

Preliminary Design Deliverable

Target Acquired

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Project Objective

The ASE Design Team and Austin Fire Department need a software able to recognize targets of interest, discern between critical/non-critical targets, and deliver accurate GPS coordinates within a generated map.

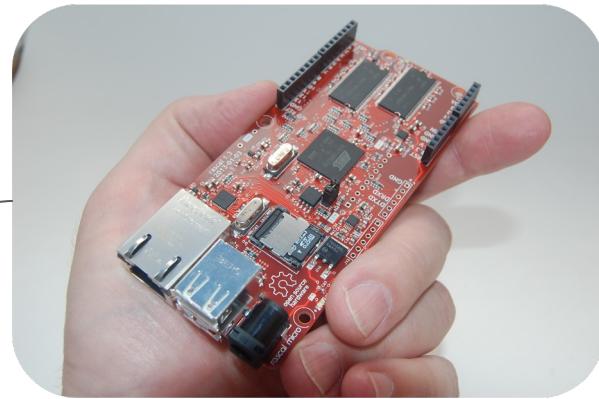
- **Guaranteed Deliverables**
 - Image recognition software able to recognize and classify TOI's
 - Targets of Interests' GPS location & classification (CAT/CRT)
 - Generated map of area of interest
- **Stretch Goals**
 - An interactive map with that is paired with the respective GPS coordinates
 - Image recognition software that can identify human emotion rather than just our preset TOI's
 - A more efficient algorithm that improves on accuracy and required search time
 - An algorithm that is capable of identifying targets on more complex terrain

Hardware Design Considerations

Camera



Co-processor



Connection to rest
of the UAV

Camera: Topotek 10x zoom



Specifications

- Dimensions: 63mm×37mm×45mm
- Weight: 122 g
- Output: HD 1080p via HDMI
- 3M pixels at 30 fps
- Can zoom up to 10x

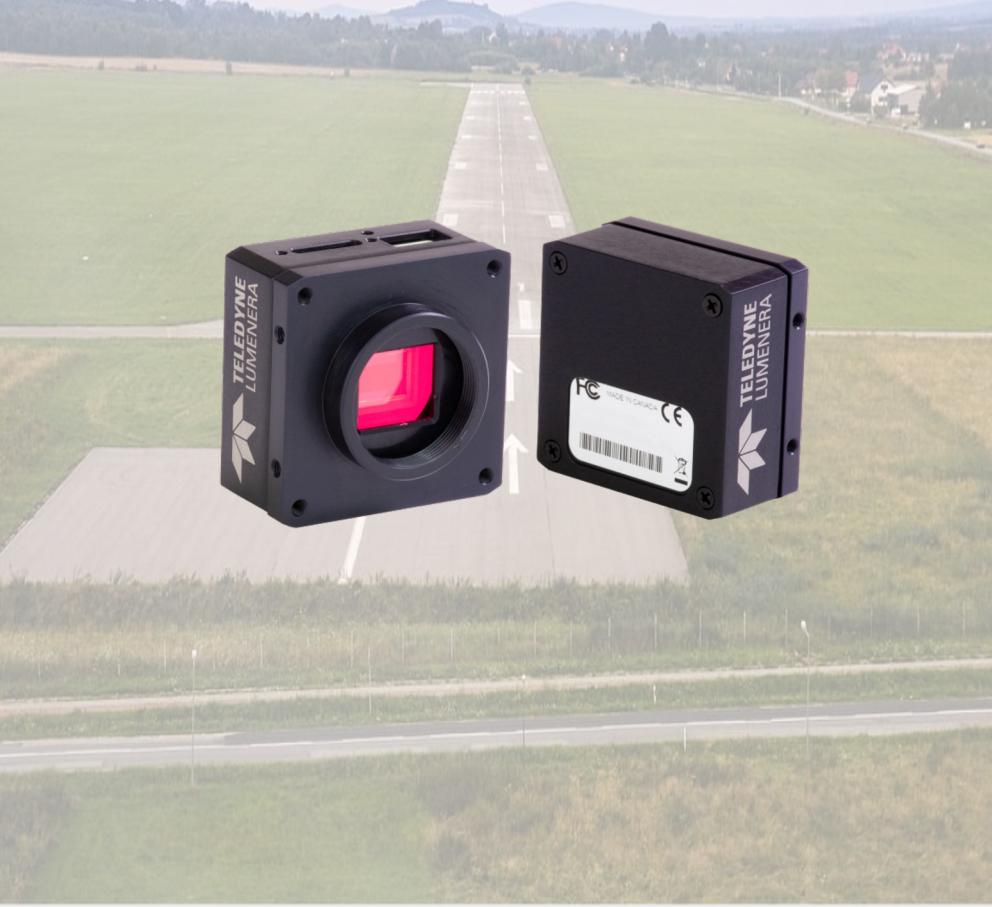
Pros

- Has been used on previous flights, so we know it can work

Cons

- Poor documentation, most of which is in Chinese
- Heavy

Camera: Lumenera Lt-C/M2020



Specifications

- Dimensions: 36.1x45x45mm
- Weight: 88 g
- Camera: 5.1Mp at up to 35 fps
- Output: USB 3.1

Pros

- Light
- Small
- 5.1 Mp is enough from research
- USB 3.1 transfers up to 5.1 Gb/s

Cons

- Untested camera
- Not sure if it can capture video

Criteria Check: Camera

Design 1: Topotek 10x Zoom

| Criteria | Criteria Satisfied? |
|---|-------------------------------------|
| Quantity of HDMI and/or USB outputs (1) | <input checked="" type="checkbox"/> |
| Operating Resolution Range (5 Mpx) | <input type="checkbox"/> |
| Frame Capture Rate (20 fps) | <input checked="" type="checkbox"/> |
| Field of Vision | ? |
| Total Weight | <input checked="" type="checkbox"/> |
| Physical Length Dimensions | <input checked="" type="checkbox"/> |
| Available Documentation | <input type="checkbox"/> |

Design 2: Lumenera Lt-C/M2020

| Criteria | Criteria Satisfied? |
|---|-------------------------------------|
| Quantity of HDMI and/or USB outputs (1) | <input checked="" type="checkbox"/> |
| Operating Resolution (5 Mpx) | <input checked="" type="checkbox"/> |
| Frame Capture Rate (20 fps) | <input checked="" type="checkbox"/> |
| Field of Vision (TBR) | ? |
| Total Weight | <input checked="" type="checkbox"/> |
| Physical Length Dimensions | <input checked="" type="checkbox"/> |
| Available Documentation | <input checked="" type="checkbox"/> |

Co-processor: Raspberry Pi Model 4



Specifications

- Dimensions: 85x49x20mm
- Weight: 46 g
- Processing Rate: 2.4 Ghz
- RAM: 4 GB

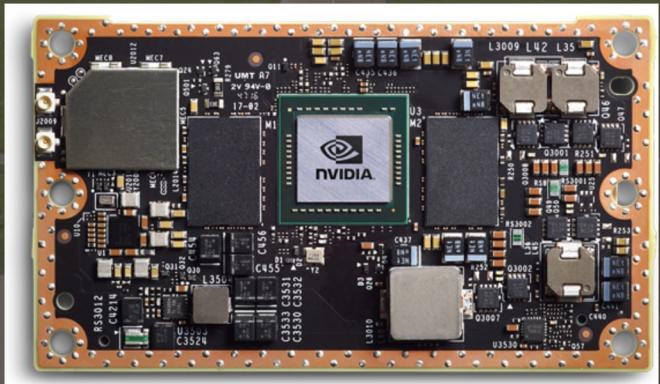
Cons

- Not meant for heavy computations

Pros

- Plenty of documentation
- Light
- Sufficient processing/RAM

Co-processor: Jetson TX2



Specifications

- Dimensions: 50x90x20mm
- Weight: 85 g
- Processing Rate: 6 CPUs and a GPU
- RAM: 8 GB
- 32 GB storage

Cons

- Heavy
- Expensive
- High power draw

Pros

- Highly optimized for machine learning
- Has been used by a team member on UAVs before

Criteria Check: Co-Processor

Design 1: Raspberry Pi Model 4

| Criteria | Criteria Satisfied? |
|--|-------------------------------------|
| Power Supply Voltage (5 V) | <input checked="" type="checkbox"/> |
| Compatible with USB and/or HDMI connection | <input checked="" type="checkbox"/> |
| Transmission Speed to/from autopilot | ? |
| CPU Frequency (Clock Time) (1 GHz) | <input checked="" type="checkbox"/> |
| CPU RAM (4 GB) | <input checked="" type="checkbox"/> |
| Total Weight | <input checked="" type="checkbox"/> |
| Physical Length Dimensions | <input checked="" type="checkbox"/> |
| Available Documentation | <input checked="" type="checkbox"/> |

Design 2: Jetson TX2

| Criteria | Criteria Satisfied? |
|--|-------------------------------------|
| Power Supply Voltage (5 V) | <input type="checkbox"/> |
| Compatible with USB and/or HDMI connection | <input checked="" type="checkbox"/> |
| Transmission Speed to/from autopilot | ? |
| CPU Frequency (Clock Time) (1 GHz) | <input checked="" type="checkbox"/> |
| CPU RAM (4 GB) | <input checked="" type="checkbox"/> |
| Total Weight | <input checked="" type="checkbox"/> |
| Physical Length Dimensions | <input checked="" type="checkbox"/> |
| Available Documentation | <input checked="" type="checkbox"/> |

Automatic Target Recognition Software: OpenCV

Haar Cascades

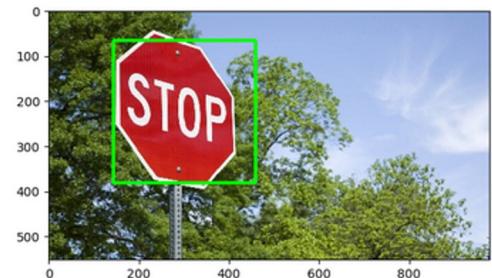
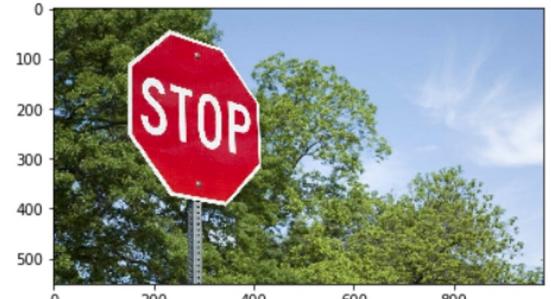
- Classifiers that are an effective way to detect objects in images
- *Rapid Object Detection using a Boosted Cascade of Simple Features* by Paul Viola and Michael Jones (2001)
- Uses a machine learning-based approach where positive and negative images are used to train the algorithm.

Advantages

- Fast
- Computationally inexpensive

Disadvantages

- Prone to false positives
- Not as accurate as modern algorithms



Automatic Target Recognition Software: OpenMV

Advantages

1. Integrated camera -> fast latency of high definition images
2. Small and lightweight
3. Pre built IDE easy to customize and train on object of interest

Disadvantages

1. Camera resolution & zoom not desirable
2. ASE team would have to modify aircraft design to accommodate a camera + coprocessor combo



Automatic Target Recognition Software: RGB Based Recognition

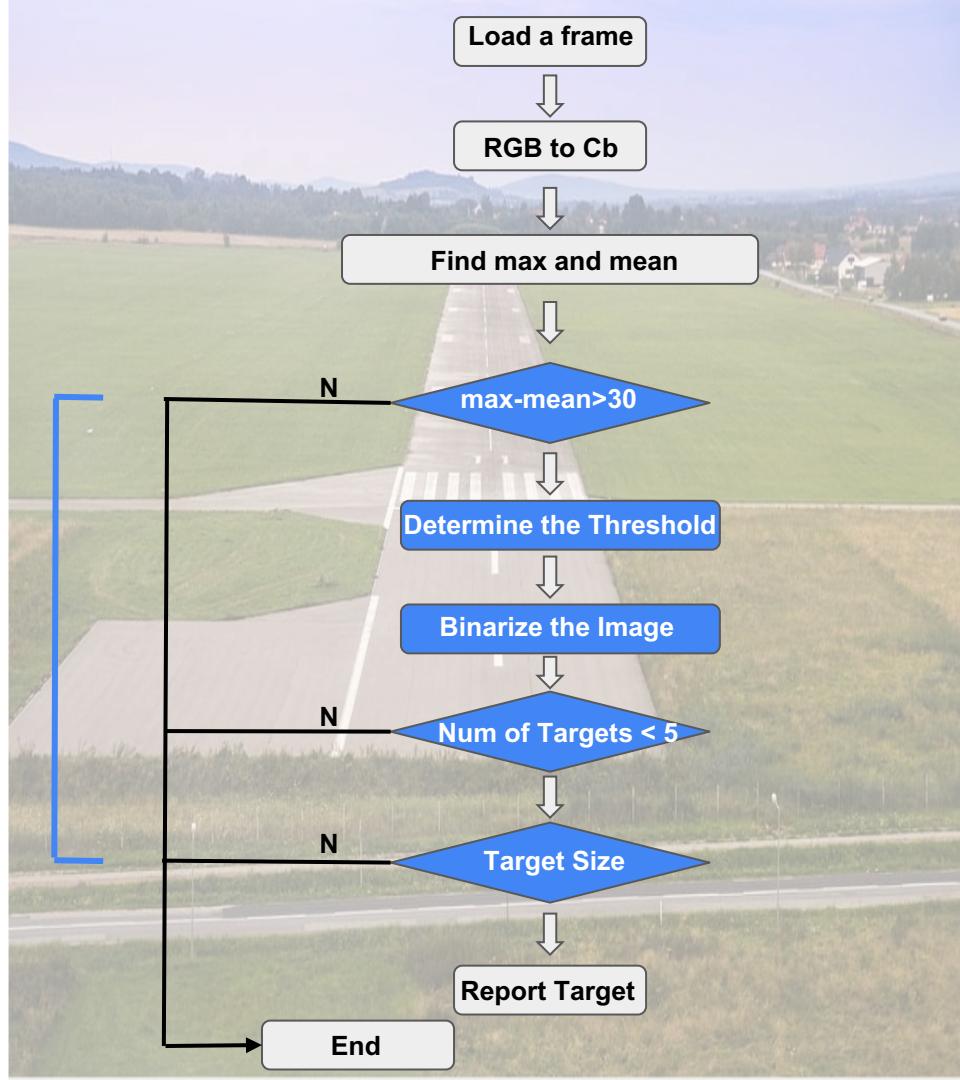
Advantages

1. Fast compute time
2. Targets contrast ground nicely

Disadvantages

1. Smiley and frowny faces do not differ by color but by orientation

Blue Tarp Identification



Criteria Check: ATR System

| | | OpenCV | OpenMV | RGB Recog. |
|---|--|--------|--------|------------|
| 1 | CPU Memory Needed (4 GB) | ✓ | ✓ | ✓ |
| 2 | Direct Access to Camera to Acquire Image/Video Feed | ✓ | ✓ | |
| 3 | Ability to detect targets (TBR) | ✓ | | ✓ |
| 4 | Ability to distinguish between smiley & frowny faces (TBR) | ✓ | | |
| 5 | Available Documentation | ✓ | ✓ | ✓ |

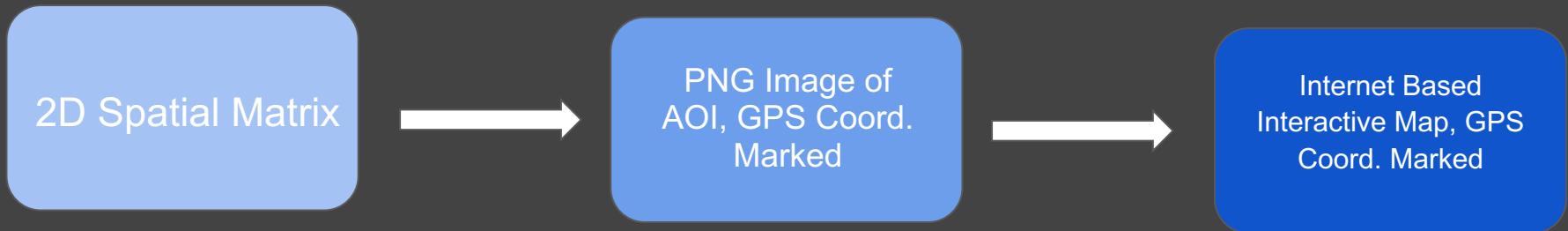
ATR Model Training Considerations

For Machine Learning, what did we consider as options for training our selected image recognition software?

- Use video feed from aboard the plane during one of the ASE team's test flight
- Use a camera mounted onto a quadcopter that we can fly into the air to take individual photos



Map Generation Considerations



Downselection of Preliminary Designs

1) Camera

- Frame Capture Rate
- Operating Resolution Range
- Quantity of HDMI and/or USB Outputs

Downselected Designs: Topotek 10x Zoom, Lumenera Lt-C/M2020

Eliminated Design: RunCam Zoom Camera

1) Co-Processor

- Power Supply Voltage
- CPU RAM
- CPU Frequency

Downselected Designs: Raspberry Pi Model 4, Jetson TX2

1) ATR System

- CPU Memory Needed
- Ability to Detect Targets
- Ability to Distinguish Between Smiley and Frowny Faces

Downselected Designs: OpenCV, RGB Recognition

Eliminated Design: OpenMV

Feasibility Analysis: Camera

| Criteria Description | Topotek 10x Zoom | Lumenera Lt-C/M2020 | Linear Scoring Methodology Legend |
|--|------------------|---------------------|---|
| CR - Operating Resolution Range | 0 | 6 | GREAT >= 85% criteria weight satisfied |
| CR - Frame Capture Rate | 5 | 5 | GOOD >= 70% criteria weight satisfied |
| CR - Quantity of HDMI and/or USB outputs | 4 | 4 | NEUTRAL >=50% criteria weight satisfied |
| CR - Available Documentation | 0 | 3 | POOR < 50% criteria weight satisfied |
| CR - Total Weight | 2 | 2 | |
| CR - Physical Length Dimensions | 1 | 1 | |
| Total Score | 12 | 21 | |

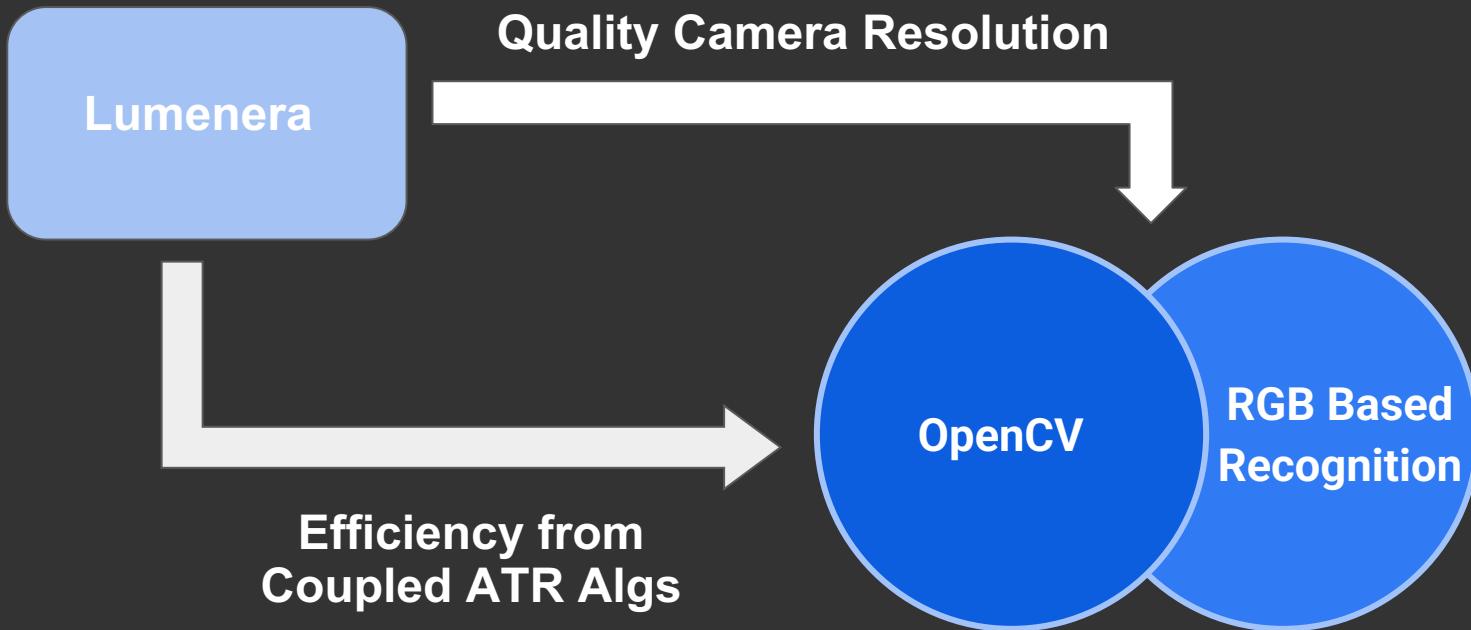
Feasibility Analysis: Co-processor

| Criteria Description | Raspberry Pi Model 4 | Jetson TX2 | Linear Scoring Methodology Legend |
|--|----------------------|------------|---|
| | Score | Score | |
| CPR - CPU RAM (GB) | 7 | 7 | GREAT >= 85% criteria weight satisfied |
| CPR - Power Supply Voltage (V) | 6 | 0 | GOOD >= 70% criteria weight satisfied |
| CPU Frequency (Clock Time) (GHz) | 5 | 5 | NEUTRAL >=50% criteria weight satisfied |
| CPR - Compatible with USB and/or HDMI Connection | 4 | 4 | POOR < 50% criteria weight satisfied |
| CPR - Available Documentation | 3 | 3 | |
| CPR - Total Weight (kg) | 2 | 2 | |
| CPR - Physical Length Dimensions (cm) | 1 | 1 | |
| Total Score | 28 | 22 | |

Feasibility Analysis: ATR Algorithm

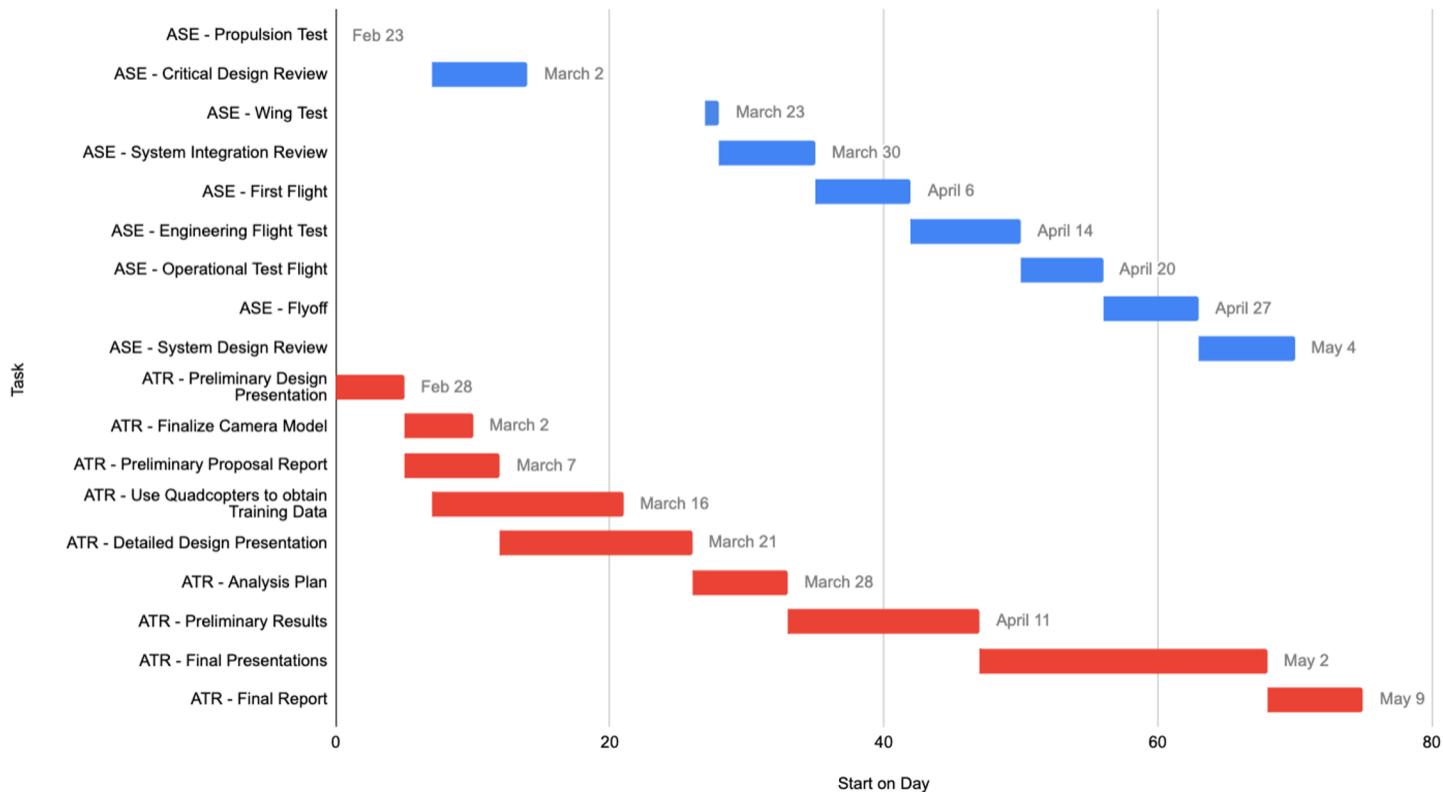
| Criteria Description | OpenCV | RGB Recognition | Linear Scoring Methodology Legend |
|--|-----------|-----------------|---|
| | Score | Raw Score | |
| ATRSR - Ability to Distinguish between Smiley & Frowny Faces | 5 | 0 | GREAT >= 85% criteria weight satisfied |
| ATRSR - Ability to Detect Targets | 4 | 4 | GOOD >= 70% criteria weight satisfied |
| ATRSR - Available Documentation | 3 | 3 | NEUTRAL >=50% criteria weight satisfied |
| ATRSR- CPU Memory Needed (GB) | 2 | 2 | POOR < 50% criteria weight satisfied |
| ATRSR - Direct Access to Camera to Acquire Image/Video Feed | 1 | 0 | |
| Total Score | 15 | 9 | |

Final Design Considerations



Joint ASE - COE Gantt Chart

Joint ASE - COE Design Team Gantt Chart



Questions?

All team members contributed equally to this presentation