# 2018 SUNY TYESA Mini UAV Competition

Friday, April 27, 2018
Monroe Community College, Rochester NY

**Project**

Teams of sophomore and freshman students will design, build, and pilot a mini Unmanned Aerial Vehicle (UAV) to transport a rescue kit through a series of obstacles and return to the starting point. The UAV must be able to maneuver around and through obstacles, change altitude and carry/deposit a payload to the proper drop zone, then navigate back to the starting zone. This project is designed to simulate a rescue kit delivery where human navigation is difficult or dangerous.

**Project requirements**

The UAV must pass all given specifications: dimensions, cost, and part constraints. Participants cannot purchase and modify an existing commercially available vehicle. Participants can purchase individual components: a frame kit, propulsion, and control system for their UAV.

Participants are encouraged to engage in research and design a frame for their UAV. It is expected that participants will become adept to line of sight piloting in preparation for the competition.

**Time and Location**

The competition will be held in the *PAC Field House* at Monroe Community College - Brighton Campus on Friday, April 27, 2018 at 9:30 AM. Participants should arrive and register at 9:00 AM. Directions to MCC can be found here: http://www.monroecc.edu/depts/webmaps/

Participating teams should report to Christopher Kumar at the MCC Engineering Department by Friday, April 13, 2018.

Christopher Kumar, ***SUNY TYESA Treasurer***
Engineering Science and Physics Dept., ***Chairman***
Monroe Community College
1000 East Henrietta Road
Rochester, NY 14623-5780
Phone: (585)292-2001; (585)292-2671
Email: ckumar@monroecc.edu

**Vehicle Requirements**

- *Budget:* The UAV budget must not exceed $250 (excluding tax and shipping). The cost of materials for the frame and RC transmitter/receiver are not included in the $250 budget. The $250 limit affects all other components on the UAV. If over budget, there is a one-time 250 point penalty.

- *Power System:* The vehicle must be powered by battery; exotic fuels/battery will not be allowed.

- *Physical Properties:* The purchase and modification of commercially available vehicles is prohibited. Off-the-shelf frame kits are not permitted; teams must engage in research and design a frame for their small UAV. The fully assembled small UAV (Propellers included) must be capable of fitting in a 24 x 24 x 12 inch box.

- *Manual Flight*: The piloting of the small UAV must be solely controlled by a wireless RC transmitter/receiver link. No other contact, interaction or influence is permitted. During the competition, during a team's run, all other team's RC transmitters/receivers should be off. Pilots are allowed to move around while the small UAV is in flight.

- *Flight Termination*: The aircraft must have a preflight safety switch and a mid-flight shut-off switch. The preflight safety switch allows you to handle your aircraft safely by disabling the motors until you activate the switch. The mid-flight shut-off switch allows you to disable motors mid-flight, in the event that the small UAV becomes unstable and/or unsafe. If a small UAV is deemed unsafe during flight, judges will require that pilots hit the mid-flight shut-off switch.

- All vehicles must adhere to the part specifications outlined on page 10 (Appendix B). A brief bill of materials must be included for each UAV. The bill of materials needs only to provide for parts included in the parts table below. Note: teams must follow the exact part order list or there is a one-time 50 point penalty.

**Competition Scoring**

There are two major elements of the competition: the mission demonstration and the poster presentation. They are worth 80% and 20% respectively of the overall scoring points.

Part I: Mission Demonstration (80%)
Part II: Poster Presentation (20%)

Part I: Mission Demonstration (80%)

*Course Description*: The rectangular course of 16 ft. by 26 ft. will consist of a flat, level section of field marked off with masking tape, and the corresponding airspace will be above the field. The course contains a starting platform, a payload delivery tower, and two obstacle gates. The location of the gates/tower will be randomized, and will maintain a minimum distance of 6 ½ ft. from each other. The payload delivery-light source tower will have a height of 36 inches and the starting platform will have a height of 4 inches (figure 1-4).

*Flight Sequence*: The team's pilot must navigate the small UAV through the course in the following sequence. Upon leaving the starting platform, the UAV must fly through the first designated gate, then through the second designated gate. Then the UAV must deliver the payload to the payload delivery-light source tower. Once completed, the UAV must fly through the gates in reverse order in which it initially traveled and land safely on the starting platform. The total time allotted for the flight sequence will be 240 seconds, and the team will receive 240 (Trial time in seconds) points.

*Obstacle Gates:* The small UAV must fly through the window opening of the gate. 100 points will be awarded each time the UAV passes through a gate. This may only be done once per gate before and once per gate after the payload delivery for a total of 400 points maximum per trial. If the small UAV hits the gate, the team will not gain any points for that gate attempt; instead, they will lose 100 points.

*Payload Delivery*: The payload is a fragile object with approximately 60 mm in diameter and weigh under 60 grams. The object could be a round or an oval shape. Judges will determine on the competition day. The payload will be loaded onto the team's UAV before the mission begins. The platform of the 12 inch high payload delivery-light source tower will be colored red. In addition, the tower will be equipped with a matching high intensity LED ring and conically focused laser arranged to point vertically in the center of the platform. Once the pilot has navigated the UAV to a payload delivery platform, the small UAV must autonomously determine when to release the payload onto the platform. The fragile object must be released onto the red platform. The team will be awarded 400 points for successful payload delivery. A successful payload delivery entails there is absolutely no damage to the payload. If the payload is damaged no points will be awarded.

Part II: Poster Presentation (20%)

Prior to the mini UAV competition, each team must participate in the poster presentation session, where each participating team will exhibit and present their UAV project to the event attendees, spectators, and judges. During the exhibition period, judges will visit each participating team and request a poster presentation. This will be followed by questions. This process will take approximately 5 to 10 minutes per team. The entire poster presentation session is scheduled to last approximately 90 minutes; however, this may change depending on the number of participating teams.

The poster presentation will occur on the same day as the mini UAV competition on Friday, April 27, 2017 at 9:30 am in the MCC PAC Field House. All the team members must be present for the entire poster presentation period along with their UAV. Teams may use laminated posters, written documents, physical prototypes, multimedia displays, and other visual aids at their booths. Each team will be provided with a table and tripod.

Judges will score on the following categories: Design Evolution, Mechanical Analysis, Electrical Analysis, software Analysis, and Exhibit Quality. They will score on a scale of 0 to 10 (10 being the best) for each category. The score will be calculated by deleting the highest and lowest scores from the judges and averaging the remaining scores (dividing by 5).

Note: teams must include cad dimensions of major components (propellers, motors, frame, flight controller, etc.) and overall design of the assembled UAV. Motor and propeller selection must be briefly explained, along with calculation for thrust and maximum payload lift.

**The final score will be the sum of scores from the three trials, including any broken rule deductions, bonuses and presentation scores.**

*Example Trial:*

*Instructions*

- All teams must report before the competition begins.

- The UAV size will be measured. If the size is exceeded, judges may disqualify the team from the competition or may give a severe penalty.

- Team members must inspect the course and location of the payload before the judges signal to start the trial. Once the trial has commenced, the run counts as an official run. There is no redo.

- If a UAV fails to operate after the judges have given the start command, the team members may work on their UAV to get it moving but the time will continue to count from the time when the start command was given. If the time exceeds 240 seconds of the start command, a score of zero will be assigned for that trial.

- The UAV must start from the starting platform; maneuver through two obstacle gates, then deposit the payload on the deposit platform and return to the starting point. There will be no penalty for maneuvering outside the bounds of the defined course area.

  Note: All pilots must fly on a line of sight basis. No First Person View (FPV) cameras may be used to navigate.

*Score*

| **Mission Trial** | **Trial 1** | **Points** | **Trial 2** | **Points** | **Trial 3** | **Points** |
|---|---|---|---|---|---|---|
| Successful Gates | 100*3 | +300 | 100*4 | +400 | 100*2 | +200 |
| Unsuccessful Gates | 100*1 | -100 | 100*0 | 0 | 100*2 | -200 |
| Time Trial | 240-90 | +150 | 240-60 | +180 | 240-100 | +140 |
| Successful Delivery | 400*1 | +400 | 400*1 | +400 | 400*1 | +400 |
| Total | - | 750 | - | 980 | - | 540 |
| Maximum Possible Score | - | 1040 | - | 1040 | - | 1040 |
| **Total % for Each Trial** | | **72.1%** | | **94.2%** | | **51.9%** |
| **The average of the 3 trials** | **72.8**% | | | | | |
| **Mission Demonstration (80%)** | **72.8%** of Mission Demonstration total (80%) is **58.21%** | | | | | |
| **Poster Presentation (20%)** | **16.4%** (see table below) | | | | | |
| **Competition Total** | 58.21% + 16.4% = **74.61%** | | | | | |

| Poster Presentation | Points |
| --- | --- |
| Design Evolution | 8.0 |
| Mechanical Analysis | 9.0 |
| Electrical Analysis | 10.0 |
| Software Analysis | 7.0 |
| Exhibit Quality | 7.0 |
| **Total** | **8.2%** |
| **Poster Presentation (20%)** | **16.4%** |

**Note**: On the competition day, designated judges will interpret the rules and determine all decisions. The decision will be final and will not be negotiable. All teams must respect the decision. The purpose of this competition is to support students' interest in mathematics, engineering, science, and technology. We expect the competition to be a learning environment, and to be cordial and courteous.

**Appendix A: Schematics of course, obstacle gates, starting platform and payload delivery-light source towers**

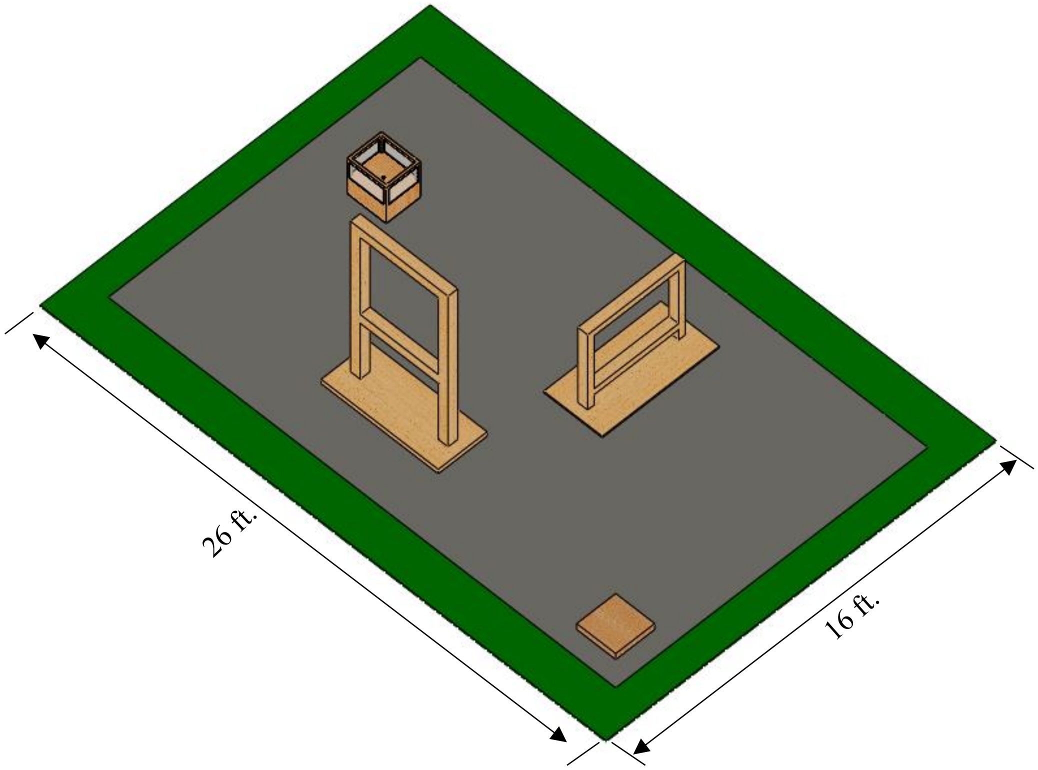



**Figure 1: The isometric view of the course constructed in the indoor field house.**

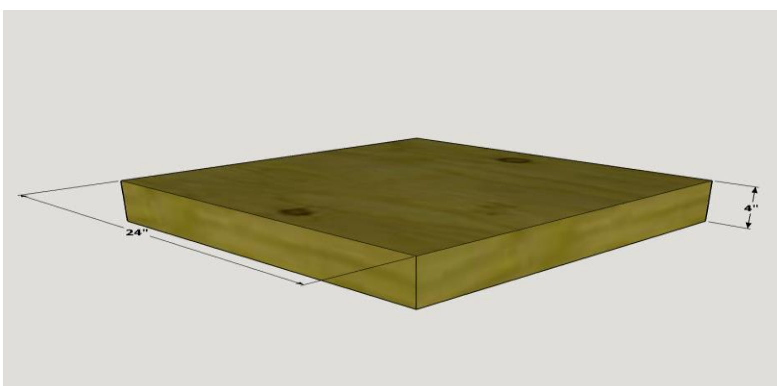
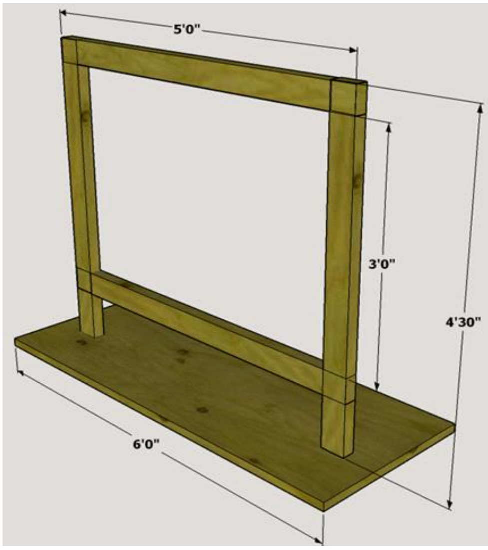



**Figure 2: Schematics for the starting platform (24" x 24" x 4").**



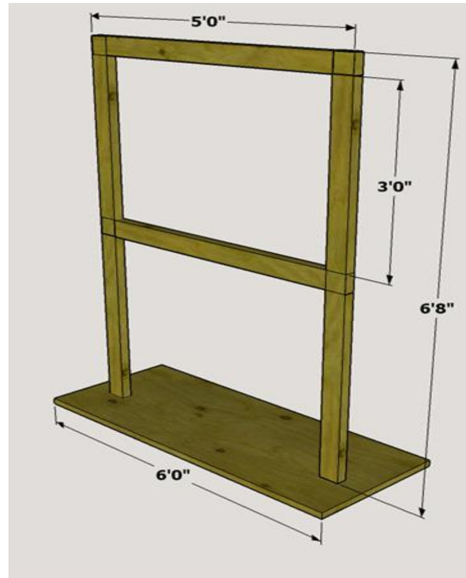



**Figure 3: Schematics for lower gate and higher gate. Each gate will be 5 ft. wide with a 3 ft. tall opening.**

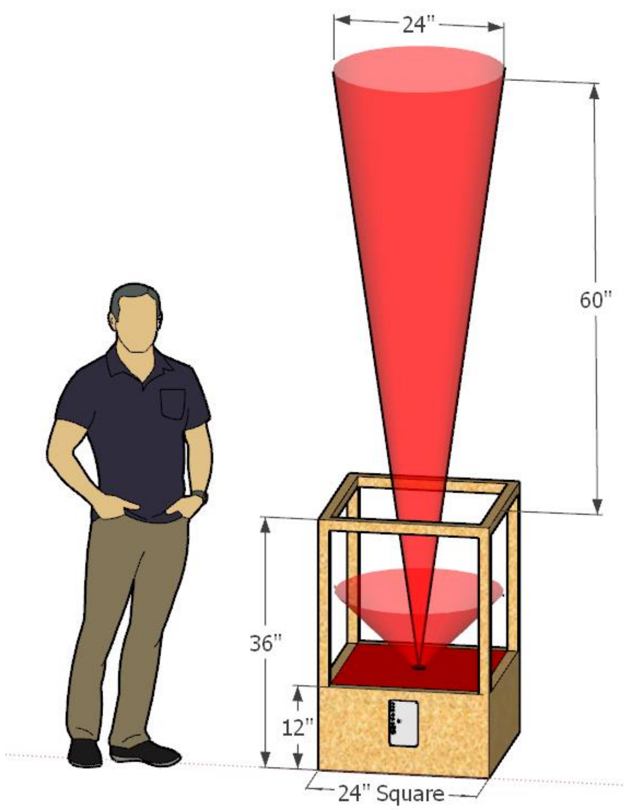



**Figure 4: Profile view of payload delivery-light source towers & light cone dimensions determined using the TCS230. The schematic for payload delivery-light source towers is 24" x 24" x 36".**

**Appendix B: Part Specifications**

The following table is an example part list to build a mini UAV. All vehicles that participate in this event must not have a cost exceeding $250 (Excluding Tax). This build ends up with a net cost of approximately $200 (not including small parts such as screws, hot glue, etc.). Students will need to devise a carry and release system for the payload in addition to the parts listed here. The carry and release system will not be considered when evaluating the budget for each UAV.

| Component | Example Build | Vendor | Qty | Unit Cost | Net Cost |
|---|---|---|---|---|---|
| Frame | Design and Fabricate | - | - | - | - |
| Flight Controller* | CC3D | getFPV | 1* | $24.99 | $24.99 |
| | KK2 Mini 2.1.5 | Hobbyking | 1* | $18.99 | $18.99 |
| Motor | NTM Prop Drive 2830s | Hobbyking | 4 | $9.99 | $39.96 |
| Motor Mounts | NTM Prop Drive 28 Series Accessory Pack | Hobbyking | 4 | $2.39 | $9.56 |
| Speed Controllers | Hobbyking 30Amp ESC 3AMP UBEC | Hobbyking | 4 | $10.76 | $42.96 |
| Propellers CCW | HQProp 10x4.7 | getFPV | 2 | $5.80 | $11.60 |
| Propellers CW | HQProp 10x4.7 | getFPV | 2 | $5.80 | $11.60 |
| Battery | ZIPPY Fightmax 3000mAH 4S1P 20C | Hobbyking | 1 | $17.85 | $17.85 |
| Power Distribution | ESC Power Breakout Cable | Hobbyking | 1 | $2.99 | $2.99 |
| Battery Alarm | Hobbyking Low Voltage Alarm | Hobbyking | 1 | $2.64 | $2.64 |
| Battery Strap | Turnigy Battery Strap 300mm | Hobbyking | 1 | $1.85 | $1.85 |
| Shock Absorbers | Gyro/Flight Controller Mount Pads | Hobbyking | 1 | $2.47 | $2.47 |
| **Autonomous Payload Release Example** | | | | | |
| Microcontroller | Adafruit Pro Trinket - 5V 16Mhz | Adafruit | 1 | $9.95 | $9.95 |
| Color Sensor | TCS230 TCS3200 Color Module | Amazon | 1 | $7.99 | $7.99 |
| Servo | Micro Servo - High Torque | Adafruit | 1 | $9.95 | $9.95 |
| | | | | **Total Cost with Example** | **$196.36** |

*Though many groups have been successful with the CC3D in the past, others have found problems with the quality of the hardware. Groups are not strictly limited to the use of the CC3D, and are encouraged to research flight controllers that they feel would be more appropriate. Though dated, the KK2 mini has also been used by groups in the past with relative success, and does not require a computer for configuration.

## Appendix C: Arduino Code for payload delivery-light source Testing

In order to use this code, you must first download the Adafruit_NeoPixel Library and install. Full instructions for how to do this can be found by clicking this link NeoPixel Library HYPERLINK "https://learn.adafruit.com/adafruit-neopixel-uberguide/arduino-library-installation" Installation. Copy and paste the code below directly into a new Arduino IDE Sketch, and save.

```
#include <Adafruit_NeoPixel.h> // LED Ring Library
#ifdef __AVR__
  #include <avr/power.h>
#endif

// TCS230 Sensor Parameters
// These variables are used to assign names to the Arduino IO pins connected to the TCS230
const int s0 = 4;
const int s1 = 11;
const int s2 = 7;
const int s3 = 8;
const int out = 10;
// These variables will be used to store sensor data from OUT pin on the TCS230. DO NOT CHANGE.
int red = 0;
int green = 0;
int blue = 0;


// NeoPixel Ring Parameters
// These variables are used to control the color of the NeoPixel Ring (Default WHITE)
int r = 255;
int g = 255;
int b = 255;
// (Default to 12 LED ring on pin 6)
// Parameter 1 = number of pixels in strip
// Parameter 2 = Arduino pin number (most are valid)
// Parameter 3 = pixel type flags, add together as needed:
//   NEO_KHZ800  800 KHz bitstream (most NeoPixel products w/WS2812 LEDs)
//   NEO_KHZ400  400 KHz (classic 'v1' (not v2) FLORA pixels, WS2811 drivers)
//   NEO_GRB     Pixels are wired for GRB bitstream (most NeoPixel products)
//   NEO_RGB     Pixels are wired for RGB bitstream (v1 FLORA pixels, not v2)
//   NEO_RGBW    Pixels are wired for RGBW bitstream (NeoPixel RGBW products)
// Syntax: Adafruit_NeoPixel name = Adafruit_NeoPixel(Parameter 1, Parameter 2, Parameter 3);
Adafruit_NeoPixel strip = Adafruit_NeoPixel(12, 6, NEO_GRB + NEO_KHZ800);

void setup() {
// This is for Trinket 5V 16MHz, you can remove these three lines if you are not using a Trinket
#if defined (__AVR_ATtiny85__)
  if (F_CPU == 16000000) clock_prescale_set(clock_div_1);
#endif
// End of trinket special code

  Serial.begin(9600); // Begin communication with computer through serial monitor
```

```
// Set IO pin types
  pinMode(s0, OUTPUT);
  pinMode(s1, OUTPUT);
  pinMode(s2, OUTPUT);
  pinMode(s3, OUTPUT);
  pinMode(out, INPUT);

// Set TCS230 Sensor pins s0 and s1 to HIGH, activating the sensor
  digitalWrite(s0, HIGH);
  digitalWrite(s1, HIGH);

// Activate the LED ring named "strip"
  strip.begin();
  strip.show(); // Initialize all pixels to 'off'
}

void loop() {

// TCS230 Loop Control
  color(); // retrieves data from OUT on TCS230 sensor for red, green, and blue.

  // Print sensor values to serial monitor
  Serial.print("R Intensity:");
  Serial.print(red, DEC);
  Serial.print(" G Intensity: ");
  Serial.print(green, DEC);
  Serial.print(" B Intensity : ");
  Serial.print(blue, DEC);

// Determine the color being detected on the sensor, & print to serial monitor
  if (red < blue && red < green && red < 20)
  {
   Serial.println(" - (Red Color)");
  }

  else if (blue < red && blue < green)
  {
   Serial.println(" - (Blue Color)");
  }

  else if (green < red && green < blue)
  {
   Serial.println(" - (Green Color)");
  }
  else{
  Serial.println();
  }

// LED Ring Loop Control
// Some example procedures showing how to display to the pixels:
```

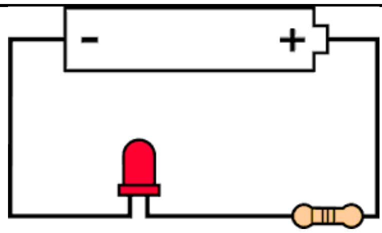
```
      for (int i=0; i<12; i++){
      strip.setPixelColor(i, strip.Color(r, g, b));
      }
    strip.setBrightness(255); // Set strip brightness from 0 to 255
    strip.show();
    delay(500);
}


// Function Color() is used to read the color information on the TCS230 Sensor
void color()
{
  digitalWrite(s2, LOW);
  digitalWrite(s3, LOW);
  //count OUT, pRed, RED
  red = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
  digitalWrite(s3, HIGH);
  //count OUT, pBLUE, BLUE
  blue = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
  digitalWrite(s2, HIGH);
  //count OUT, pGreen, GREEN
  green = pulseIn(out, digitalRead(out) == HIGH ? LOW : HIGH);
}
```

**Appendix D: Light Source Specifications & Test Procedures**

Testing the light sensing apparatus (payload delivery system) and the program can be achieved using regular clear LED's. A link is provided with RGB LED's that can be used to test the red sensing on your color sensing unit. It should be noted that an appropriate resistor should be used to limit the current through the common ground on these LED's based on your input voltage (470 ohm works for 12V input, less for 5V)

| **Alternative Light Sensor Testing Equipment** | | | | | |
|---|---|---|---|---|---|
| RGB LED | RGB LED | Microtivity | 2 | $5.22 | $5.22 |
| | | | | **Total Cost** | **$5.22** |




The following table is the list of parts used to construct the light sources located in each payload delivery tower**. It is not necessary to build your own light sources** to test the payload delivery system. Teams are welcome to build their own payload delivery-light source towers.

Figure 4 illustrates the effective range (conic regions) of each of these sources determined using the TCS230 color sensor with its face straight down (as if fixed on the bottom of the UAV). The lower cone represents the light being projected by the LED ring and the upper cone represents the light being projected by the laser module. Both light sources produce luminous conic regions of intense light. The interior of these conic regions represent the positions in which the TCS230 sensor was able to detect the light sources on the payload platform.

The Arduino code for testing the recommended hardware (Appendix B) is in Appendix C. The TCS230 sensor was capable of detecting the laser signal well beyond the 86" listed in figure 4. This value is limited to 86" because any higher would cause the beam diameter to exceed the perimeter projection of the payload platform.

NOTE: *Do not* attempt to power the laser units using power from an Arduino board. They require current in excess of 300mA and will likely damage the board. The laser modules were tested using a single protected 3.7V 18650 cell, and worked nicely.

| **Payload delivery-light source towers Components** | | | | | |
|---|---|---|---|---|---|
| Microcontroller | Adafruit Pro Trinket - 5V 16Mhz | Adafruit | 1 | $9.95 | $9.95 |
| LED Ring | NeoPixel Ring 12x5050 RGB | Adafruit | 1 | $7.50 | $7.50 |
| Laser (Red) | 650nm 50mW Red Laser Focusable | Generic | 1 | $15.20 | $15.20 |
| | | | | **Total Cost** | **$32.65** |