System for High Integrity Elimination of Low-Altitude Drones (SHIELD)

Milestone 2 Progress Evaluation

1. Project Title, Team Members

System for High Integrity Elimination of Low-Altitude Drones (SHIELD)

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2. Faculty Advisor

Madhur Tiwari, PhD - mtiwari@fit.edu

3. Client

Firat Irmak, PhD - Aerospace Engineering Department, Florida Institute of Technology

4. Progress of current Milestone

Task	**Completion %**	**Bryson Noble**	**TODO**
Test the pipeline and model on Orin Nano	25%	25%	Flash JetPack once the SD card arrives, run the pipeline on the Orin, and collect latency and thermal data.
Refine the model and begin training the final model	40%	40%	Merge the Seraphim and DUT Anti-UAV sets into the combined dataset, then train YOLO26s at batch size 64 on AI.Panther.
Add moving targets to the STE test library	100%	100%	none
Continue development on GCS	40%	40%	Add Land Now / Shut Down buttons, the 1 Hz heartbeat, and a command link to the drone hardware.
Stereo-camera target ranging (added this milestone)	100%	100%	none
Avionics wiring schematics (added this milestone)	100%	100%	none

Avionics trade studies and AVS cost breakdown (added this milestone)	100%	100%	Finalize the stereo camera and RC receiver choices.

5. Discussion of each accomplished task (and obstacles) for the current Milestone:

- **Test the pipeline…:** The Orin Nano is checked out from the HSDC. I powered it up for the first time and took inventory of the HSDC peripherals, but the OS is not installed yet: I am waiting on the SanDisk Extreme 128 GB SD card it will boot from, so the pipeline has not yet run on the Orin itself. In the meantime I prepared everything I could for bring-up, including checking the Orin and DSBOARD CSI port pinouts against each other so the camera will connect without an adapter. I finalized the avionics hardware with Tharushi: the Forecr DSBOARD-ORNXS carrier board (smaller and lighter than the reference carrier, and Zach confirmed that swapping carrier boards does not risk the Orin), the Holybro Kakute H7 flight controller, and a TFmini-S micro LiDAR for indoor altitude. We are also switching to a stereo camera for depth; the IMX219-83 is the leading candidate, and I am still comparing other options. I also made setup.bat install the CUDA build of PyTorch whenever an NVIDIA GPU is present, so the same setup script works on both my PC and the Orin. The main obstacle is the SD card delay; thermal throttling and tail latency are still the biggest open risks once testing starts.
- **Refine the model…:** I combined four sources into a two-class (drone/balloon) dataset: two Kaggle drone sets, a Kaggle balloon set, and 2,000 synthetic drone images I generated with a Unity data-collector tool I built. The tool randomizes drone placement, camera rotation, and day/night lighting, and computes ground-truth labels automatically. I also downloaded two much larger drone sets, Seraphim (83,483 images) and DUT Anti-UAV (10,000 images), and documented their sources and licenses. Seraphim already contains both Kaggle drone sets, so it has to be merged carefully to avoid the same image appearing in both training and validation. Dr. Irmak sponsored my AI.Panther HPC access, which is now approved, but the final full-dataset training run has not started yet.
- **Add moving targets…:** Test scripts can now spawn drones that fly from a start point to an end point at a set speed. The autopilot drives the drone through the drone pack's own physics, so it pitches and banks realistically instead of sliding. With moving targets I added two new test scripts, AVS_Tracking_Test (no track-ID swaps across three drones in parallel flight; continuous reporting on a 20 m to 1 m approach) and AVS_Edge_Case_Test (drones half outside each frame edge, at 0.5 m, and flying in from out of frame). I also extended the detection range sweep to night scenes and two more airframes. These tests caught two pipeline bugs, which I fixed: every new Kalman track started at (0,0) and slid toward the target, and the detector put duplicate nested boxes on one drone, giving it several track IDs. The STE library is now 8 test scripts and 31 test cases, and 30 of 31 pass. The one failure is a small airframe (Toad) at 20 m, which the current model misses. That is a model accuracy issue and should improve with the AI.Panther training run.
- **Continue development on GCS…:** The GCS shows the live feed with bounding boxes, the target list, and range to each target. Engage is disabled while the selected target's confidence is under the 25% floor (AVS.03), and an engaged target can be aborted. The button to shut down the drone or land immediately, requested by Dr. Irmak on 09/28, is not implemented

yet, and neither is the heartbeat. Engage and abort are UI-only until the command link to the drone hardware exists.

- **Stereo-camera target ranging:** This was not in the original plan. I replaced the monocular depth-model range estimate with stereo ranging. The Unity virtual camera now renders a rectified stereo pair (currently 1920x1200, 61.6° vertical FOV, 20 cm baseline; these will be updated to match the final stereo camera) and returns a stereo frame in ~14 ms. The Python pipeline matches each tracked box in the right image and converts disparity to range and relative position. On the built Unity player, range is within ~2% from 5 to 30 m, which covers the 20 m detection requirement (AVS.01). The 3D relative position is what GNC's guidance law will need.
- **Avionics wiring schematics:** I drew the wiring schematics for the avionics stack: flight controller connections, carrier-board connections (including the stereo camera), and the Orin Nano to DSBOARD-ORNXS pin mapping.
- **Avionics trade studies and cost breakdown:** I ran trade studies for two sensing problems. For altitude, a Pugh matrix comparing a barometer, a depth camera, a micro LiDAR, and GPS favored the micro LiDAR, and a weighted matrix of three LiDAR modules selected the TFmini-S (3.75/4.00) for its size, mass, and cost. For target range, I compared ten forward depth-detection options, from monocular box-size ranging and depth models to stereo pairs and depth cameras. A depth camera with template matching scored highest (3.50), followed by a stereo pair with template matching (3.20); both far outscored the monocular options on accuracy and on working with any airframe. We are going with a stereo camera because dedicated depth cameras such as the OAK-D LR are too expensive, which led to the stereo-ranging work above. I also wrote up the relative-position math (Z = fB/d, then X and Y from the pixel offset). With Tharushi I built the AVS cost breakdown, which answers Dr. Irmak's 10/16 request for actual BOM cost: $1,164.56 estimated in total, $517.27 of it already purchased.

6. Discussion of contribution of each team member to the current Milestone:

- **Bryson Noble:** As the Avionics and Software lead, I am responsible for all targeting and detection software on SHIELD. This milestone I built moving targets into the STE test harness and wrote the new tracking and edge-case test scripts. I also fixed the Kalman and duplicate-box tracking bugs those tests exposed, implemented stereo-camera target ranging, and built the combined training dataset and the Unity synthetic-data tool. I got AI.Panther access approved, finalized the avionics hardware selection with Tharushi Pelendagama, and drew the avionics wiring schematics. I also ran the altitude, LiDAR, and depth-detection trade studies, did the first Orin Nano startup, and built the AVS cost breakdown with Tharushi.

7. Plan for the next Milestone

Task	Bryson Noble
Bring up the pipeline on the Orin Nano ("Hardware" mode) with the selected stereo camera and benchmark it	Implement, run, collect data
Train the final YOLO26s model on AI.Panther with the full combined dataset	Collect data, train, evaluate
Integrate detection/tracking output with GNC guidance (emulation)	Design, implement

Finish GCS manual override: Land Now / Shut Down buttons and heartbeat	Implement, test
Trace all AVS requirements to STE test scripts and run a full end-to-end emulation demo	Implement, test, demo

8. Discussion of each planned task for the next Milestone:

- **Bring up the pipeline…:** Once the SD card arrives, flash the Orin and run the same pipeline that passes in emulation. Measure per-frame inference time against the 33.33 ms limit (AVS.04), sustained FPS, and temperature under load. Then make any changes needed before the Orin is mounted on the drone, after which changes are harder.
- **Train the final model…:** Merge Seraphim and DUT Anti-UAV into the combined dataset without train/validation overlap, then train YOLO26s at batch size 64 on AI.Panther. Re-run the STE suite with the new model, aiming to fix the small-airframe 20 m failure.
- **Integrate…:** Define the interface that passes target state (relative position and velocity from stereo ranging and the Kalman filter) to GNC at 30 Hz or faster, matching GNC.01. Then hand it off to the GNC team's proportional navigation guidance in emulation.
- **Finish GCS manual override…:** Add the two override modes Dr. Irmak asked for (land immediately, or shut down and lose the drone), implement the 1 Hz heartbeat (AVS.05.01), and connect engage/abort to the drone over the telemetry link.
- **Trace requirements…:** Make sure every AVS requirement has an automated STE test, then run detection, tracking, ranging, and GCS control together end to end in emulation as a demo.

9. Date(s) of meeting(s) with Client during the current milestone:

- 10/16/2026
- 10/26/2026

10. Client feedback on the current milestone

- 10/16: Show the total cost (everything included) and the actual cost on the bill of materials at the Monday GSA meeting.
- 10/16: Design must be ready by November 15th; FEA done before November 15th; PDR slides done by the November 16th meeting.
- 10/16: Include LQR in the PDR report.
- 10/16: Find state parks to fly at; flying outdoors depends on getting approval.
- 10/26: This evaluation is due one hour after the 10/26 meeting, so feedback from that meeting is not included here and will not be added to the signed copy.

11. Date(s) of meeting(s) with Faculty Advisor during the current milestone:

- None during this milestone.

12. Faculty Advisor feedback on the current milestone

- N/A, no Faculty Advisor meeting during this milestone.

Signature: _____ Date: _____

13. Evaluation by Faculty Advisor

- Faculty Advisor: detach and return this page to Dr. Chan (HC 209) or email the scores to pkc@cs.fit.edu
- Score (0-10) for each member: circle a score (or circle two adjacent scores for .25 or write down a real number between 0 and 10)

Bryson Noble	0	1	2	3	4	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10

Signature: _____ Date: _____