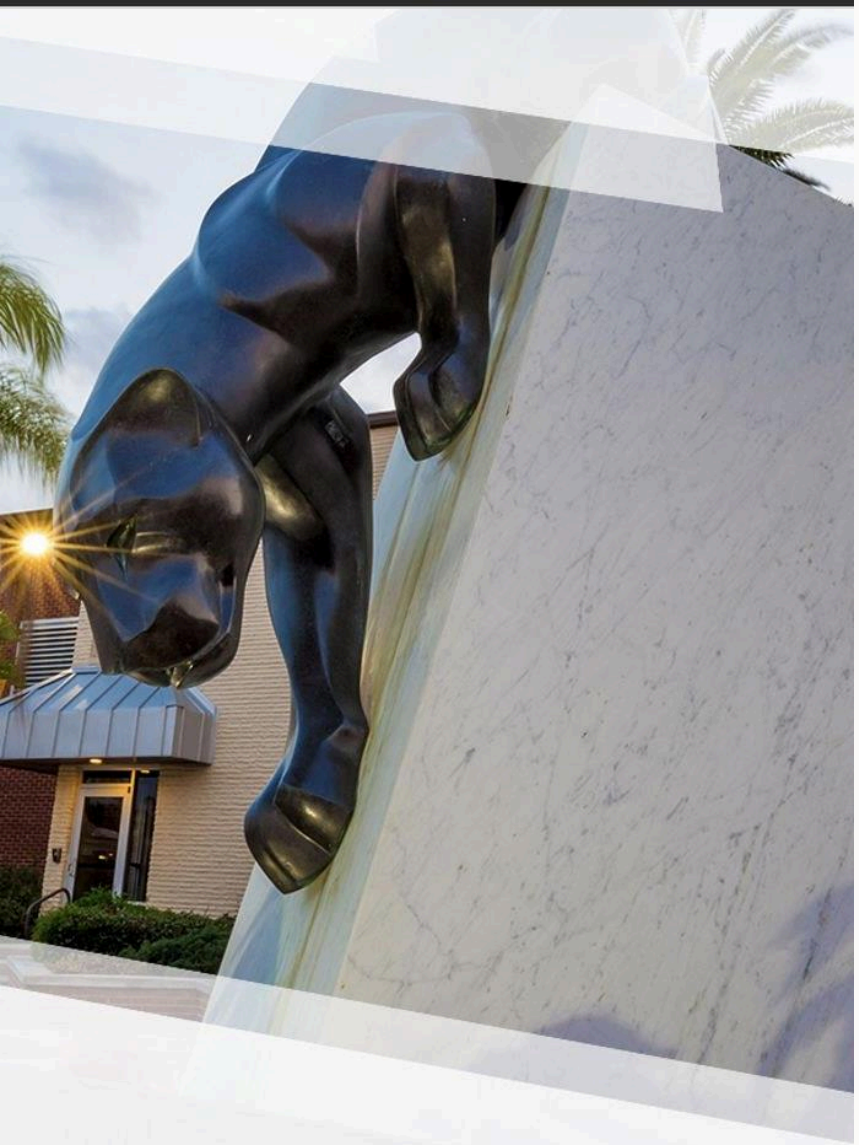


MILESTONE 2 PROGRESS PRESENTATION

S.H.I.E.L.D.

System for High Integrity Elimination of Low-Altitude Drones

Bryson Noble, Avionics & Software Lead (SWE)

Faculty Advisor: Dr. Madhur Tiwari · Client: Dr. Firat Irmak

October 2026

FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

Milestone 2 Progress

Task	Status	Remaining
Test the pipeline and model on Orin Nano	25%	Waiting on SD card; then flash JetPack and benchmark
Refine model and begin final training	40%	Merge new datasets; train YOLO26s on AI.Panther
Add moving targets to the STE test library	Done	None
Continue development on GCS	40%	Land / shut-down modes, heartbeat, drone link
Stereo-camera target ranging (added)	Done	None
Avionics wiring schematics (added)	Done	None
Avionics trade studies & cost breakdown (added)	Done	Finalize stereo camera and RC receiver

Moving Targets in the Test Harness

- Test scripts spawn drones that fly from a start point to an end point at a set speed.
- The autopilot drives the drone pack's own physics, so drones pitch, bank and yaw like real aircraft, with acceleration capped at 4 m/s^2.
- New **AVS_Tracking_Test**: three drones in parallel lanes keep one track ID each; drones approaching from 20 m to 1 m stay reported.
- New **AVS_Edge_Case_Test**: drones half outside each frame edge, at 0.5 m, and flying in from out of frame.
- Detection range sweep extended to night scenes and two more airframes.

31

STE test cases across 8 test scripts (27 at M1)

30 / 31

passing. The one failure is the small Toad airframe at 20 m, a model-accuracy gap for the AI.Panther retrain.

Test Plan Status

THIS MILESTONE

4 test cases scripted

T-04, T-05, T-06 and T-10 now run automatically, using the new moving targets.

NEXT MILESTONE

Hardware runs

The same scripts move to the Jetson Orin Nano. No requirement closes until it passes there.

Test case	Status
T-01 Range sweep detection	Scripted
T-02 Detection latency under load	Scripted
T-03 Autonomous detection	Scripted
T-04 Environment & airframe variety	**Scripted (M2)**
T-05 Multi-target track identity	**Scripted (M2)**
T-06 Confidence on approach	**Scripted (M2)**
T-07 Engage and Abort commands	Placeholder, M3
T-08 GCS heartbeat rate	Placeholder, M3
T-09 Non-drone decoy	Moved to M3
T-10 Frame edge & close range	**Scripted (M2)**
T-11 Video link loss	Planned, M3
T-12 Target lost mid-track	Moved to M3
T-13 Invalid operator commands	Planned, M3

Bugs the New Tests Caught

Fixed

Kalman tracks started at (0,0)

Every new track reported position (0,0) and slid toward the target over ~10 frames, overshooting on the way. The filter now starts from the first detection, so a track reports its true position from its first frame.

Fixed

Several track IDs on one drone

The detector drew looser nested boxes around a drone near the frame edge or at mid range, and ByteTrack gave each its own ID. Nested same-class boxes are now dropped before tracking, independent of the model.

After both fixes, AVS_Tracking_Test and every frame-edge and close-range check pass.

Forward Depth Detection

Criteria	Wt.	Size Learning While Tracking		Fixed-size Box Ranging		YOLO26n-depth Drone-trained		Stock Depthnet		Stock YOLO26s-depth		Stock Depth Anything V2		Stereo Pair, Template Match		Stereo Pair, Dual Detection		Depth Camera, Template Match		Depth Camera, Depth Image	
		R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W
Accuracy	25%	2	.50	2	.50	3	.75	0	.00	0	.00	0	.00	4	1.00	3	.75	4	1.00	3	.75
Tail Robustness	15%	1	.15	1	.15	3	.45	0	.00	0	.00	0	.00	4	.60	2	.30	4	.60	3	.45
Airframe-agnostic	15%	3	.45	0	.00	0	.00	0	.00	0	.00	0	.00	4	.60	4	.60	4	.60	4	.60
Compute Cost	15%	4	.60	4	.60	1	.15	2	.30	1	.15	0	.00	4	.60	2	.30	4	.60	4	.60
Hardware/SWaP	10%	4	.40	4	.40	4	.40	4	.40	4	.40	4	.40	1	.10	1	.10	2	.20	2	.20
Operational Fit	10%	1	.10	3	.30	1	.10	3	.30	3	.30	3	.30	2	.20	2	.20	3	.30	3	.30
Evidence Strength	10%	2	.20	3	.30	0	.00	2	.20	2	.20	2	.20	1	.10	2	.20	2	.20	2	.20
Total	**100%**		**2.40**		**2.25**		**1.85**		**1.20**		**1.05**		**0.90**		**3.20**		**2.45**		**3.50**		**3.10**

R = rating (0–4), W = weighted. Rating scale: 0 Unsatisfactory · 1 Just Tolerable · 2 Adequate · 3 Good · 4 Very Good.

Stereo Target Ranging

RANGE FROM DISPARITY

$$Z = f \cdot B / d$$

Z = distance to target · f = focal length (~2322 px on the IMX219-83) · B = stereo baseline · d = disparity in px

POSITION IN THE DRONE'S FRAME

$$X = (u - c_x)Z / f_x \cdot Y = (v - c_y)Z / f_y$$

u, v = target pixel from YOLO · c = image center

Each tracked box is matched along the same rows of the right image (normalized cross-correlation, sub-pixel peak). The Unity virtual camera now renders a rectified stereo pair, so this runs fully in emulation.

0.6%
median range error (99.4% median accuracy)

0.27 ms
added processing per frame

~14 ms
to deliver a stereo frame from Unity

5–6%
median error at the extremes: under 2 m and beyond 25 m

[1] https://www.pishop.us/product/imx219-83-stereo-camera-8mp-binocular-camera-module-depth-vision/

Indoor/Outdoor Altitude

Key Criteria	Importance	Barometer (datum)	Camera w/ Depthnet	Micro LiDAR	GPS Module
Indoor Accuracy	5	datum	–	+	–
Outdoor Accuracy	5	datum	–	S	–
Compute Cost	2	datum	–	S	S
Size	4	datum	–	–	–
Mass	4	datum	–	–	–
Cost	2	datum	–	–	–
		Sum of Positives	0	1	0
		Sum of Negatives	6	3	5
		Sum of Sames	0	2	1
		Weighted Sum of Positives	0	5	0
		Weighted Sum of Negatives	22	10	20
		Total	**−22**	**−5**	**−20**

Compared with the barometer: + better · S same · – worse. Weighted sums use the importance rating.

RESULT

A downward-facing micro LiDAR is the only option that is accurate indoors, where test flights happen.

Micro LiDAR Modules

Criteria	Wt.	TFmini-S		TFmini Plus		Garmin LIDAR-Lite v4	
		Rating	Weighted	Rating	Weighted	Rating	Weighted
Max operating range	10%	4	0.40	4	0.40	4	0.40
Accuracy	15%	3	0.45	3	0.45	3	0.45
Update rate	10%	3	0.30	4	0.40	4	0.40
Size	25%	4	1.00	3	0.75	2	0.50
Mass	25%	4	1.00	3	0.75	2	0.50
Cost	15%	4	0.60	3	0.45	4	0.60
Total	**100%**		**3.75**		**3.20**		**2.85**

Rating scale: 0 Unsatisfactory · 1 Just Tolerable · 2 Adequate · 3 Good · 4 Very Good. Weighted = rating × weight.

DECISION

TFmini-S selected: smallest, lightest and cheapest, with range to spare for indoor flights.

[2] https://www.sparkfun.com/tfmini-s-micro-lidar-module.html
[3] https://www.sparkfun.com/tfmini-plus-micro-lidar-module.html
[4] https://www.sparkfun.com/garmin-lidar-lite-v4-led-distance-measurement-sensor.html

Flight Controller Comparison

Criteria	Wt.	Pixhawk 4		Pixhawk 6C Mini		Kakute H7 V1.5		Matek H743	
		Rating	Wtd.	Rating	Wtd.	Rating	Wtd.	Rating	Wtd.
PX4 Support	20%	4	0.80	4	0.80	4	0.80	1	0.20
Jetson Integration	15%	4	0.60	4	0.60	3	0.45	2	0.30
Sensor Capability	15%	4	0.60	4	0.60	3	0.45	3	0.45
Size	20%	1	0.20	2	0.40	4	0.80	4	0.80
Mass	20%	2	0.40	1	0.20	4	0.80	4	0.80
Cost	10%	2	0.20	1	0.10	3	0.30	3	0.30
Total	**100%**		**2.80**		**2.70**		**3.60**		**2.85**

Rating scale: 0 Unsatisfactory · 1 Just Tolerable · 2 Adequate · 3 Good · 4 Very Good. Weighted = rating × weight.

DECISION

Kakute H7 selected: full PX4 support in a far smaller, lighter board.

[5] https://docs.px4.io/main/en/flight_controller/pixhawk4
[6] https://docs.px4.io/main/en/flight_controller/pixhawk6c_mini
[7] https://holybro.com/products/kakute-h7
[8] https://www.mateksys.com/?portfolio=h743-slim-v4

Orin Nano Carrier Board

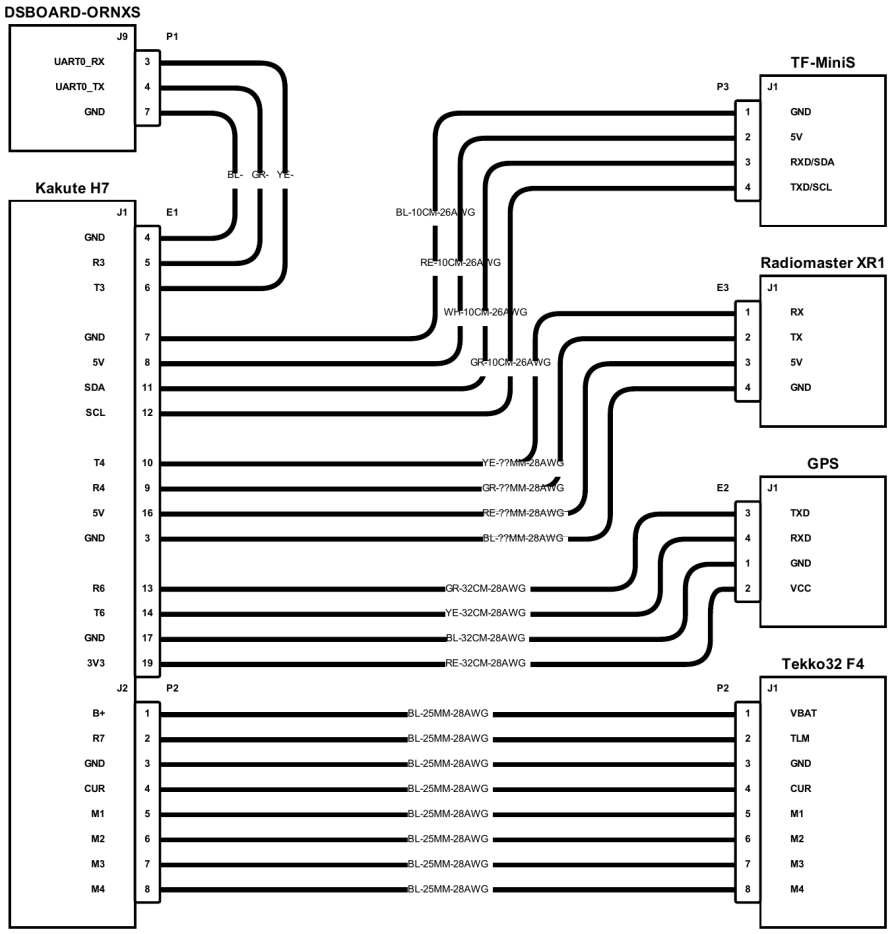
	Orin Nano Dev Kit	DSBOARD-ORNXS	Difference
Length (mm)	103	91	−12
Width (mm)	90.5	60.5	−30
Height (mm)	34.8	29.9	−4.9
Total Mass (g)	175	125	**−50**
Additional Cost ($)	0	246	+246

RESULT

The Forecr DSBOARD-ORNXS cuts 50 g and a third of the footprint for $246. The HSDC confirmed swapping the carrier board does not risk the Orin.

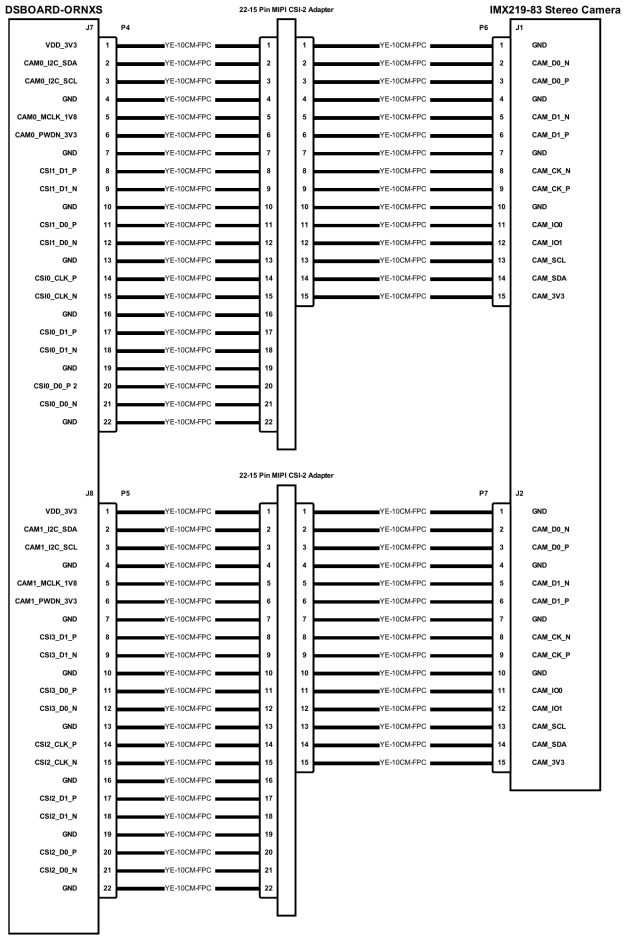
[9] https://www.forecr.io/blogs/connectivity/dsboard-ornxs-overview-and-connector-definitions

Flight Controller Wiring



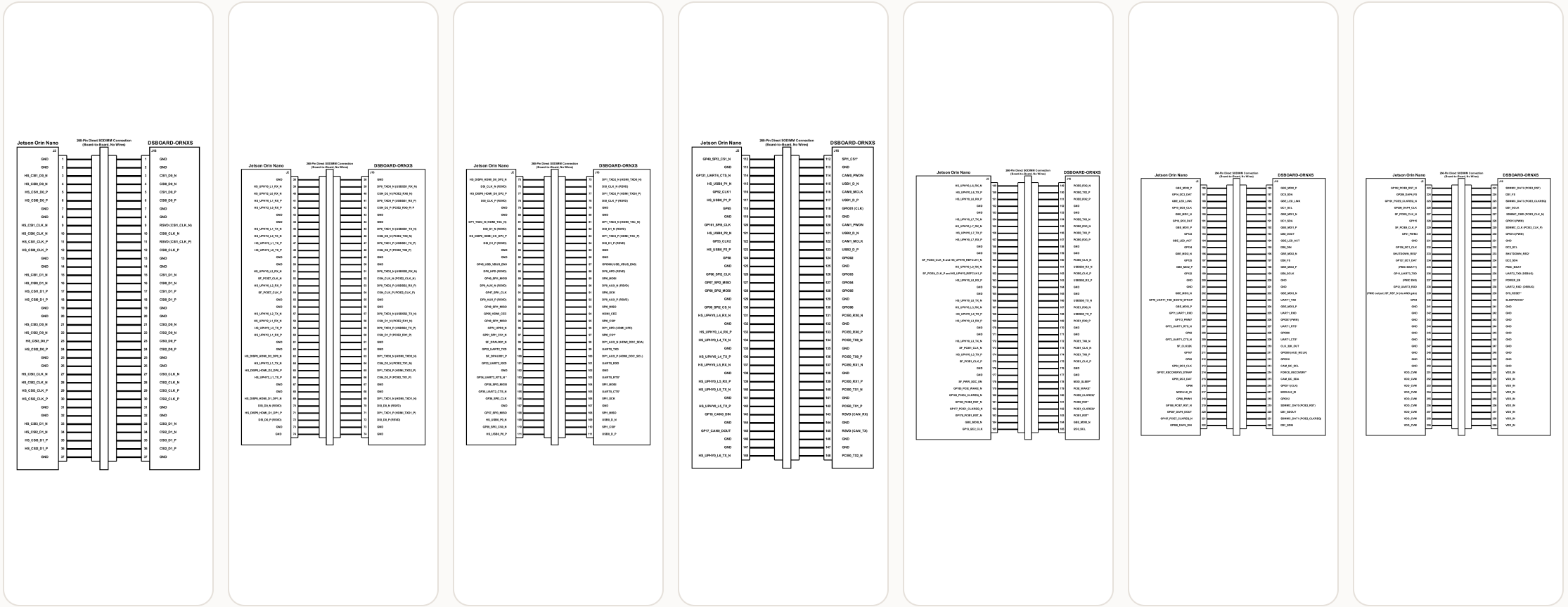
- Kakute H7 to the DSBOARD-ORNXS (Orin carrier) over UART3.
- TFmini-S LiDAR on I^2C; RadioMaster XR1 receiver on UART4; GPS on UART6.
- Tekko32 F4 ESC: battery, telemetry, current sense and motors M1–M4.
- Wire colors, gauges and lengths specified per run.

Carrier Board to Stereo Camera



- DSBOARD-ORNXS CSI connectors to the IMX219-83 stereo camera through 22-to-15-pin MIPI CSI-2 adapters.
- Orin and DSBOARD CSI pinouts checked against each other, so the camera connects without custom wiring.

Orin Nano to Carrier Board



Full 260-pin SO-DIMM mapping from the Jetson Orin Nano to the DSBOARD-ORNXS, across seven sheets.

Orin Nano Bring-Up

Item	Status
Orin Nano checked out from HSDC	Yes
All peripherals	Yes
DisplayPort cable	Yes
First power-on	Yes
128 GB SD card	**On order**
OS (JetPack) installed	No
Ethernet cable	No
Test harness updated for hardware	No

Blocked

Waiting on the SD card

JetPack goes on as soon as it arrives. Then the same pipeline that passes in emulation runs on the Orin.

Ready

Setup script

setup.bat now installs CUDA PyTorch whenever an NVIDIA GPU is present.

AVS Cost Breakdown

Item	Description	Item Cost	Actual Cost
Edge Computer	NVIDIA Jetson Orin Nano	$399.00	$0.00
Camera	Waveshare IMX219-83 Stereo Camera	$76.08	$76.08
Carrier Board	Forecr DSBOARD-ORNXS	$246.00	$246.00
Flight Controller & ESC	Kakute H7 v1.5 stack with Tekko32 F4	$184.43	$184.43
LiDAR Module	TFmini-S	$43.98	$43.98
Storage	SanDisk Micro SD (160 MB/s)	$42.00	$42.00
GPS / Remote ID	NewBeeDrone BeeID V1.1 M10Q	$46.98	$46.98
RC Receiver	RadioMaster XR1	$21.99	$21.99
RC Transmitter	RadioMaster TX15	$175.99	$0.00
Total		**$1,236.45**	**$661.46**

NOTE

Item cost includes shipping. Actual cost is $0 for items the team already has: the Orin Nano and RC transmitter.

Training Data

COMBINED SET

9,738

images, two classes (drone, balloon): two Kaggle drone sets, a Kaggle balloon set and 2,000 Unity synthetic frames.

DOWNLOADED

93,483

more drone images: Seraphim (83,483) and DUT Anti-UAV (10,000). Seraphim already includes the Kaggle sets, so it is merged without train/val overlap.

COMPUTE

AI.Panther approved

HPC access sponsored by Dr. Irmak. Final YOLO26s run at batch size 64, which my GTX 1660 cannot fit.

Technical Challenges

Resolved

Training compute

AI.Panther access approved. The full training run is next.

Pending

Hardware bring-up

Orin Nano is checked out but cannot boot until the SD card arrives.

Planned, M3

Sustained real-time

Worst-case frame time and thermal throttling over a 6-minute flight must stay under 33.33 ms.

Feedback Incorporated

Client: Dr. Irmak

- Show actual BOM cost (10/16) → **AVS cost breakdown**
- Two disengage modes: land or shut down (9/28) → **GCS, M3**
- Design ready by Nov 15, PDR slides by Nov 16 → **avionics selected, schematics done**
- Include LQR in the PDR report → **GNC subsystem**

Advisor: Dr. Tiwari

No advisor meeting this milestone. Detection and GNC are still developed separately, with the target-state interface to GNC planned for M3.

Milestone 3 Plan (Nov 23)

01

Orin Nano bring-up

Run the pipeline on hardware with the stereo camera; benchmark latency and thermals.

02

Final YOLO26s model

Train on AI.Panther with the full merged dataset; re-run the STE suite.

03

GNC interface

Send relative target position and velocity to GNC at 30 Hz or faster.

04

Manual override

Land Now and Shut Down modes, plus the 1 Hz heartbeat (AVS.05.01).

05

Full traceability

Every AVS requirement traced to an automated STE test.

06

End-to-end demo

Detection, tracking, ranging and GCS control together in emulation.

Questions?

brysonnoble.github.io/SHIELD