DEVELOPING AND TESTING GPS ENABLED INERTIAL REFRENCE NAVIGATION SYSTEM FOR NEXT GENERATION FLIGHT COMPUTERS
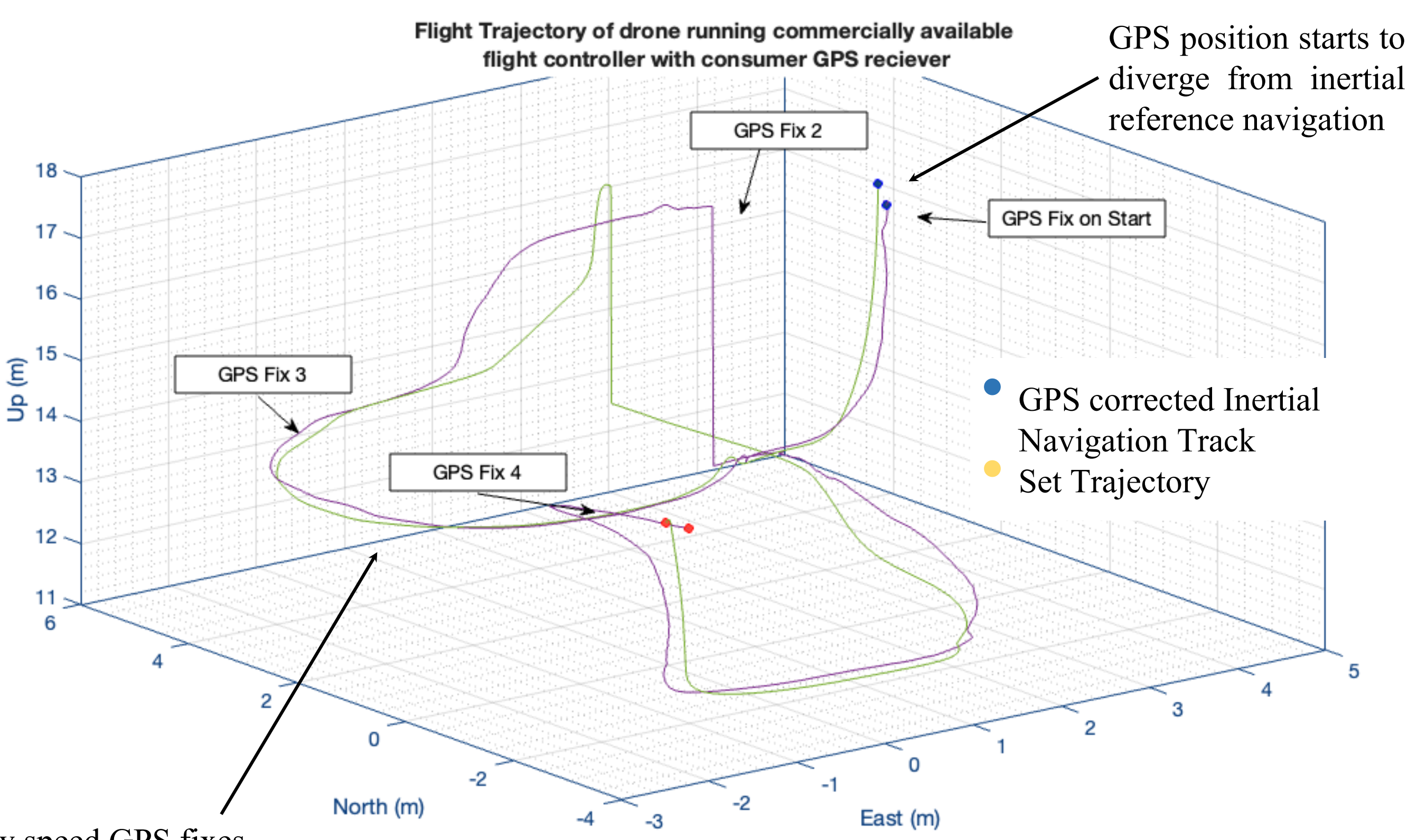
STUDENTS: GOKUL NATHAN

Motivations

Understanding GPS performance in aerospace is crucial for improving navigation accuracy, ensuring mission success, and advancing UAV capabilities.
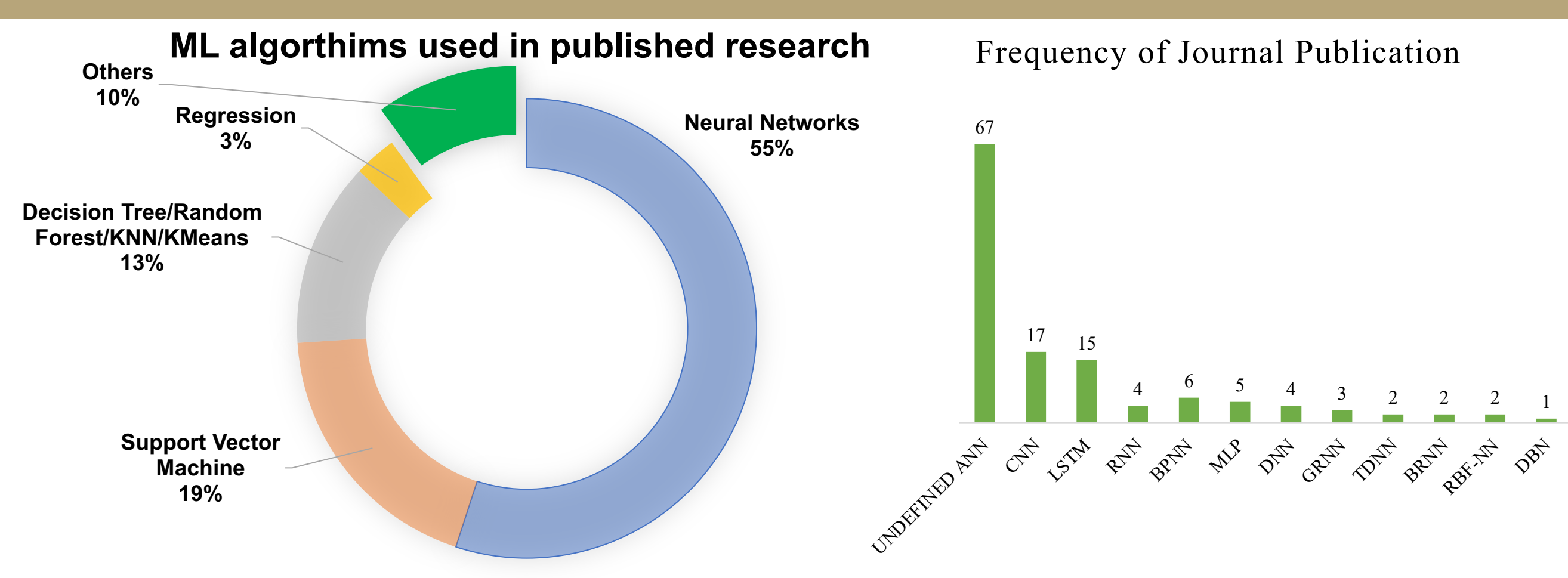
		Status quo		System Performance Target
	Weight	20 – 100 lbs.		<5 lbs
	Cost	$10K – $100K		<$5K
	Power Consumption	200 - 1500 W		<25W
	Modularity	Platform Specific		Cross platform compatibility
	Real-Time Precision	Not Guaranteed Performance		Guaranteed Performance

Performance Gap

Flight Trajectory of drone running commercially available flight controller with consumer GPS reciever

GPS position starts to diverge from inertial reference navigation

GPS Fix 2
GPS Fix on Start
GPS Fix 3
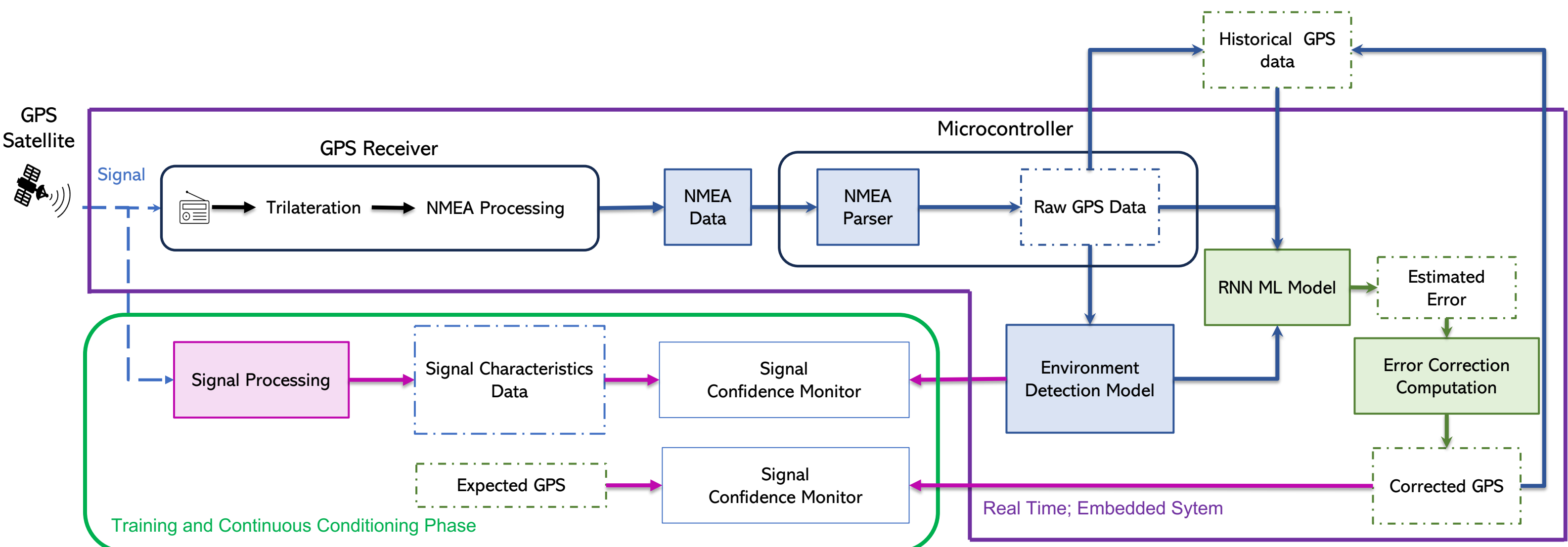GPS Fix 4

- GPS corrected Inertial Navigation Track
- Set Trajectory

Low speed GPS fixes
- 4 verified high quality GPS fixes in 2 minutes 42 seconds

Current State of Art Approaches in ML for GNSS

ML algorthims used in published research

- Others 10%
- Regression 3%
- Neural Networks 55%
- Decision Tree/Random Forest/KNN/KMeans 13%
- Support Vector Machine 19%

Frequency of Journal Publication

67, 17, 15, 4, 6, 5, 4, 3, 2, 2, 2, 1
UNDEFINED ANN, CNN, LSTM, RNN, BPNN, MLP, DNN, GRNN, TDNN, BRNN, RBF-NN, DBN

A. Siemuri Et Al., "A Systematic Review of Machine Learning Techniques for GNSS Use Cases," *IEEE Transactions on Aerospace and Electronic Systems,* 2022

Our Algorithm Approach

GPS Satellite → Signal

GPS Receiver: Trilateration → NMEA Processing → NMEA Data → NMEA Parser → Raw GPS Data

Microcontroller

Historical GPS data

RNN ML Model → Estimated Error

Signal Processing → Signal Characteristics Data → Signal Confidence Monitor → Environment Detection Model → Error Correction Computation

Expected GPS → Signal Confidence Monitor → Corrected GPS

Training and Continuous Conditioning Phase
Real Time; Embedded Sytem

Hardware Solution

Positioning and **A**cquisition **T**oolkit for **H**igh **F**requency **I**nertial **N**avigation, **D**ata **E**valuation and **R**esearch
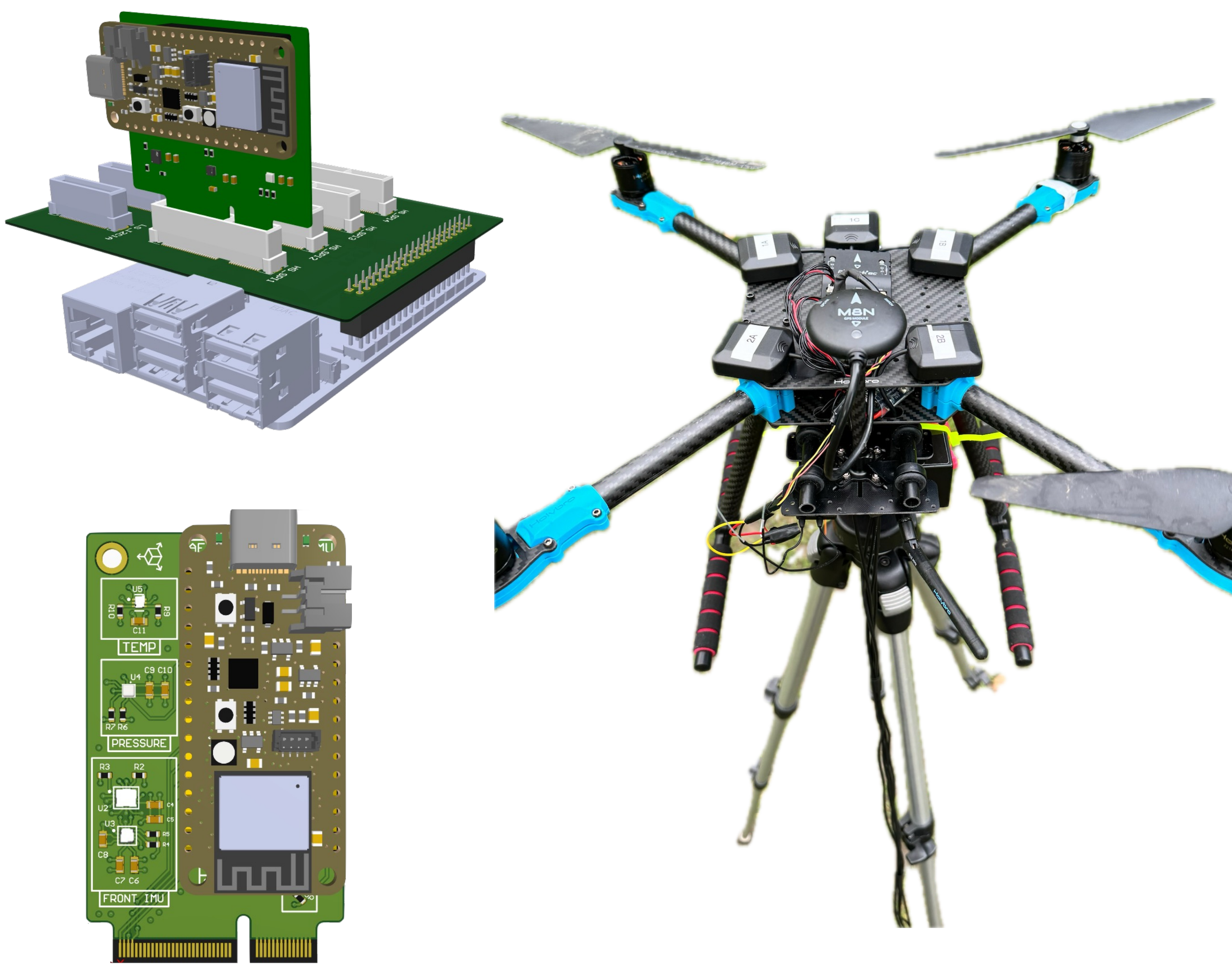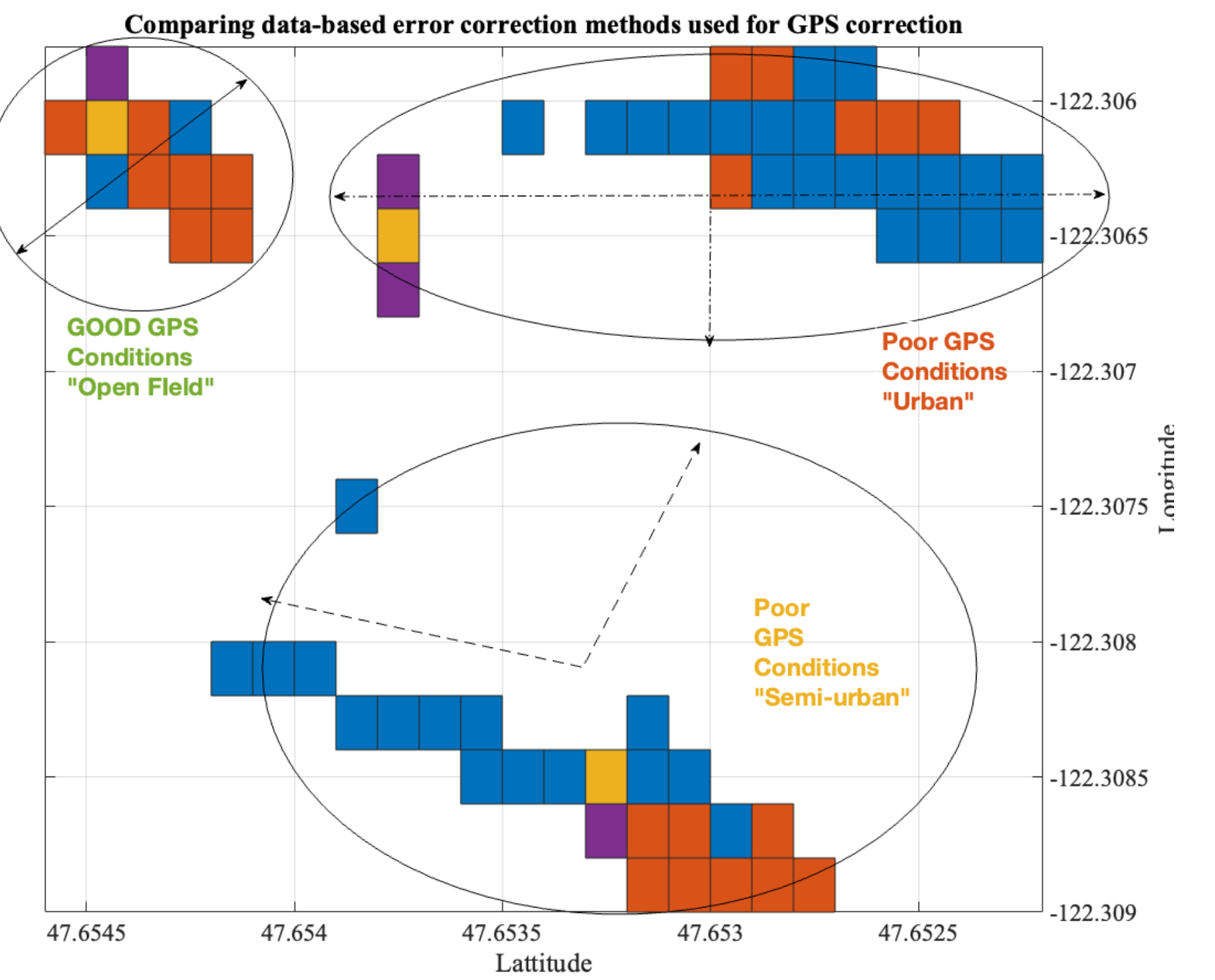

Our Results
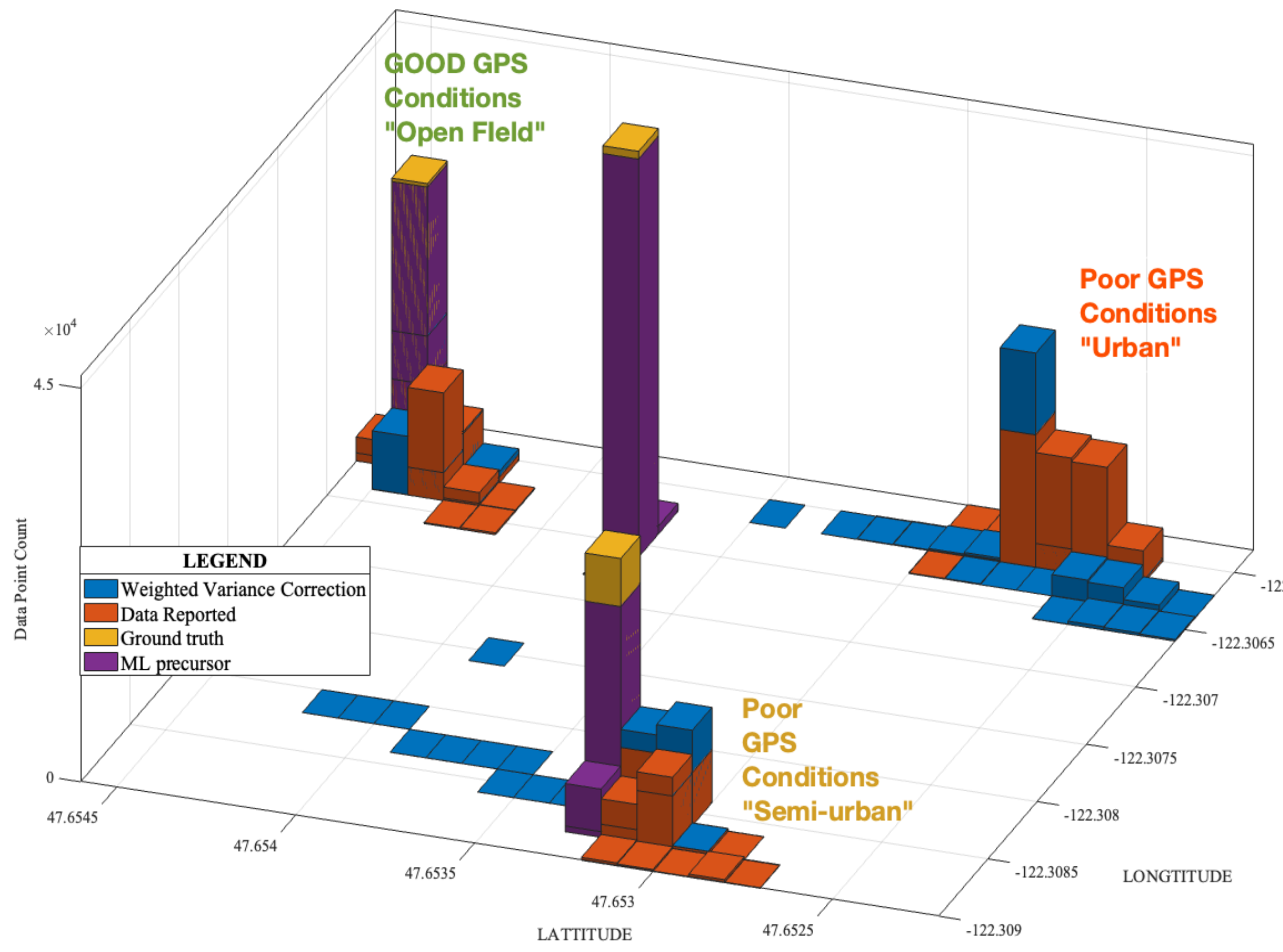
The inverse variance weighting technique is commonly used in industry to estimate GPS positions, focusing on precision rather than accuracy. Our method, compared to this standard approach, improves both precision and accuracy, offering a more comprehensive solution.

GOOD GPS Conditions "Open Field"
Poor GPS Conditions "Urban"
Poor GPS Conditions "Semi-urban"

LEGEND
- Weighted Variance Correction
- Data Reported
- Ground truth
- ML precursor

Ongoing research endeavors aim to elucidate the underlying mechanisms and to explore avenues for the development of further real-time mitigation strategies.

Our study demonstrates that the performance of the LSTM RNN model exhibits enhancement. . The nominal residual error in **raw data stands at 200 meters**. However, our proposed model has successfully **reduced this error to under 1** meter in semi-urban locales, achieving comparable outcomes in urban settings as well.

Analyzing the distribution of reported data and the ellipticity of their spread holds promise for classifying the operational environment of GPS receivers.

Such classification facilitates the real-time application of environment-specific corrective measures to enhance GPS position accuracy.

Comparing data-based error correction methods used for GPS correction

GOOD GPS Conditions "Open Field"
Poor GPS Conditions "Urban"
Poor GPS Conditions "Semi-urban"

OUR STARTUP : FUSIONFLIGHT

amazon

BOEING