims at ensuring the compliance of LAIKA with the H2020 Open Access policy.

Deliverables

- **D1.1** Project management plan [M1] (PLD)
- **D1.2** Communication tool kit for participants [M2] (PLD)
- **D1.3** Project collaborative platform [M3] (PLD)
- **D1.4** Ethics management plan [M3] (PLD)
- **D1.5 – D1.13** Quarterly report [M3, …, M27] (PLD)
- **D1.14** Final report [M30] (PLD)
- **D1.15** Final report executive summary [M30] (PLD)

Work package No	2	Lead beneficiary	Ayalon	Start month	M1	End month	M10
Work package title	**Services specifications**						

Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	4	2	2	0	8	0	4	2	4	5.5	1	1	2	3	0

Objectives

The final goal of this work package is to present a clear understanding of the UAM services considered by the project (air taxi, emergency and logistics) and detail their particularities considering the inputs provided by local stakeholders and the environment needs/constraints.

To this purpose, it is expected to perform an initial identification of relevant stakeholders and definition of the deployment environment, the holding of local stakeholder workshops to collect inputs, and the assessment of the local demand and application possibilities in the UAM deployment area.

Description of work

WP2.1 – Preliminary local assessment

In order to properly implement UAM services in any urban location it is mandatory to identify who are the relevant stakeholders, who could be involved at some level in the UAM services, and which are their interests. This includes the city administrations, public transport service providers, and the air traffic control among others. Furthermore, it is also crucial to depict the environment where the UAM services are going to be deployed and operated, aiming to identify any needs or limitations that should be taken into account at the time of defining the service. This includes local regulations that could affect the service, similar services already provided, architectural barriers, etc.

In this framework, the present task aims at conducting an initial identification of relevant stakeholders and in the considered pilot cities (see section 1.3.1.5). For this purpose, expert interviews will be conducted in order to identify them, and to determine the interconnections that should be stablished between them for the UAM service deployment/provision. Additionally, information about the local environment needs and limitations will be also collected during these expert interviews.

All the information collected in this task will be gathered inside the ‘D2.1: (Preliminary) UAM Services Specifications’ report.

WP2.2 - Stakeholder workshops

Aiming to extend the knowledge about the local particularities and get a coordinated vision about the local deployment / operation of LAIKA proposed UAM services, this task will hold a set of workshops gathering local stakeholders. Among others, the following topics will be tackled during workshops: expectations and restrictions of UAM services integration; use cases of each UAM service (air taxi, emergency, logistics); infrastructure design and deployment (vertiport locations, routes, power provision, etc.); required data service providers; and interconnection with other mobility services.

In this framework, at least one workshop will be conducted in each city supporting the project (see section 1.3.1.5). Follow up webinars will be organized to answer any potential new questions from workshop participants.

All the information and materials collected during the workshops will be synthesized and gathered inside the ‘D2.2: (Final) UAM Services Specifications’ report. Such contribution will include a final use case per each UAM service, to be used as reference when defining the CONOPs for each UAM service in WP4.

WP2.3 - Mobility demand assessment

Before deploying a new UAM service, it is crucial to evaluate the local demand, taking into account factors like acceptance and preferences of possible service consumers, and the requirements of possible service providers. With this aim, the present work package will conduct the following local assessments:

- **Urban Air Taxi: Acceptance and Preferences**

  This assessment will focus on the local acceptance, preferences and willingness-to-pay of potential users of urban air mobility in order to find out, what the potential demand for air taxis will be. For this, a questionnaire will be developed and a stated preference analysis with mode choices will be performed amongst the local people. In this analysis, also the topic of privacy will be covered. Effective measures such as a demonstrator exhibition or use of VR will be taken to ensure that there will not be hypothetical distortions due to the radical character and high degree of innovativeness of urban air taxis and the lack of consumer experience.

- **Emergency: Routes and Capacities**

  For the use of air taxis in emergency services, which represents one of the few application fields already experienced with aerial mobility and might thus be one of the highest accepted use cases in the beginning, relevant areas of operation, possible vertiport locations and the desired passenger capacity have to be stated from the service operator perspective based on provided mobility data. A special focus will be laid on the connection of city centre with hospitals.

- **Logistics: Routes, Schedules and Capacities**

  The focus for the application of drones in logistics will be on the connection of logistic centres outside of the city along specific routes in the suburban and rural area with large drones and the local fine distribution of goods with small drones. For the analysis, relevant freight routes, possible vertiport locations and the desired capacity (number, volume and weight of goods, etc.) have to be stated from the service operator perspective.

All the information collected during the assessments will be synthesized and gathered inside the 'D2.2: (Final) UAM Services Specifications' report.

Deliverables

- **D2.1** (Preliminary) UAM Services Specifications [M4]
- **D2.2** (Final) UAM Services Specifications [M10]

Work package No	3	Lead beneficiary	Tecnalia	Start month	M3	End month	M20
Work package title	**Vehicles systems**						

Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	0	0	0	0	2	0	0	0	8	0	0	74	45	25	36

Objectives

This work package is focused on the development of the necessary systems and tools (software and hardware solutions) for the future design and development of urban air vehicles and transport platforms, with the objective of facilitating the progress of the UAM vehicle industry, supported by technology validation platforms/vehicles for real environment testing. Among others, efforts will be devoted to the following solutions: (1) development of mathematical modelling tools, aimed to simulate new aircraft topologies and virtually test them. Model Based Design methodology will be applied to standardize a procedure to accelerate new aircraft architecture validation; (2) definition of software procedures, aimed to progress in two lines: (a) increasing the TRL up to 6 (permit to fly) of the flight control algorithms validated virtually and tested in technology validation platforms and (b) working at critical manoeuvres in low TRLs applying advanced techniques from optimal control and machine learning; (3) development of power-plant and propulsion hardware systems, paying special attention to the most critical parts of the value chain: battery, electronics (control and power) and electric motors; and (4) Integration and validation of all these systems in three UAM vehicles (see section 1.3.1.2).

Description of work

WP3.1 – Design tools development

Nowadays, aircraft topologies can be basically classified as: multirotor, tilt-wing, fixed-wing concepts and all the combinations among them. However, in research and development programs, new topology concepts are being studied such as over actuated aerial vehicles. In this stage, it will be evaluated the optimum solution for each application/use case inside UAM framework. With this aim, a set of simulation tools for to ease the assessment will be developed:

- **Dynamic analysis and modelling of new Distributed Electric Propulsion (DEP) topologies**

  Tecnalia has already developed an innovative over actuated topology that demonstrates several potential benefits, and Model Based Design methodology has been applied to develop the prototype, speeding up all the design and development process. An air-taxi prototype for people transport (scale 1:1) has been manufactured and tested in record time thanks to this design methodology. The next goal is the standardization of this design procedure to evaluate different types of topologies, considering safety and security, certification, sustainability, and public acceptance inputs.

  Each DEP topology virtually tested needs the definition of basic flight control to ensure its feasibility. Moreover, once the topology is virtually validated and the basic flight control for the topology developed, this control algorithm can be easily tested in a real environment through automatic code generation. Taking advantage of scaled platforms, the new concepts can be tested in a real environment easily and cost-effectively. In this case, the objective is also the standardization of this modelling procedure to evaluate different types of topologies.

- **Power-plant/propulsion hardware systems modelling**

The second objective of this design tool development task is the precise modelling of the key systems of the vehicle power-plant: propeller, electric motor, inverter, battery and flight controller. In this way all the critical subsystems will be modelled in order to implement a detailed virtual validation before the integration and real-environment validation. Pipistrel will play a key role in this task.

- **Tools for the integration of on-board intelligent autonomous functionalities (including a simulation environment for 3D perception)**

In general, there is a wide spectrum of platforms and autopilots available due to the specific constraints associated with each application, and in particular in LAIKA several autopilots and platforms are considered. Nonetheless, high-level intelligent autonomous functionalities should be able to operate vehicles in a transparent manner, regardless of the autopilot or platform underneath. Otherwise, it would become too complex maintaining multiple versions of the application software depending on the particular communication protocols for each autopilot. In this task, USE will extend its software framework for drone operations providing users with an abstract interface independent of the autopilot. For each LAIKA autopilot, a backend dealing with its specific features will be created, making easier the development pipeline of on-board intelligent autonomous functionalities and their deployment into real platforms. In addition, we will also enhance our software framework with a backend that provides an interface to simulate in realistic environments using Unreal Engine (UE) and its plugin AirSim. With this enhancement, it will be possible to test computer vision algorithms thanks to the powerful rendering engine of UE. This can be used in simulations to monitor sustainability with regard to UAM visual pollution in urban environments.

WP3.2 – Advanced flight control

- **Certifiable flight control for over-actuated systems**

The main goal if this task is increasing the TRL of the flight control up to TRL6, starting from an available proof-of-concept level (TRL4) in which automatic code generation has already been used to validate the aerial platform in a real environment. TRL6 means obtaining a Permit to Fly, hence the flight control will be robust and certifiable.

This control would enable easy manual control for the people transport aerial platform and easy remote piloting for all the platforms. Such technology is key to reduce the time to market for this kind of architectures before autonomous flight technologies are fully developed and validated, and it could help increase user acceptability. Moreover, it can provide a necessary fall-back solution in abnormal flight situations. The allocation part of this development forms a sound basis for any higher level automatic or autonomy function.

The activities in this task will draw from an existing flight control solution, developed and validated with the indoor testing campaign performed by Tecnalia, which will be improved following the DO-178 guidelines to test the technology validation platforms assembled with all the hardware and software systems developed within the project. The new flight control solution will be tested and validated in a test campaign deployed in Stuttgart UAM Test Field (outdoor testing) carried by the University of Stuttgart with the support of the Tecnalia.

As a result of this task, two outcomes will be produced:

  - Reliable technology validation platforms will be available for this project and future European research programs. Moreover, this platform will be managed by a non-profit research company as Tecnalia and University of Stuttgart, being easier for the different relevant European stakeholders to make use of it.
  - Definition of a procedure to advance a flight control for an innovative UAM aircraft topology from TRL 4 to 6.

- **Perception to increase situational awareness in urban environments**

While flying in urban environments it is really important to add to the UAM vehicle the capability to perceive and automatically understand the environment around. This means not only to build a 3D map of the environment in real time, but also to be able to semantically identify and classify the relevant infrastructure and objects around the UAM vehicle. This capability could be used for advanced autonomy functionalities, such as an automatic response mechanism under failures of the UAM system or even as a support for the pilot of the UAM vehicle at the early stages of the application of this new transportation system. In this task we will develop a multi-resolution multi-sensor 3D mapping scheme capable of building accurate maps of large-scale environments such as these considered in LAIKA. The scheme will be based on two layers. The low-level layer is a feature-based multi-sensor mapping scheme that integrates measurements from 3D LIDAR, cameras, RTK-GPS and IMU, among others, and exploits their synergies in order to build detailed, accurate and robust multi-sensor maps suitable for LAIKA operations in unstructured and dynamic scenarios. A graph-based approach will be adopted as initial solution due to its scalability properties. The mapping scheme will include map-merging tools enabling multi-vehicle cooperative map building. The high-level layer will consist of a semantic mapping scheme. It will include machine learning techniques capable of analysing the multi-sensor low-level map and detecting, classifying and 6DoF mapping different types of objects that can be found in LAIKA scenarios (trees, power lines, buildings among others). Once classified and mapped, the objects are treated as semantic features in the high-level feature-based mapping scheme. The high-level layer will also include map-merging tools. Both mapping layers will be equipped with map optimization mechanisms.

- **Pilot assistance in critical manoeuvres**

Optimal control and machine learning algorithms will be used to explore the increased dynamic capabilities of such over actuated aerial platforms. These algorithms will reach TRL 4 and will only be applied to the small platforms. Some examples of the kind of critical manoeuvres that will be studied include fast trajectory changes (obstacle avoidance), precise landing, emergency landing with degraded vehicle functions, ensuring vehicle stability in the presence of wind gusts or trajectory tracking with minimal energy consumption.

This development will include the preliminary design of the control algorithm of the platforms, virtual validation and critical design of the control algorithms.

WP3.3 –Development of power-plant and propulsion systems

- **Propulsion system architecture (vehicle level, power-string level)** (Pipistrel, Tecnalia, University of Stuttgart)

Pipistrel will establish a new propulsion system architecture, providing not only adequate levels of safety and reliability (given the strong flight-control-system and propulsion-system interactions in novel vehicles), but also the composition of a propulsion monitoring and control string. This introduces the capability for smart health monitoring and propulsion system performance forecasting which will be integrated to form an intricate and certifiable propulsion system. This enables the inclusion of cost-effective COTS components from different electromobility segments, and elevates their level of performance, integrity, and reliability, to requirements applicable to UAM vehicles.

- **Determination of powertrain requirement for performance-based-navigation** (Pipistrel and Tecnalia)

Pipistrel, together with inputs from Technalia, will establish the methodology of translating high-level vehicle requirements into performance requirements for individual powertrain components. This will enable the identification and procurement of cost-effective COTS components for the thrust actuation elements, i.e. electric motors and inverters, so that they will seamlessly integrate into the vehicle and provide the expected performance capability. Electric motors and inverters will be procured as COTS components based on the performance requirements established under this activity.

- **Advanced power management and control** (Pipistrel)

In order to enable use of COTS components for the electric motors and inverters, the foreseen element in the propulsion system architecture is the proposed Power Management and Control Module (PMCM), which is able to determine the health status of the thrust actuation components, as well as receive high level control commands from flight control computers. This module will feature dissimilar solutions to facilitate integrity of all received signals/commands, perform voting of FCC outputs, monitor health and performance of the thrust actuation elements and have the ability to forecast performance of components based on current status, trends and model-based behaviour prediction. The PMCM introduces aerospace-levels of reliability of control and monitoring to COTS levels of cost, and represents a significant cost saving measure in the propulsion system execution as well as elevating the state of the art in propulsion-based flight path control for UAM vehicles. The capability of performance forecasting is also unprecedented and key to autonomous decision making related to vehicle navigation and trajectory control.

- **Energy storage and delivery assurance** (Pipistrel)

By principle of similarity to PMCM, an energy storage system will be developed which, on its own, will control, monitor and forecast the heath, capacity and power-delivery performance of lithium battery cells integrated into a single enclosure. Pipistrel will utilise state-of-the-art techniques for battery packaging, which assure robustness against lithium battery cell thermal events, and develop new delivery assurance system functionality which current battery and battery-management-systems lack. For propulsion-controlled vehicles capable of hovering, vertical take-off and/or landing, it is critical that the flight control system continually receives feedback from the battery system related to battery health, remaining reserve, power reserve, etc, respecting the actual condition of the energy storage provision, as well as its history, trends and aging properties. The result will be an energy storage system capable of not only robust mechanical handling of ill-effects, but also smart forecasting of output performance and reserves – a considerable step above the state-of-the-art in aircraft propulsion batteries and a critical element for autonomous operations and related decision making.

- **Redundant and safe flight controller for over-actuated architectures**

Commercial flight controller technology will be adapted to the modular and over-actuated nature of the technological demonstrators of the project. The adopted solution will be physically and logically redundant, and it will reach TRL 6 (permit to flight). An appropriate interface to integrate the algorithms developed in previous tasks will be developed.

WP3.4 – Integration and tuning on vehicles

Mechanical, electrical and flight control integration will be performed at Tecnalia's facilities making some preliminary flight tests in the Donostia Arena, a controlled indoor environment in San Sebastian (Spain), and modifying subsystems as required to comply with the specifications of the project. Afterward, the developed platforms will be validated in real-world conditions at the Testfield for Electric and Autonomous Flight BW, located at the Airport Mengen (EDTM), close to Stuttgart (Germany). University of Stuttgart is leading a consortium that is currently building up this airfield for test purposes. Suitable interfaces will be defined for all subsystems (software, electrical, mechanical).

Among others, the following activities will be conducted:

- Definition of suitable interfaces for all subsystems (software, electrical, mechanical);
- Definition of a test plan in accordance with simulation and hardware in the loop tests that will be carried out before;
- Flight demonstrations, focussing on selected scenarios that represent the functional envelope that is reached by this project; and
- Flight data evaluation that eventually demonstrates the functional achievements.

Deliverables

- **D3.1** Report on the systems, its architecture, assumptions and the final vehicles [M20]

Work package No	4	Lead beneficiary	PildoLabs	Start month	M3	End month	M24
Work package title	**Operations and safety**						

Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	40.5	0	19	0	12	0	0	2	30	0	4.5	0	2	18	0

Objectives

The main goal of this work package is the safe integration of people transport, logistics and emergencies in the urban environment. Efforts will be devoted to the following actions: (1) definition of the concept of operations that will specify how the different actors and stakeholders interact in order to achieve a safe and secure intermodal urban air mobility; (2) implementation of an infrastructure including vertiports and the network of routes, taking into account PBN procedures and RNP concepts tailored to the dynamics of the air vehicles in use; (3) development and deployment of the software tools that will enable cooperation between stakeholders and the safely and expeditious flow of urban air traffic, including the research and development of leading-edge technology to cover safety and security in a distributed responsibility air traffic paradigm (including concepts such as DAA, blockchain, Satellite-Terrestrial hybrid IoT, etc.)

Description of work

WP4.1 – Concept of Operations

The mobility in the urban sky is a complete novel concept that has to be structured. In conventional aviation, airports and helipads serve as the entry point of the air vehicles to the airspace. From one airport of origin to one airport of destination, a connecting flight follows three phases: departure, en-route and arrival. A conventional helicopter will nowadays follow specific procedures (usually in form of a standard instrumental route) to increase safety and efficiency along the three phases. Such procedures are based on PBN concepts, which usually rely on RNAV or RNP specifications both on the route (ensuring clearance of obstacles along the flight) and on the helicopter (certifying its capacity to fly within the prescribed protection volumes). Specifically, instrumental helicopter operations are secured by Point-in-Space (PinS) departure and approach procedures plus RNP low-level routes for the en-route phase. Referenced projects have proposed (some still ongoing) PBN/RNP navigation specifications for small utility drones in different scenarios, some of them in urban environments, proposing design criteria tailored to the dynamics of small drones in different applications (package delivery, mapping, emergency, etc.).

In LAIKA, it is more than ever important to create routes cleared from obstacles and designed to enable strategic separation of traffic. In the urban environment, a myriad of services will require use of the urban airspace. Every UAM service (people transport, package delivery, emergencies, etc.) will have different infrastructure requirements depending mostly on the typology of air vehicle in use and the routing needs. Therefore, the CONOPS (D4.1) that will be defined within LAIKA will envisage the different airspace uses and platforms, creating departure/en-route/arrival instrumental procedures tailored to the dynamics of the vehicles and clearing from nearby obstacles (mainly buildings), and strategically separating traffic not only between different UAM services but also within a same service. In WP 4.1, this concept will be specified in the CONOPS, even if the concrete design criteria, and the specific infrastructure in the city, will be defined in WP4.2.

Furthermore, the CONOPS defined in WP4.1 will tackle the off-nominal situations. Where other projects have only measured the mathematical and numerical approach to the definition of the design criteria, within LAIKA the measures taken when an aircraft flying a prescribed procedure perceives that something is not going as expected will be defined. As an example, procedures will be defined in the CONOPS to establish the default behaviours and corrective actions when the navigation protection levels (calculated from the position integrity) exceed the alert limit threshold (previously defined from the NSE and TSE values for a specific procedure); or the expected behaviour upon an *intruder* entering a corridor owned by an *ownship*.

Besides, the CONOPS will specify how the air infrastructure is defined and the systems and users that interact to ensure the safe management of air traffic.

WP4.2 – Infrastructure

The city has to be prepared for the daily movements in the third dimension. This includes both the **location of the vertiports** and the **network of routes** that interconnect these. The location of vertiports has to be thoroughly studied in order to maximise the number of potential users, ease as much as possible the final-approach and take-off manoeuvres, and minimise the risk associated with these critical phases of the flight. Also, the neighbourhood acceptance is something to consider, mainly regarding privacy and noise aspects (from WP2, WP5 and WP6 outcomes).

The network of routes interconnecting the vertiports will be defined based on a specific tailored PBN/RNP design criteria, as described previously. From the outcomes of the referenced projects, and taking the simulation capabilities defined in WP3, this WP will first define the design criteria specific to each of the three UAM services in LAIKA.

Once the design criteria specifications have been defined, the air movements within LAIKA will be defined in accordance to a gradual approach, starting with pre-defined routes and corridors based on the RNP criteria (specially for people transport and logistics) and ending with real-time generation of RNP routes (specially for emergency services). The air corridors must be designed in such a way to allow the continuation of the flight under a degradation of the navigation performance (e.g., 'downgrade to LNAV') due to **degradation of GNSS**, and also must allow **conflict avoidance manoeuvres**, in case an intruder is detected in the corridor (see WP4.5).

This work-package will define the infrastructure over the city of Barcelona for the three UAM services, and also in specific locations for the demonstration purposes: a PinS procedure for UAM demonstration in Stuttgart, a BVLOS route in Rozas for emergency and procedures in ATLAS for package delivery.

WP4.3 – Operations Management

This work-package will define systems that are required for the management of traffic. First, a distributed architecture, to which all operators will integrate, will be defined. This architecture, backed with the required front- and back-end tools, will enable the publication of intents and the exchange of real-time information. Specifically, following the stages defined in the previous sub-work-packages, the routes (pre-defined or real-time-defined) will be published (and permanently updated) in a distributed manner using *blockchain* concepts. This will ensure that all interested actors are notified upon new publications and updates, including the distributed authorities, responsible for the acceptance of the designs.

The systems defined in this work-package are framed in the **provision of layers of service to the urban operators, managed by the city council, for the specific city**. It is envisaged that these systems can be integrated to a U-space/UTM environment, specifically for the management of the city boundaries and the transition to outer airspaces if needed.

At the operators' side, systems will be defined to enable their integration to the described infrastructure. All platforms will be integrated with PLATERO, either at the remote-piloting station or providing instructions directly to the autopilot, guiding the vehicle inside the prescribed track and alerting for any potential deviation or degradation of the navigation capabilities. Futhermore, Babcock's LUA on-board systems will be upgraded to enable e-identification (taking concepts from parallel TRACE project and also inputs from WP4.4 regarding satellite IoT for contingency plans), and the ground mobile station will be improved beyond its current cooperative detect and avoid (based on ADS-B) to integrate further off-nominal alerts, plus WP4.5 DAA concepts. Finally, Correos' ground systems will be integrated into a mobile station that will include CRS's Mission Control Centre, and the operator's tools.

Besides, the multimodal mobility as a service tool 'Ne-mi' will be integrated as an entry to the infrastructure defined in WP4.2 for the people's transport service. ne-mi will receive service requests from the operator (in form of point of origin and point of destination) and will provide with a feasible route with the available infrastructure, which will then be published to the distributed architecture for the route to be accepted or rejected.

WP4.4 – Technological Challenges

This work-package will explore the technologies that will enable the UAM operations described in the previous sub-work-packages.

Communication, Navigation and Surveillance (CNS) equipment is nowadays strongly based on ground radio links and GNSS. In LAIKA we want to **explore the benefits of new constellations of low earth orbit satellites**. A hybrid communications device will be designed and developed to be accommodated on the UAVs as independent add-ons. This *e-identification* beacon will include commercial terrestrial links (LTE-M or 5G) and satellite IoT fallback. The satellite IoT communication link is of importance as it will provide the ability to stay connected, with limited bandwidth but at almost no power drain. In the whole, this system will enable e-identification features, provide its own means of geo-localisation independent to GNSS (with an estimation accuracy of around 150m at the time of writing), and also limited command and control functions when everything else fails. LAIKA will assess to what extend a contingency operation can rely on this bidirectional communication link (and positioning source).

Besides, this WP will select and integrate the systems needed to **characterise the vehicles and 'certify' their flyability and navigation performance**, as described in WP4.2. For this purpose, an in-kind navigation unit will be integrated in the vehicle. This will follow closely the efforts in WP4.2, as the hardware will have to experience improvements if the simulations and/or defined infrastructure in WP4.2 requires it. The outcomes of WP4.4 will then be integrated in the platforms to generate further results that are valid for the definition of the design criteria in WP4.2.

WP4.5 Autonomy and Safety

The development of advanced autonomy functionalities will have an important impact on the safety level of UAM operations. These advanced functionalities are then essential to enable the CONOPS. Based on the types of operations considered in LAIKA project, it has been decided to focus on the following functionalities:

- **Precise navigation in GNSS degraded environments** will make use of advanced sensor fusion techniques in order to ensure a robust and precise estimation of the UAS position and velocity even in GNSS degraded environments. This will require good cooperation with WP3.2, going a step forward with respect to the current state of the art, and fuse advanced 3D range sensors-based odometry (like LIDAR) with GNSS, IMU, baro and magnetometer information in order to continuously get a full state estimation of the aerial-vehicle. The LIDAR-based odometry will be based on advanced SLAM techniques that have been successfully in used ground robots and autonomous cars in the last years.
- **Cooperative Detect and Avoid (DAA)** will be broadcasting own information (e.g., e-identification, ADS-B, FLARM, GSM) so all other equipped actors can know not only the current position, but the velocity and the intents to be able to produce a future projection of the position and predict potential conflicts. The autonomous DAA system will be based on the sensors on-board and cooperative communications (network identification, etc.) and will be applied in situations where a trajectory re-planning (tactical de-confliction) is not possible (imminent collision or avoidance of non-cooperative obstacles or aerial vehicles).
- **Non-cooperative DAA** will be based on on-board sensors that enable enhanced perception for detecting non cooperative nearby traffic.

With respect to autonomous and non-cooperative DAA, it is expected to develop an advanced architecture that will allow to implement complex avoidance behaviours taking into account not only a 3D map of the surrounding obstacles, but also the interaction with the strategic deconfliction services. The fact that the strategic deconfliction will already have separated the traffic, in different corridors, will be taken into account in order to plan and calculate in real-time the avoidance manoeuvres in order to execute the correction actions minimizing the probability of actually leaving the corridor (minimising or even removing the network effect). On the other hand, and for decentralized cooperative collision avoidance, the fact of high number of aerial vehicles in UAM will be taken into account to develop new functionalities, while keeping safe distances to the urban scenarios' obstacles. The algorithms will operate reactively without high computational requirements allowing the vehicles to integrate measurements of other aerial vehicles within communication range.

Deliverables

- **D4.1** Concept of Operations (M13)
- **D4.2** UAM Operations and Safety Report (M24)

- **D4.3** Advanced autonomous functionalities oriented to increase UAM safety (M24)

Work package No	**5**		**Lead beneficiary**		Envisa			**Start month**		M6		**End month**		M27	
Work package title	**Sustainability Assessment**														
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	2	2	2	18	2	0	0	20	0	7	2	0	1	2	0

Objectives

Assist the European Commission, EASA, EUROCONTROL or any other EU organisations to develop environmental related policy, regulations and guidelines for UAM integration under SUMPs. Provide an overview of state-of-the-art efforts regarding environmental impact of UAMs and provide initial KPIs at the first specification phase of the project. Develop a critical analysis for specification of initial KPIs and data needed for holistic approach of combining data from the technical work packages. Assess the full life cycle impact of selected UAM vehicles for comparison with traditional vehicles. Develop a practical test platform that estimates the environmental impact level of UAM vehicles in operations. Assist the system level integration in order to have real time data for environmental impact.

Description of work

WP5.1 – Needs and Gap Analysis for SUMPs

Under this task, current approaches for sustainable mobility will be analysed, and the area where improvements or new approaches are needed for UAM will be highlighted.

For this purpose, multiple surveys will be conducted in collaboration with WP2 in order to understand the perception, the needs and gaps. Such information, together with the data obtained from collection campaigns or simulations, will be used to conduct product, trajectory and network analysis (WP5.2) and a city integration assessment (WP5.4).

The surveys will cover, among others, the following topics: general concepts of SUMPs and application areas for UAMs (considering the three type of systems); stakeholders involvement and medium/long term vision for sustainability expectations for three different platforms; boundaries (vertiports), minimisation travel distances, connectivity, etc.; environmental concerns (noise, emissions, local quality, etc.) and public perception (on environmental matters) related to three different service levels.

WP5.2 – Operational Aspect

In this task, LAIKA will investigate the sustainability and environmental impact of each UAM service covered by the project at operational level by considering: environmental, social and economic aspects. The aim will be to guide the operations planning (WP4) in a most sustainable level, obtaining the proper public perception and acceptability.

State-of-the-art emissions and noise calculation methodologies will be developed and improved during the project execution to work under UAM conditions. Through these systems, trajectories using PBN design criteria developed in WP4 will be simulated in order to analyse generated emissions and noise, and propose modifications to optimize them in terms of: design of low level corridors, location of vertiports or variations based on timeframe among others.

WP5.3 – Product Aspect considering specific use cases

This task will focus on assessing each UAM service covered in LAIKA through the product life cycle aspects. This assessment will involve a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. Four main areas will be considered: upstream, core, downstream and end of life processes

This assessment will also include comparison between UAM services against other alternatives providing similar services (private car, taxi, train, etc.).

WP5.4 – City level integration and environment assessment

This task will support UAM services developed in LAIKA to be applied under Sustainable Urban Mobility Plans (SUMPs) in the new era of Smart Cities., based on the CONOPs defined per each UAM service in WP4. To this purpose, it will be taken into account the sustainability criteria, while assessing its impact by changing parameters such as: operation altitudes, traffic/obstacles separation, free flight concept vs structured network of routes, etc.

Aiming to review the UAM services integration into the cities supporting the project, it will be considered environmental data provided by each city council. In this framework, the BSC will perform and environmental assessment study by quantifying the changes in direct emissions and air quality levels derived from the implementation of different urban air mobility scenarios in the city of Barcelona. The impact of reducing the vehicle kilometre travelled using traditional on-road vehicles will be evaluated in terms of emission and air pollution concentration changes (dioxide nitrogen, NO_2 and particular matter, PM) at high spatial and temporal resolution (1km, 1 hour) using the in-house HERMES emission modelling tool (Guevara et al., 2020) and the CALIOPE[6] air quality modelling system. The evaluation will include two scenarios: one representing a low penetration of urban air mobility devices, and a second one representing a high penetration of this technology. The definition of the scenarios, including shift between traditional on-road vehicles and UAM devices as well as aircraft routes and corridors, will be provided by WP4. The two scenarios will also consider changes in emissions from the energy production sector due to the increasing demand associated to the use of the new aircraft technologies. The results of the environmental assessment study will be summarised in the sustainability assessment report.

In addition, AYA will coordinate the Tel-Aviv case study, which will also be integrated in the city specific assessments and similar criteria will be investigated in a different city environment with different constraints The case study will consider drafting of an initial survey with Civil Aviation Authority and Regulatory stakeholders (acting and pending new regulations on UAM and other issues). In addition, public survey will be conducted and questions will be provided from WP5.1. It will set up the operational centre to fly and to conduct the demonstrations (permissions, localisation, availability, preparing and monitoring flight tests, conduct noise monitoring with protocol provided from WP5.2). Besides, it will forecast the economic and environmental implication by scaling up the case study to the city level and include all the outcomes in the sustainability assessment report.

Deliverables

- **D5.1** Gap analysis and specification Report (M27)
- **D5.2** Sustainability report (M27)

Work package No	**6**			**Lead beneficiary**		Fraunhofer		**Start month**		M6		**End month**		M30
Work package title	**Service integration and acceptability**													
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

[6] http://www.bsc.es/caliope/?language=en

Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	4	2	0	0	2	0	1	1	0	12	1	2	1	2	0

Objectives

The goal of this work package is to develop and define the mobility system to put urban air mobility into place. This involves the derivation of relevant routes and vertiport locations as well as the establishment of a viable business model based on traffic simulations and multi-criteria evaluations. Specifically, the most relevant possible routes and vertiport locations for the urban air mobility will be determined based on a traffic simulation taking into account the air vehicle configuration (vehicle type, number of passenger seats, thrust technology, take-off and landing technique as well as power and capacity) and thus operating and lifecycle costs on the one hand and the spatial possibilities and intermodality requirements stated by the municipalities and service providers and the mobility demand from work package "Specifications" on the other hand. Different fleet sizes and schedules will be considered and the optimum solution will be determined in a multicriteria evaluation of social and economic aspects. In all use cases, historic origin-destination trip data will be used provided by the local mobility providers.

The implementation of UAM services into companies may be difficult, as entrepreneurial processes have to be adapted accordingly. This work package focuses on the harmonization of the current internal processes of emergency and logistics companies with the ones required through the employment of UAM services.

Description of work

WP6.1 – Derivation of Routes and Take-off and Landing Locations and Traffic Simulation

In this task, a simulation of the effects of an integration of air taxis will be performed for each of the considered cities and use cases. In all cases, different possible route and vertiport location settings shall be considered to determine the best solution from a processual (time savings) and economic (viability) perspective. For this, operations research heuristics and optimization algorithms will be employed.

For the simulation of the urban air taxi use case, it is first important to define the air vehicle configuration with regard to the vehicle type, the number of passenger seats, the thrust technology, the take-off and landing technique as well as the power and battery capacity. This allows the definition of price points for the service. Based on this and the identified generally possible routes and vertiport locations, the intermodality requirements, the provided historical mobility data, and the assessed mobility demand especially with regard to mode choices and a sufficient willingness-to-pay from the work package "Specification", the effects of air taxis on traffic will be determined.

For the simulation of the emergency use case, it is first necessary to define the air vehicle configuration with regard to the vehicle type, the number of passenger seats, the maximum payload, the thrust technology, the take-off and landing technique as well as the power and battery capacity. Based on this and the identified generally possible routes and vertiport locations and the provided historical mobility data from the work package "Specification", the traffic effects of air taxis on emergency services will be determined.

For the simulation of the logistics use case, it is first important to define the air vehicle configuration with regard to the vehicle type, the maximum payload, the thrust technology, the take-off and landing technique as well as the power and battery capacity. Based on this and the identified generally possible routes and vertiport locations, and the provided historical mobility data from the work package "Specification", the traffic effects of air taxis on logistics will be determined.

WP6.2 – Profitability Analysis and Definition of a Viable Business Model

In this task, a business model will be developed for the urban air taxi use case based on the Business Model Canvas approach. For the emergency and logistics use cases, the adjusted business processes will be defined. These activities will be accompanied by a profitability analysis for each use case.

WP6.3 – Learnings from practical Flight Demonstrations

The real-world demonstrations of the use cases air taxi, emergency and logistics will deliver valuable insights with regard to the actual effects of urban air mobility on traffic and sustainability. In this task, the practical implications of the real-world testing will be identified and used to improve the findings from the theoretical analysis of the traffic effects of urban air mobility. The implications of real-world testing will be incorporated in D6.2.

Deliverables

- **D6.1** Infrastructure Analysis(M24)
- **D6.2** Business Model, Business Process Adaption and Viability (M30)

Work package No	7	**Lead beneficiary**	FADA CATEC	**Start month**	M18	**End month**	M30
Work package title	**Validation**						

Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	11	3	43	0	21	0	0	0	17	0	1	0	25	18	0

Objectives

This work-package has the following objectives: perform experiments (including simulations and real-flights) that will allow validating, in safe and secure environments, the designed concept of operations, the developed operational management tools and also the novel safety functionalities for the different use cases; obtain real flight data that will support the sustainability assessments and service integration studies to be developed in WP5 and WP6; compile evidences from flight campaigns to facilitate the process of obtaining the required flight permits that will allow in-service demonstrations in more representative urban environments at city locations (WP8); compile best practices and lessons learnt that will support EASA in future regulation related to UAM.

Description of work

WP7.1 – Advanced simulation for complex UAM operations

In this task the ROS-MAGNA framework (ROS-based Multi-AGent mission maNAgement; previously developed by University of Seville) will be extended, integrating it with the UAM systems developed within WP4 to enable novel UAM operations simulations including on-board intelligent autonomous functionalities of the vehicles. This framework makes transparent the type of autopilot on-board and creates the state machines that control the behaviour of the different drones from the specification of the multi-drone mission. In addition, it integrates a virtual world generation tool to manage the information of the environment and visualize the geometrical objects of interest to properly follow the progress of the mission. The framework supports the coexistence of software-in-the-loop, hardware-in-the-loop and real aerial vehicles cooperating in the same arena, being a very useful testing tool for the developer of drone advanced functionalities such as autonomous detect and avoid and distributed perception to increase situational awareness.

Therefore, this task will include the definition of complex UAM environments, using this integrated simulated environment, that will allow to compare the benefits of using advanced autonomous functionalities in realistic simulations of UAM environments considering large number of UAM vehicles and the three use cases of LAIKA project (transportation of people, logistics and emergencies).

WP7.2 – Remotely piloted UAM operation

This task will be focused on the air ambulance use case that will be remotely piloted but with enhanced pilot assistance both in normal and in critical flying manoeuvres like take-off, landing, critical failure of motors/propellers or windy conditions. The proposed aerial platform has an overactuated nature that offers some advantages, such as greater dynamic redundancy, safety, and stability, but to exploit these characteristics while allowing the aircraft to be piloted remotely, it is necessary to improve the flight control to ensure that critical maneuvers are simplified, thus ensuring easy piloting and reduced pilot mental workload during flight.

During this task, different algorithms for improving the controllability, stability and decreasing the mental workload of the pilot will be tested, as a way of improving the flight control to offer a safe and easy piloting experience. Besides, a platform for the remote control of the aircraft will be used to evaluate the algorithms developed with real pilots, obtaining subsequently conclusions that will serve to improve the algorithms.

The test campaign will be carried out at the UAM Test Field (outdoor testing) managed by the University of Stuttgart, who will be involved in this task collaborating with Tecnalia team. The site that will be used is located at the Airport Mengen (EDTM), about one hour south of Stuttgart. Furthermore, the research group of the University of Stuttgart, that is involved in this proposal, is leading a consortium that is currently building up this airfield for test purposes.

The tests planned in the test campaign (all of them in remote piloting mode) will include taking off and landing with different payload and wind conditions, taking off and landing in aerial platform degraded performance mode, cruising at high speed and high dynamic manoeuvres and air ambulance mission assessment. In this final test, an air ambulance mission will be replicated under the most real conditions achievable in the test field. This will include flying the RNP routes designed for this purpose.

This task will conclude with a piece of validation evidence (KPIs both for the aerial platform and for the performed mission by the pilot) that will demonstrate the enhanced vehicle capabilities (safety, stability, easy piloting) in real-world conditions for the defined air ambulance mission. This assessment of the flight control and control algorithm of the aerial platform within an air ambulance mission constraints will be the main output of this task.

WP7.3 – Autonomous drone operations for logistics validation

This task will be focused on the logistics use case with autonomous drones. It will validate the novel autonomy functionalities, especially the ones related to safety, proving that they present enough level of robustness and allow non-experts users to trust in the overall aerial system performance. This is even more crucial where non-nominal situations are presented. Also, and in order to validate the aerial systems in the most challenging conditions, this validation campaign will be focused on the most complex phases of the operation, such as approaching and landing.

This validation campaign will be performed in ATLAS Experimental Test Centre, which has been already used for complex flight, being able to obtain the required flight permits from Aviation Authorities. Furthermore, RNP routes have been already designed in ATLAS during other projects, specifically tailored to the flight dynamics of a multicopter, similar to the one used for this campaign. The flight campaigns will include the measurement of the accuracy of the trajectories flown by autonomous drones using GNSS-augmented systems with on-board sensors, approaching and landing operations with autonomous Detect&Avoid in an area cluttered with obstacles, approaching and landing operations with autonomous Detect&Avoid of other drones that are flying close by, and finally, a complete intermodal mission where the drone platform will be integrated in a Correos' ground vehicle, and different combinations of ground and aerial segments of the delivery mission will be executed (including the full delivery workflow, from service request to flight planning and acceptance and service provision and finalisation).

During these validation campaigns, CORREOS personnel will be involved in the operation of the aerial systems in order to assess: the level of difficulty to operate such aerial autonomous systems, the required level of training, and the level of trust that operators and end-users perceive after several flight campaigns. This gathered information will be used as well for the sustainability assessments and service integration studies to be developed in WP5 and WP6.

WP7.4 – Emergency UAS for peri-urban operation

This task will address the peri-urban scenario in UAS emergency operations. In this use case, concepts and solutions addressed for the general UAM framework will be tailored and applied to specific emergency operations in peri-urban environments, which have particular requirements and, at the same time, must be taken into account to ensure safe integration of high-priority flights (such as those providing emergency services) into the overall scheme. An operational UAS, specifically developed for such emergency services, will be used as a test system and to showcase the results. It will also address subjacent technology enhancements to provide the UAS operators with automated traffic alarms and intelligent real-time suggestions to avoid risks of conflict that can be foreseen by the management system. To this purpose, the contingency CNS unit from WP4.4 will be used to demonstrate and validate the defined RNP criteria and the potential of hybrid terrestrial-satellite IoT, measuring coverage of terrestrial and satellite systems (both in space and time), quality of service (% successful transmissions, latency, etc.), integrity and accuracy of data, etc.

Whenever possible these indicators will be matched with external conditions (buildings, weather, etc…) and flight conditions (altitude, speed…). The goal is to assess objective performance to determine the use cases where this contingency technology is the most suitable.

All these developments and integrations will be evaluated in a test campaign that will take place in the CIAR UAS flight test facilities, Rozas airfield, and also in real operational scenarios for the specific case of medical emergency services provided by the UAS.

In particular, the operational case deals with fast-response operations for cardiac arrest emergencies. The unmanned system integrates a medical kit that includes a defibrillator, an electrocardiogram device and several medicaments and tools required in such events. An operational area is already defined in Galicia (Spain) to cover a strech of 50 Km of the Camino de Santiago with a response time of less than 10 minutes in any target location. This is a particularly interesting scenario for dynamic traffic coordination, as response times are critical and flight planning (and other related tasks) must be carried out as fast as possible.

Deliverables

- **D7.1** Preparation of validation flight campaigns [M24]
- **D7.2** Results and best practices from the validation campaigns [M30]

Work package No	**8**	**Lead beneficiary**	Drone Think Do	**Start month**	M1	**End month**	M30
Work package title	**Dissemination and awareness**						

Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Short name of participant	PLD	AHC	BMCSFM	BSC	CORREOS	DTD	EENA	ENV	FCAT	FH	KIN	PVS	TEC	USE	USTUTT
Person months	4	3	7	1	5	24	9	3	12	3	3	0	11	7	23

Objectives

This WP will be dedicated to produce communication tools and materials, and to organize tailored communication activities (workshops, trainings, exploitation events), promoting technologies through targeted communication towards stakeholders and target audiences and facilitating the involvement of stakeholders and key European research groups to foster a mutual exchange and a contamination of the approaches, priorities and needs. Besides it will foster the development of urban air services towards integration in cities and other with means of transportation, highlighting research gaps and needs for technology maturation. Through an advisory board, the organisation of dedicated events with interested stakeholders and target audience with the main purpose of disseminating the results of the project and raise awareness on the benefits that air services could bring to an all connected multimodal city infrastructure.

Description of work

WP8.1 – Communication activities

This task will broadly disseminate the applications previously identified in order to ensure high promotion and impact of the implemented technologies and services adapted to urban air services. In order for the dissemination to be effective, an integrated approach will be pursued, combining templates, guidelines and approval processes on one side with a communication platform, publication, event participation and release plan of the other. Social networks will be used by project partners to disseminate information on project events and results. A project web site will be designed and developed as main and central information point. Media attention is an important part of this project. Media material will be collected during all the demonstrations and events so videos, posters, flyers and pictures can be generated for distribution. The communications plan will define how research data will be handled, including access rules, how they will be exploited, shared and protected during the project lifetime and beyond. The plan will be updated throughout the project.

Besides, it will open a slot at the annual EENA Conference to communicate about the project progress and its conclusions at the end. There will be 3 EENA conferences during the project duration where there will be the chance of presenting updates on the project. The operational conclusions and insights from other consortium partners will be used to publish an EENA Paper, aiming at educating Emergency Services about the potential of Urban Air Mobility and UAVs for their operations. Furthermore, it will give awareness to technology developers and lawmakers about Emergency Services needs. It will also serve as a practical example of how this technology can be beneficial for our communities, contributing to its public acceptance.

WP8.2 – Advisory board

An Advisory Group will be established with all the experts identified as key stakeholders for the development of the solutions proposed within this Project. Two meetings will be organised with technical and operational experts. The first one will be devoted to present the progress of the project, discuss the requirements and CONOPS definition, get advice from the experts and share experience with other stakeholders. The second one will be devoted to discuss the results of the activities and raise conclusions.

WP8.3 – Demonstrations

On top of the validation activities of WP7, this workpackage will be devoted into raising public awareness of the project objectives and achieved results. To this purpose, this WP will create demonstration activities in the cities that are involved in the project, such as a demonstration in Lugo with Babcock on emergencies, in Sevilla with Correos on logistics, in Tel-Aviv with Tecnalia on goods mobility emergencies, in Ingolstadt with Tecnalia on people mobility and in dedicated congresses such as the Smart City World Congress in Barcelona and the Drone-Show in Sao Paulo (both focussed on people and goods transport). Not all demonstration activities will involve flights, but will ensure that the objectives of each demonstration are covered with the specific possibilities and the target audience

Deliverables

- **D8.1** Dissemination plan and material (incl. website, publications, etc.) [M3-M30]
- **D8.2** Best Practice Guidelines for Cities implementing urban air services [M30]

3.1.3 GANTT chart

The figure below presents the GANTT chart of the proposed WP structure.

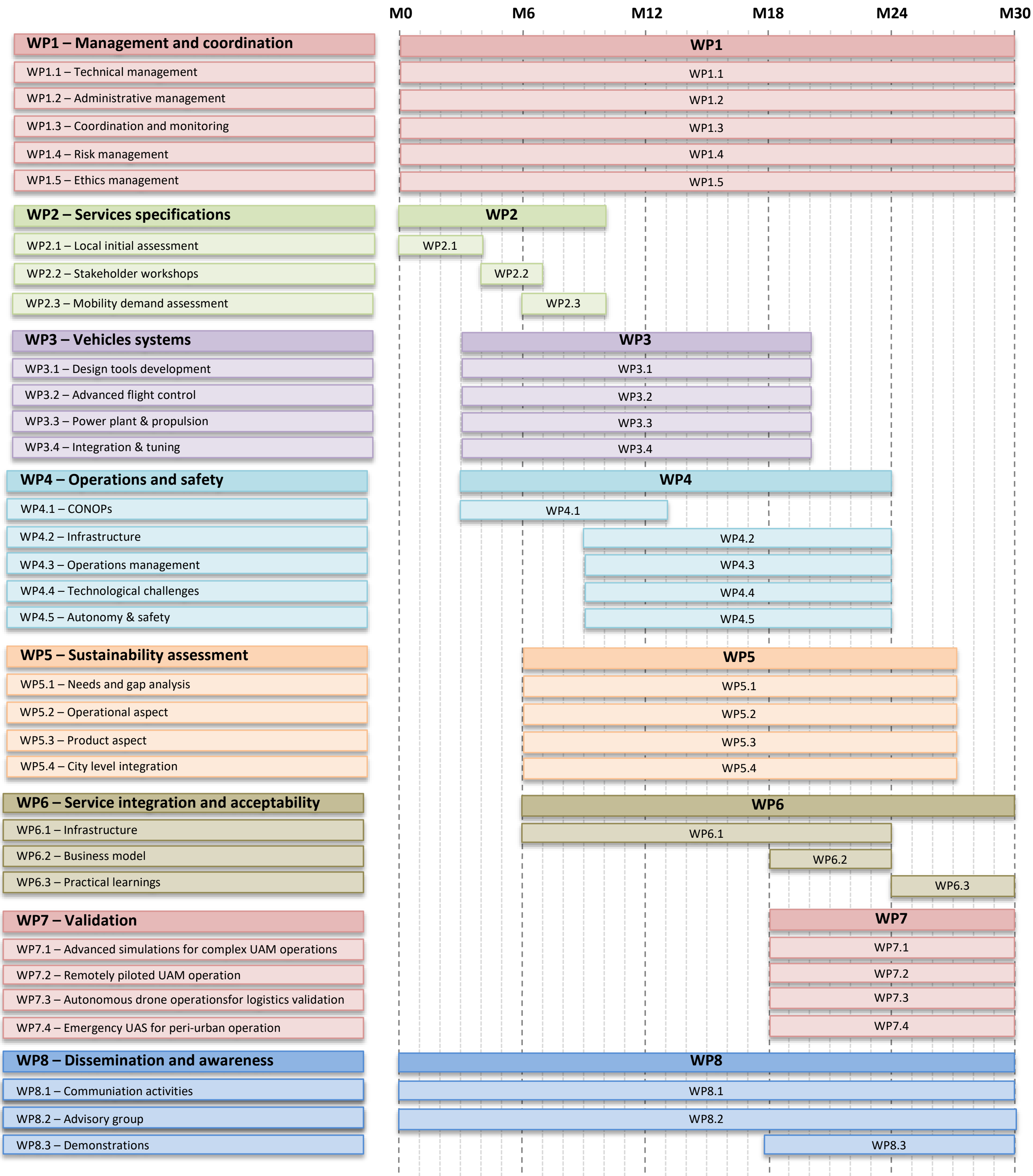


Figure 3-3 - LAIKA GANTT Chart

3.1.4 Deliverables

ID	Deliverable name	WP	Lead	Type	Target	Due date
D1.1	Project management plan	WP1	PLD	R	CO	M1
D1.2	Communication tool kit for participants	WP1	PLD	DEC	CO	M2

ID	Deliverable name	WP	Lead	Type	Target	Due date
D1.3	Project collaborative platform	WP1	PLD	DEC	CO	M3
D1.4	Ethics management plan	WP1	PLD	R	CO	M3
D1.5-13	Quarterly report	WP1	PLD	R	CO	M3-M27
D1.14	Final report	WP1	PLD	R	CO	M30
D1.15	Final report executive summary	WP1	PLD	R	PU	M30
D2.1	(Preliminary) UAM Services Specifications	WP2	AHC	R	CO	M4
D2.2	(Final) UAM Services Specifications	WP2	AHC	R	CO	M10
D3.1	Report on the systems, its architecture, assumptions and the final vehicles	WP3	TEC	R	CO	M20
D4.1	Concept of Operations	WP4	PLD	R	CO	M13
D4.2	UAM Operations and Safety Report	WP4	PLD	R	CO	M24
D4.3	Advanced autonomous functionalities oriented to increase UAM safety	WP4	FCAT	R	CO	M24
D5.1	Gap analysis and specification Report	WP5	ENV	R	CO	M24
D5.2	Sustainability report	WP5	ENV	R	CO	M24
D6.1	Infrastructure Analysis	WP6	FH	R	CO	M24
D6.2	Business Model, Business Process Adaption and Viability	WP6	FH	R	CO	M24
D7.1	Preparation of validation flight campaigns	WP7	FCAT	R	CO	M24
D7.2	Results and best practices from the validation campaigns	WP7	FCAT	R	CO	M30
D8.1	Dissemination plan and material	WP8	DTD	DEC	PU	M3-M30
D8.2	Best Practice Guidelines for Cities implementing urban air services	WP8	DTD	DEC	PU	M3-M30

Table 3-2: List of deliverables

3.1.5 Meetings and travel plan

Next table presents the list of meetings planned for the project.

Meeting description	Location	Participants	Nature	Expected	Duration (days)
KoM	Barcelona	All	Kick-off	M1	1
Stakeholders workshops	Barcelona	All	Workshop	M6	2
Systems	Stuttgart	WP3	Technical	M12	3
Mid-term PM	Barcelona	All	Progress	M18	1
Operations Integration	Sevilla, Rozas, Bilbao	WP4	Technical	M20	3 (each)
Validation	ATLAS, Rozas, Stuttgart	WP7	Technical	M24	5 (each)
Demonstrations	Lugo, Sevilla, Ingolstadt, Smart City (BCN), Drone-Show (Sao Paulo)	WP8	Demo	M28	1 (each)
Final meeting	Barcelona	All	Final meeting	M30	1

Table 3-3: List of meetings

3.2 Management structure, milestones and procedures

3.2.1 Management requirements and objectives

The objective of project management tasks is to ensure that all the activities performed within the project will be performed successfully and according to contractual and technical requirements. The main objectives of project management tasks are: set-up of contractual and relational aspects; tuning of project organisation; project planning and control; budget control; quality control; and contingency planning and dispute settlement.

The framework for control activities shall be the Work Breakdown Structure (WBS) as presented in this proposal, in conjunction with the project planning and the Work-Packages (WPs) description.

The project will be managed according to state-of-the-art project management methods. The planned monitoring and controlling mechanisms, to be rigorously applied during the project execution phase for managing the work, include: continued performance measurement actions will be performed, including design reviews and audits; risk assessment and mitigation will be conducted; schedule and financial control will be performed continuously; work package descriptions will be used and their status continuously tracked; and progress meetings will be held regularly.

All the management principles described hereafter are subject of agreement with European Commission.

3.2.2 Management approach

PildoLabs, a very experienced company in the management of pan-European projects, will execute the project management by maintaining responsibility for technical and contractual tasks, in order to achieve the contractually defined project objectives, in accordance with the technical performance specification and within the agreed scheduled dates. The overall management procedure will be based on a close co-ordination between all the project partners, including European Commission when required.

The management procedure to be implemented will include, among others, the following actions: planning of periodic teleconferences with European Commission to ensure that progress is satisfactory; peer review of all deliverables before final release; application of PildoLabs internal project management procedures, which are designed to ensure quality of deliverables; production of progress reports on request by European Commission, to check progress against the plan; and maintain a risk register for the project and update this at progress meetings with the client.

Major changes in work-packages, particularly creation, reallocation, or termination of work-packages, as well as the general management of the project, shall be handled directly between **PildoLabs Coordinator** and **European Commission project manager**.

3.2.3 Organisation overview

The management and coordination structure proposed for the project is outlined in the following figure.

Structures that have been proven as successful in this type of projects in the past will be adopted here. Due to the scope of this particular project it is planned to keep a structure as simple as possible but with defined relationships between European Commission and contracted company. PildoLabs project manager will be the point of contact with the European Commission, while getting support from PildoLabs technical coordinator. Figure below shows the consortium overview.

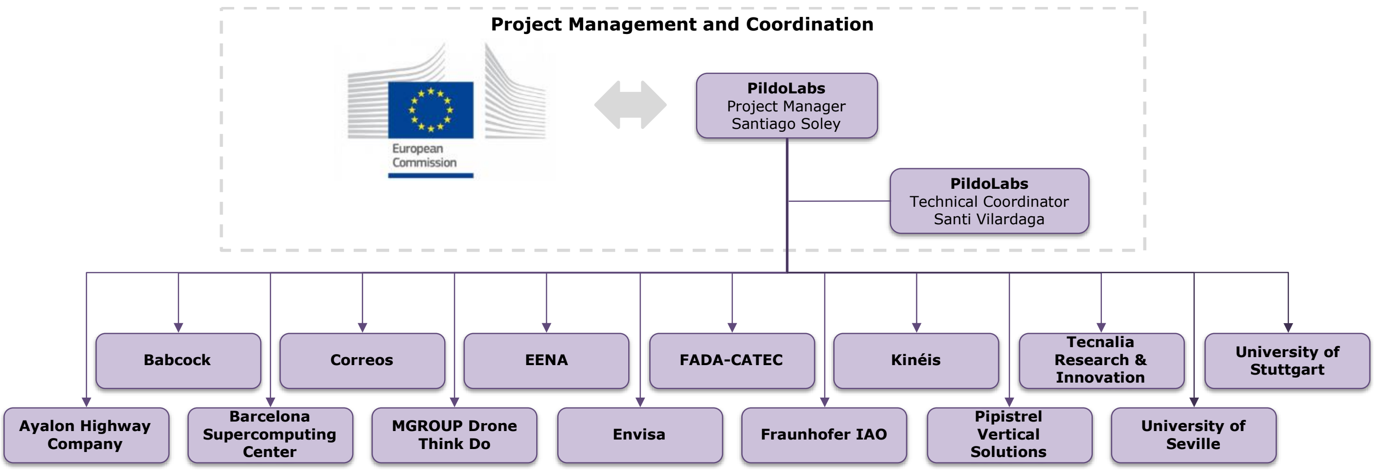


Figure 3-4 – LAIKA Consortium organisation overview

3.2.4 Project management and Coordination

Governance of the project and Decision Making will be implemented by the General Assembly (GA), Executive Board (EB) assisted by the Advisory Board (AB) put in place for LAIKA. The management structure will ensure that the project is continuously assessed and evaluated in terms of its results and the stated goals and objectives.

The Executive Board (EB) is led by the Project Coordinator (PildoLabs) and includes the work package leaders among which the Technical Coordinator (PildoLabs). It is responsible for making overall project management decisions, monitoring project progress and ensuring a high quality of work. The Executive Board will report to the General Assembly, and will keep it informed about project status. Management/Progress meetings are planned to be held monthly and technical meetings are planned to be held as per request of either side, European Commission or the Executive Board. The Advisory Board (AB) consists of the partners and European Stakeholders that support the project such as [list some advisory board entities]. This group, closer to the European End Users, advise the Executive Board for a full exploitation of the project results in Europe.

The General Assembly (GA) consists of the LAIKA project leaders for each of the consortium partners and is led by the Project Coordinator. The General Assembly is responsible for the overall success of the project. The GA has two main functions: executive (based on EB inputs) and administrative.

Coordination between European Commission as a client and PildoLabs as a contracted company shall cover the following: managing all contractual matters (all financial issues; and making proposals to the European Commission for the review and/or amendment of terms of the contract); monitoring the activities of the project conformity to the Contract; defining the project overall strategy and deciding on a technical roadmap for the project; reviewing and maintaining the objectives of the project; reviewing and proposing changes in the work plan. The Coordinator will inform the client on the above changes at management/progress meetings and possibly at any time at its own initiative or upon request of client in the case of contingency situation.

3.2.5 Project Manager

PildoLabs Project Manager will be responsible for the day-to-day coordination of the project and responsible for the internal administration of the project. The Coordinator will be at managerial level coordinating with client's single point of contact. In particular, the project manager shall be responsible for:

- Project schedule monitoring & control (periodic comparison between foreseen and actual schedule);
- Implementation of corrective actions (when necessary) in order to maintain the agreed schedule and project objectives, in case of deviation from expected achievements;
- Budget monitoring & control (period comparison between foreseen and actual resources);
- Coordination, on a day-to-day basis, of the progress of the technical work performed within the project, with the assistance of the project team;
- Collection of contractual technical deliverables and delivery to the European Commission on due date;
- Review and consolidation of all the contractual technical deliverables;
- Organisation, administration, preparation and distribution of the minutes of the Kick-Off Meeting, the different Management/progress meetings and the different project reviews;
- Organisation and chairing of regular progress meetings with the client;
- Follow-up and execution of the European Commission decisions agreed if changed significantly from the contractual terms of reference;
- Follow-up and tracking of all the action items agreed during the progress meetings;
- Production and delivery to the European Commission of the contractual management deliverables as closure of the project reporting periods: activity report, management report, cost statements, audit certificates (if specified in the contractual term of reference);
- Communication with external interfaces;
- Consolidate the project planning, progress reporting, financial issues; etc.
- The preparation and enforcing of all project management documentation;
- Convening and organising those meetings, preparing the agenda and afterwards the meeting minutes.

Santiago Soley will act as Project Manager on PildoLabs side and will work together with **Santi Vilardaga** from PildoLabs as Technical Coordinator.

3.2.6 Milestones

Milestones are control points where decisions are needed with regard to the next stage of the project. The following table lists the milestones identified for this project.

Milestone number	Milestone name	Related WPs	Due date	Means of verification
1	Kick-Off	All	T0	KOM Minutes
2	Stakeholders workshop	WP2	T0+7	Minutes of workshops
3	CONOPS	WP4	T0+13	D4.1
4	Mid-term meeting	All	T0+18	Minutes of mid-term meeting
5	Vehicles completed	WP3	T0+20	D3.1
6	Infrastructure and service integration	WP4, WP6	T0+24	D4.2, D4.3, D6.1, D6.2
6	Final meeting	All	T0 + 30	All validation and demonstration activities performed. All deliverables submitted.

Table 3-4 – List of milestones

3.2.7 Risks

A risk is any foreseeable circumstance that might affect the project in a negative way. Project risk management also covers the optimisation of the exploitation of unplanned opportunities (e.g. cost savings, product enhancement, accelerated development, etc.). The risks must be evaluated in terms of criticality (low, medium, high) and the causes leading to the risk. There must always be a plan to mitigate all the risks in the project or to maximise the opportunity, especially those with a high probability and/or criticality. The risks are not a static element in a project; they appear, disappear or are modified as the project progresses.

Our quality system dictates that an adequate risk control needs to be put into practice in any project. Aimed at that, a risk database will be maintained for this project and the European Commission will be informed of the state of the risk in all the progress reports. The following table shows some risks currently identified.

Description of risk	Likelihood	WPs	Proposed risk-mitigation measures
Deviation of the project plan in time	Low	All	Project coordinator and work package leaders will monitor the project progress to help prevent and detect early deviations from the plan. A new plan for the deviated project activities should be elaborated by the project coordinator and the affected work package leaders that compensates the deviation by assigning more resources or by affecting the delivery dates.
Lack of human resources	Low	All	Ensure transparency of the management of the project and agreement with reporting and quality procedures. Provide the project with other staff with similar or similar skills
Bad weather conditions for flights	Low	WP4, WP7, WP8	Organise the demonstrations during days with a higher probability of good weather conditions
Drone or pilot not available for flights	Low	WP4, WP7, WP8	All operators do not rely on only one crew to operate their air platforms. Make sure that a principal crew and a secondary crew are designated and that the secondary crew is duly notified to be prepared if needed.
Lack of support from Regulatory bodies	Medium	All	EASA is an active member of the project. Prepare in advance with them so they can participate in the regulatory activities, as well as make sure that the national authorities are also duly notified.

Description of risk	Likelihood	WPs	Proposed risk-mitigation measures
Flights and demos cannot be performed in the proposed locations due to authority's reluctance	Medium	WP7, WP8	The validation flights will happen in facilities where flight permits are granted or have been granted for the type of activities of the project. Also, the municipalities where demonstration activities are planned are supporting members of the proposal.
Delay in the acquisition of approval by national authorities to perform the validation and demonstration flights.	Medium	WP7, WP8	Keep close contact with national authorities on the scope of the project in advance, and apply for the Permit to Fly with high anteriority. Also, involve EASA in the loop, as an active member of the project, and also AESA and CAAI as supporting member.
Lack of satellite visibility during the satellite IoT validation activities	Low	WP4, WP7	Kinéis is already counting with enough satellites to cover at least 10 minutes of visibility time per hour, and increasing. Align the flights accordingly.
Mobility limitations, at least during 2020 period, to attend dissemination events due to COVID-19 countermeasures.	High	All	Conduct an efficient management of dissemination events based on countries travel restrictions due to COVID-19. Promote the use of video conferences, webinars and add extra effort for social media marketing and dissemination of scientific materials online.

Table 3-5 – Critical risks for implementation

3.3 Resources to be committed

The following table provides a summary of the effort dedicated per WP in person-month:

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	TOTAL
1.PLD	20	4	0	40,5	2	4	11	4	85.5
2.AHC	1	2	0	0	2	2	3	3	13.00
3.BMCSFM	1	2	0	19	2	0	43	7	74.00
4.BSC	1	0	0	0	18	0	0	1	20.00
5.CRS	1	8	2	12	2	2	21	5	53.00
6.DTD	1	0	0	0	0	0	0	24	25.00
7. EENA	2	4	0	0	0	1	0	9	16.00
8.ENV	1	2	0	2	20	1	0	3	29.00
9.FCAT	1	4	8	30	0	0	17	12	72.00
10.FH	3	5,5	0	0	7	12	0	3	30.50
11.KIN	1	1	0	4,5	2	1	1	3	13.50
12.PVS	1	1	74	0	0	2	0	0	78.00
13.TEC	1	2	45	2	1	1	25	11	88.00
14.USE	3	3	25	18	2	2	18	7	78.00
15.UST	1	0	36	0	0	0	0	23	60.00
Total	39	38.5	190	128	58	28	139	115	735.5

Table 3-6 – Summary of staff effort in Person-Month

3.4 Consortium as a whole

The LAIKA consortium offers well-balanced and independent sources of expertise to carry out the project. The partners bring a wide range of experts with high knowledge, know-how and background, which will contribute to the quality of the work performed in the frame of the activity, providing an inherent coordination synergies flavour.

The consortium is composed of a rich combination of European partners, covering the complete market sector chain, which will ensure the networking between European technology developers, UAM operators, service providers and European institutions. LAIKA consortium roles have been defined as follows:

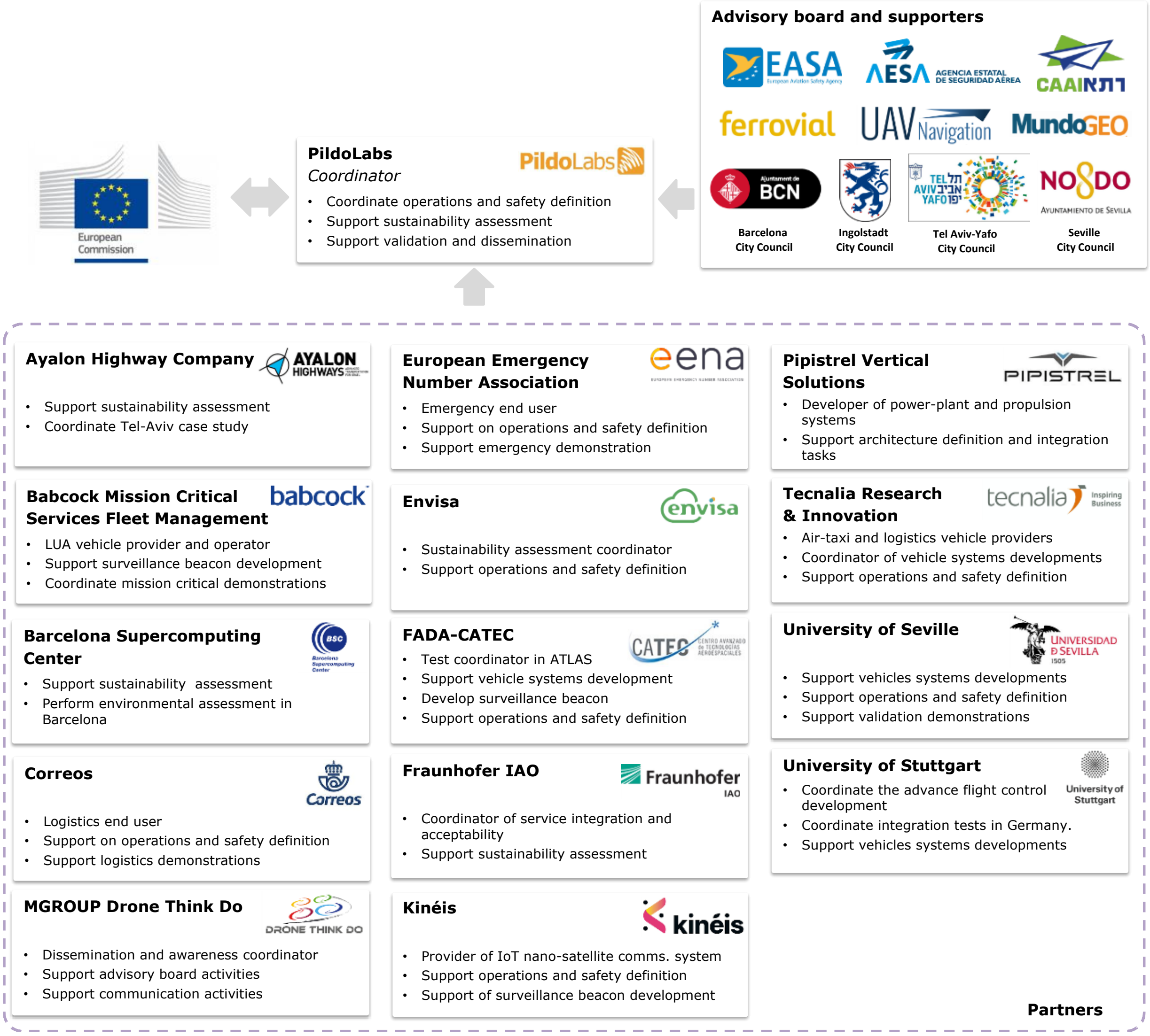


Figure 3-5 - LAIKA consortium roles

PildoLabs will assume the coordination and management of activities. Complementing LAIKA consortium, a group of experts will take part in the Advisory Group to provide their feedback on the solutions proposed and the progress of the project and to discuss any potential issue arisen during the execution of the activities. The group will include representatives from municipalities and regulatory bodies among others.

3.4.1 Other direct costs

This section provides a justification of the "other direct costs" for participants exceeding 15% of its "personnel costs".

AHC	Cost (€)	Justification
Travel	24,000.00	Travel to integration test sites, attendance to consortium meetings
Other goods & services	64,000.00	Material to build take-off and landing in 2 new operation centers. Moving of 2 caravans to the sites. Electric link on site.
Total	88,000.00	

BMCSFM	Cost (€)	Justification
Travel	17,000.00	Travel costs for ordinary project management, technical meetings, etc. Travel costs for flight evaluations outside the CIAR flight test center.
Other goods & services	23,000.00	Two small UAVs for real-flight testing and evaluation of proposed solutions. Spare parts, fuel and other consumables for flight testing. Hosting for the proposed data repository to be used during the development and validation flights. Materials for dissemination activities.
Total	40,000.00	
BSC	**Cost (€)**	**Justification**
Travel	9,000.00	Attendance to consortium meetings
Other goods & services	7,000.00	Publications
Total	16,000.00	
EENA	**Cost (€)**	**Justification**
Travel	28,000.00	Logistics for EENA staff to workshop, funding for Experts logistics to workshop, logistics for EENA staff to attend demonstrators, logistics Experts to attend demonstrators
Total	28,000.00	
FCAT	**Cost (€)**	**Justification**
Travel	15,000.00	Project meetings and experimental campaigns
Equipment	15,000.00	Two drone systems for logistics use case
Other goods & services	20,000.00	Sensors, electronics and comms to increase autonomy on drones
Total	50,000.00	
KIN	**Cost (€)**	**Justification**
Travel	12,000.00	6 technical meetings 2 persons
Other goods & services	5,000.00	Small equipment to develop the embedded comms system
Total	17,000.00	
PVS	**Cost (€)**	**Justification**
Other goods & services	131,000.00	Inverter and battery materials and services
Total	131,000.00	
TEC	**Cost (€)**	**Justification**
Travel	55,500.00	Travels for the technical and administrative meetings. Travels of 2 Flight Testing campaigns (Stuttgart; Ingolstadt, ...) - total 1 month
Other goods & services	203,917.00	Mechanical and electrical consumables, sensors, electronics and communications consumables for the deployment of the aircraft below 25 kg MTOW according to project requirements + consumables formed by new or modified Air taxi structure parts to be integrated and deployed to comply with the requirements and specifications given in this project for the air taxi vehicle (106,000€). Autopilot technology (61,917€). 2 transports of material to Test Field Campaigns abroad and 2 transports close to Tecnalia (13 k€). 2 transports of material to Demos. Audit reports of 3 years. Dissemination materials (1.000 €). Assistance to an international workshop (1.000 €). 1 open access publication (3.000 €)
Total	259,417.00	

Table 3-7 - Other direct cost items