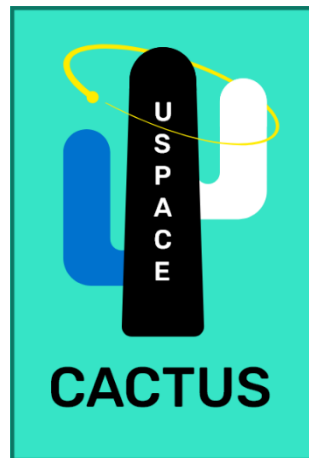


Development of an Unmanned Aerospace Test Site U-space Sandbox

Project CACTUS



U-space Sandbox Use Cases

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1. Introduction

ANRA Technologies, Inc. (ANRA), in partnership with the Tartu Science Park Foundation (TSP) are pleased to submit this document in support of the Development of an Unmanned Aerospace Test Site (U-space Sandbox). The project is called CACTUS, an acronym for “Competent Authority Coordinating Testing in U-space Sandbox.”

This document satisfies Deliverable 2.3 (U-space Sandbox Use Cases).

2. Background

Sandboxes are becoming increasingly crucial as a centre to enable innovation by ensuring that the technology is ready for deployment by testing in an environment that is close to reality. It provides an opportunity to validate new technologies, expand market opportunities, identify existing risks and how it may be mitigated, understand legal and regulatory requirements and how they must be met, while ensuring that there is adequate social acceptance for the technology. This document describes potential use cases for the U-space sandbox in Tartu and lists which ones generated most interest among the stakeholders at the workshop held on 30 June 2023.

3. U-space Sandbox Use Case Descriptions

● Testing and validating U-space services and design

It is important to determine and test U-space architecture before implementing it on a wide-scale to ensure that it is fit for purpose. It must be determined if a centralised or decentralised architecture is preferred, the nature of the common information service provider (CISP), and ensure that it is adapted to each Member State’s requirements. The sandbox would allow USSPs to test their capabilities in terms of the mandatory and, if preferred, optional services. The requirements and capabilities of the competent authority could also be identified through testing in the sandbox, thereby reducing regulatory arbitrage. Processes pertaining to certification and oversight activities, and tasks for the competent authority as listed in Article 17 and Article 18 of (EU) 2021/664 could be further developed through activities conducted in the sandbox.

● Testing Uncrewed Aerial Vehicle (UAV) systems and UAVs

A market analysis was conducted to identify the major activities carried out by Estonian companies that are in the uncrewed aircraft (UA) industry. Several companies developing specific systems for UAVs, robotics solutions, and UAVs were present in the Estonian market, who could greatly benefit from a sandbox where their technology can be thoroughly tested in conjunction with U-space services. The availability of U-space services within the sandbox would aid UAS developers in understanding how their

technology must interact with the available services and ensure that it is ready for deployment in U-space airspaces.

● **Testing UAV flight in the open and specific category**

Operators could use the sandbox to conduct operations in the open and specific category with the possibility to test in the certified category of operations in the future. The sandbox could be used as a tool to validate complex operations in a high-risk environment, such as BVLOS operations in a populated environment. In case of a complex operation, using U-space services would also enable operators to reduce the air risk class associated with their operation from ARC-d to ARC-b when conducting a SORA. In the future, if the sandbox is expanded to Tallinn and other parts of Estonia, where multiple U-space sandboxes are established, coordination between USSPs can also be assessed.

● **Testing monitoring solutions**

Based on an extensive literature review, it was noted that companies would be interested in testing monitoring solutions. Monitoring solutions may refer to detect and avoid systems, products or services for monitoring infrastructure, or monitoring solutions employed in the context of Beyond Visual Line Of Sight (BVLOS) operations. Corridors established to connect sandbox locations could provide the required means for conducting BVLOS flights. Testing these solutions with the use of the available U-space services, such as conformance monitoring could support this exercise, especially in the context of BVLOS operations.

● **Testing communication tools**

There are several Estonian companies involved in the development of communication technology. UAVs require communication tools in order to operate and therefore, a user survey conducted in the scope of a thesis titled 'Analysis of the Airspace of the Tartu Region for the Creation of a Test Area for Unmanned Aircraft Systems' by Ingrid Roosileht highlighted that conducting tests for communication, use of communication tools, and communication jammers was of high importance. Another aspect that would benefit operators is identifying the communication coverage area. This test would also offer operators the possibility to obtain the required information on developing a procedure on loss of communication in a controlled test environment with U-space services available.

● **Testing innovative technologies to mitigate risk in future operations**

All innovative technologies have an inherent risk associated with their operation. Testing in a sandbox environment can support in understanding these risks and their mitigation measures, as well as aid in developing a regulatory framework that can keep pace with innovative technologies without compromising safety. Conducting several simultaneous operations, testing fairly mature technologies in a high-risk environment, and conducting operations that require multi-crew coordination in a U-space sandbox environment are some examples of exercises that could be conducted in the sandbox. Through

these tests, companies that require regulatory advice or clarification are able to obtain the necessary information from the Operations Center or through discussions with other stakeholders involved in the sandbox.

- **Validating regulatory compliance**

Demonstrating evidence of regulatory compliance is key in conducting commercial operations and in ensuring that the highest levels of safety are maintained. The sandbox could offer companies the possibility to validate their technology in order to ensure that it is compliant with the U-space regulation and associated performance requirements. It could also be used as a form of onboarding for U-space Service Providers (USSPs), so that USSPs are able to demonstrate that they are compliant with regulatory requirements before providing services to UAS operators. In addition, coordination between the Common Information Service Provider (CISP) and USSP could be tested, and in case it is necessary, the coordination between several USSPs could also be tested and validated.

- **Developing and validating operating procedures**

The U-space sandbox could provide users with the opportunity to develop operating procedures for their operations. In addition, if required, emergency response plan (ERP), loss of communication, or failure of a secondary system could be evaluated and understood in detail, so that operating procedures for contingency and emergency situations can be developed.

- **Supporting educational activities, conducting trainings, and practice flights**

Considering that the U-space sandbox will be located in Tartu, it is important to note that the Estonian Aviation Academy will be located in close proximity to the sandbox locations. The academy has several aviation courses and the sandbox could act as a space for students to participate in training and practice flights. Demonstrations could be performed at the sandbox, thereby supporting students in understanding the practical aspects pertaining to the operation of UAVs and U-space.

- **Offering opportunities for strategic partnerships among businesses**

The U-space sandbox would offer networking opportunities and potential to build strategic partnerships among users, thereby strengthening the drone ecosystem in Estonia. The sandbox could be an attractive option to companies from across the EU to develop and test their services in the U-space sandbox.

- **Testing to obtain waivers, such as regulatory exemptions**

For companies that have a product with a high Technology Readiness Level (TRL 7 and above) and where tests conducted in the sandbox show no unmitigated risks, regulatory waivers may be provided if

deemed appropriate by the regulatory authorities. Exemptions may also be provided to state operations based on the use case, such as for emergency medical transport.

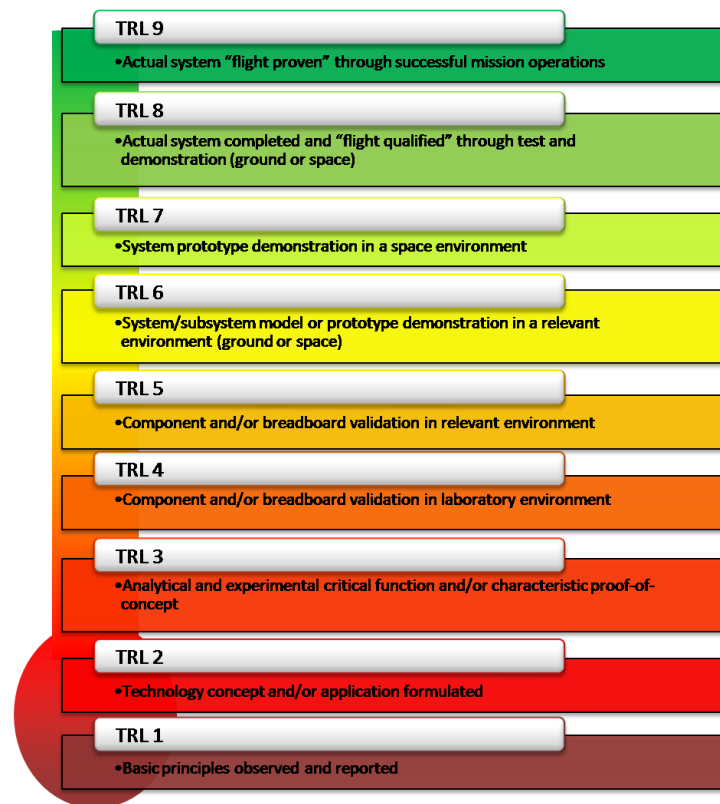


Fig.1: NASA Technology Readiness Level (TRL)

- **Social acceptance, especially related to acoustic impact and sustainability**

The U-space sandbox could play a crucial role in ensuring social acceptance of UAVs for various use cases in Estonia. A study on the societal acceptance of Urban Air Mobility (UAM) in Europe, conducted by EASA, proved that 83% of respondents felt very or rather positive about the introduction of UAM in Europe. Demonstrations have a significant role to play in the social acceptance of new technologies. Hosting a public open day and inviting the general public to the sandbox for demonstrations and interactions with the industry would greatly foster acceptance of the technology in Estonia.

- **Paving the way for commercial operations and network expansion in Estonia**

The sandbox is a test environment that would pave the way for commercial operations, both for UAV operators and USSPs. This would also support network expansion across Estonia and facilitate operations in different operational scenarios, such as offshore operations, cross-border operations, and operations

in areas with varying ground risk and air risk. The following image depicts some locations for future sandboxes.

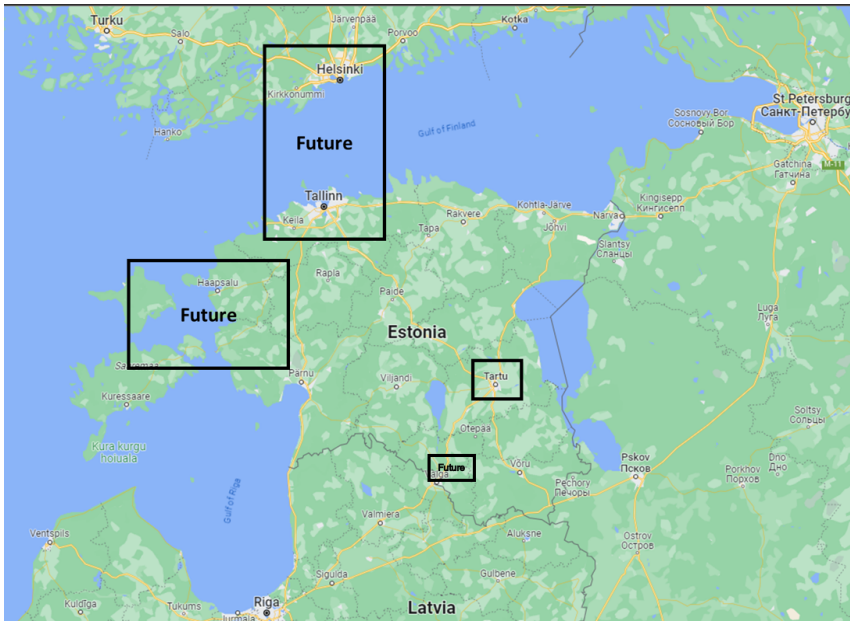


Fig.2: Future locations for expansion of the U-space sandbox

Based on a poll conducted by ANRA at the Stakeholder Workshop, it was found that stakeholders are most interested in the following use cases:

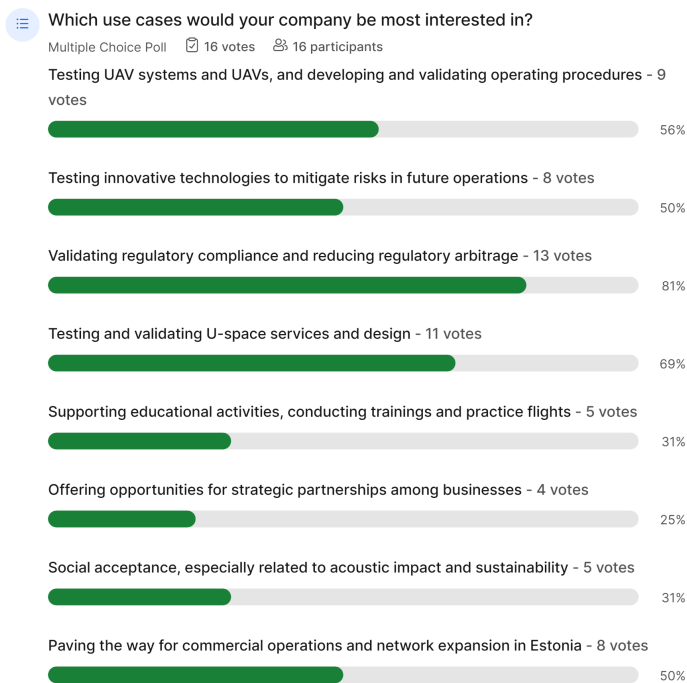


Fig.3: Poll on use cases conducted by ANRA Technologies at the CACTUS Stakeholder Workshop

4. Stakeholder Business Models

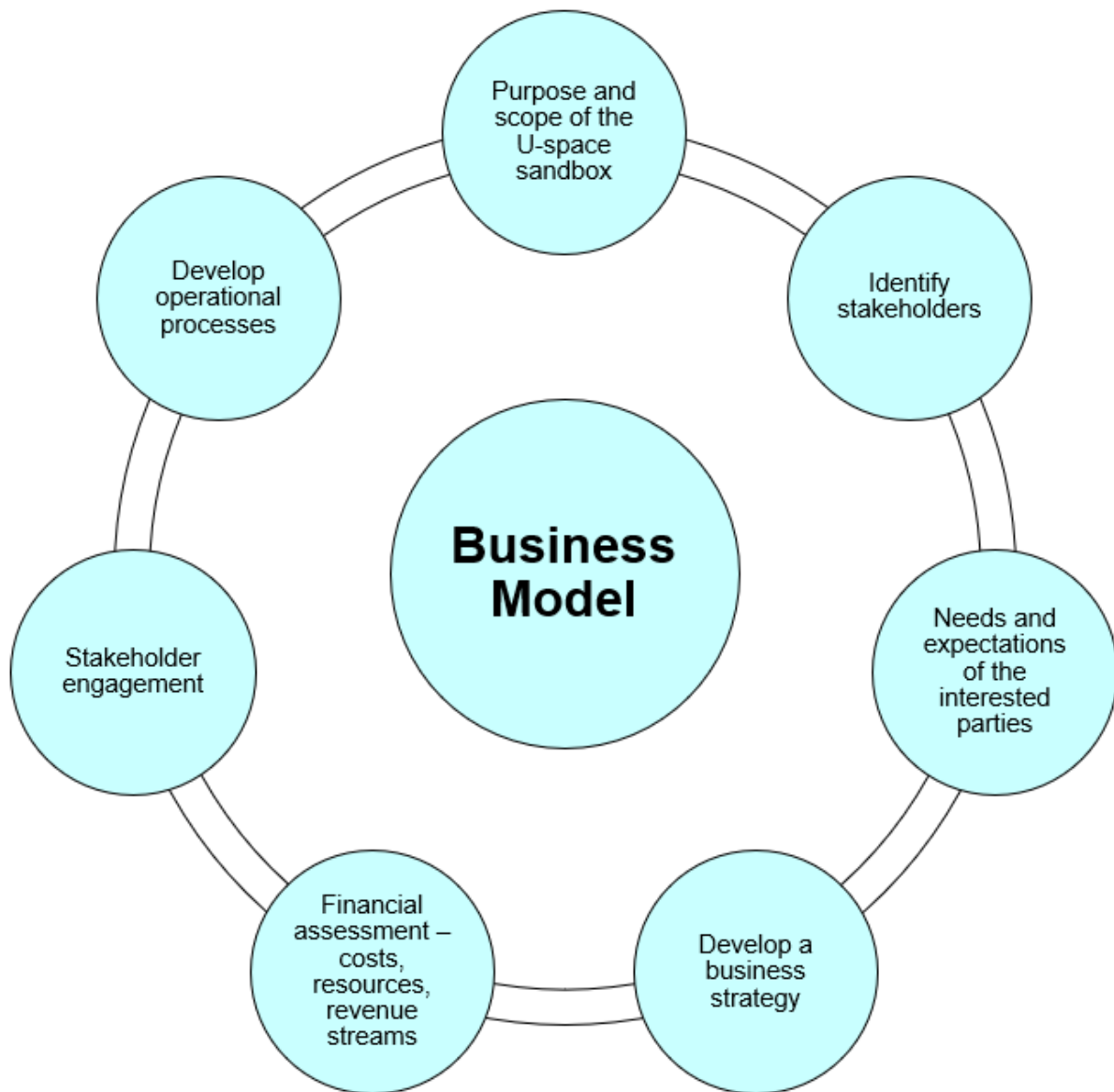


Fig.4: Aspects to consider when building a business model

The stakeholders for the U-space sandbox are national authorities, local authorities, regulatory agencies, USSPs, CISP, UAS operators, and educational institutions, among others. The sandbox aims to fulfil stakeholder needs at a competitive price and through sustainable costs. The U-space sandbox can be used to develop the U-space services, for testing and validation purposes, and to perform the preferred use cases in a controlled environment. In addition, when the U-space sandbox is marketed effectively, companies from other EU countries may be interested in developing and validating their services in the sandbox, which would attract more businesses to Estonia, and potentially ensure a harmonized approach to U-space in Europe.

The business model may need to be adjusted depending on the stakeholder category. UAS operators can validate their business case in the sandbox by ensuring that their technology is compatible with U-space services. USSPs can test their services to ensure compliance with regulatory requirements and to verify that performance requirements are met. In addition, the business plan can be validated to ensure financial sustainability.

The level of implementation in terms of requirements in the U-space sandbox can either be full scale such that every requirement in (EU) 2021/664 is adhered to, or limited to specific articles, depending on the use case. It is believed that all mandatory U-space services, namely network identification service, geo-awareness service, traffic information service, and UAS flight authorization service should be tested in the sandbox environment. If feasible for the USSP, optional services, namely weather information and conformance monitoring, could also be tested in the sandbox. The functionality of these services could be tested both as strategic and tactical measures at various stages of flight, including pre-flight, during flight, and post flight. In addition, it would be crucial to test the interfaces between the models to ensure that it operates as expected. The interfaces and integration between USSPs, CISP, and UAS operators can be tested in the sandbox. This ensures that the sandbox can act as a form of USSP onboarding before commercialization. In addition, CIS can be provided in the sandbox, either through s-CISP or decentralized CISP, and the benefits of each of these options can be assessed.

The application for testing in the U-space sandbox can either be in the form of application windows or always open models. An always open model would allow stakeholders to perform testing activities in the U-space sandbox throughout the year, while an application window would only permit testing during specific intervals. During certain application windows, a regulatory challenge geared towards the information required by the competent authority could be posed to applicants. Applicants could be screened to ensure that the nature of their business would provide the required inputs. In addition, when an application window is used, operational expenses associated with the U-space sandbox and the resources to operate it would be lower, when compared to an always open model. The application window also provides stakeholders with sufficient time to prepare for testing activities, and it ensures that there is adequate time to process the data that is obtained from each test. However, it is important to note that an always open model would provide more testing opportunities to stakeholders, thereby providing more inputs to competent authorities, which may advance the industry at a faster pace.

The eligibility criteria is an important aspect that must be considered when establishing the business model for the U-space sandbox. The eligibility criteria can be considered in terms of positive indicators and negative indicators. It must be identified if the testing activities proposed by the stakeholder are in scope and intended for the purpose specified, how innovative it is, if it offers a benefit to consumers such as higher quality, better price-value ratio, enables market entry and compliance with regulatory requirements for UAS operators, and if it has a medium to high TRL. The stakeholder should have assessed how their services would comply with regulatory requirements and any rules imposed by the sandbox operator. They should have a detailed testing plan with objectives and criteria identified, have adequate resources to carry out the tests, and a risk assessment should have been performed so that it can be mitigated in an appropriate manner.

In order to understand how the Estonia sandbox concept can be financially viable and attractive, financial feasibility aspects including how to approach a cost-benefit analysis are described in Section 5 in D2.1, which is a separate document titled 'U-space Sandbox Concept'.