Interreg Baltic Sea Region
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SMART GREEN MOBILITY CITYAM

Deliverable 2.2: UAM Use Cases & Landing Site Infrastructure

Lessons Learned from the CITYAM Lead Cities

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1. Introduction

This deliverable documents the project's key learning experiences, lessons, and recommendations by summarizing the use cases and landing sites that the lead cities of Hamburg, Stockholm and Helsinki piloted in the second and third year of the CITYAM project. Each of the lead cities developed two use cases that are non-commercial flights, aimed to support the city itself, city-owned medical sector, or other city-owned entities.

The infrastructure elements that we examined over the course of this project included a fixed site (Hamburg), landing stations for smaller drones such as drone-in-a-box solutions (Stockholm) and designated temporary landing areas located either on rooftops or at street level (Helsinki). Together, these use case demonstration flights and various types of take off and landing sites seek to offer helpful guidance to other cities who are looking to implement and scale urban air mobility operations.

2. Hamburg

2.1 Description of Use Cases

In the summer of 2024, Hamburg conducted pilot flights in the port area for the two use cases of the CITYAM project. The Hamburg Port Authority (HPA) was the technical partner in the Hamburg team and is both the owner and operator of several drones. Initially, five new drone pilots were trained in accordance with the HPA's own aviation regulations, which require four employees per mission: one operator in the command centre, one at the take-off and landing site, one safety pilot to provide visual surveillance, and one supervisor. The long-term goal of enabling a single operator to control up to five drones required extensive data collection and refinement of procedures. As the HPA used different drones for the project, extensive training on new drone models and the 'drone-in-a-box' system is necessary. With new software, two other European companies, FlyNex and Drone Harmony, were involved in the commissioning and series production of software for mission planning, crew management and photogrammetry to ensure compatibility with DJI systems and meet the safety requirements for critical infrastructure.

From mid-June to mid-September of 2024, the main phase of our application flights took place, with a total of around 150 flights and several major public demonstration events at DronePort. These operations focused on validating the documentation of the operational concept, improving flight procedures and collecting performance and safety data.

The ground infrastructure at DronePort was also further developed during this period, with the insights gained during the demonstration flights being continuously incorporated. This included the installation of cameras for the site and the landing platform, landing lights and markings for the safety area. Both the fixed landing platform and a mobile station were successfully tested and operated. Although some minor technical issues arose, such as occasional images without georeferencing or missing photos, these issues were identified and actively resolved.

The polder inspection use case progressed from the initial testing phase to more routine flights, and the initial results of the "drone-in -a-Box" solution used during this use case demonstration were positive, with flights able to reach up to 8 km via 4G connectivity but always remaining within the line of sight of the safety pilot due to the legal situation in the Hamburg port area. The HPA noted that an upgrade to 5G would significantly increase the usable range throughout the port. Police and other public safety authorities participated in the demonstrations, reinforcing the goal of integrating drone operations into emergency workflows. Additional flights and scenarios were successfully conducted with other Hamburg units, and flights continued into the autumn to gather further data for this use case.

During the summer months of 2024, use cases in infrastructure management and traffic were also advanced. Inspection tests of bridges in the port confirmed the performance of the communication links, and preparations began for traffic counts, which would also provide helpful data for the infrastructure management use case. The Hamburg Transport

Department requested drone footage of traffic jams to analyse congestion patterns – a process made possible by hovering during flight, but complicated by high data volumes and bandwidth limitations. As an interim solution, crews exchanged SD cards throughout the operation to back up the recorded footage.

2.1.1 Use Case 1: Polder Control

Hamburg is an inland port city connected to the North Sea via the Elbe River. The North Sea, and therefore also the Elbe, are subject to the tides. This means that the current and water level change several times a day. A normal tide has a difference in water level of approx. 3 meters, but in the event of a storm surge, this can reach 5-6 meters. These storm surges are rare, but do occur several times a year. Due to climate change, the melting of the poles, and the steadily rising sea level, it can be assumed that these events will increase in the future.

For this reason, the Port of Hamburg has been divided into 39 polders. These are areas enclosed by sheet piling and dikes that can be “sealed” via flood gates in the event of a storm surge. When the flood gates are closed, people, buildings, and other infrastructure are protected up to a height of at least 5.5 meters. In total, the Port of Hamburg has over 70 kilometers of such protective structures, which must be checked regularly.

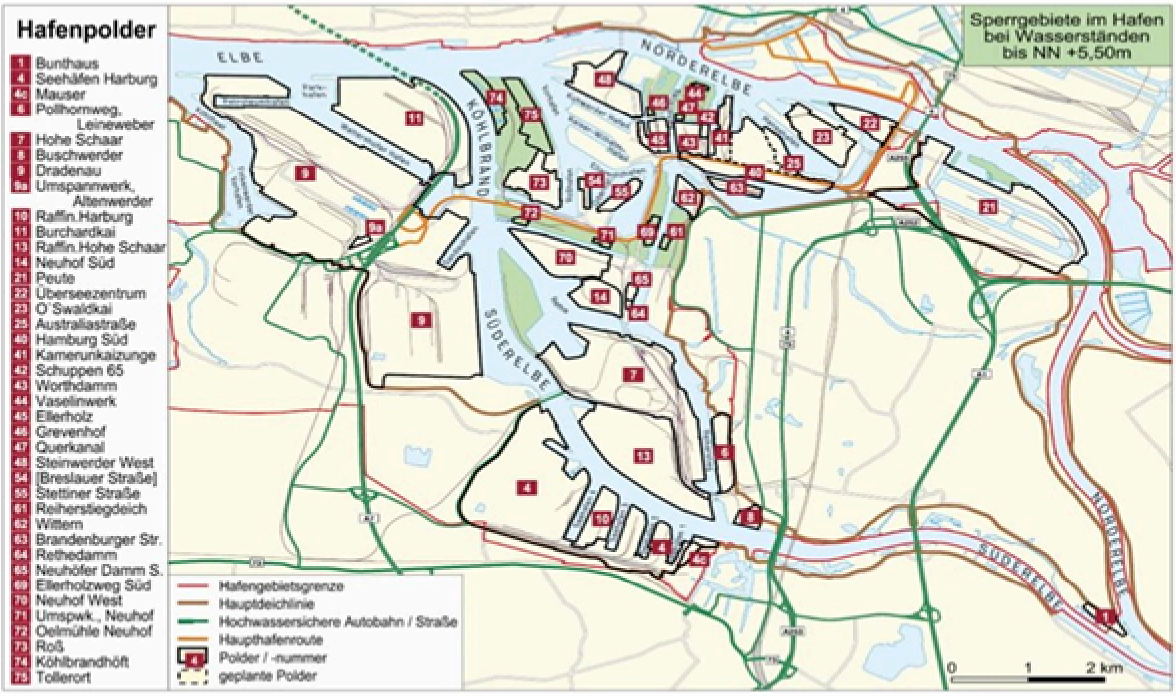


Image 1: Hafenpolder Freie & Hansestadt Hamburg

This use case involves using drones to check the existing protective structures made of sheet piling and flood gates and, in the event of damage, dispatching a repair team. A benefit that can save lives, protect goods, and preserve property.

In 39 flights with different drones, various sensor units, and under different weather conditions, a suitable procedure was developed in a total flight time of over 27 hours.

Tested flight systems:

- DJI Matrice 300
- DJI M30T Dock 1

- DJI M3E
- HHLASky V25
- DJI Dock2

Tested sensor technology:

- NextVision
- DJI P1
- DJI L1

No.	Date	System	Area	Remark	Airtime/min
1	12.04.2024	M300	Reiherstieg	Photo documentation of the bank and sheet pile walls	28
2	16.04.2024	V25	dronePORT	Camera Test NextVision	48
3	16.04.2024	V25	dronePORT	Camera Test NextVision	25
4	16.04.2024	V25	dronePORT	Camera Test NextVision	22
5	08.05.2024	DJI Dock 1	Brandenburger Str.	First flight to check the floodgates	40
6	08.05.2024	DJI Dock 1	Brandenburger Str.	Check the floodgates	41
7	17.05.2024	DJI M3E	Peute	Photographic record of the shoreline area	22
8	17.05.2024	DJI M3E	Peute	Photographic record of the shoreline area	21
9	03.06.2024	V25	dronePORT	Test Second Screen solution Spreehafen	35
10	03.06.2024	V25	dronePORT	Test Second Screen solution Spreehafen	38
11	03.06.2024	V25	dronePORT	Test Second Screen solution Spreehafen	33
12	03.06.2024	V25	dronePORT	Test Second Screen solution Spreehafen	50
13	13.06.2024	V25	dronePORT	Testflight Spreehafen control for opening	48

14	13.06.2024	V25	dronePORT	Testflight Spreehafen control for opening	41
15	13.06.2024	V25	dronePORT	Testflight Spreehafen control for opening	22
16	14.06.2024	V25	dronePORT	Demoflight Opening dronePORT	44
17	14.06.2024	V25	dronePORT	Demoflight Opening dronePORT	47
18	14.09.2024	DJI Dock2	Spreehafen	People search in Polder 63	40
19	14.09.2024	DJI Dock2	Spreehafen	sheet pile wall control	42
20	14.09.2024	DJI Dock2	Spreehafen	sheet pile wall control	38
21	16.10.2024	DJI Dock 1	dronePORT	Demo Flight for Port of Riga	7
22	12.02.2025	DJI M3E	Polder 63	Photo control sheet pile walls inside and waterside	30
23	12.02.2025	DJI M3E	Polder 63	Photo control sheet pile walls inside and waterside	32
24	12.02.2025	DJI M3E	Polder 63	Photo control sheet pile walls inside and waterside	27
25	12.02.2025	DJI M3E	Polder 63	Photo control sheet pile walls inside and waterside	35
26	18.02.2025	DJI M3E	Altenwerder	Photo Dyke and drainage ditch control	20
27	18.02.2025	DJI M3E	Altenwerder	Photo Dyke and drainage ditch control	35
28	18.02.2025	DJI M3E	Altenwerder	Photo Dyke and drainage ditch control	18
29	18.02.2025	DJI M3E	Altenwerder	Photo Dyke and drainage ditch control	33
30	18.02.2025	DJI M3E	Altenwerder	Photo Dyke and drainage ditch control	40
31	18.02.2025	DJI M3E	Altenwerder	Photo Dyke and drainage ditch control	36
32	06.03.2025	DJI M3E	Polder 63	Video from sheet pile walls	122

33	18.03.2025	DJI Dock 1	dronePORT	Testflight Thermal	86
34	20.03.2025	DJI M3E	dronePORT	Testflight Video	25
35	20.03.2025	DJI M300 RTK	dronePORT	Testflight Stitching	28
36	20.03.2025	DJI Dock 1	dronePORT	Long Distance Test Cases	210
37	20.03.2025	DJI M300 RTK	dronePORT	Testflight P1	30
38	20.03.2025	DJI M300 RTK	dronePORT	Testflight L1	30
39	28.03.2025	DJI M300 RTK	dronePORT	Photogrammetrie P1	60
				Total in minutes	**1629**
				Total in hours	**27,15**

The planned task of inspecting the flood gates and sheet pile walls proved to be much more complex than expected right from the start. During the first flight tests to select the technology, we found that the drone in automatic flight mode quickly lost focus on the area to be photographed, and the photos often showed only parts of the desired image or did not achieve the necessary overlap of images.

In our search for a solution, data privacy uninvolved persons also became an issue. Time and again, photos revealed said persons,, which either subsequently rendered them unusable for reporting purposes or, which had to be laboriously pixelated by hand. Other personal data, such as vehicle license plates, also presented us with this problem.

After some time researching, we found the solution by using software from FlyNex and Droneharmony. This software completely changed our planned process, which was subsequently transformed into a two-stage flight procedure:

1. In the first flight, the entire site, including the sheet pile wall and flood gates, is flown in a checkerboard flight pattern with a camera angle of 70°. The software uses the images to create a 3D model of the site. This so-called point cloud contains all buildings, obstacles, and other objects in the area and, above all, knows the exact heights of the objects.

This digital 3D terrain can be used repeatedly and does not have to be flown in again each time. A new flight is only necessary if an area has changed significantly due to construction measures.

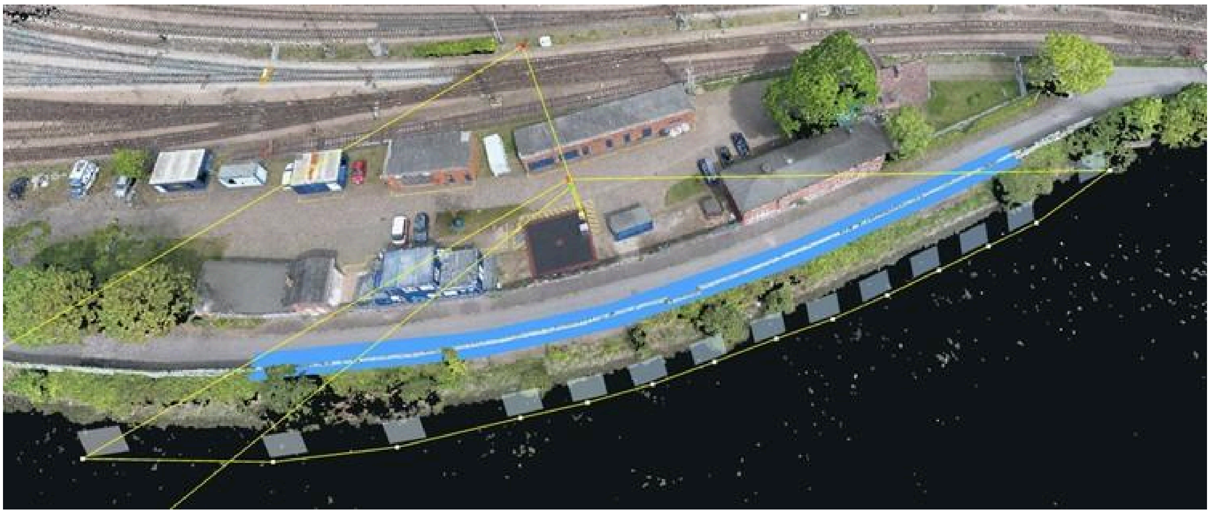


Image 2: Drone footage (Terrain)

2. A second flight thereafter was planned based on this point cloud. The drone flew precisely at a constant distance and with clear overlap over the infrastructure to be inspected. The slope of the edge or a change in the height of the structure is irrelevant. The drone adapts its flight to these conditions. In addition, immediately after landing, all personal information is automatically pixelated and made unrecognizable for any further use. A more advanced automated reporting process shows the damage in detail with images and can be easily and quickly shared in PDF format.

The next step is to integrate image AI that independently detects and evaluates problems on the sheet pile wall and includes them in the report. We assume that the AI will need to learn from approximately 10,000 images in order to be able to classify damage independently with a confidence level of over 80%.

2.1.2 Use Case 2: Infrastructure Management

The Port of Hamburg was founded over 800 years ago and is the third largest seaport in Europe. When the Port Authority (HPA) was established 20 years ago, it was given responsibility for hundreds of kilometres of roads and paths in the port area, as well as structures such as tunnels and bridges.

To this day, these structures not only have to be maintained, but also inspected regularly. However, sudden events, such as a ship collision with a bridge and the resulting inspection of the structure, are also part of the HPA's remit.

Our specific use case focused on flying drones over the HPA's hundreds of kilometres of paths and inspecting them, instead of sending people with vehicles out every few weeks to carry out on-site inspections. In order to actually save time, the live image from the drone must be evaluated directly during flight.

Various solutions were tested in 32 hours of flight time using different systems and sensors.

Tested flight systems:

- HHLA Sky X11
- DJI Matrice 300
- DJI M30T Dock 1
- DJI M3E

Tested sensor technology:

- Sony Alpha
- Gremsi Zio
- DJI P1
- DJI L1

Flight documentation:

No.	Date	System	Aerea	Remark	Airtime / min
1	16.04.2024	X11	dronePORT	Camera Test Sony alpha	11
2	16.04.2024	X11	dronePORT	Camera Test Sony alpha	15
3	16.04.2024	X11	dronePORT	Camera Test Sony alpha	9
4	08.05.2024	DJI Dock 1	dronePORT	Test Bridge Control	15
5	08.05.2024	DJI Dock 1	dronePORT	Test Bridge Control	18
6	23.05.2024	X11	dronePORT	Camera Test Grempsy Zio	8
7	23.05.2024	X11	dronePORT	Camera Test Grempsy Zio	11
8	23.05.2024	X11	dronePORT	Camera Test Grempsy Zio	12
9	23.05.2024	X11	dronePORT	Camera Test Grempsy Zio	15
10	03.06.2024	X11	dronePORT	Streetcontrol Test with Grempsy Zio	18
11	03.06.2024	X11	dronePORT	Streetcontrol Test with Grempsy Zio	15
12	03.06.2024	X11	dronePORT	Streetcontrol Test with Grempsy Zio	11
13	03.06.2024	X11	dronePORT	Streetcontrol Test with Grempsy Zio	10
14	03.06.2024	X11	dronePORT	Bridgecontrol Test with Grempsy Zio	12
15	03.06.2024	X11	dronePORT	Bridgecontrol Test with Grempsy Zio	12

16	03.06.2024	X11	dronePORT	Bridgecontrol Test with Grempsy Zio	15
17	13.06.2024	X11	dronePORT	Streetcontrol Testflight for opening	7
18	13.06.2024	X11	dronePORT	Streetcontrol Testflight for opening	8
19	13.06.2024	X11	dronePORT	Streetcontrol Testflight for opening	7
20	13.06.2024	X11	dronePORT	Streetcontrol Testflight for opening	7
21	14.06.2024	X11	dronePORT	Streetcontrol Opening dronePORT	7
22	14.06.2024	X11	dronePORT	Streetcontrol Opening dronePORT	7
23	14.06.2024	X11	dronePORT	Streetcontrol Opening dronePORT	7
24	14.06.2024	X11	dronePORT	Streetcontrol Opening dronePORT	7
25	02.07.2024	DJI M300	dronePORT	Mission based testflight	12
26	02.07.2024	DJI M300	dronePORT	Mission based testflight	10
27	02.07.2024	DJI M300	dronePORT	Mission based testflight	10
28	10.07.2024	DJI Dock 1	dronePORT	Testflight with flynext Software	15
29	10.07.2024	DJI Dock 1	dronePORT	Testflight with flynext Software	22
30	10.07.2024	DJI Dock 1	dronePORT	Testflight with flynext Software	21
31	10.07.2024	DJI Dock 1	dronePORT	Testflight with flynext Software	18
32	10.07.2024	DJI M3E	dronePORT	Testflight with flynext Software	19
33	10.07.2024	DJI M3E	dronePORT	Testflight with flynext Software	12
34	08.08.2024	DJI Dock 1	dronePORT	Demo Flight Open Day for CITYAM	6
35	08.08.2024	DJI M300	dronePORT	Demo Flight Open Day for CITYAM	6
36	08.08.2024	DJI Dock 1	dronePORT	Demo Flight Open Day for CITYAM	6
37	08.08.2024	DJI M300	dronePORT	Demo Flight Open Day for CITYAM	6

38	06.09.2024	DJI Dock 1	dronePORT	Demo Flight Open Day 2 for CITYAM	6
39	08.08.2024	DJI M300	dronePORT	Demo Flight Open Day 2 for CITYAM	6
40	06.09.2024	DJI Dock 1	dronePORT	Demo Flight Open Day 2 for CITYAM	6
41	08.08.2024	DJI M300	dronePORT	Demo Flight Open Day 2 for CITYAM	6
42	06.09.2024	DJI Dock 1	dronePORT	Demo Flight Open Day 2 for CITYAM	6
43	08.08.2024	DJI M300	dronePORT	Demo Flight Open Day 2 for CITYAM	6
44	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	33
45	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	33
46	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	32
47	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	33
48	12.09.2024	Mavic 3E	B75	Traffic monitoring dangerous situation at turn right for bicycles	42
49	12.09.2024	Mavic 3E	B75	Traffic monitoring dangerous situation at turn right for bicycles	42
50	12.09.2024	Mavic 3E	B75	Traffic monitoring dangerous situation at turn right for bicycles	43
51	12.09.2024	Mavic 3E	B75	Traffic monitoring dangerous situation at turn right for bicycles	42
52	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	31
53	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	33
54	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	33
55	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	35
56	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	32
57	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	35
58	12.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	31
59	12.09.2024	Mavic 3E	Rampenstraße	Traffic monitoring locking for the reason of traffic jam	41

60	12.09.2024	Mavic 3E	Rampenstraße	Traffic monitoring locking for the reason of traffic jam	39
61	12.09.2024	Mavic 3E	Rampenstraße	Traffic monitoring locking for the reason of traffic jam	40
62	12.09.2024	Mavic 3E	Rampenstraße	Traffic monitoring locking for the reason of traffic jam	38
63	19.09.2024	Mavic 3E	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	40
64	19.09.2024	Mavic 3E	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	41
65	19.09.2024	Mavic 3E	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	39
66	19.09.2024	Mavic 3E	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	43
67	19.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	30
68	19.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	32
69	19.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	31
70	19.09.2024	Matrice 300	Veddeler Marktplatz	Traffic monitoring locking for the reason of traffic jam	25
71	27.09.2024	Dock1	dronePORT	Mission Training with Livestream	42
72	27.09.2024	Dock1	dronePORT	Mission Training with Livestream	44
73	28.09.2024	Dock1	dronePORT	Mission Training with Livestream	43
74	28.09.2024	Dock2	dronePORT	Mission Training with Livestream in 4G Network	44
				Total in minutes	1605
				Total in hours	26,75

The aim was to detect potholes, subsidence and cracks in the road surface. Particular attention was paid to the various manhole covers, which always represent a gap in the asphalt and can often be the cause of damage at the edges due to water ingress and frost. The following challenges were experienced during flight times:

1. One difficulty, for example, was flying accurately to manhole covers using existing maps and satellite data and taking a picture of the object.
2. It quickly became apparent that the quality of the live data transmission was insufficient to make a qualified statement about a crack or break due to data limits in the LTE range. The remedy was to fly closer to the object or to work with an optical zoom. The image quality stored in up to 4K on the memory cards of the various drones was sufficient, but only available after the drone had landed. The time saved

by flying a drone was however lost as an employee had to view and evaluate the collected image material after the flight. On the contrary, the evaluation also adds to the flight time of the drone.

Image 3: Testflight X11 with Gremsi Zio

3. Another problem arose when trees or buildings obscured the area to be inspected. Either this area could not be captured at all, or it could only be captured with significantly poorer quality from another position using high zoom factors and other perspectives. Both results are perceived as a significant disadvantage by the route inspection colleagues and often require a follow-up inspection on site due to poor data and image quality.

Overall, the total time saved was significantly less than was envisioned at the start of the project. In addition, during the three years of the project, new systems have come onto the market that are better at controlling roads and routes than the drone-based solution we tested. With this AI-based system, all employees' work mobile phones are equipped with software and fixed in the vehicle using a mobile phone holder. While driving in the port area, regardless of the reason, images and videos of the routes are created by the mobile phones and downloaded upon return to headquarters and evaluated by AI. A complete picture of all roads and routes is thus created within 48 hours and is automatically updated on a regular basis. This is a time advantage that could not be achieved using drone technology. This being the case, the HPA will not pursue this use case any further at this point and will refocus on other promising use cases with drones.

Image 4: Testflight X11 with Sony Alpha

Image 5: Zoom Test height 40m, DJI M3E

2.2 Landing Site Infrastructure:

Even before the CITYAM project began, the HPA had already decided to build a drone airport in the Hamburg port area. Unlike the other two lead cities, our planned flight systems allowed us to build a permanently installed infrastructure.

As there are still no regulations governing the design of drone related charging pads, we relied on the experience and ideas of dronePORT users. The result is a metal structure with an area of 100 m². It is designed for all types of unmanned aircraft that can take off and land vertically and which weigh up to a maximum of 25 kg.

The construction was planned by the drone specialists at the HPA structural inspection department. The base frame was then manufactured by HPA trainees and finally treated in a galvanising plant to protect it from rust. After delivery to dronePORT, the construction was assembled. The base frame was bolted onto castors and the running rails were anchored to the cast foundation. This means that the entire landing pad can be moved if necessary. Multi-part steel gratings serve as the working surface. The entire landing pad was covered with 40x40cm tartan mats and the corresponding markings were made using different colours as inlay work. Two steps provide easy access to the landing pad.

Image 6: Building up the first elements

In order to comply with occupational health and safety regulations, yellow flashing lights were installed at the corners and sides to indicate the increased risk during flight operations. These flashing lights can be switched on from two different positions in the adjacent office containers. A video system also allows the pilot in command or the air-ground observer to keep an eye on the landing pad at all times. Yellow markings on the ground secure the area around the landing pad.

Image 7: Landing pad with installed Dock1

Basics:

- Dimensions: 10 x 10 m
- Area: 100 m²
- Height: 50 cm
- Lighting: 8 x yellow flashing lights (switchable)
- Surface: tartan
- Load: max. 500 kg/m²

In the course of the project, a DJI Dock1 was permanently installed on the landing pad and testing with this aircraft began in spring 2024.

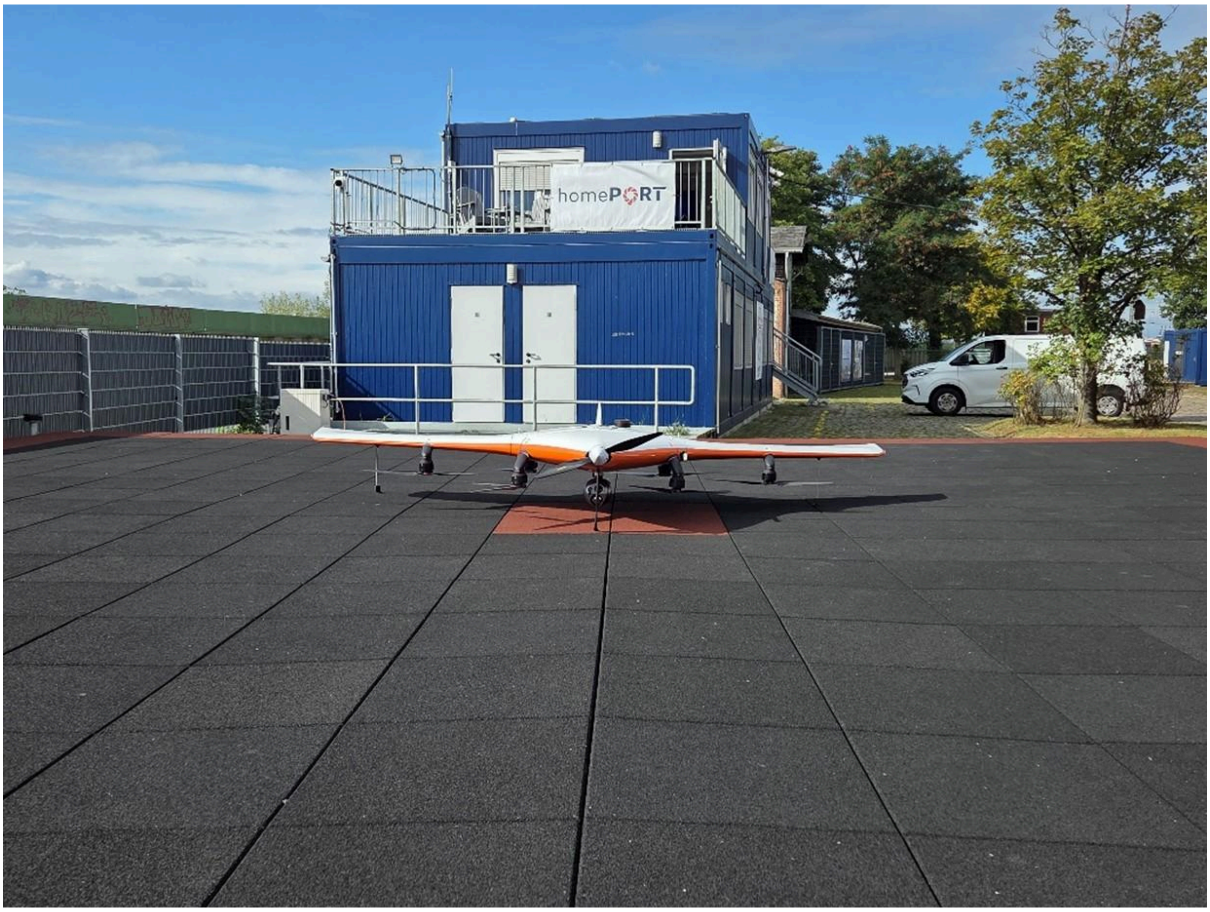


Image 8: Ready to Fly the VTOL System on the Landingpad

The landing pad has proven itself for long-range VTOL systems and, thanks to its extensive safety features, offers an ideal opportunity to operate systems with a wingspan of up to approx. 3 meters. The landing pad has also proven itself as a take-off and landing point for multicopter systems, even though these systems do not require such a large landing platform.

3. Stockholm

3.1 Description of Use Cases

3.1.1 Use Case 1: Herding geese

During the summers of 2023 and 2024, the City of Stockholm conducted a pilot project using drones to deter geese from three public beaches. The purpose was to reduce fecal contamination and minimize the risk of beach closures. Flights were conducted manually within VLOS and the Open Category.

The initiative was jointly run by the Traffic Administration, the Executive Office, and three district administrations. The need originated from recurring beach closures during peak season. To ensure transparency and public involvement, all beaches were equipped with information boards and QR codes allowing visitors to report goose sightings.

The initial three-week pilot in 2023 received highly positive feedback, leading to a ten-week extension in 2024. The results demonstrated both operational feasibility and strong citizen support. In 2024, 7,200 of 7,614 observed geese were herded away, 287 citizen interactions were recorded, and a 95% deterrence rate was achieved. The project generated valuable insights into workflows, regulations, and technical requirements for future scaling.

Image 8: Pilot project testing ground

Image 10: Information sheet that was set up at the beaches. The title says "Report geese!"

3.1.2 Use Case 2: Drone as a Service - Farsta Swimming Hall

The City of Stockholm's second use case focused on installing and integrating a drone-in-a-box system on the rooftop of a municipal swimming hall in the southern part of Stockholm, Farsta. The pilot operated under an STS-01 declaration and ran for two weeks, between 1–15 October 2025. Nokia Drone Networks, contracted in August 2024, served as the drone operator.

During the pilot, Nokia carried out vertical flights up to 20 meters. The drone launched and landed from an automated rooftop docking station, enabling fully remote operations. The setup tested the feasibility of fixed drone infrastructure in an urban environment and its potential for future applications such as data collection, surveillance, and emergency response for example.

The project required close coordination among several stakeholders:

- **Nokia Drone Networks**, ensuring operational readiness and regulatory compliance.
- **The municipal real estate department**, granting rooftop access and verifying structural suitability.
- **Certified electricians**, managing power and technical installation.
- **Swimming hall staff**, supporting safety and minimizing disruption to activities.

- **Traficom (Finland) and later Transportstyrelsen (Sweden)**, handling the STS-01 declarations.

This collaborative process demonstrated both the technical viability of drone-in-a-box systems in public facilities and the importance of cross-sector planning when integrating drones into city infrastructure.

Two weeks before the pilot, information was distributed to nearby residents, explaining the purpose of the test, involving partners, and providing contact details. Posters inside and outside the swimming hall also kept visitors informed.

A research provider conducted a qualitative study during the pilot, including observations and interviews to assess public reactions. Key insights from this study will be presented in the *Learning Experiences* section.

Image 11: Project drone flying over test area

Image 12: Stationary drone on landing pad

Image 14: One of the information sheets that was set up at the swimming hall. The title says "We are testing a landing site for drones"

3.2 Documented Learning Experiences

3.2.1 Geese Herding

FLOX Robotics used a DJI Matrice-series drone for the City of Stockholm, conducting regular deterrence flights at three locations throughout the summer. The system was later demonstrated with a DJI Dock to illustrate the potential for future autonomous operations.

Operational challenges mainly concerned battery management in relation to the number of sites and reported goose activity, as well as integrity and ground safety. In some cases, flights had to be adjusted to avoid interfering with scheduled swimming lessons and other activities at the beaches. A scalable DJI Dock solution would require further analysis of beach infrastructure, including reliable power supply and measures to ensure visitors are not affected by the operations.

The pilot demonstrated strong public support for drone-based goose herding as a way to improve beach conditions, confirming its potential as a viable urban service. Citizens responded positively and viewed the solution as relevant and useful in everyday city life.

The experience indicates that operational efficiency could be significantly improved by transitioning to more automated, dock-based systems, reducing the need for continuous on-site staffing and enabling deployment across multiple locations. Successful scaling would, however, require sustained citizen engagement, stable electricity at beach sites, and clear communication via both signage and digital channels. Integrating technological innovation with structured public feedback proved crucial for refining operations and ensuring that the service remains responsive to real-world conditions.

Overall, the project provided important insights into how drone technology can be embedded in municipal operations and laid the groundwork for broader urban air mobility solutions that are both technically effective and socially accepted.

3.2.2. Public attitudes and survey results

Following the geese herding pilot, a survey with 500 Stockholm residents was conducted using the CITYAM Public Acceptance Toolbox to assess attitudes toward Urban Air Mobility (UAM) and the specific use case.

Key insights included:

- High awareness of drone operations among residents aged 18–45, with a slightly higher awareness among men.
- Strongest support for drones used in infrastructure inspection and emergency management; more skepticism toward air taxis and delivery services.
- Preferred locations for take-off and landing were industrial areas and public rooftops.

- Main concerns related to privacy, data protection, and national security.

The survey gave a solid basis for designing future UAM initiatives that balance technical feasibility with social acceptance. A demonstration day at Sätra beach, where partners jointly viewed a drone-in-a-box solution in operation, further supported this dialogue.

3.2.3 Drone as a Service - From BVLOS ambition to VLOS pilot

The Drone as a Service use case was initially designed to test BVLOS flights in an urban environment for scalable traffic data collection. While VLOS flights are already common, BVLOS is more complex, operates in a higher risk category and requires formal permits. The project's mission was to document the path from idea to operation and capture lessons learned for future actors.

A kick-off workshop defined the drone's role as a service and its BVLOS mission: collecting data for traffic analysis. The next key decision was location. Stockholm's airspace is partly controlled due to Bromma Airport, hospitals, helipads and first responder operations, creating restrictions for new BVLOS operators. To avoid controlled airspace while staying within city limits and a relevant traffic context, Farsta in southern Stockholm was selected. The municipally owned Farsta swimming hall was identified as a suitable rooftop site for a drone-in-a-box installation.

An RFI was issued to explore market capabilities, followed by an RFP for drone service providers. Three proposals were received. Nokia Drone Networks was selected based on its experience in BVLOS deployments in other EU countries and its solution tailored for 4G/5G urban connectivity. The original plan was to operate in autumn 2024, but during project start-up in August 2024, the partners agreed to extend the timeline to autumn 2025 to allow sufficient time for permit processing.

Throughout autumn 2024, weekly coordination meetings were held. These covered mission definition and expected data outputs with the city's traffic planning unit, coordination with the facility owner, structural load analysis of the rooftop (approx. 300 kg system), crane logistics, and data protection. The City of Stockholm worked with IMY to ensure compliance with GDPR and surveillance legislation, and produced documentation on how data would be captured, transferred, stored and used.

To operate BVLOS in an urban environment, a SORA-based permit is required. As a Finnish operator, Nokia first had to apply for SORA approval from Traficom in Finland before requesting cross-border permission for Sweden. Documentation was submitted in early 2025, with an expected decision before summer. However, increased application volumes delayed the process, putting the BVLOS schedule at risk and prompting a strategic pivot.

Because VLOS operations do not require the same level of risk assessment and permitting, the partners agreed to explore a VLOS alternative that did not rely on SORA. Options such as changing to a smaller drone in the Open Category or moving to an unpopulated area under STS-02 were assessed but found unsuitable. The selected solution was to operate under STS-01 in VLOS at the same site.

STS-01 requires that the entire ground area be secured from uninvolved persons, which is challenging in a public urban environment. In practice, flights were limited to a small zone where access could be controlled without significantly disturbing local routines. This reduced the value of traffic data collection, and the scope was therefore redefined: instead of a traffic data mission, the pilot became a test of public perceptions of a drone-in-a-box system as part of a local recreational facility.

In September 2025, Kista Science City and the City of Stockholm met with Farsta swimming hall staff to explain the project and prepare them to answer questions from visitors. The operator submitted an STS-01 declaration, shipped and installed the drone-in-a-box, and recruited four local visual observers. These observers, experienced Swedish drone pilots, supported ground safety and acted as a bridge between Nokia and the public, communicating in both Swedish and English. Information was shared via letters, posters, online channels, radio and social media in the two weeks prior to the flights.

Under STS-01, no aerial data was needed, so no payload was used, eliminating GDPR and surveillance concerns. Flights were limited to 20 meters in height and approximately 10 minutes in duration, allowing up to three daytime flights on weekdays during the two-week test period. A qualitative study based on observations and interviews assessed public reactions, experiences and attitudes.

Key findings were:

- Public attitudes were generally positive but conditional, with acceptance depending on responsible, regulated use under public authority.
- Trust and transparency were crucial; the city’s proactive communication significantly increased confidence.
- Respondents saw strong societal benefits in applications such as rescue, police and emergency work, traffic monitoring and logistics (e.g. medical transport).
- Main concerns focused on surveillance, data misuse and harmful or unauthorized use, highlighting the need for clear rules, licensing and transparent data management.
- Noise was noted but considered a minor issue, mainly related to beeping during take-off and landing.

- The swimming hall rooftop was perceived as a neutral and appropriate location that minimized disruption.

The Farsta pilot thus demonstrated a high degree of public acceptance for urban drone operations when transparency, safety and societal value are clearly communicated, providing an important foundation for future CITYAM implementations and engagement strategies.

3.2.4 Identified use cases from workshop 06.02.24

Parking	Environment & Vegetation	Permit monitoring & inspection
Parking management	Climate monitoring, heat islands, tree canopies, stormwater flow paths	Traffic management plan and site inspections
Continuous collection of surface data for street parking	Monitoring how the city's waterways are used	Project documentation (before/during/after)
Steering parking enforcement	Irrigation of plantings	Inspections and follow-up documentation

Traffic Flows (incl. pedestrian & cycling)	Object/Location Inspection & Inventory	Other Applications
Improved overview and data to analyze recurring bottlenecks (flow, congestion spread, etc.)	Identification of specific objects/vehicles	Emergency light coordination (e.g., preceding a fire truck)
Queues and traffic to/from Klaratunneln	Inspection of barriers, fences, operational areas, warehouses	Geospatial mapping, point numbering, scanning
Flow measurement during events	Situational analysis of street elements, use of environmental zones	Baseline measurement of OD matrices
Traffic data: vehicle and pedestrian flows	Presence inventory in MZ23 (weekday/weekend, day/evening)	Bicycle maintenance service, ordering supplementary materials

Capturing correct/incorrect trips and clarifying destinations	On-site imagery as complement to street view/site visits	Leaf collection in autumn – before and after
Enhanced input for traffic models: jam density, segment speed parameters	Night-time information/inspection, flow and site guidance	Litter monitoring
Traffic control and signal timing planning	Lighting mapping	
Quick overview of traffic events in areas without camera coverage	Multifunctional drone	

Recommendations

1. **Define the drone service jointly with an experienced operator.** Align on time, budget, regulation and purpose, and allow flexibility in early stages. If location is fixed, timeline may need to be flexible, and vice versa.
2. **Focus on planning and outcomes rather than the flight itself.** The key questions are what the flight should deliver, how data will be handled and how the service fits into existing processes.
3. **Involve stakeholders early.** Identify authorities and actors who must approve or may be affected by the operation – such as airspace authorities, other airspace users and local communities – and involve them from the start.
4. **Ensure clear, accessible public communication** when flights occur in areas where people will see and hear the drone.
5. **Choose an operator with proven experience and the ability to propose alternative plans** if the original concept becomes unfeasible, and let technical and operational expertise guide the design of the final solution.

3.2 Landing site infrastructure

In the geese herding use case, all flights were conducted manually within VLOS, meaning a dedicated landing site was not required. However, the experience showed that future scalability would benefit from automated dock-based systems, which would reduce on-site staffing needs and support operations across multiple locations. This section therefore focuses on the Farsta drone-in-a-box installation.

For the Farsta use case, we chose to implement the test on a municipally owned rooftop, placing the docking station on top of Farsta swimming hall in southern Stockholm. To identify a suitable location, we leveraged internal expertise, municipal map systems, and existing contacts within the City of Stockholm. As the project lead from the city of Stockholm is a land use manager, this enabled us to independently assess city-owned properties with potential for drone operations. Our search focused on flat rooftops in Farsta, ultimately leading us to Farsta swimming hall.

Following initial identification, we contacted the building's facilitator at the Real Estate Department. In coordination with the swimming hall staff—under the Sports Department—the feasibility of hosting a drone system on the rooftop was explored. To proceed, the Real Estate Department required a bearing capacity assessment of the roof. This assessment was conducted and confirmed that the structure could support the planned installation, allowing us to move forward with the site.

On June 4th 2024, a joint site visit was held with representatives from the CITYAM team, the Real Estate Department, swimming hall staff, and Nokia. The purpose was to evaluate the rooftop and surrounding infrastructure in preparation for the pilot. Key topics discussed included electricity access, Wi-Fi connectivity, rooftop accessibility, fencing, emergency landing zones, and storage options—both inside the facility for drone and camera equipment, and outside for the docking station. The visit highlighted the complexity of infrastructure planning and the importance of close collaboration between CITYAM, Nokia, the facility owner, and on-site staff.

In the final week of September, the docking station and drone system were delivered to Farsta swimming hall. Nokia was present to receive the equipment and had arranged for a crane to lift the system onto the rooftop. That same week, an electrician from the Real Estate Department installed temporary electrical connections to power the docking station, completing the initial setup phase. After two weeks, on the 17th of October, the system was de-installed with a lift, taking the system down.

Learning Experiences

One crucial requirement for the project was the bearing capacity assessment of the landing site. This mandatory evaluation, requested by the real estate administration, was essential to obtain official approval for operations. It ensured structural safety, compliance with local regulations, and provided formal assurance that the installation would not pose any risks to the building or its users.

Another major learning was the value of early and transparent communication with the staff working in the building—even those not directly involved in the drone operations. Engaging them from the start helped create awareness, build trust, and foster understanding. By clearly explaining the project's purpose, scope, and safety measures, the team reduced uncertainty and gained the staff's cooperation, which proved vital for smooth and safe operations.

Collaboration with on-site staff became one of the project's key success factors. Their practical insights and feedback enabled the project team to adapt operations to the daily routines of the facility, preventing disruptions and improving overall efficiency. This experience highlighted that technical success depends not only on engineering excellence but also on effective human and organizational collaboration.

Both Nokia and the swimming hall staff confirmed that the test period ran very smoothly, supported by excellent communication, careful planning, and a professional attitude from all parties. Nokia's team was described as exemplary—attentive, thorough, and proactive in asking relevant questions, which contributed to a highly efficient working relationship. One key factor was the use of Visual Observers who consisted of 4 local drone operators which could communicate in English with Nokia, and in Swedish with local residents and staff members. The on-site personnel were equally cooperative and accustomed to working with contractors, always ready to assist and ensure that daily operations continued without interruption.

Clear communication among all project partners, particularly regarding shared responsibilities such as electrical work, was also identified as critical. Transparent dialogue helped avoid misunderstandings, scheduling conflicts, and potential delays, further contributing to the project's overall success.

Finally, noise management emerged as an unexpected yet valuable learning point. The sound from the docking station affected staff whose lunchroom was located below, as well as a nearby school class during physical education lessons. After discussing the issue with the school, Nokia and the staff agreed to delay drone operations by 15 minutes. This small adjustment eliminated disturbances while maintaining operational continuity.

This incident demonstrated the importance of proactive communication and flexibility when addressing environmental and social impacts. By engaging with affected stakeholders and finding mutually beneficial solutions, the project strengthened community relations and reinforced the long-term acceptance of the technology.

4. Helsinki

4.1 Description of Use Cases

4.1.1 Use Case 1: Water rescue operations by drone and floating device delivery

The core of one of the use cases piloted in Helsinki in August 2024, within the broader scope of the CityAM project, focused on the application of drone technology in water rescue missions. It was developed and piloted in close and continuous cooperation among the innovation company of the Helsinki City (Forum Virium Helsinki), the Helsinki City Rescue Department, and Port of Helsinki.

The pilot was launched out of a critical need to rigorously test and validate the efficacy of drones as a rapid, first-response tool for emergency assistance. This necessity stems from the high frequency of water rescue incidents in the Helsinki region, particularly involving its numerous inland lakes. The Helsinki City Rescue Department is actively pursuing innovative solutions to significantly improve response times and successful water rescue missions.

Documented learning experiences from piloting water rescue operations by drone in Helsinki: Water rescue missions by drone were successfully trialled in Helsinki on 27 August 2024, in a simulated life-threatening scenario in the Eastern Harbour's closed area. A staff member from the Helsinki City Rescue Services played the role of the victim, jumping into the water. The drone, flown from approximately half a kilometre away but within visual range, delivered a floating device. This device was safely dropped near the victim and inflated upon contact with the water, allowing the victim to hold onto it until the rescue boat arrived.

Image 15: A staff member of the Helsinki City Rescue Department, simulating distress, was kept afloat by a floating device dropped by the drone.

Image 16: The device inflated upon contact with the water, providing support until the rescue boat arrived.

VTT (Technical Research Centre of Finland) conducted a total of nine pilot flights - one operational and eight practice sessions - using a Dji M350 drone. This type of drone is commonly employed in search and rescue missions. During the flights, the drone maintained an altitude of approximately 60 metres above ground level. The wind speed during the flights was 5.6 m/s, whereas the maximum flight speed achieved was 16.52 m/s. Overall, the weather conditions were favourable.

Image 17: The Technical Research Centre of Finland VTT operated the drone within the Eastern Harbour's closed area.

Recommendations from piloting water rescue operations by drone in Helsinki:

1. Water rescue concerns safe operations in challenging environments (such as the harbour area). Effective communication between emergency services and authorities (e.g rescue department, port authority, coast guard) is essential.
2. Optimise the potential of drones by adopting a holistic approach to water emergency response, supported by solid regulatory frameworks.
3. Develop and maintain essential physical and digital infrastructure to facilitate drone operations, including reliable equipment, designated drone launch and landing sites, and strong network signals.
4. Address potential risks from inaccurate positioning information of the drone and GNSS interferences, which can jeopardise the entire rescue operation.
5. Increasing automation and flying the drone out of sight range (Beyond Visual of Sight - BVLOS flights) can support water emergency systems even more efficiently.

4.1.2 Use Case 2: Healthcare logistics by drone

The healthcare logistics use case, which involved drone delivery of essential healthcare items between two city-owned facilities, was piloted as an additional demonstration in Helsinki. The items delivered - including disinfection products, surgical masks, and protection gloves - were selected from a list of 20 products identified by the city's healthcare department as crucial for immediate availability during a future pandemic. While these items are considered non-urgent under normal circumstances, they are nonetheless vital in a public health crisis.

The primary goal was to evaluate the potential of drones in healthcare logistics, and establish a complementary, fast logistics chain, building on lessons learnt during the COVID pandemic. The development and execution of the pilot involved continuous collaboration between the innovation company of the Helsinki city (Forum Virium Helsinki) and two key city units:

1. The Helsinki city-owned maintenance and infrastructure provider (Stara), responsible for city-internal logistics and capable of implementing and scaling up drone healthcare deliveries.
2. The Helsinki city-owned healthcare logistics coordinator (Sotepe Logistics), who manages transport services and the distribution of healthcare products to public health centers and hospitals according to their needs.

Documented learning experiences from piloting healthcare logistics by drone in Helsinki:

From October 29 to November 7, 2025, Helsinki served as the testing ground for a successful trial of drone-based logistics aimed at enhancing healthcare supply delivery. Pilot flights were carried out by the Norwegian drone logistics company, Aviant, which brought to Helsinki established expertise from its experience in healthcare logistics operations across Norway and Sweden. The pilot demonstrated the viability of using drones to transport medical supplies swiftly and efficiently within an urban environment, such as the one of the Finnish capital.

The specific drone deployed for Helsinki's trials had a substantial 2.6-meter wingspan. It is designed with a cargo capacity to carry a maximum payload of two kilograms. Throughout the test flights, the drone maintained a safe operational altitude, flying consistently between 60 and 100 meters above ground level. For the purposes of this pilot, the cargo consisted of everyday healthcare essentials, including items like masks, medical gloves, needle boxes, and disinfectants. However, the successful integration of this air transport method in healthcare logistics holds significant promise for future expansion to encompass a much wider and more critical range of medical products, potentially including blood samples, lab specimens, and urgent medicines.

The pilot project flights covered a distance of approximately seven kilometers. After being loaded at the warehouse, the drone embarked on its journey to the city-owned healthcare station situated on a large island located to the east of the city, reaching its final destination in about seven minutes. The quick flight time underscores the potential of drone technology for expediting logistics, particularly in urban environments with complex geography or where ground transport may be slower. The test flights (39 in total) were carried out beyond the visual line of sight, with a permit granted by the Finnish Transport and Communications Agency, Traficom.

Image 18: The drone was flown several times per weekday, and completed its approximately seven-minute flight to the city-owned healthcare station after being loaded at the warehouse.

Although the flights were fully autonomous, continuous human oversight was maintained for safety and compliance. A dedicated human operator continuously supervised the flight path and drone performance from a remote command centre. The operational control of the flights was remotely managed by Aviant from Oslo. Simultaneously, ground staff stationed in Helsinki played a vital role, ensuring that the drone was meticulously prepared for each takeoff, that batteries were charged and that all necessary pre-flight checks and safety protocols were strictly followed. This combination of remote expertise and ground checks proved highly effective in managing the end-to-end logistics chain.

Image 19: The Aviant's ground crew in Helsinki was diligently preparing the drone for each takeoff and conducting all necessary pre-flight checks and safety protocols.

Pilot data in summary:

Parameter	Value
Flights planned before project start	30-60
Flights planned project start	30
Flights completed media and route transport	36
Flights to health care center	31
Take-off coordinates	60.1870° N 24.9812° E (Kyläsaari)
Landing coordinates	60.1735° N 25.0303° E (Laajasalo)
Drone type	Aviant Notus 15 / 16 (VTOL fixed-wing)
Max take-off weight	16 kg
Payload capacity	1 kg
Average payload	700 g
Total air time	~ 7h
Total distance	~504 km
Avg. flight duration	13.5 min
Avg. flight speed	21 m/s (≈ 76 km/h)

Max altitude	100 m AGL
Technical events	1 minor (locking error) Commanded retract on winch and got homing complete
Cancellations	2 days (due to wind)
Incidents reported	0
Weather	+4 °C to +10 °C, wind 6–10 m/s
Avg. operational cost	€ 180 per flight hour

Date	Deliveries	Remarks
Oct 29	2	System check
Oct 30	3	Media Day
Oct 31	11	Route transport
Nov 3	6	Route transport
Nov 4	3	Route transport Wind limit during the day
Nov 6	7	Route transport
Nov 7	4	Final day with demo and route transport
Total	36	No incidents

Estimated cost per delivery:

The cost of drone deliveries in this pilot is influenced by three main factors:

- Variable costs per flight
- Personnel on site
- Daily flight volume

Variable costs are currently estimated at 4–8 EUR per flight. This includes wear on the drone, batteries and routine maintenance. Personnel on site represent the largest fixed cost. When Aviant provides ground staff, the minimum daily personnel cost is approximately 250 EUR. This cost can be significantly reduced if the municipality or customer operates the ground segment themselves under an agreed model.

Daily flight volume has a strong impact on the cost per delivery, as many costs (for example personnel, infrastructure and approvals) are fixed regardless of the number of flights that day. With higher volume, the cost per flight decreases.

For this project, we estimated a cost per flight of 25–42 EUR under the current setup. Aviant's target was to reduce this to around 17 EUR per flight within the two years as technology, procedures and volume matured.

As a general rule of thumb, Aviant typically looked for contracts where the minimum annual transport value exceeds approximately 83 000 EUR when Aviant operates the system, and around 50 000 EUR per year when the customer operates the drones themselves. This gives municipalities a reference point for when drone logistics can become economically attractive at scale.

Recommendations from piloting healthcare logistics by drone in Helsinki: The experience of piloting drone-based healthcare logistics in Helsinki highlights several key areas for recommendation to facilitate future urban drone operations.

1. Regulatory and Institutional Streamlining

- **Proactive Civil Aviation Authority (CAA) leadership and clear procedures:** The Civil Aviation Authorities need to take a more proactive approach and assume clear leadership in establishing procedures for BVLOS flights, especially within controlled airspace. The current lack of regulatory frameworks and over-reliance on Air Navigation Service Providers practically hinder such operations.
- **Clarification and standardisation of interpretations:** Address the inconsistent interpretation by different authorities of EU regulations, such as the definition of "assembly of people". A conservative and strict interpretation by Civil Aviation Authorities (CAA) significantly complicates risk assessment and flight planning. Recommendations include developing a clear and consistent approach across all inspectors and initiatives, moving beyond differing internal CAA perspectives.
- **Establish a digital, transparent application system:** Replace the current email-based application process. A dedicated digital platform is needed for large file uploads and structured submission. Furthermore, the process must be made transparent for all involved actors by establishing clear / standardised rules / timeline, and providing regular updates to applicants.
- **Resource allocation for efficient approval timelines:** CAAs must address prolonged approval timelines due to resource constraints, such as staff shortages and dependency on a single inspector. A documented experience involved significant delays due to the limited number of personnel available to handle complex BVLOS applications. Increasing human resources and cross-training inspectors is crucial to maintaining project schedules.

2. Operational Planning and Data Utilisation

- **Contingency planning for all risks:** Helsinki pilot in healthcare logistics confirmed the need of a contingency plan, not only for delayed regulatory permission but also for technical risks like GNSS interference. Future initiatives must integrate robust contingency measures into their operational plans from the outset.
- **Leverage high-precision population data:** The importance of population density data was evident for planning feasible and safe flight routes. Collaboration with city or regional organisations to acquire the most precise and ideally real-time population data is highly recommended to improve risk models and increase the likelihood of approval.
- **Promote innovation:** CAAs should reconsider their risk-averse approach, which favours established methods (like Tempo-D) over more effective, modern solutions (like ADS-B/L). Regulatory flexibility to evaluate new technologies is key.

3. Stakeholder Collaboration and Communication

- **Systemic inclusion of use case owners / contractors:** The current application process solely between drone operator and CAA excludes the use case owner (in case that the use case is outsourced) from crucial information loops. A formal mechanism is required to keep the contractor informed about the status, expected timelines, and next steps in the approval process.
- **Foster positive institutional relationships:** Helsinki's experience showed that relationship-dependent factors (e.g. good communication and connection with the handling inspector) were crucial. Future initiatives should prioritise transparent and open communication channels with CAA staff, though the ultimate goal remains a less informal and more formalised, standardised application process.
- **Capitalise on city support:** The strong support from city-organisations (healthcare logistics and maintenance units) should be fully leveraged. This institutional support and their identified needs are powerful justifications for drone operations and can facilitate the integration of drone services into existing urban infrastructure and city services.

4.1.3 GNSS interference Pilot

Background and transnational value

Manned aviation navigation systems accuracy is severely affected by man-made factors in the Gulf of Finland region. Airplanes are reporting back their navigation data integrity to the global ADS-B Exchange system, where it is available for analysis and can be visualized in services like gpsjam.org. From this data it's possible to further analyse GNSS interference on higher altitudes where manned aircraft operate. However, similar data is not yet available from lower altitudes, where unmanned aviation - such as drones - is emerging.

In the current political situation, it's known that active GNSS jamming operations by Russians are taking place in the region from multiple different sources; land, marine and aerial. Effects of the jamming take place both inside countries national borders and international waters, possibly hindering international drone traffic in the future.

The drone community in the Helsinki region has reported a sudden and total loss of GNSS positioning in-flight on several occasions during the last few years. What is common with these reports is that when a pilot brings down their drone, positioning might become suddenly available closer to the ground. The hypothesis includes following a) urban structures block intentional man-made interference signals for reaching lower altitudes further away from the Helsinki coastline b) the interference source is likely ground or marine based.

Goal of the pilot

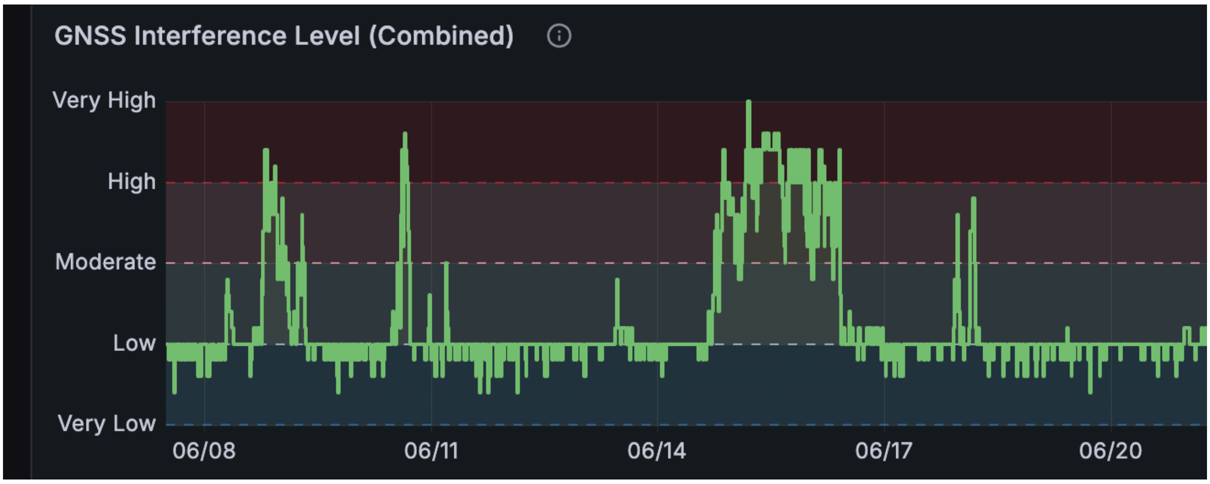
Current development is showing that drones are becoming one of the autonomous mobility methods in the cities of the future. A safe testing environment, especially for Beyond Visual Line of Sight flights, is crucial in urban areas. Forum Virium Helsinki, as the innovation organisation of the City of Helsinki and a living lab for technological innovations, needs to understand better if the lower air space of Helsinki can be used as a testing environment in a safe manner.

The healthcare logistics BVLOS flights use case that took place in November 2025 was able to benefit from real-time situational awareness regarding the GNSS interference in the area of the pilot route.

Pilot phase

To learn more about the interference, we put out a tender for a rapid pilot to measure GNSS interference. One approach was to trial a low cost custom sensor, which was the selected approach. Several sensors were installed by the service provider at different elevations at tall structures around the city center. The sensor was powered by a small solar panel & lithium battery. Network connectivity was obtained through low data rate and low power Lorawan network.

The analysis method to determine the expected interference was a simple analysis of positioning deviation of the sensors. Severity of the interference was categorized to five levels and the algorithm was improved during the data collection pilot. Data was collected from April 2025 until November 2025.



Recommendations from piloting GNSS interference detection

Currently used high-accuracy GNSS ground stations https://gnss-finland.nls.fi from the National Land Survey of Finland are recording the navigational signal quality levels. However, there is not, at least publicly known, any collection and analysis campaigns taking place in

Finland currently regarding GNSS signals at the lower altitudes relevant to drone operations. It is important that this data becomes available on a wider scale.

1) Exploring how existing sensor networks like mobile network base stations or IoT devices with GNSS receivers could be used as a large virtual sensor for detecting interference for broader regions. This approach would need a lot of legwork to find suitable partners with existing hardware, but would provide a comprehensive outlook with proven maintenance processes.
2) Alternatively, due to the low cost of hardware developed in the pilot, the detection network with new devices could be rapidly deployed to cover larger areas, even internationally. This approach would be more straightforward and likely faster to implement.
3) Using 4G instead of Lorawan would allow the sensors to report in more frequently, but needing a larger solar panel and battery. The main benefit would be a real time detection of the interference.
4) Simulation of GNSS signal and interference propagation in the urban digital twins would allow finding optimal locations for the interference detection sensors and interference-proof zones in the lower airspace.

4.2 Landing site infrastructure

4.2.1 Water rescue pilot

The CITYAM water rescue pilot in Helsinki demonstrated that a permanent, pre-designated landing site was not, in fact, a requirement for the successful completion of the rescue mission on the receiving end. Instead of necessitating a fixed location for the drone to land, the operational protocol focused on the drone's capability to deliver the life-saving equipment directly to the target. In this specific simulating scenario, the drone successfully "whinged down" the floating device close enough to the person in distress. This method bypasses the logistical complexities and time delays associated with preparing and clearing a dedicated landing zone, particularly in dynamic and unpredictable maritime or coastal environments. The pilot's success validates an approach where the drone acts as a precise, aerial delivery mechanism rather than a transport vehicle requiring complex infrastructure at both the launch and landing sites.

Image 20:The drone successfully brought the floating device down and close enough to the Helsinki City Rescue Department staff member who was simulating a person in distress.

4.2.2 Healthcare logistics pilot

The successful drone delivery pilot operations conducted in Helsinki relied on designated launch and landing sites, which comprised several critical components designed to ensure both operational efficiency and safety.

Image 21: Designated fenced 4x4 take off area at the warehouse, where the drone was stored and charged.

The launch and landing sites were clearly marked 4x4-meter areas, strategically positioned at the warehouse take off area and in close proximity to the main logistics entrance of the health station. In particular, the landing site location at the healthcare station was chosen to minimise transit time for personnel receiving the package and to integrate seamlessly with existing logistical workflows. The defined size was adequate for the necessary drone maneuvering and package drop-off procedure.

To guarantee the safety of both the drone operation and passers by, both launch and landing sites were fenced. A minimum 3-meter radius of clearance around the precise drop-off location was mandated. This safety perimeter was essential to prevent any accidental interaction with the drone, particularly during the critical package lowering phase, and to provide a secure operational area for the aircraft. To comply with regulatory requirements and maintain the highest standard of operational safety, antenna installation at both the launch and landing sites was required. This enhanced situational awareness and ensured the overall security and viability of the drone delivery service.

Upon arrival over the delivery area, the drone maintained a precise hovering altitude of 60 meters. The package transfer itself was executed using a winch mechanism via a robust cable. This method allowed for the safe delivery of the payload without requiring the drone to physically land. Importantly, the operational model did not incorporate any facilities for on-site recharging; the drone was not designed or provisioned to be recharged at the destination health station. The entire operation was designed to be rapid, safe, and minimally disruptive to the health station's daily activities.

Image 22 & 23:The drone hovered at an altitude of 60 meters before lowering a shoebox-sized box via a cable on a specified 4x4-meter designated landing site right next to the health station's logistics entrance.

Image 24: A health station staff member is retrieving the shoebox-sized package containing healthcare items.

As a concluding comment, it is nice to mention that a month after the Helsinki pilot, Aviant and their partners were awarded around 1.7 million Euros to deploy drones for healthcare as part of Norway's national drone initiative for hospitals. Use cases are streaming of video from accident to ambulance, sending defibrillators, and transport of biological samples for analysis.

Learning Experiences

Water rescue pilot:

1. The water rescue pilot in Helsinki successfully demonstrated that complex, permanent landing site infrastructure is *not* necessary for successful drone-based water rescue delivery missions. The operational focus on direct aerial delivery ("whinging down") maximises flexibility and rapid response, freeing the receiving end from setup requirements.
2. Since the delivery end is infrastructure-free, the primary focus for operational improvement shifts to the launch site. Standardising procedures and potentially establishing fixed launch locations (e.g., fire stations) is crucial for future Beyond Visual Line of Sight (BVLOS) capability and faster, routine deployment.
3. The piloted solution is designed for flexibility, emphasising low costs for the landing site infrastructure. This strategic focus is essential for scaling the implementation and

adoption of the drone technology in water rescue missions. By minimising the upfront investment required for establishing and maintaining landing infrastructure, the piloted solution in Helsinki can significantly reduce financial barriers for various stakeholders, including the Rescue Departments and port authorities.

Healthcare logistics pilot:

1. The selection of the landing site at the health station was highly effective because it minimised transit time for receiving packages and integrated smoothly with existing logistical workflows.
2. The defined 4x4-meter area proved sufficient for drone maneuvering, safe hovering, and the package drop-off procedure using the winch mechanism.
3. The mandatory fencing and 3-meter radius clearance successfully prevented unauthorised access and accidental interaction, particularly during the critical package lowering phase, providing a secure operational delivery.
4. Utilising a winch for package transfer at a 60-meter hover altitude allowed for safe delivery without requiring a full landing, minimising disruption to the health station's daily activities.
5. The mandatory installation of antennas at both sites was crucial for enhancing situational awareness, thereby maintaining a high standard of operational security and viability.
6. The operational model successfully functioned without on-site recharging facilities at the delivery site, indicating that for specific rapid, short-distance delivery operations, this infrastructure is not a prerequisite.

Recommendations

Water rescue pilot:

1. Clearly document and formalise this successful "aerial delivery only" strategy for water rescue and similar supply delivery missions to maximise the advantage of flexibility and rapid deployment over traditional landing requirements.
2. Since the landing / receiving end is infrastructure-free, future efforts should focus on standardising take-off locations. For Beyond Visual Line of Sight (BVLOS) operations, prioritise establishing fixed take-off locations (e.g. main fire station). For current Visual Line of Sight (VLOS) operations, optimise the process for rapid deployment from transport vehicles (e.g. fire trucks), focusing on quick setup away from high structures and ensuring a clear, safe perimeter (no people allowed nearby) for the take-off / delivery sequence.
3. As BVLOS flight becomes more common in urban areas, develop a clear roadmap for the fixed launch sites (like the fire station) to handle routine BVLOS water rescue missions, enabling significantly faster response times by flying directly from the base.
4. Invest in refining the precision and reliability of the delivery mechanism ("whinging

down") to ensure the floating device is deployed accurately, consistently, and safely in various weather and water conditions, further validating the infrastructure-free receiving end.

Healthcare logistics pilot:

1. Future launch and landing site locations should be selected based on proximity to the final recipient / storage area to minimise human transit time and ensure seamless integration with the existing facility's logistics and workflows.
2. Continue to use clearly marked and adequately sized areas to facilitate precise drone navigation and package drop-off, ensuring visibility and reducing operational risk.
3. It is highly recommended to continue mandating physical safety infrastructure, such as fencing, and the minimum 3-meter operational clearance around the drop-off point to ensure public safety and a secure zone for drone operations, especially during the payload transfer phase.
4. Infrastructure design should accommodate package delivery via a hovering winch mechanism to avoid the complexities and safety risks associated with full ground landings at a busy facility.
5. Ensure that antenna installations are a mandatory part of the infrastructure design at both launch and landing sites to meet all regulatory standards and guarantee reliable situational awareness for secure operations.
6. Assess the need for on-site charging on a case-by-case basis. For short, rapid routes, the current model of non-provisioned destination charging is viable. For longer routes or higher-frequency operations, a modular, non-disruptive charging infrastructure may be necessary.

5. Conclusion

Across the CITYAM pilots in Hamburg, Stockholm, and Helsinki, the project demonstrated how urban air mobility can be safely and effectively integrated into complex city environments when supported by clear procedures, committed stakeholders, and adaptable infrastructure. The three cities tested a wide range of use cases from environmental management and public-safety operations to healthcare logistics and infrastructure inspection, offering a broad foundation of practical evidence on what is required to scale drone operations in urban settings.

A key learning across all pilots is that successful drone operations are driven as much by planning, coordination, and communication as by technology itself. All project cities consistently emphasized the importance of early engagement with aviation authorities, emergency services, facility owners, and the general public. Transparent communication, whether through signage at beaches in Stockholm, information campaigns around the Farsta

Swimming Hall, or coordinated exercises with rescue personnel in Helsinki, proved essential for public acceptance, regulatory alignment, and operational safety.

The pilots also highlighted that ground infrastructure must be treated as a core enabler, not an afterthought. Hamburg's development of its DronePort, Stockholm's rooftop deployment at Farsta, and Helsinki's flexible launch solutions each underscored the need for structurally suitable sites, reliable power and connectivity, and procedures that fit seamlessly into existing city operations. Even in cases where landing sites were not required, such as Helsinki's water-rescue scenario, the findings reinforced the value of predefined, safe operating environments and robust communication channels.

Operationally, all cities noted that the path to scaled, high-value drone services depends on enabling BVLOS operations, supported by clear regulatory frameworks, risk-based permissions, and stable digital infrastructure. While Hamburg collected the data needed to work toward multi-drone oversight, Stockholm documented the challenges of shifting from a planned BVLOS mission to STS-01 operations, and Helsinki demonstrated the potential of BVLOS healthcare logistics when regulatory approval is secured. These experiences show both the value and the difficulty of advancing towards routine, automated BVLOS missions in populated areas.

Finally, the CITYAM pilots show that urban drone services can deliver clear public value; from cleaner beaches and safer harbors to faster access to medical supplies. Residents and frontline city staff responded positively when operations were purposeful, transparent, and responsibly managed. At the same time, concerns around privacy, safety, and noise highlight the need for ongoing dialogue and inclusive governance as drone adoption expands.

Taken together, the experiences of Hamburg, Stockholm, and Helsinki provide a practical blueprint for cities aiming to integrate drones into everyday municipal services. The project concludes that future success will depend on strong interdepartmental cooperation, proactive regulatory engagement, thoughtful infrastructure planning, and a commitment to public trust, ensuring that urban air mobility develops not only as a technical achievement but as a socially accepted and sustainable part of city life.