Field Test Implementation Plan

Project title:

Hybrid UAV-UGV for Efficient Relocation of Vessels (HUUVER)

MODIFICATION RECORD

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1.2		30.11.2021	Final version. Updated version due to integration testing schedule changes.	Antero Kutvonen, Ilkka Donoghue, Kirsi Kokkonen, Aino-Maria Hakamäki (LUT), Jakub Węglarz (Dronehub), Florian Lipok, Dieter Meinhard (BRI), Gerhard Peller, Philipp Sterlich (BLDS), Boris Prochazka (GINA)

Executive summary

The purpose of this deliverable D5.2 is to describe in detail the functional test and technical validation of the HUUVER system. In the document, the detailed description of factory and field testing of HUUVER system is provided, and the interview procedure for collecting the qualitative input from end users is presented.

The core work of D5.2 is to provide an overview on how the objectives for HUUVER performance, functionality and mission accomplishment set in D5.1 (Evaluation and Validation plan) are validated by testing HUUVER with different pre-operational (factory) tests as well as with chosen field tests that will act as demonstrators to selected end users. The deliverable will specify the functional and technical tests, key performance indicators and metrics, validation environments and exercises.

The system integration testing is divided into the driving test cased, flight testcases in the cage, and free flight test cases. The field tests are planned to be done in location with end-user entities to demonstrate the ability of the HUUVER in Search and Rescue (SAR) and Patrol & Monitoring (P&M) use cases. Validation exercises will be accompanied by the collection of user feedback.

The conducted testing process has not been straightforward, as some challenges appeared during the system integration phase which required improvements to the different system elements. Moreover, the COVID-19 pandemic has caused problems with the availability of components, delays in the logistics, and restrictions in the movement of project personnel. Due to these challenges, the testing approach has been modified several times during the year 2021. This deliverable presents the ongoing testing process, with possible adaptations still to be considered.

Table of content

Executive summary 3

Table of content 4

1 Introduction 5

1.1 Project overview 5

1.2 Purpose and structure of the deliverable 5

1.3 Methodology and approach 6

1.4 Acronyms and abbreviations 9

2 Validation scenarios and exercises 10

2.1 Execution of pre-operational and field tests 10

2.1.1 Common attributes 11

2.1.2 Test schedule and test day agenda 11

2.2 Factory and field test scenarios 12

2.2.1 Pre-operational (“factory”) tests 12

2.2.2 Field test 1, Search & rescue: Finding a missing person in the East Moravia Beskydy Mountains, Czech Republic 16

2.2.3 Field test 2: Patrolling and monitoring in Nuclear Powerplant Dukovany 18

2.2.4 Field test 3, Search & rescue: Finding two missing persons in South Moravia region, Czech Republic 20

2.2.5 Field test 4, Patrolling and monitoring: Autonomous surveillance of large industrial sites – outside and inside 22

2.3 Customer interview guide 24

3 Discussion 27

1 Introduction

1.1 Project overview

The project HUUVER (Hybrid UAV-UGV for Efficient Relocation of Vessels) will result with a prototype UAV-UGV platform that combines two types of propulsion systems. This patented technical solution will activate flying and driving capabilities in one compact and highly integrated autonomous drone. The HUUVER drone will be the first fully integrated with the Galileo navigation system that provides the authentication service and precise navigation and will be fundamental in the navigation system, enabling high positioning accuracy, reliability and credibility. The HUUVER platform is designed to provide users the flexibility, reliability and extended range that they require. Completing for interfacing with an end-user, the HUUVER system will also include a core management system with features like mission planning navigation, guidance and control. A complementary part of the system will be an end-user mobile application enabling mission demand and launch control. The HUUVER platform is expected to be successful in professional missions for Search & Rescue (SAR), Patrolling & Monitoring (P&M) and industrial logistics (IL).

The solution will be tested with pre-operational (factory) tests and operational tests during the project realization. After factory testing, HUUVER will be deployed in ground and flight tests in cage tests as well as with different test scenarios. Depending on the prevailing situation, HUUVER will be tested on different pilot sites in Europe that directly address the main use scenarios and provide evidence to validate its performance.

1.2 Purpose and structure of the deliverable

This deliverable reflects the work performed in tasks 5.2 (Functional tests and technical validation), and relationship to 5.1 (Evaluation and validation plan) and 5.3 (Technical and organizational setup). The purpose of this deliverable is to describe in detail the functional test and technical validation of the HUUVER system. To this end, the deliverable will specify the functional and technical tests, key performance indicators and metrics, validation environments and exercises. This deliverable is the third step in reporting on the HUUVER project validation process that stats from collecting stakeholder requirements (as part of the earlier deliverable 2.2.) up to the reporting and analysis of validation results in D5.3 Evaluation report at the end of project lifetime. The document is intended to give a detailed description of the HUUVER functional and technical validation. In summary, this document will describe:

- Functional field test
- Technical tests

- Key performance indicators and metrics to be recorded
- Validation scenarios and exercises
- Detailed use case scheduling and constraints of the field tests
- User interview template

This deliverable builds on the work initially reported in D2.2 and D5.1. In D2.2, user requirements analysis and test case scenarios, where initial *validation requirements* and *Key Performance Indicators* have been derived from analysing the user needs and requirements. From this first understanding of the user expectations for the HUUVER system were defined in D51 to form more precise *functional, performance and mission requirements* which set validation targets. These *validation objectives* are substantiated by attached *Key Performance Indicators* and metrics that are applied in evaluating the solution across a set of specified *validation scenarios and exercises*. *D5.2 Field test implementation plan* is where specific factory and field test plans are summarized and the user interview guideline used in the tests is provided. Finally, this plan will be the basis for conducting the field tests and other evaluation actions within *task 5.4 Field tests* and for the reporting of those within *D5.3 Evaluation report*.

1.3 Methodology and approach

The validation process has been defined in document D2.2 and here the summary is presented as shown in Figure 1. Document D2.2 defined the validation requirements and KPI based on the user requirements for the selected operational scenarios and use cases. The purpose of Document D5.1 is to define the functional, performance and mission requirements to be used for validation. The Key Performance Indicators (KPI) and metrics shall be used to validate the systems compliance to the goals for the technical, performance and impact to Patrolling and monitoring (P&M) and Search and rescue (SAR) operations. The previous validation areas and the user experience and acceptance will form the overall user acceptance validation for the selected SAR and P&M scenarios. This document also describes the test case scenarios used for validation and the procedures to validate the set KPI and metrics. Document D5.2 will summarize the factory and field tests and detail the interview procedure for collecting the qualitative input from end users. In Document 5.3, the test results are collected and reported to form the basis of the validation and evaluation of this system ability to achieve the set performance and business goals. This document will as act a detailed description on the executed technical and field test to understand how well these complied with the objectives set in previous documents.

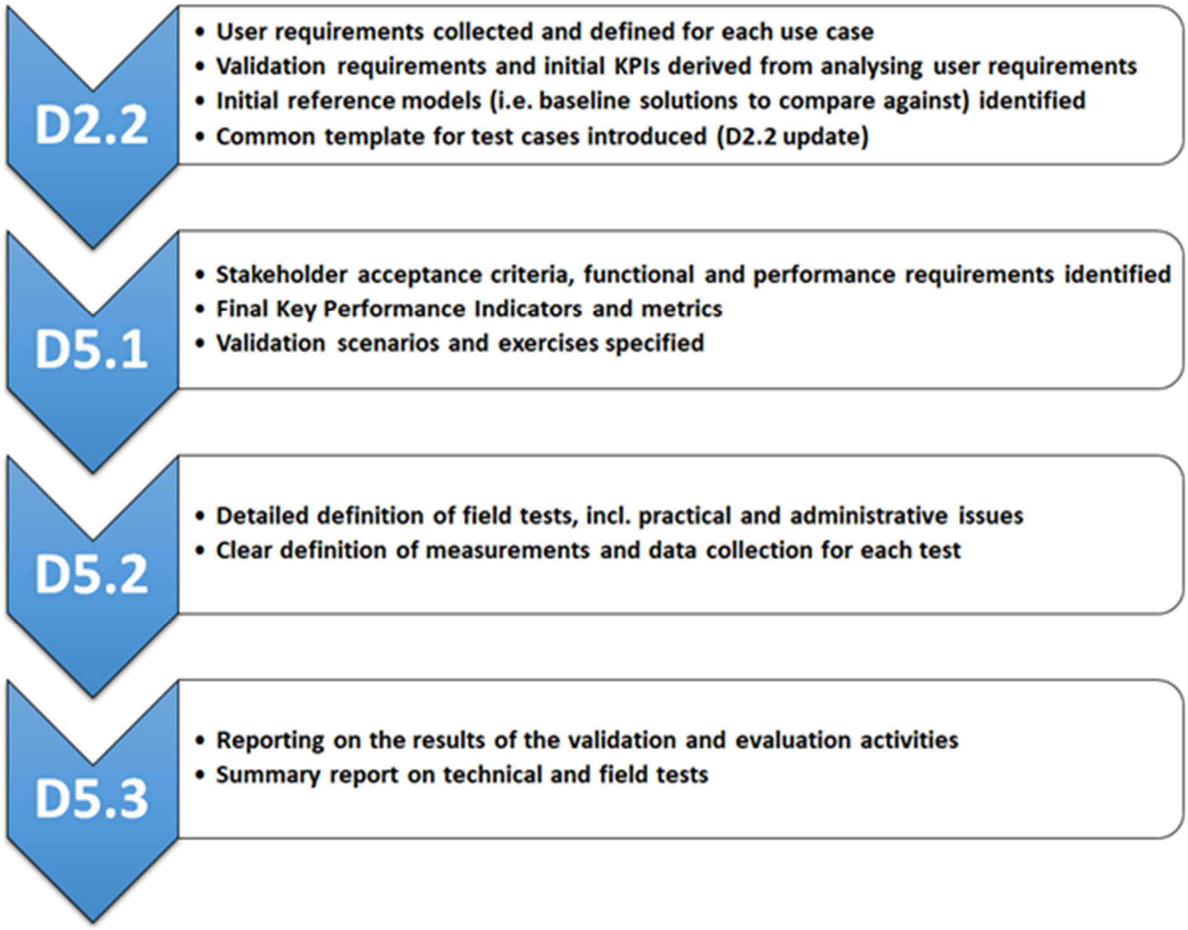


Figure 1: Summary of key validation steps by deliverable

The validation logic and objectives have been selected to simulate as closely as possible the real use cases that can occur for Patrolling & Monitoring (PM) and Search & Rescue (SAR) missions. The test cases selected represent the key missions and represent the areas where the system can have clear impact to traditional operations. The goal of the validation is to identify areas where the system improves existing ways of working or extends current activities. The validation scenarios have been selected to show that the system functions and performs technically as planned. In addition, the validation covers anticipated or designed behaviour to verify in abnormal conditions from both technical and functional aspect. The evaluation is primarily conducted based on designed exercises and qualitative user feedback. Each test cases have a set KPI or KPI combinations to validate the performance. The validation process and KPI also include some quantitative KPI to verify, for example the ease of flight stability and positional accuracy. In addition, test cases have been defined to validate areas where the system could extend current services in SAR and P&M today.

The qualitatively evaluation will be carried out over the following areas:

- Technical evaluation to verify that functional requirements are fulfilled and achieved.

- Performance evaluation to verify the performance requirements are fulfilled from the operational mission elements and complete mission.
- Impact evaluation will be used to validate the set impact objectives are fulfilled for the set SAR and P&M scenarios to understand efficiency improvements and extended mission capabilities.
- The goal of validation is to achieve level of user experience and satisfaction over the different scenarios and test cases.
- The User Acceptance will be verified for the SAR and P&M scenarios based on the overall validation criteria.

1.4 Acronyms and abbreviations

CCTV	Closed-Circuit TeleVision
CO2	Carbon dioxide
EASA	European Aviation Safety Agency
EGNSS	European Global Navigation Satellite System
ETAM	Extended Technology Acceptance Monitor
EU	European Union
EVLOS	Extended Visual Line Of Sight
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IL	IntraLogistics
ML	Machine Learning
MTOFM	Maximum Take-OFf Mass
NOX	Nitric OXide
PM, P&M	Patrolling and Monitoring
QR	Quick Response
RFID	Radio Frequency IDentification
SPIN	Situation-Problem-Implication-Need
SR, SAR	Search and Rescue
TPC	Technology-to-Performance Chain
TO	TakeOff
TTF	Time To Fix
UAS	Unmanned Aircraft Systems
UGV	Unmanned Ground Vehicle

2 Validation scenarios and exercises

2.1 Execution of pre-operational and field tests

The validation objectives are tested in the pre-operational (factory) tests as well as in chosen field tests that will act as demonstrators to selected end users. The factory and outdoor tests will be done in Poland testing driving and flight modes as part of the system integration testing. The system integration testing will be divided into the driving test cases, flight test cases in the cage, and free flight test cases. The field tests will be done in location with end-user entities to demonstrate the ability of the HUUVER system to fulfil the business and operational needs Search and Rescue (SAR) and Patrol & Monitoring (P&M).

The test cases aim to cover as many validation objectives as possible with different test types. The pre-operational tests (factory) and field tests (end-user demonstrations) will be performed using the HUUVER prototype. For risk mitigation, the drone will be tested by the representatives from HUUVER project consortium; from Cervi Robotics, Rectangle and Everis, and depending on the test scenario, from BLADESCAPE or GINA. Moreover, Brimatech takes part in the field tests to gather user feedback from the end users. The HUUVER platform will be mainly operated by a pilot from Cervi. Moreover, several observers will be needed to validate the HUUVER platform in operation in the test areas.

The demonstrations and factory tests are executed as Extended Visual Line of Sight (EVLOS), which means that HUUVER can be flown up to 2 kilometers, with observers on the path of UAV flight informing the pilot continuously on the status and position of the drone. As all the tests will be executed in areas with no people from outside, country-specific permissions will be determined field test location by location. Note that general EU regulation covers all of the test sites.

The field tests (end-user demonstrations) will be executed as a set of 4 consecutive, one day tests in various locations in Austria and Czech Republic. The test plan must take into consideration the packing and transporting the drone, the external peripherals and test personnel from one location to another, and the preparation of the drone and briefing of participants at site before the tests. The same test group which consists of representatives from Cervi, Rectangle, Everis, Brimatech and BLADESCAPE / GINA, execute all the test scenarios. In addition, depending on the test case, representatives of end users, such as fire brigades, rescue organizations and security personnel on the industrial sites will participate in the tests as supporters and observers. The group travels by car from one site to another. The field tests are planned once the factory test has been completed and the System Integration Test cases have been passed. The example plan with more detailed scheduling in Figure 2. The test dates will be fixed later between the different partners.

2.1.1 Common attributes

The general execution for all the field tests is the same; as the test group comes to the test area, at least half a day will be first reserved for HUUVER platform setup and user briefing. The test cases will need at least one day at each site. During and after the tests, user feedback from the participants is gathered (see the Interview guide in 2.3). In each field test, certain common actions are taken, and common features are observed that are described here for brevity. For each site, the test begins with unpacking, setting up and inspecting the HUUVER equipment by using a predefined checklist. The checks confirm that that the equipment is intact and operational mechanically and electrically. Both ground operation and flight are checked, and the communication and data logging verified before the actual test begins. The end user is briefed on the test plan for the day where a mutual understanding of the route, actions and objectives for that test is confirmed between the pilot, observers and the end user to facilitate sound evaluation and safety in operation.

- The assembly or the HUUVER system and system integration test to start field tests
- Pre-flight and ground test before the start of the field tests.
- Test script review with participants and test site personnel
- Interview of participants using provide interview template.

2.1.2 Test schedule and test day agenda

The high-level testing plan is shown in Figure 2. The plan is to run tests at four test sites where the tests cases will be performed. The factory test is planned to be completed before the field tests are started. If issues are identified during the factory tests, the testing team have time to correct identified issues before the start of the field tests. The duration of the field tests is 1 day, and the plan is to travel during the same test day evening to the next site. The field test week will be agreed separately.

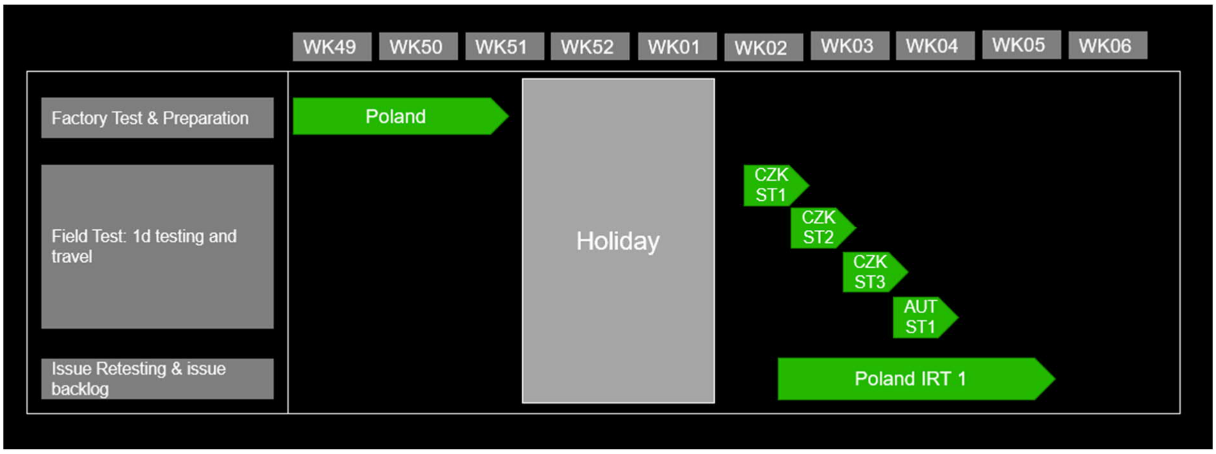


Figure 2 – Example Field Test Plan (dates to be agreed between partners)

The Test Day Agenda example is shown below in Table 1.

Table 1: Example of test day agenda

Time	Topic	Responsible
09:00 – 09:30	Kick-off meeting with site team & introduction to test day agenda	Project Manager
09:30 - 10:30	Test system setup and SIT	Project Team
10:30 – 11:00	Test Script & safety review with testing teams	Project Manager
11:00 - 11:30	Preflight test and test team preparation to run test scenarios	Project Team
11:30 - 13:30	Test use case execution 1	Test participants
13:30 – 15:30	Test use case execution 2	Test participants
15:30 – 16:30	Optional use case execution 1	Test participants
11:30 – 17:00	Interview session with test participants	Project Team
17:00 – 17:30	Test day debriefing and closing	Project Manager
17:00 – 18:00	Test setup dismantling and packing	Project Team

2.2 Factory and field test scenarios

2.2.1 Pre-operational ("factory") tests

The purpose of the pre-operational tests is to validate that the HUUVER drone fulfils its design specification and performance parameters. The Factory Tests also serves as the validation that the drone can start safe Field Tests in a controlled environment and concludes the integration process between developers.

The purpose of the factory tests is to review the interaction between the subsystems, users and HUUVER platform. The integration testing has been done according to WP 3.2 where the detail testing is done over the following key areas: (1) Driving, (2) Flying and (3) Optical System Integration and use. The project has documented, for internal use, the following areas for each module to be recorded:

- Performance metrics
- Technical metrics and acceptable thresholds

- Equipment to be used
- Methods to store and record data.

The development teams and LUT have defined the testing areas to be carried out that cover not only unit testing but the complete end-to-end System Integration Testing (SIT) scenarios. All of the integration testing shall be done as well as the end-to-end SIT.

The HUUVER platform is provided by three consortium members; Cervi Robotics is responsible for the drone platform itself, Rectangle provides navigation and control subsystems, and Everis provides optical subsystems. The pre-operational tests have been conducted in all the companies internally, and during the mechanical and electrical integrations of the systems from different parties. After finishing the integrations, the platform will be tested as an entity before lauching the field tests.

The validation objectives to be tested in the pre-operational tests are presented in Table 2.

Table 2: Validation objectives in pre-operational testing

Type of validation	Validation objective
Functional	Use GALILEO authentication service
Functional	Withstand typical amounts of rain, dust and snow (as specified by compliance to standard defined by national aviation authorities and EASA both in UGV and UAV operations.
Functional	Compliance to relevant European law and regulations
Functional	Vertical take-off and landing
Functional	Connectivity to a charging station
Functional	Capability extension through use of external peripherals: sensors, manipulators, etc. that use power
Performance	Flight envelope
Performance	Ground operations envelope
Performance	Transition between flight and ground operation
Performance	Payload
Mission	Safe autonomous operation in proximity to humans
Mission	Sufficient flight stability for visual sensors

Most of the validation objectives in the above summary list for factory tests are validated by a binary (yes/no) determination. However, for the flight and ground performance, an operational envelope and (maximum) payload, target values have been determined to satisfy the validation requirements.

The HUUVER performance parameters meet the criteria for unmanned system. The drone, according to aviation law, can weigh a maximum of 25kg, which is the Maximum Take-Off Mass (MTOFM). The mass of the HUUVER drone without batteries and an additional charge is 12kg. The mass of the drone with batteries allows for a flight duration of about 30 – 35min. The 3kg payload (total take-off mass 25kg) allows for 20 – 25min flight. The maximum driving time at a maximum speed of 10 km/h is 120min – 180min (the time depends largely on the terrain).

The estimated maximum speed of the forward flight of the platform is about 15 m/s, while driving due to the use of caterpillar tracks 10 km/h. NOTE that the design criteria are maneuverability and movement in difficult terrain (high torque and relatively low speed, which will allow steep climbs, moving on many surfaces).

The platform can operate in very demanding weather conditions, temperature from -5 to +45 degrees Celsius. HUUVER has high resistance to continuous wind and gusts due to its mass and compact size, aerodynamic construction of the fuselage in the front and side. In the basic version, the maximum range of radio control over the drone is 3000m.

The table 3 below shall be filled for each test case run at each test site.

Table 3: Test diary for performance parameters

Technical Performance	Design / Planned	Test Site:
Test Case:		
Weight of drone		
Weight of drone in basic configuration without battery:	12 kg	
Weight of drone with battery:	22 kg	
Maximum take-off mass:	25 kg	
Payload:	3 kg	
Endurance		
Flight time (maximum):	30 – 35min at MTOM	
Drive endurance:	120 – 180min at 10 km/h	
Airspeed (maximum):	15 m/s – 54 km/h	
Drive speed:	10 km/h	
Other		
Operating Range (Maximum)	3000m	
Operating Temperature	-5 to +45C	

The test cases for driving and flight modes will be recorded on video for validation purposes for all partners and end users to review as part of the field test analysis. Separate story boards for each video will be defined before testing.

Depending on the prevailing situation regarding COVID-19 pandemic, additional field tests will be executed in pilot sites in Europe during January 2022. The descriptions of possible field test sites, field test scenarios and executions are presented in the following sections 2.2.2.-2.2.5.

2.2.2 Field test 1, Search & rescue: Finding a missing person in the East Moravia Beskydy Mountains, Czech Republic

<table>
<tr><td colspan="2">FIELD TEST 1: Finding a missing person</td></tr>
<tr><td>
Place: East Moravia Beskydy Mountains, Czech Republic
Responsible organization: GINA with Mountain Rescue unit from Bílá Mountain
Mission: Finding a missing person in the mountain
Reference solution and expected improvement: SAR ground team operations with or without helicopter support. Faster reaction time to mission start and location of missing person. Reduction in operations cost.
</td><td>


</td></tr>
<tr><td colspan="2">Scenario description: In the scenario, the test area is in the forest in the mountains. The area and terrain will be quite hard for the drone to operate on the ground, so HUUVER is used in flight mode during the test. In the test, time spent searching with the drone and time spent with the group of people in the field are measured. HUUVER will be tested two times. In the first test, the drone will be in a supporting role for conventional solutions. In the second test, HUUVER is used as the main search solution.</td></tr>
<tr><td colspan="2">Test execution:

Test equipment and drone system setup, and preflight test to ensure functionality of drone system and data acquisition.
Test scenario review with HUUVER testing team and Site personnel.
Review with missing person script to follow in the test (injured vs. wondering).
Define the operational area (map) and the waypoints for the mission. Define the outer boundaries for safe operations.
Define the observation points for test team to be positioned to log test data (e.g. arrival time, manoeuvres).
Review the Drone SAR Team script & and SAR ground team.
Preflight test and missing person test script execution.
Observation team X move to position 1. etc.
Drone SAR tests script execution of HUUVER in (1) supporting and (2) main search roles.
First sighting and interaction with missing person.
Guide SAR team to missing person.
Rescue of missing person (guide to safety or direct SAR Team).
Interview of observers on the test scenarios.
Review of the test results and issues.
Dismantling of the test site and drone system for transportation.

</td></tr>
</table>

Example of documentation for travelled route on map for field test with documented actions:

- Procedures carried out by the pilot and requirements that are fulfilled / logged in normal operations (can drone complete these tasks).
- Waypoints and action done at each waypoint.
- Time estimate (x hours) to complete route and time to each waypoint.
- Observer positions to maintain EVLOS.
- Information that observer logs.

The test script must be detailed from the pilot and customer perspectives to complete the mission defined through each waypoint to complete route and actions needed on the route.

2.2.3 Field test 2: Patrolling and monitoring in Nuclear Powerplant Dukovany

<table>
<tr><td colspan="2">FIELD TEST 2: Patrolling and monitoring in a nuclear powerplant</td></tr>
<tr><td>Place: Nuclear Powerplant Dukovany

Responsible organization: GINA with the power company

Mission: Patrolling and monitoring in the area of the nuclear power plant

Reference solution and expected improvement: P&M use cases done with humans and CCTV. Increase QEHS aspect in P&M use cases. Reduce P&M blind spots and increase quality. Increase the number of P&M rounds done. Safe identification of abnormal events and evaluation of how human intervention can be done.</td><td>
</td></tr>
<tr><td colspan="2">Scenario description: In this scenario, HUUVER will patrol in a Nuclear powerplant to offer better security. HUUVER will be tested two times and used on the ground as well as in the air for monitoring the area. The drone will be used to simulate the existing patrolling use case and to observe/identify an out of the ordinary event (e.g. intruder & faulty equipment).</td></tr>
<tr><td colspan="2">Test execution:

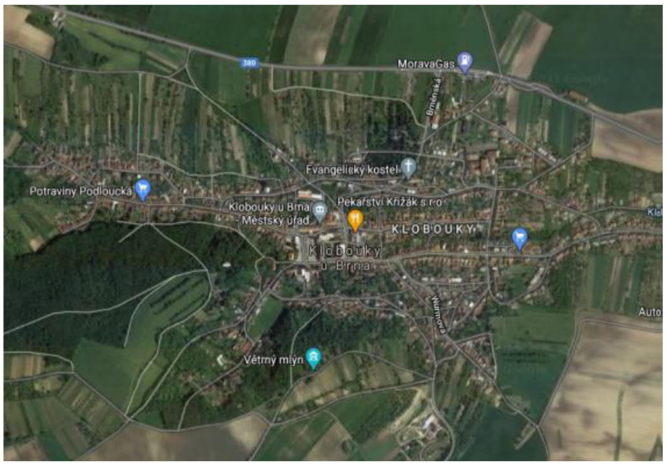
1. Test equipment and drone system setup, and preflight test to ensure functionality of drone system and data acquisition.
2. Test scenario review with HUUVER testing team and Site personnel.
3. Review the patrolling use case script and agree if the “out-of-the-ordinary” event script will be executed, and what this event will be.
4. Define the operational area (map) and the waypoints for the mission. Define the outer boundaries for safe operations.
5. Define the observation points for test team to be positioned to log test data (e.g. arrival time, manoeuvres).
6. Review the script with the P&M Drone Team & and P&M ground team.
7. Preflight test and start P&M test script execution.
8. Drone P&M test script execution of HUUVER in (1) supporting P&M ground team in P&M use case and (2) independent P&M with HUUVER drone without P&M ground team (PM ground team used to observe the test).
9. Execute P&M use case P&M checkpoints in advance of the P&M ground team.
10. Execute P&M use case where the Drone identifies the out-of-ordinary situation from air and approaches on ground to do final identification.
11. Interview of observers on the test scenarios.
12. Review of the test results and issues.
13. Dismantling of the test site and drone system for transportation.</td></tr>
</table>

Example of documentation for travelled route on map for field test with documented actions:

- Procedures carried out by the pilot and requirements that are fulfilled / logged in normal operations (can drone complete these tasks).
- Waypoints and action done at each waypoint.
- Time estimate (x hours) to complete route and time to each waypoint.
- Observer positions to maintain EVLOS.
- Information that observer logs.

The test script must be detailed from the pilot and customer perspectives to complete the mission defined through each waypoint to complete route and actions needed on the route.

2.2.4 Field test 3, Search & rescue: Finding two missing persons in South Moravia region, Czech Republic

FIELD TEST 3: Finding two missing persons	
Place: South Moravia Region, Czech **Responsible organization:** GINA with voluntary fire brigades from Klobouky and Brna **Mission:** Finding two missing persons from a forest **Reference solution and expected improvement:** SAR ground team operations with or without helicopter support. Faster reaction time to mission start and location of missing person. Reduction in operations costs.	
Scenario description: In the scenario, the test area is in the forest near the village. The area will be quite hard for the drone on the ground, so HUUVER is used in the flight mode during the test. In the test, spent time for searching with drone and time spent with the group of people in the field are measured. HUUVER will be tested two times. In the first test, drone will be in a supporting role for conventional solutions. In the second test, HUUVER is used as the main searching solution.	
Test execution: 1. Test equipment and drone system setup, and preflight test to ensure functionality of drone system and data acquisition. 2. Test scenario review with HUUVER testing team and Site personnel. 3. Review with missing person script to follow in the test (injured vs. wondering). 4. Define the operational area (map) and the waypoints for the mission. Define the outer boundaries for safe operations. 5. Define the observation points for test team to be positioned to log test data (e.g. arrival time, manoeuvres). 6. Review the Drone SAR Team script & and SAR ground team. 7. Preflight test and missing person test script execution. 8. Drone SAR tests script execution (in (1) supporting and (2) main searching roles). 9. First sighting and interaction with missing person. 10. Guide SAR team to missing person. 11. Recovery of missing person (guide to safety or direct SAR Team) 12. Interview of observer on the test scenarios 13. Review of the test results and issues. 14. Dismantling of the test site and drone system for transportation.	

Example of documentation for travelled route on map for field test with documented actions:

- Procedures carried out by the pilot and requirements that are fulfilled / logged in normal operations (can drone complete these tasks).
- Waypoints and action done at each waypoint.
- Time estimate (x hours) to complete route and time to each waypoint.
- Observer positions to maintain EVLOS.
- Information that observer logs.

The test script must be detailed from the pilot and customer perspectives to complete the mission defined through each waypoint to complete route and actions needed on the route.

2.2.5 Field test 4, Patrolling and monitoring: Autonomous surveillance of large industrial sites – outside and inside

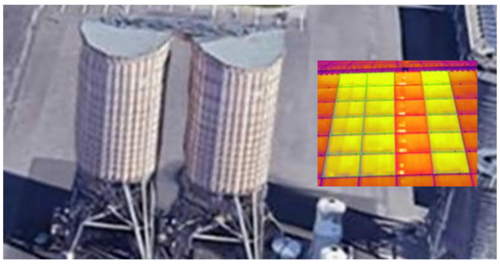
<table>
<tr><td colspan="2">FIELD TEST 4: Autonomous surveillance in a large industrial site</td></tr>
<tr><td>
Place: ASFINAG, Graz-Raaba, Austria

Responsible organization: BLADESCAPE with the industrial customer

Mission: Autonomous monitoring in air and on ground of a large industrial complex where the drone has access to internal facilities. Video live-streaming to operations center at site.

Reference solution and expected improvement:

Manned P&M use cases and CCTV. Improve surveillance quality and reduce risk to personnel. Increase surveillance uptime and decrease blind spots. Flexible increase and decrease of surveillance as incidents change dynamically. Reduce surveillance cost. Exact repeatability of route enables automatic deviation analysis.
</td><td>


</td></tr>
<tr><td colspan="2">Scenario description: The customer’s industrial site consists of several buildings, masts, dirt-track roads, and a salt silo system. In this scenario, HUUVER will patrol across the industrial site in flight-mode both inside and outside. It detects abnormal event or finding, subsequently, after having documented that, lands and switches to drive mode in order to gather further and more detailed information. In parallel it informs the operations centre or security staff in real-time. Demonstrating prohibitive measures for intruders (thieves) is part of the concept. HUUVER will be tested as to be in a supporting role for the conventional solutions, and also, as a supplementer for these solutions. The drone will be tested in fly + drive modes by two operators from BLADESCAPE or Cervi.</td></tr>
<tr><td colspan="2">Test execution:

Test equipment and drone system setup, and preflight test to ensure functionality of drone system and data acquisition.
Inform Tower prior to commencing flights
Test scenario review with HUUVER testing team and Site personnel.
Define surveillance script to be followed. Normal surveillance and abnormal event surveillance with dynamic situation analysis and action plan.
Define the operational area (map) and the waypoints for the mission. Define the outer boundaries for safe operations (demonstrate geofencing)
Define the observation points for test team to be positioned to log test data (e.g. arrival time, manoeuvres).
Review the surveillance scripts with Drone Team script & and ground team.
Preflight test for HUUVER system.
Drone surveillance use case tests script execution.
Interview of observer on the test scenarios.
Execute the abnormal event use case to identify events and define action plan to engage.
Execute interventions and support ground team is used to give updated situation information.

</td></tr>
</table>

13. Interview of observers on the test scenario.
14. Review of the test results and issues.
15. Dismantling of the test site and drone system for transportation.

Example of documentation for travelled route on map for field test with documented actions:

- Procedures carried out by the pilot and requirements that are fulfilled / logged in normal operations (can drone complete these tasks).
- Waypoints and action done at each waypoint.
- Time estimate (x hours) to complete route and time to each waypoint.
- Observer positions to maintain EVLOS.
- Information that observer logs.

The test script must be detailed from the pilot and customer perspectives to complete the mission defined through each waypoint to complete route and actions needed on the route.

2.3 Customer interview guide

All validation exercises will be accompanied by the collection of user feedback. User representatives will not actively control the HUUVER platform but will be present in the exercise to experience its operation and to provide related feedback for their potential usage contexts. This user feedback will be collected as well as analysed and serves as an essential input for further technical development and as the basis for successful exploitation.

Based on HUUVER demonstration video provided from the field testing in Poland, user feedback is collected by user interviews conducted by Brimatech. Additional interviews will be held, if HUUVER is tested on pilot sites.

The interview approach will be the following:

- Assessment of the validation exercise setup (story board for e.g. on-site demo/video demo)
  - What will be tested (which features, etc)?
  - In which environment?
  - Who will be piloting etc.?
  - What scenarios will be shown?
- Executing the user interviews according to the interview guide below where applicable.

Based on the above-mentioned concepts, the study team will conduct personal, problem-centred interviews with the user representatives participating in the exercise, including the following topics:

- Situation
  - What is your job/ your role in your organisation?
  - Is the given test scenario comparable to your normal working scenarios?

This question aims to trigger a transfer of the experiences made during the test trial to the real-world. Due to the fact, that is a very open, a lot of aspects following in the interview guide are likely to be handled in the course of this question. Issues not dealt with will be asked for explicitly afterwards.

  - What are the biggest differences between the test scenario and normal working scenarios?
  - What UAVs/systems do you normally use in the given scenario?
    Aim of this question is to collect and analyse the degree of satisfaction with the current operational situation, supporting systems used, partnerships necessary, etc.
  - Are you fully satisfied with these systems? Why / why not? Advantages /

    - Disadvantages?
    - For which operations do you use these systems?
    - Which other systems do you know?
    - Do you have experiences with some of the mentioned tools? If yes, which ones?
    - From our experience, each system has its strengths and weaknesses. Do you know some of them for the offerings mentioned?
    - If you require information on such offerings / technologies – where do you get them from (e.g., conferences, journals, magazines, colleagues, etc.)?
- Problem
    - Which problems do you face using your equipment?
- Implication
    - What are the consequences of the challenges faced?
    - Is it possible to quantify them?
- Need
    - What do you miss using your present solution?
    - What are your primarily requirements regarding a “perfect solution”?
- Critical Incidence
    - Which experiences made during the test scenarios did surprise you most (positive / negative)?
    - What happened exactly? In which situation?
- Perceived Usefulness
    - How does the HUUVER prototype fit into your working operations?
    - Does the HUUVER prototype provide advantage over your present solution?
    - What is the primary benefit the solution is likely to generate?
    - Using the product/service(s) tested, my work becomes more ... (please complete this sentence). If necessary, the interview will introduce categories: easier, more cost/time-efficient, safer, etc.
    - Is it possible to give a rough quantitative indicator for benefits likely to be generated?
    - Who else would benefit from the usage of this system?
- Ease of Use
    - How easy to use seems the new solution?
    - Do you think the HUUVER platform could be integrated in your current work processes efficiently?
    - What should be improved?
- Attitude towards Using
    - Do you think the HUUVER prototype is near to be usable?

    - What is missing?
- Behavioural Intention to Use
    - Would you use the HUUVER solution in your operations?
    - What should be improved?
    - Are there any barriers concerning the adoption / usage of the equipment demonstrated you would face within your organisation?
    - In which situation(s) would you never use the HUUVER prototype?
    - Do you see any regulatory concerns regarding the usage of the system?
- Use (Quality and Quantity of Use)
    - How often would you use the HUUVER solution?
    - What are the preconditions for your use?
- Benefits
    - What are the main advantages of the HUUVER prototype compared to existing / other solutions?
- Business Model
    - Where in the supply chain are you situated? Are you the end user / are you a service provider / etc.?
    - Which products / services do you usually buy?
    - How is the purchase procedure usually organised in your organisation?
    - In which business models are these products usually wrapped into, e.g. yearly/monthly/demand-triggered approaches?
- Pricing
    - How much do you pay in your present operations?
    - What selling price would you estimate for the HUUVER drone?
    - What could be HUUVER-based service offerings and a related pricing?
    - What additional costs do you expect for adapting / implementing a HUUVER solution to your context (e.g. customisation, workflow adaptions, training, etc.)?[1]
    - From your point of view, is the purchase of such equipment likely in the next 24 months? If no, why?
- Network effect
    - Does the fact of a larger group of people using the same type of solution have any positive / negative impacts on you or your business?

[1] In review of Thamhain's work, MacElroy found that in general, industry tends to be most constrained by cost considerations and organisational barriers to adopting new technologies and services. For those organisations worrying about cost implications, the majority of the costs associated with technology are "after installation" costs, particularly due to training and implementation time. The barriers related to organisational constraints tend to form around resistance to anything that might change "the way things are currently done".

3 Discussion

This deliverable describes the plan for the functional test and technical validation of the HUUVER system. In the document, the detailed description of factory and field testing of HUUVER system is provided, and the interview procedure for collecting the qualitative input from end users is presented. What has to be mentioned is the issue, that some field tests were conducted during the phase of integration (August-September 21). Because of that, this part of report will consider conducted activities as well as plans for fully operational tests and demos.

The factory tests were divided into 2 parts: the integration phase and testing the drone in factory conditions. During these tests, some challenges appeared, and solving these issues caused some changes to the testing process, as well time of project works. Thanks to joint cooperation of project partners, issues were solved efficiently, and project could be conducted farther. Driving tests have been executed successfully. Specific carefulness has been followed with the flight tests, at the phase of integration, as the tests have been conducted with one prototype only. The risk level and assessment have thus been relatively high. Because of these issues, as well safety – tests were conducted in cage, and steering commanders were set on 37% of engines power range. Such attitude was held in order to mitigate risk of damaging or destructing the prototype.

The prevailing COVID-19 pandemic has set several challenges such as changes in the availability of components (supply chains enhanced up to 8 weeks and longer), delays in the logistics, and restrictions in the movement of project personnel. The pandemic has thus by its part delayed the integration phase of HUUVER system development, especially in matter of integrating platform with sensors. These issues were able to go through in October.

Due to delays in the integration phase, the scheduling for main tests and demos in factory and field has been modified several times during the project. Also, the weight of pre-operational testing has been added to the initial testing plans. In the time of writing this deliverable, the driving tests have been conducted successfully (like mentioned before), and the flight final testing is under way (some tests were conducted in order to check operational capabilities). Because of unsure situation with COVID-19 pandemic, two alternative approaches for field testing have been planned; one with testing different scenarios in Poland, and second with additional field tests on pilot sites. In both cases, the objectives set for HUUVER functionality, performance and mission accomplishment can be plausibly validated. There was also decision made to prepare video from pre-tests, connected with end-integration phase and proper test – especially if they won’t be conducted as were planned in the beginning.

In planning and implementing such an adaptive testing approach, the consortium members have learned that regular meetings with developers and test case providers are key to maintaining alignment between validation actions and the development process. The gathered knowledge from the testing process is experienced to be useful for experimenting also in other Horizon Europe projects around highly innovative prototypes, especially in the case of autonomous and remote-controlled solutions.