

Low-Cost Strapdown Stellar-Inertial Positioning for High-Altitude Platforms

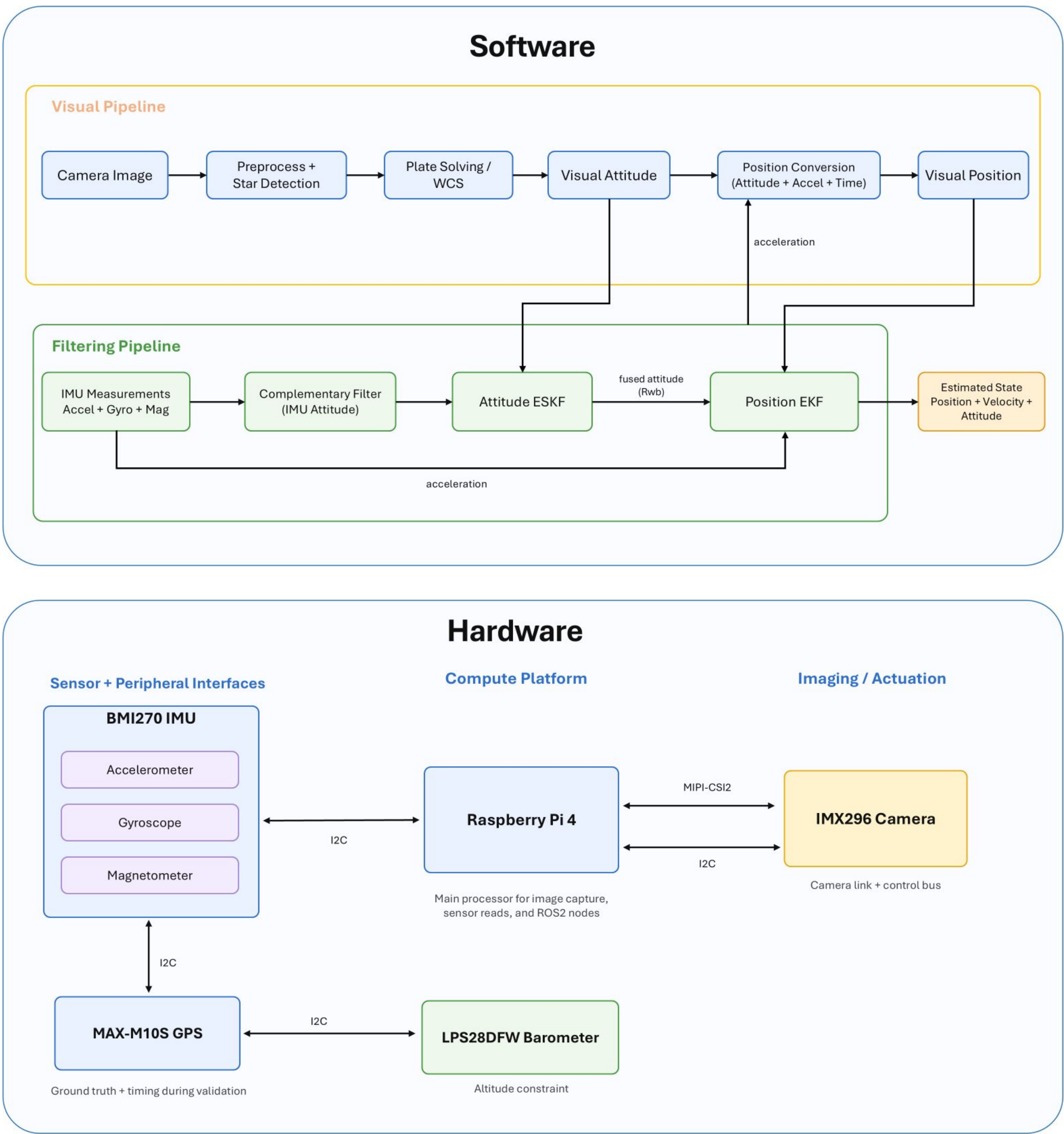
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18-500 Capstone Design, Spring 2026
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Product Pitch

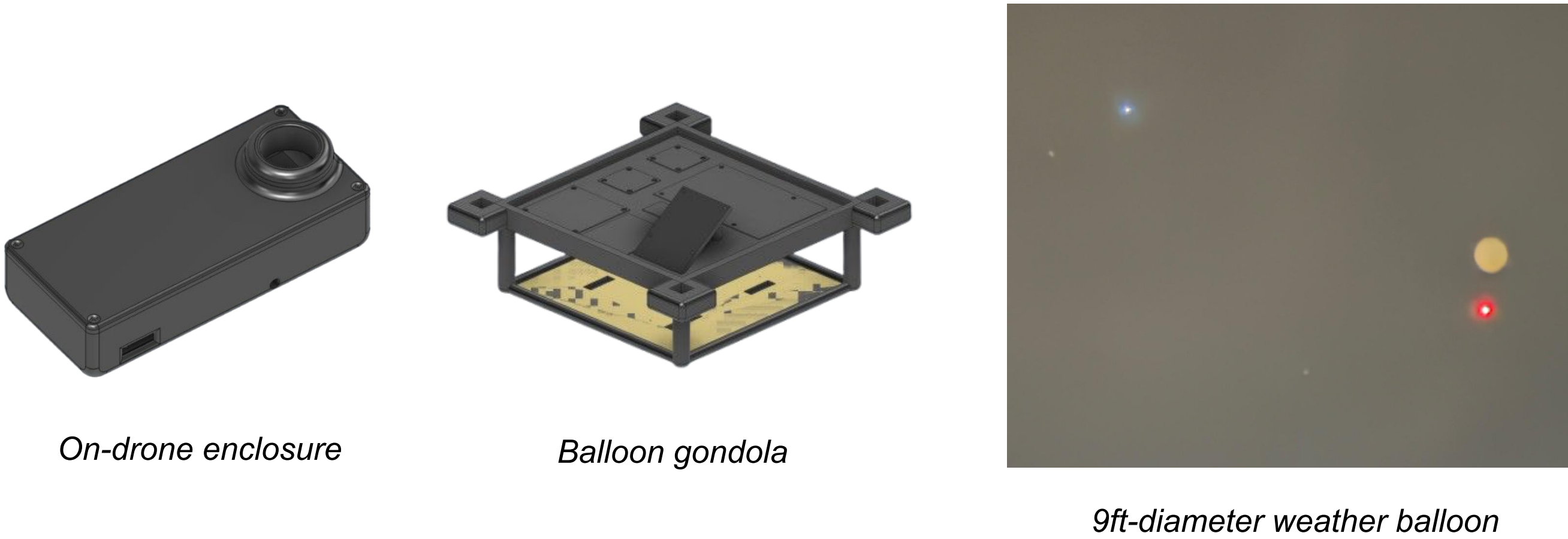
GNSS-denied UAV navigation has matured rapidly, but most proven techniques degrade or fail at night: visual odometry loses features, terrain matching needs daylight imagery, and pure inertial navigation drifts unboundedly. Celestial positioning has guided high-altitude and spaceborne platforms since the first star tracker in 1959, but legacy systems rely on gimbaled optics too heavy and expensive for small UAVs.

We present a low-cost, strapdown stellar-inertial positioning module that fuses intermittent star fixes with IMU propagation to deliver <3km positioning, an improvement over prior work, at under 300g and \$300 improving nighttime GNSS-denied navigation to long-endurance fixed-wing and balloon platforms previously priced out of celestial navigation.

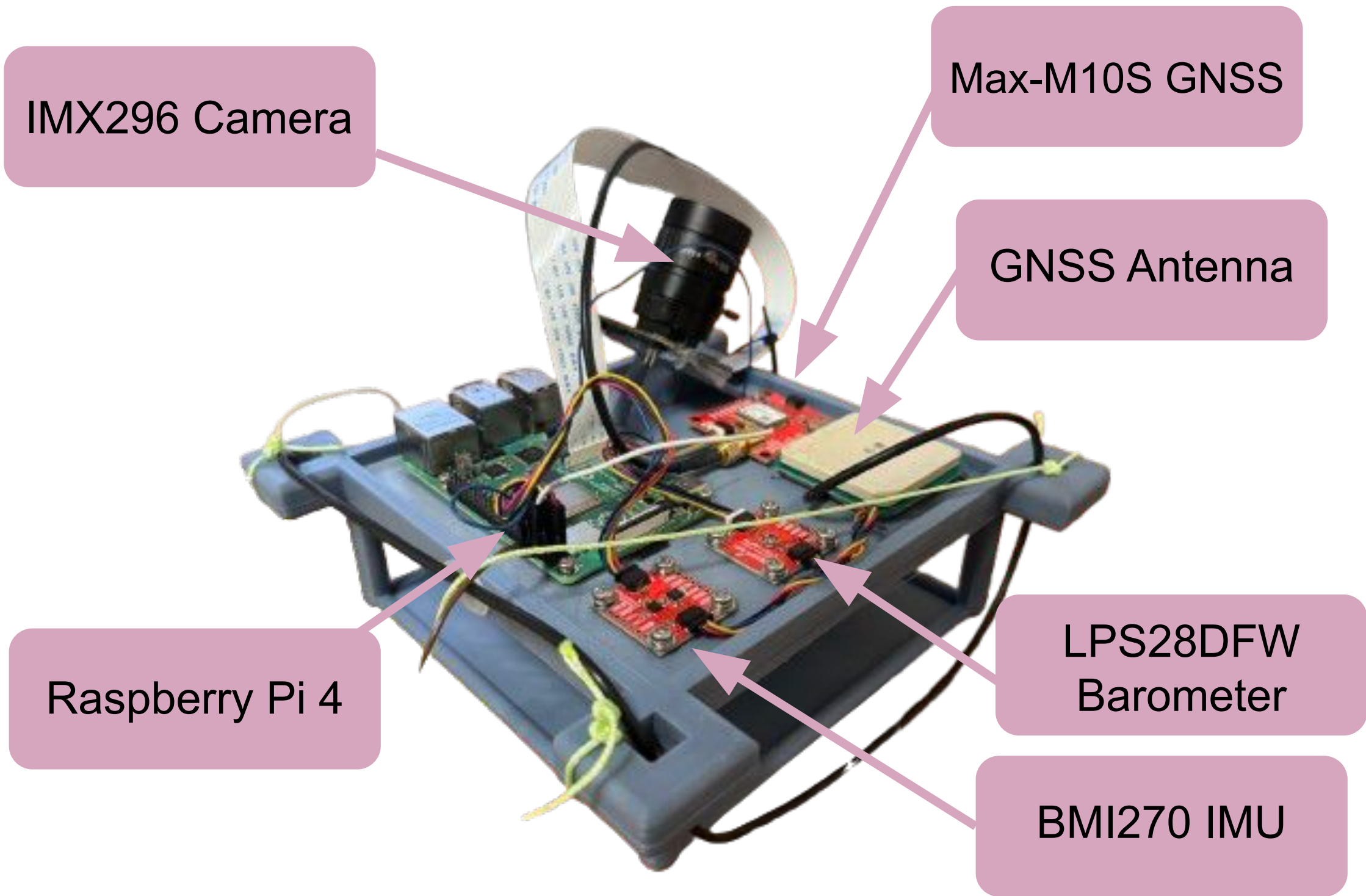
System Architecture



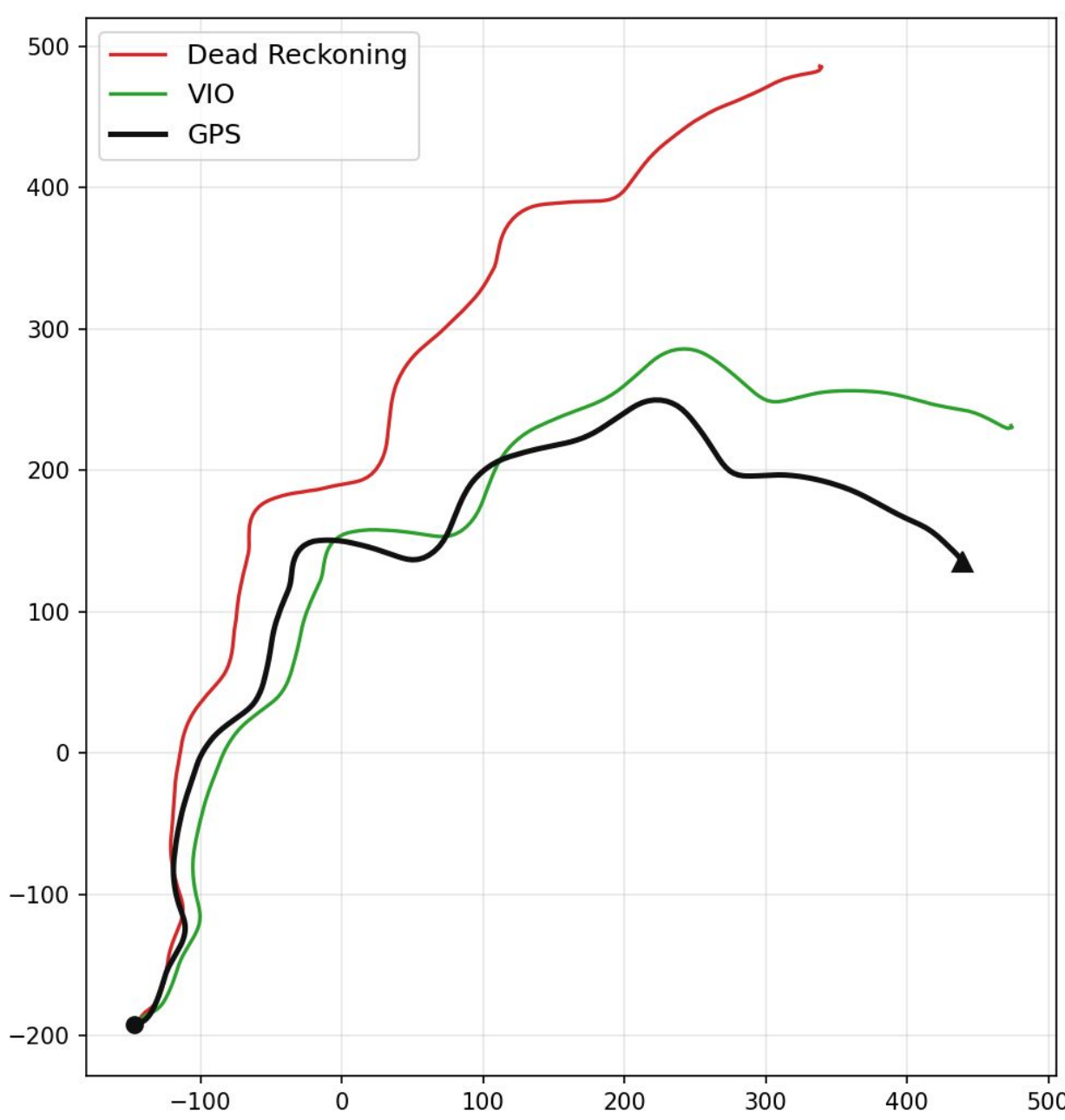
Hardware Design



System Description

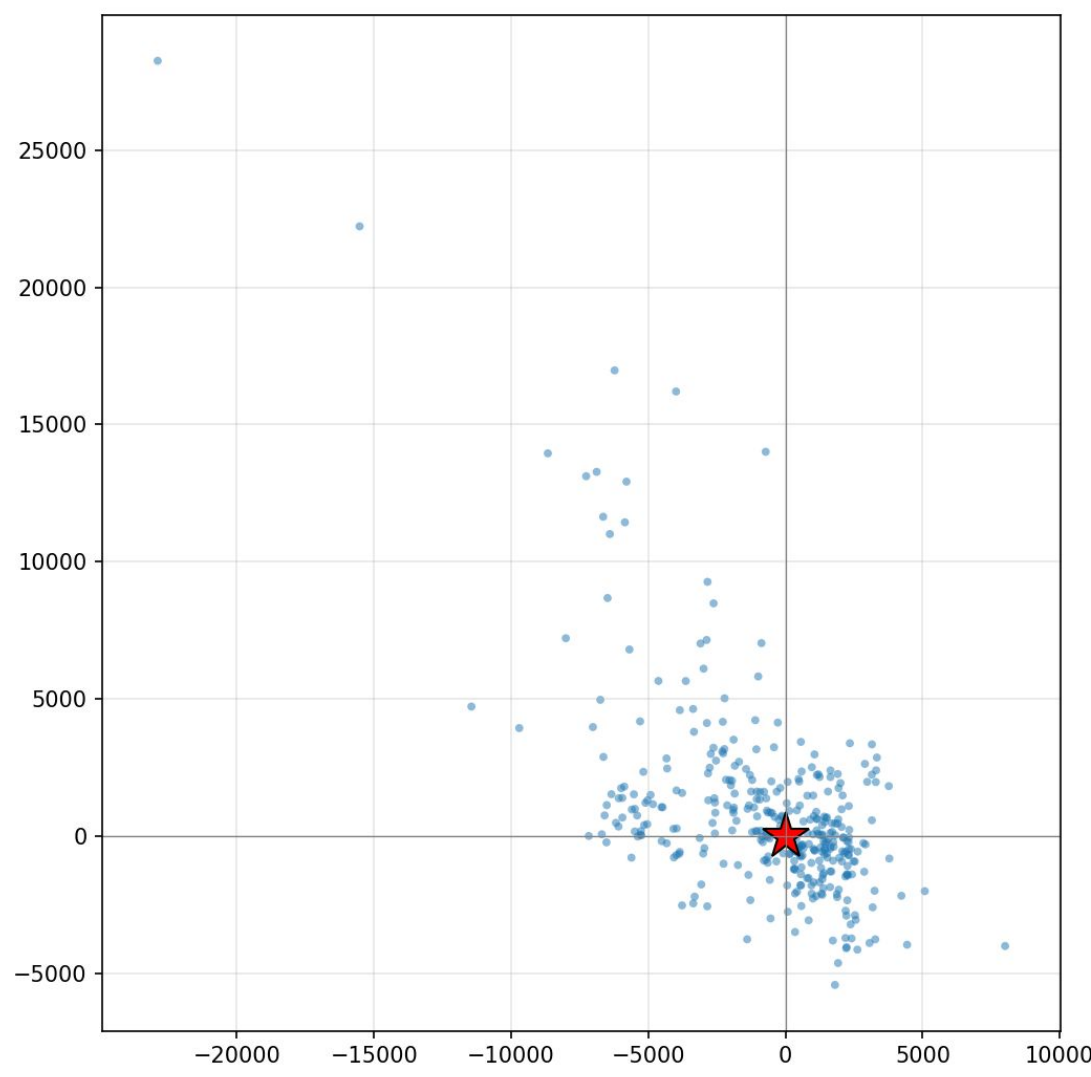


System Evaluation



Stellar-inertial and dead reckoning trajectories against GPS course on moving vehicle test

	IMU + Barometer	VIO + IMU + Barometer
Final Trajectory Error	360.4m	105m
Final Heading Error	52.4°	19.2°



Static test on a tripod global positioning accuracy test in San Jose, CA

	Median	p95	Requirement
Static Global Positioning Error	2.1km	6.5km	10km

Component	Requirement	Achieved
Power Draw	5W	2.23W
Per-Image Compute Latency	1000ms	3ms
Time Synchronization	50ms	500us
Calibration	0.5px	0.32px

System power efficiency, accuracy, compute latency verification