Bavovna AI
FLIGHT REPORT

Non-GNSS Autonomous Navigation at 99.99% End-point Accuracy

Summary

On January 23, 2025, Bavovna AI performed a successful flight demonstration of its AI-powered Hybrid Inertial Navigation System (H-INS) on the Aurelia X6 Max hexa-copter.

The flight covered a **total distance of 30.88 km over a duration of 57 minutes**, consisting of two distinct segments: High-entropy Loiter Phase and Return-to-Launch (RTL) Phase. After 30.11 km of chaotic flight maneuvers in the Loiter Phase, the Bavovna H-INS successfully navigated a 0.77 km RTL Phase, executing a soft landing 4.2 meters from the launch point, **achieving an End Point Position Accuracy of 99.99%**.

0.01% End Point Error at >30 km (4.2 meters)

FEBRUARY 5, 2025

Equipment and Personnel

- **Airframe:** Aurelia X6 Max
- **Navigation:** Bavovna H-INS
- **Flight Team:**
  - **Pilot:** Eugene Nayshtetik (Head of Product)

Environmental Conditions

- **Condition:** Mist transitioning to cloudy
- **Temperature:** 0°C (32°F)
- **Dew Point:** 0°C (32°F)
- **Humidity:** 100%
- **Pressure:** 749.55 mmHg
- **Precipitation:** 0.0 in
- **Wind:** 13-22 km/h (8-14 mph) SE/SSE

Flight Details

High-Entropy Loiter Phase (Red)

The UAV was subjected to more than 30 kms of highly chaotic maneuvers, creating a challenging environment for the H-INS to maintain an accurate position reading.

- **Distance:** 30.11 km
- **Duration:** 53 minutes and 38 seconds
- **Mean Speed:** 9.22 m/s
- **Maximum Speed:** 11.21 m/s
- **Distance-based Entropy:** H = 11.6

RTL Phase (Orange)

After 54 minutes of flight at freezing temperatures, the Bavovna H-INS successfully returned the UAV home, executing a soft landing within 4.2 meters of its original launch point.

- **Distance:** 0.77 km
- **Duration:** 4 minutes and 18 seconds
- **Mean Speed:** 3.00 m/s
- **Maximum Speed:** 5.14 m/s

Accuracy

- **Distance between Launch and Landing Points:** 4.2 meters
- **End-Point Positioning Accuracy:** 99.9864%

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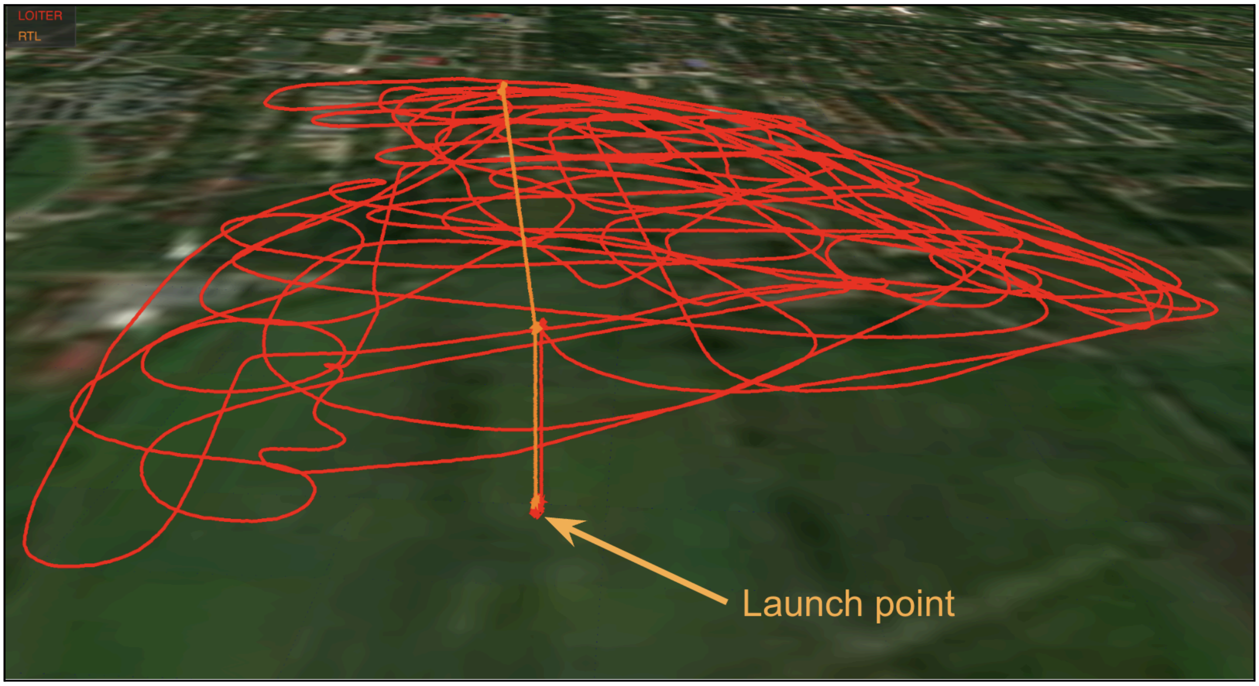
Flight Details

Complete Flight Trajectory

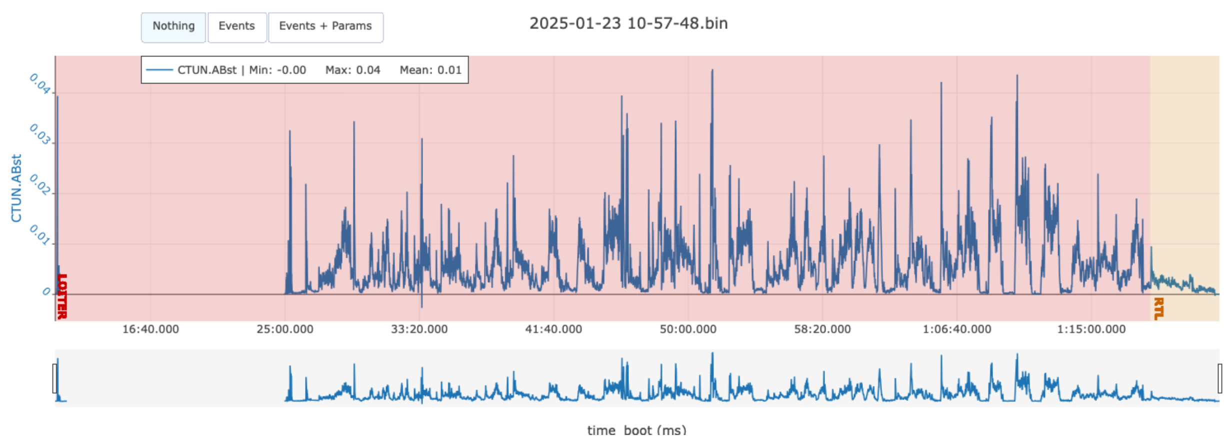


Red: High-entropy Loiter Phase
Orange: Return-to-Launch Phase

Flight Log Details

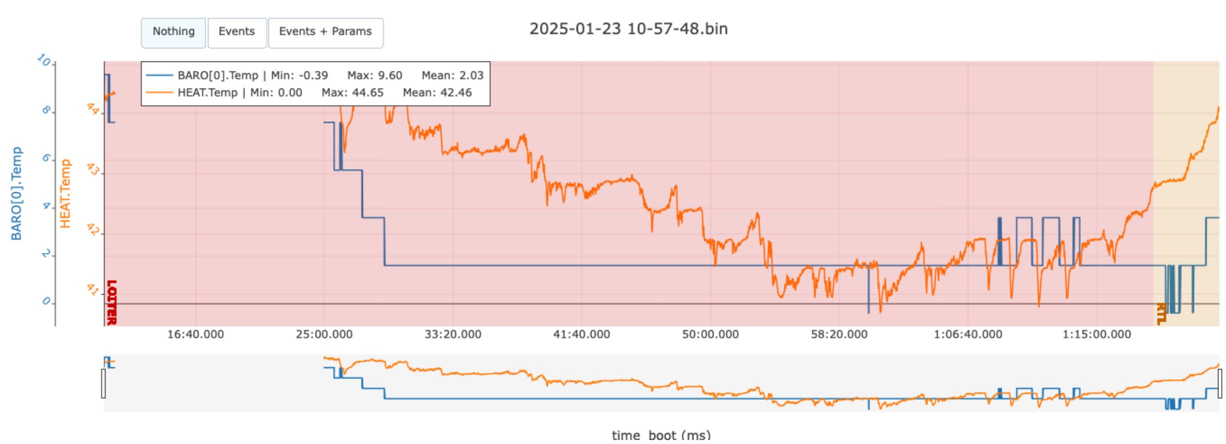
High-entropy Flight

The **CTUN.ABst** graph (below) shows fluctuations in Throttle Above Midpoint, indicating the execution of dynamic flight movements during the Loiter Phase. These flight movements were performed to demonstrate the capabilities of the Bavovna H-INS to perform in complex flight environments.



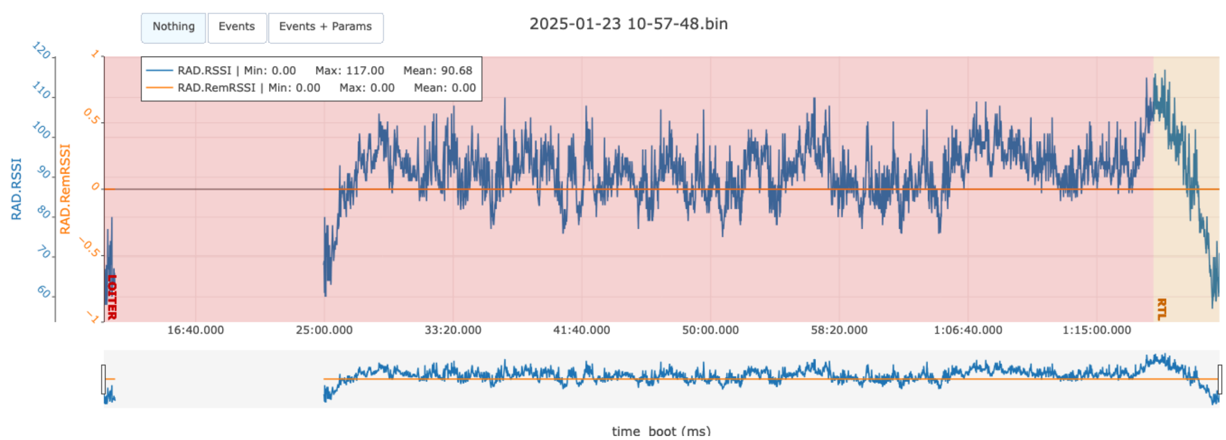
Drone Temperature

The plot below illustrates the temperature recorded by the drone's barometer / thermometer over time as well as the internal temperature of the Bavovna H-INS.



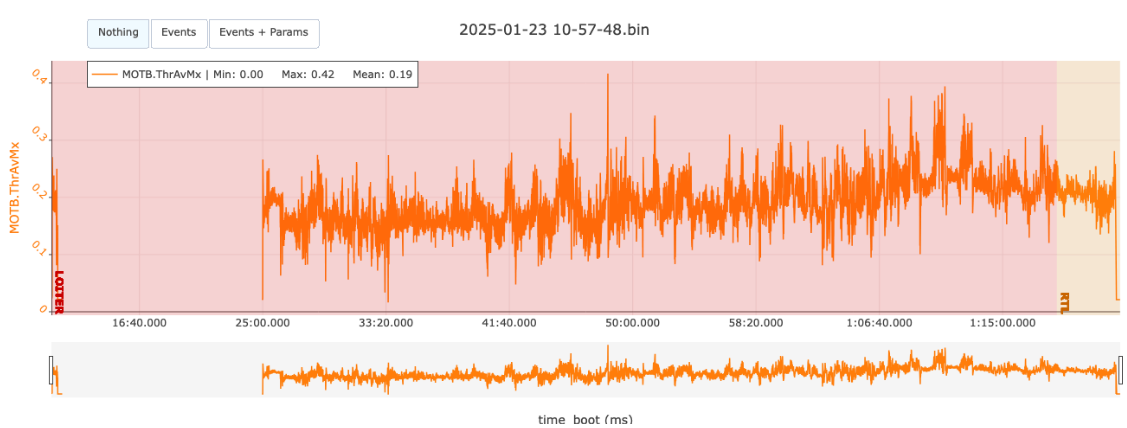
Radio Link Stability

The RSSI dynamic in the drone's log shows a generally strong signal (**mean ~90.68**) with fluctuations throughout the flight, likely due to environmental interference or drone orientation changes. The initial phase shows a signal increase, possibly during takeoff, followed by a stable but variable period in flight. Marked events like "LOITER" at the start and "RTL" near the end suggest operational transitions, with a noticeable RSSI drop during return, possibly due to distance or obstacles. Overall, the communication link remained strong, but variations indicate potential areas for signal optimization.



Motor Balance

The **MOTB.ThrAvMx** values (mean: **0.19**, max: **0.42**) indicate continuous micro-adjustments throughout the flight, reflecting the navigation system's ability to maintain an accurate trajectory in non-GNSS mode. The fluctuations remained within a controlled range, with no sudden drops to **0** or extreme spikes beyond **0.42**, demonstrating consistent correction rather than instability. The stable execution of RTL, without erratic throttle behavior, further confirms the system's reliability.

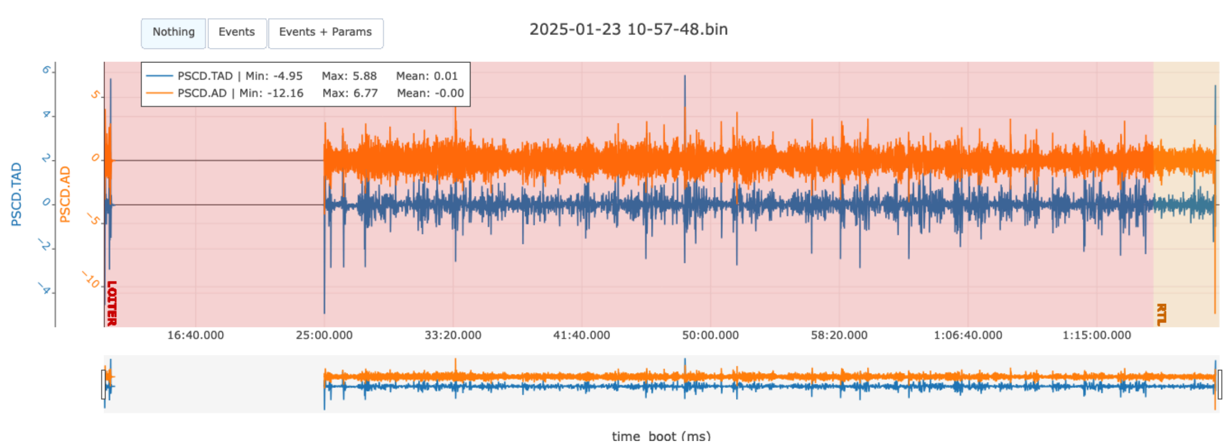


Position control

"PSCD" refers to the Position Controller's data along the Down axis (Z-axis). The "TAD" suffix stands for "Target Acceleration Down," indicating the desired acceleration in the downward direction. "PSCD.TAD" represents the target acceleration set by the position controller for descending movements. The suffix "AD" stands for "Actual Acceleration Down," representing the actual acceleration experienced by the vehicle in the downward direction. These parameters are crucial to assess the performance of the position controller by comparing the intended acceleration against the actual movement of the vehicle..

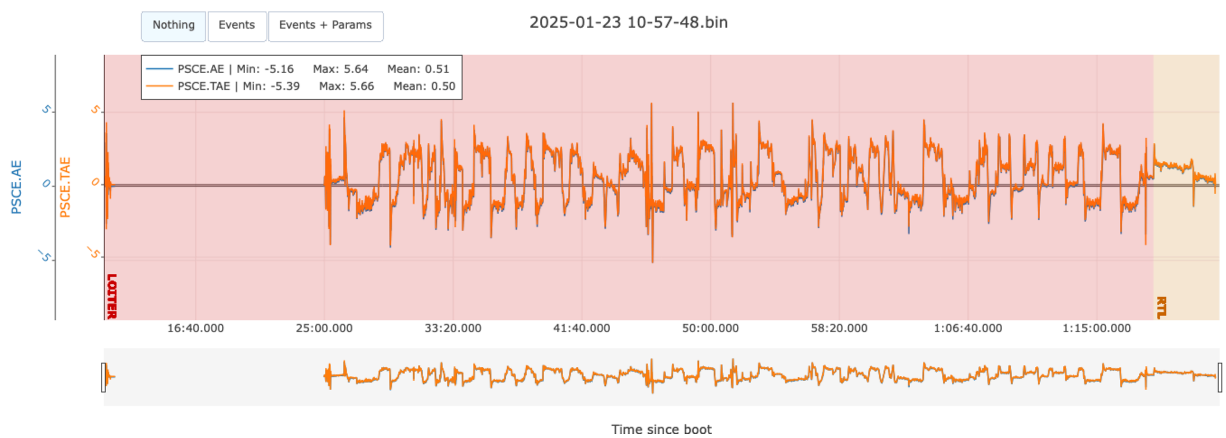
The **PSCD.TAD** (blue) and **PSCD.AD** (orange) values reflect the drone's attitude and acceleration corrections during the flight, further confirming the stability and reliability of the non-GNSS navigation system. The PSCD.TAD fluctuates within a controlled range (**Min: -4.95, Max: 5.88, Mean: 0.01**)

PSCD.AD shows slightly higher variability (**Min: -12.16, Max: 6.77, Mean: -0.00**). These values indicate continuous fine-tuning rather than instability, as the system actively compensated for deviations without erratic behavior. The absence of prolonged extreme values suggests that the navigation system effectively maintained control throughout the flight, even in a chaotic trajectory. The RTL phase remains consistent with previous observations—no sharp deviations or uncontrolled movements, reinforcing that the system maintained precise positioning through adaptive real-time corrections.



The PSCE message pertains to the Position Controller's data along the East axis (Y-axis). The AE field represents the Actual Acceleration East, indicating the vehicle's measured acceleration in the eastward direction. Similarly, the TAE field stands for Target Acceleration East, denoting the desired acceleration set by the position controller for eastward movement.

The **PSCE.AE (blue)** and **PSCE.TAE (orange)** values represent position and trajectory attitude errors, confirming the navigation system's reliability without GNSS. Fluctuations remain within a controlled range (**PSCE.AE: Min -5.16, Max 5.64, Mean 0.51; PSCE.TAE: Min -5.39, Max 5.66, Mean 0.50**), showing that the system continuously adjusted and corrected positioning without significant drift. The absence of extreme deviations or prolonged instability shows a high level of accuracy, even during the chaotic phase. The RTL phase demonstrates the same controlled, uninterrupted performance with no major positioning errors.

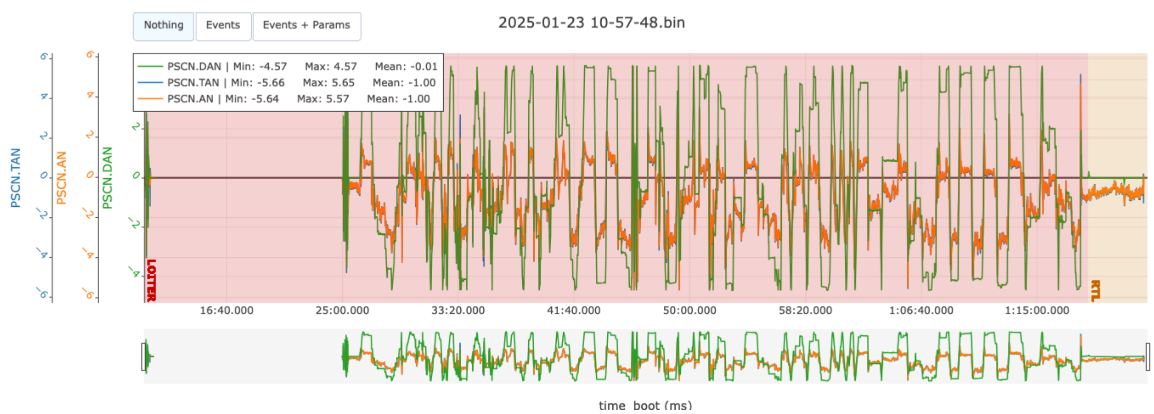


PSCN message pertains to the Position Controller's data along the North axis (X-axis). The fields within this message are defined as follows:

- TAN (Target Acceleration North): This represents the desired acceleration set by the position controller for movement in the northward direction.
- AN (Actual Acceleration North): This indicates the actual acceleration experienced by the vehicle along the northward axis.
- DAN (Desired Acceleration North): This denotes the acceleration that the position controller aims to achieve in the northward direction.

By analyzing these parameters, users can assess the performance of the position controller by comparing the desired, target, and actual accelerations along the North axis. This comparison is crucial for tuning the position controller to ensure accurate and responsive navigation.

The **PSCN.TAN (blue), PSCN.AN (orange), and PSCN.DAN (green)** values (see chart below) indicate position corrections and navigation adjustments, further reinforcing the reliability of the non-GNSS navigation system during the chaotic trajectory. The data shows frequent and sharp corrections, with PSCN.DAN ranging from -4.57 to 4.57 (Mean: -0.01), PSCN.TAN from -5.66 to 5.65 (Mean: -1.00), and PSCN.AN from -5.64 to 5.57 (Mean: -1.00). These fluctuations suggest continuous real-time adjustments, ensuring that the UAV remained on course despite external disturbances. The absence of long periods of flatlined values confirms that the system was actively correcting drift and deviations without any dead zones or loss of tracking. The RTL phase shows a return to more stable corrections, demonstrating that the system successfully guided the drone back without major trajectory errors. These consistent, structured adjustments indicate a highly effective inertial navigation system that maintained accuracy despite the lack of GNSS input.



Conclusion

This demonstration of the Bavovna Hybrid Inertial Navigation System (H-INS) on the Aurelia X6 Max further confirms our capability to navigate at high precision in a non-GNSS environment. The system flew 32km over 54 minutes in freezing conditions. Achieving an end-point accuracy of 99.99%, the system demonstrated exceptional reliability during both high-entropy maneuvers and a precise execution of automated return-to-launch (RTL).

Analysis of the flight data confirms that the H-INS continuously adapted to real-time conditions, maintaining stable motor control, attitude adjustments, and positioning accuracy with immaterial loss of tracking. The system successfully managed complex flight dynamics, counteracting external disturbances, and ensuring a smooth and controlled trajectory.

This test adds to the body of validation of the Bavovna H-INS as a field-proven solution for autonomous UAV operations in GNSS-denied environments.

END REPORT