MISSION 8 Arena Props
Design Manual

Introduction
This document describes the designs developed by the International Aerial Robotics Competition organizers for the conduct of IARC MISSION 8 in accordance with the Official Rules posted at: http://www.aerialroboticscompetition.org/rules.php .

Caution: This information can be used by teams to create similar arena resources to those used during MISSION 8 for the purposes of testing, but teams are cautioned that any or all the specific specifications for the arena props could change from year to year. For example, in 2018, the "Kill frequency modulation" of the Sentry lasers will be centered around 21 kHz, but that could change without notice in subsequent years. Because the "Kill frequency modulation" is NOT part of the team's hardware, this should have no effect on team Helper aerial robot developments. The "Kill" beam of the Sentries will continue to exist regardless of how the supplied sensor helmet is implemented from year-to-year. Teams should not base their designs on the arena prop specifics contained in this document, rather they should base all of their designs on the level of information found in the Official Rules.

Sentry Aerial Robot
Sentry aerial robots are based on the DJI Mavic Air platform. Built-in target designation and following routines ("Active Track") are used to follow targets using human safety pilots to reposition the Sentries within the arena and to designate targets. Eventually, it is hoped that the new DJI Mavic Air Software Design Kit (SDK) will allow lost targets to be reacquired automatically.

The Sentry robots have an elevated laser carriage that is attached to the top of the Mavic Air 1.5 inches from the rear of the upper fuselage cover. The next section discusses the Sentry "Kill" beam and its attachment cradle.

The Mavic Air comes with prop guards which will be installed during operations within the arena. Safety pilots (one per Sentry) will monitor the flight of the Sentries and wrest control if the Sentry begins to act erratically. The Mavic Air battery is more than sufficient for a complete run. Flight time for the Sentries with their laser payloads is approximately 12 minutes. The MISSION 8 run time is 8 minutes. A battery charger rotation must be established to assure that four Sentries are always ready for the upcoming run. A compliment of six Sentries should be on hand to assure that competition runs can continue were one of the Sentries to become disabled. Six Sentry vehicles would allow two units to be put out of service before runs could not continue. The likely source of a Sentry being totally disabled would be due to a team vehicle crashing into the Sentry.

Spare laser "Kill" beams should be on hand to allow a velcro swap-out should one become damaged. A supply of at least four spare "Kill" beam lasers should be on hand.

Mavic Air Sentry with laser carriage and riser mounted to upper surface with velcro.

Replication of Arena Assets

Some arena assets such as the Mavic Air Sentry robots, lasers, bins, locks, barriers, etc. can be purchased from various vendors. In particular,

DJI Mavic Air Sentry vehicles: https://store.dji.com/product/mavic-air?vid=38961

Keyes KY-008 Laser: Search eBay, Amazon, Ali-Express, or Bang Good

Ardino Laser Sensors: Search eBay, Amazon, Ali-Express, or Bang Good

Laser Battery Holder: https://www.digikey.com/products/en?keywords=BH223-L-ND

Helmet: https://www.amazon.com/gp/product/B01AJYBX2U/ref=oh_aui_detailpage_o03_s00?ie=UTF8&psc=1

Bins: https://www.homedepot.com/p/Sterilite-92-Qt-Footlocker-Storage-Box-18429001/204303284

Bin Locks: https://www.amazon.com/gp/product/B0009V1WMA/ref=oh_aui_detailpage_o03_s00?ie=UTF8&psc=1

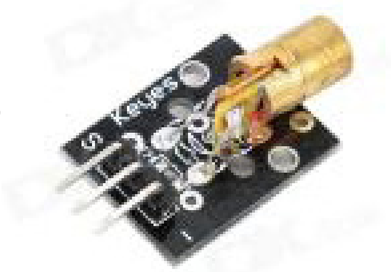
Barriers: http://www.mightypaintball.com/index.php?route=product/category&path=101_102

Some arena assets have been created using 3D printing techniques. As an aid to the teams, certain 3D printer .stl files are provided at the Official IARC website. In particular:

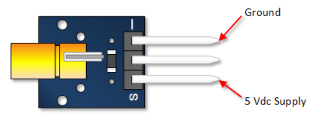
- **Laser Carriage Support.stl**
- **Sentry Laser Carriage Assy.stl**
- **Helmet Light Blocker.stl**

Sentry Kill Beam

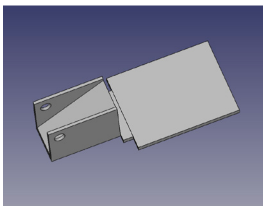
The “Kill” beam emitted from the Sentry aerial robots emanates from a 650nm RED laser that is square wave modulated at a frequency centered on 21 kHz. A Keyes KY-008 laser drawing 30 mA at 5VDC is used to implement the “Kill” beam. The KY-008 is available from multiple online sources (eBay, Amazon, Ali-Express, and Bang Good).

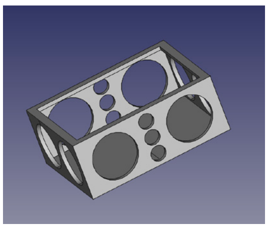


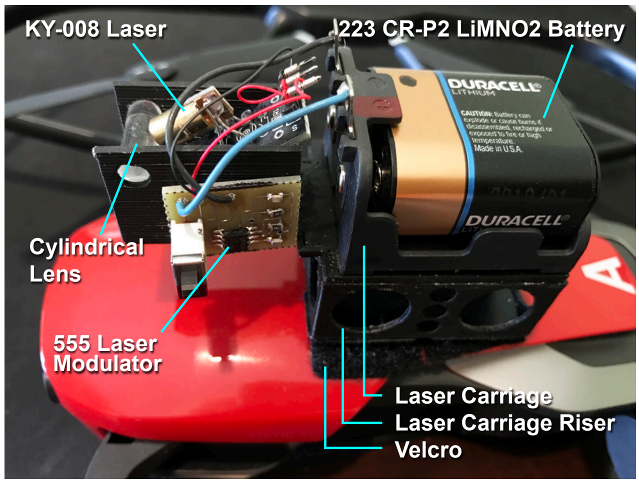
Keyes KY-008 Laser Module



The laser is mounted on a 3D-printed carriage that aims the laser slightly down from the plane of horizontal hover of the Mavic Air Sentry. The beam passes through a horizontal cylindrical lens to create a vertical sheet. A 3D-printed riser raises the laser carriage so that the vertical sheet does not intersect the front on the Mavic Air upper fuselage cover.

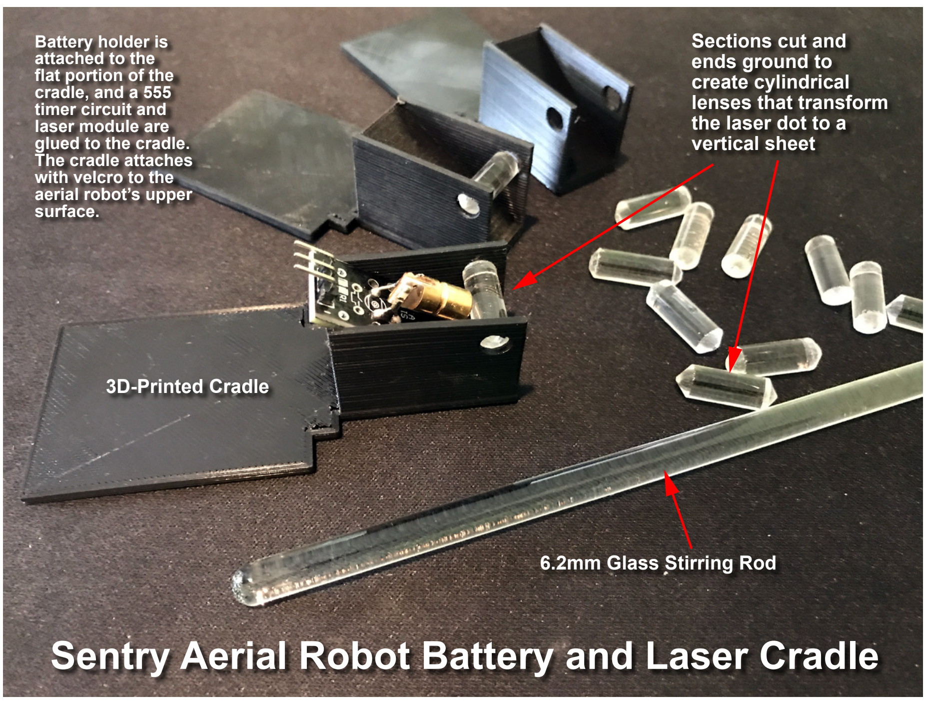






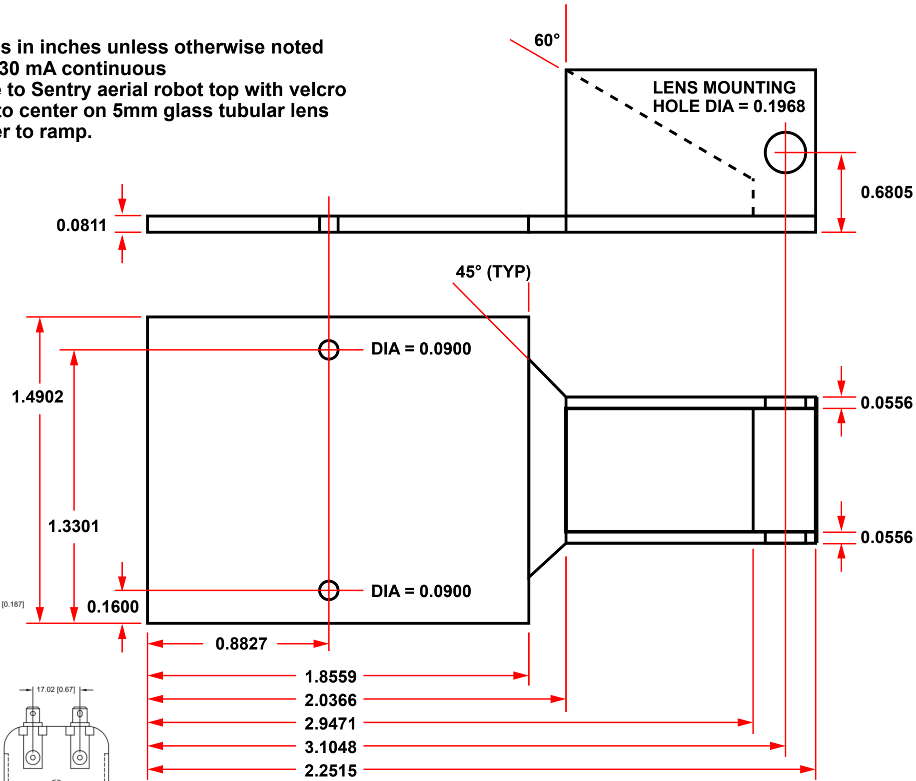
The riser is glued to the laser carriage on its top side and is attached to the Mavic Air upper fuselage cover on its bottom side.

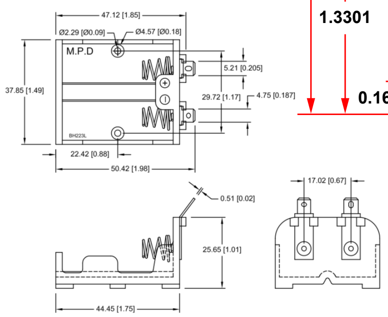
The laser operates from a 223 CR-P2 1400mAh 6V Lithium (LiMNO2) Photo Battery mounted in a battery holder directly behind the laser. This battery is capable of operating the laser for multiple runs. A printed circuit board containing a 555 timer is attached to the side of the laser cradle. An SMD resistor pair determines the modulation frequency for the laser. The board accommodates a switch to allow the laser to be turned off between runs for battery conservation, however hard-wiring the switch “ON” can also be done, with the battery being removed from its holder between runs.



Sentry Aerial Robot Battery and Laser Cradle

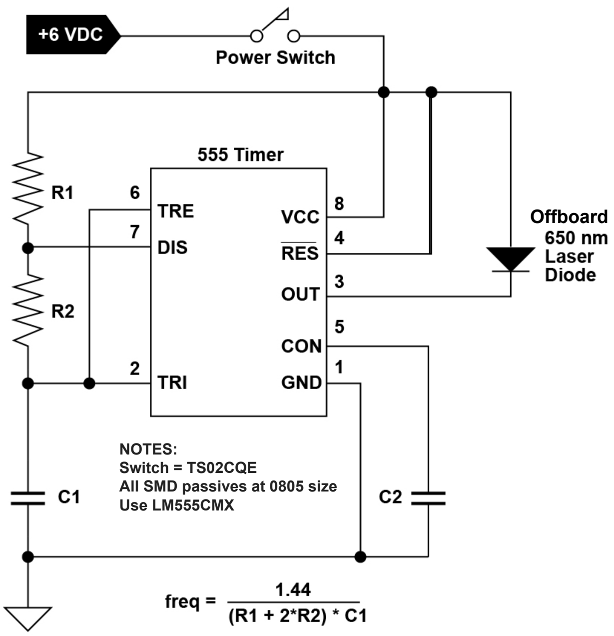
NOTES:
1. Alldimensions in inches unless otherwise noted
2. Laser draws 30 mA continuous
3. Attach cradle to Sentry aerial robot top with velcro
4. Adjust laser to center on 5mm glass tubular lens and glue laser to ramp.





TYPE 223 Lithium Manganese, 6 volt Battery; 1.28 oz
Compatible DigiKey Battery holder at:
https://www.digikey.com/products/en?mpart=BH223-L&v=61

SENTRY BATTERY AND LASER CRADLE



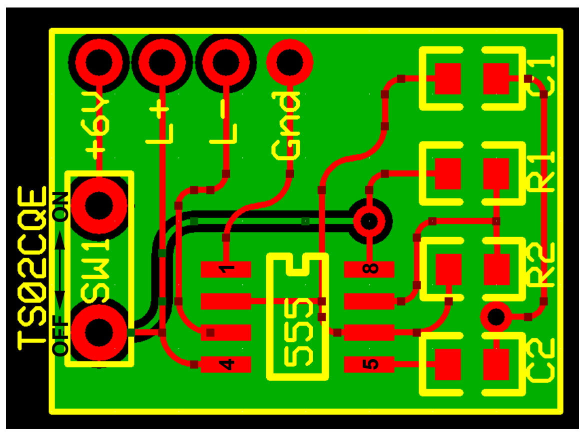
$$freq = \frac{1.44}{(R1 + 2*R2) * C1}$$

For 13 kHz, 50% duty cycle operation:

R1 = 8.2 KΩ, R2 = 51 KΩ, C1 = 0.001 µF, C2 = 0.01µF

For 21 kHz, 50% duty cycle operation:

R1 = 3.0 KΩ, R2 = 33 KΩ, C1 = 0.001 µF, C2 = 0.01µF



555-BASED TIMER CIRCUIT AND CORRESPONDING PRINTED CIRCUIT

Player’s Sensor Helmet

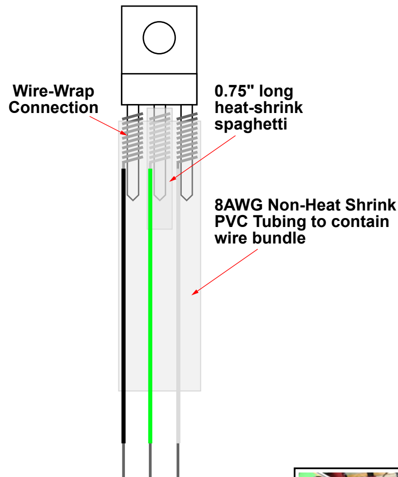
The sensor helmet worn by the team player will be provided by the IARC during official runs and is considered part of the arena. It is sensitive to 650nm RED laser light that, for the “Kill” beam, is square wave modulated at a frequency centered on 21 kHz, and for the “Healing” beam, a square wave modulated at a frequency centered on 13 kHz (the frequency and modulation of the “Healing” beam will remain the same throughout MISSION 8).

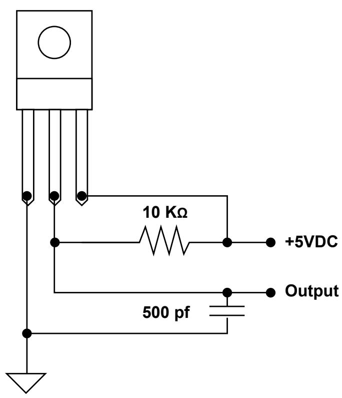
The helmet has 12 sensors ISO103 sensors chips distributed around the crown of the helmet. Each sensor is surrounded by a shroud to block off-axis light interference. A cable runs from the back of the helmet to a box worn on the belt at the back of player. This box contains an Arduino Nano processor that interrogates the 12 sensors and determines if any of them are being hit by the “Kill” beam or the “Healing” beam. Based on its continuous sampling, the hit display on the box will increment if a “Kill” beam hit is detected, or will decrement (up to four times maximum) if a “Healing” beam is detected. An audible beep will tell the player when a hit or healing has occurred. When the maximum number of hits has been sustained (i.e., the player is “dead”), the beeper will sound continuously.

Upon applying power via the switches found on each of two 9V battery holders located on the sides of the box, the Arduino Nano processor will allow interrogation of the helmet sensors (1 through 12). Within 60 seconds, a technician will need to ping each of the sensors with a hand-held “Kill” or “Healing” beam laser. This test assures that all sensors are functional.

Upon passing the start-up test, the helmet will be active and ready to be used in the arena. The twin 9V batteries are wired in parallel, so the helmet will operate with one or both switches closed.

ISO 103 Laser Sensor**
(Sensor dome Face-up)



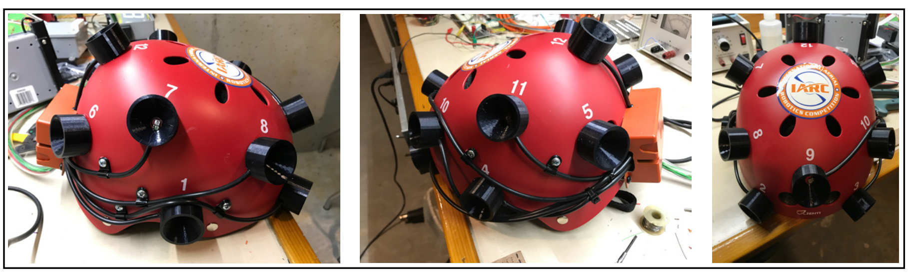


Sensor	Arduino Nano Pin
No. 1	5 (D2)
No. 2	6 (D3)
No. 3	7 (D4)
No. 4	8 (D5)
No. 5	9 (D6)
No. 6	10 (D7)
No. 7	11 (D8)
No. 8	12 (D9)
No. 9	13 (D10)
No. 10	14 (D11)
No. 11	15 (D12)
No. 12	16 (D13)
+5VDC	V IN
Ground	GND

Color Code:
Black = Ground
Green = Sensor Output
White = +5VDC

** Maximum Ratings:
Vcc = 17V
Low level output current = 30 mA
Output transistor power = 200 mW
Nominal Ratings:
Supply voltage = 4.5 - 17V
High level supply current = 3 - 6 mA
Low level supply current = 3 - 6 mA
High level output voltage = 4.5 V
Low level output voltage = 0.4 V
switching speed: L-H = 2 - 6 µs; H-L = 3 - 9 µs

Sensor Locations

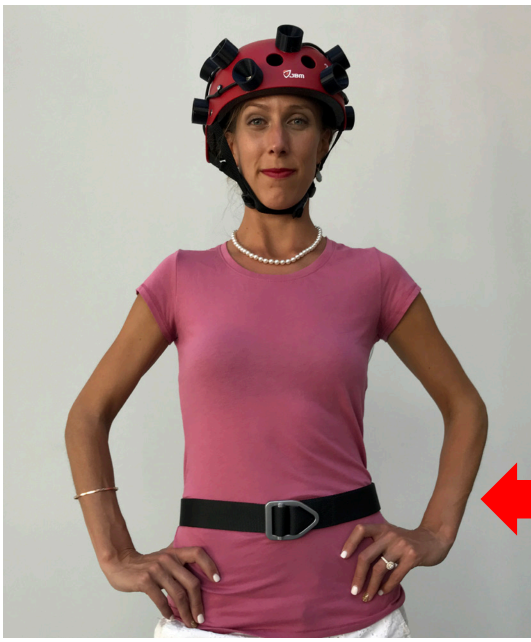


The helmet is correctly worn as shown below. Arena technicians should fit and remove the helmet from the player to assure that it is treated carefully and turned on/off appropriately. Testing of the sensors can be conducted while the helmet is in place on the player.

The helmet is adjustable to head size with a back strap and is always worn with a chin-strap.

The data cable is designed to extend down the back and out of the way of the player.

The helmet is similar to: https://www.amazon.com/gp/product/B01AJYBX2U/ref=oh_aui_search_detailpage?ie=UTF8&psc=1.



The data cable attaches to a processor box that is worn on the belt at the rear. A display on the processor box indicates the number of effective laser hits sustained by the player.

A web belt is provided to secure the processor box to the waist.

To simplify the intelligence of the various lasers, the helmet is programmed to interrogate its sensors and when a "Kill" or "Healing" beam is detected, a 5 second delay will lock out any further hits to simulate the fact that Sentry aerial robots are only capable of attacking once every five seconds.

Four "Healing" beams can be invoked by the player. These can be commanded from one or more of the Helper aerial robots, but only a total of four will be accepted during the run. "Healing" beam hits will cancel one previously sustained "Kill" beam hit, but they can be wasted.

For example, if the player has sustained 7 “Kill” beam hits, the Helper aerial robots can be summoned to provide 1, 2, 3, or 4 “Healing” beam hits and the counter on the helmet belt-mounted electronics will be decremented by the corresponding number of “Healing” beam hits. If, however, the “Kill” beam count was 3 and the player called for 4 “Healing” beam hits, the counter would only decrement down to zero and the fourth “Healing” beam hit would be forever forfeited. Therefore, the “Healing” beam should be used judiciously by the player.

The display on the helmet belt-mounted processor is identical to the bin display and its driver electronics except that it is only two digits (0-99) rather than four digits. See the section on bin electronics for details of the display.

HELMET BELT BOX ARDUINO NANO WIRING

Arduino Nano		Connection
TX [D0]	(pin 1)	No Connection
RX [D1]	(pin 2)	No Connection
RESET	(pin 3)	Reset (active low) (Tie HIGH)
GND	(pin 4)	Ground (Tie LOW)
D2	(pin 5)	Sensor No. 1
D3	(pin 6)	Sensor No. 2
D4	(pin 7)	Sensor No. 3
D5	(pin 8)	Sensor No. 4
D6	(pin 9)	Sensor No. 5
D7	(pin 10)	Sensor No. 6
D8	(pin 11)	Sensor No. 7
D9	(pin 12)	Sensor No. 8
D10	(pin 13)	Sensor No. 9
D11	(pin 14)	Sensor No. 10
D12	(pin 15)	Sensor No. 11
D13	(pin 16)	Sensor No. 12
3V3	(pin 17)	No Connection
AREF	(pin 18)	No Connection
A0	(pin 19)	SRCLK (Shift Register Clock)
A1	(pin 20)	RCLK (Storage Register Clock)
A2	(pin 21)	SER (Serial Data Input)
A3	(pin 22)	Beeper
A4	(pin 23)	No Connection
A5	(pin 24)	No Connection
A6	(pin 25)	No Connection
A7	(pin 26)	No Connection
+5V	(pin 27)	No Connection
RESET	(pin 28)	Reset (active low) (Tie HIGH)
GND	(pin 29)	Ground (Tie LOW)
VIN	(pin 30)	9VDC (Tie to battery switch)

IS0103

The IS0103 is a digital output detector which incorporates a photodiode with signal processing circuit (amplifier, Schumitt Trigger, voltage regulator).

FEATURES

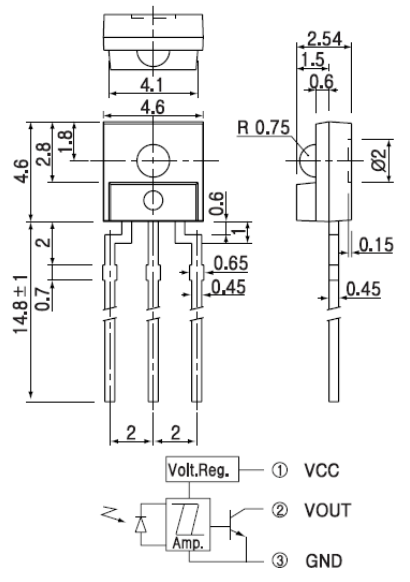
- Built - in Schumitt Trigger circuit
- Wide Vcc range
- Compatible to TTL and LSTTL

APPLICATIONS

- Floppy disc drives
- Copiers
- VCRs, Cassette decks

DIMENSIONS

(Unit : mm)



MAXIMUM RATINGS

(Ta=25℃)

Item	Symbol	Rating	Unit
Supply voltage	V_{CC}	17	V
Low level output current	I_{OL}	30	mA
Output transistor power dissipation	P_O	200	mW
Operating temp.	Topr.	−25~+85	℃
Storage temp.	Tstg.	−40~+100	℃
Soldering temp.*1	Tsol.	260	℃

*1. For MAX. 5 seconds at the position of 2 mm from the resin edge.

ELECTRO-OPTICAL CHARACTERISTICS

(V_{CC}=5V, Ta=25℃)

Item		Symbol	Conditions	Min.	Typ.	Max.	Unit.
Supply voltage		V_{CC}		4.5		17	V
High level supply current		I_{CCH}	E_V=100lx		3	6	mA
Low level supply current		I_{CCL}	E_V=0lx		3	6	mA
High level output voltage		V_{OH}	E_V=100lx, R_L=10KΩ, V_{OUT}=5V	4.5			V
Low level output voltage		V_{OL}	E_V=0lx, I_{OL}=16mA			0.4	V
L→H Threshold illuminance		E_{VLH}			40	80	lx
H→L Threshold illuminance		E_{VHL}		15	35		lx
Hysteresis		E_{VHL}/E_{VLH}	R_L=280Ω	0.5	0.8	0.95	—
Switching speed	L→H propagation time	t_{PLH}	E_V=100lx, R_L=280Ω		2	6	μsec.
	H→L propagation time	t_{PHL}			3	9	μsec.
	Rise time	tr			0.1	0.5	μsec.
	Fall time	tf			0.05	0.5	μsec.

Bin Displays

Originally, in 2018, there was a 7-segment display associated with each bin that displayed a partial lock code that when taken together, revealed the complete code. This code display has been replaced with QR code displays because the use of a QR code prevents the team player from being able to guess the code because it is not in a human-readable format. Therefore, each bin will have a full-sized iPad placed behind it on the floor so that the team player can not see it from the barriers. The iPads will each display slightly more than one quarter of a QR code, and will be set so as not to go to sleep (no screen saver).

The QR code segments will be preprogrammed into picture files that can be selected by the arena staff. Each QR code will represent a 4-digit lock code. The QR code will be the same on each of the iPads, however only about 30% of the code will be displayed. Each iPad will display a quadrant of the QR code. Each quadrant will show about 30% of the QR code so that merging of the code quadrants will not result in gaps when each "quadrant" is overlaid upon the other "quadrants". Figure 3 shows an example QR code representing the lock code "2468". When each quadrant is overlaid, the complete QR code is revealed. Even with error correction, the QR code can not be deciphered from any combination of quadrants without the information in all four quadrants being merged correctly.

The QR code to the left represents the lock code "2468". The quadrants of this QR code shown in (a), (b), (c), and (d) below contain insufficient information to reconstruct the encoded "2468" lock code. Any one, two, or three quadrants taken individually, or together, will not reveal the code. Only an overlay of all four quadrants will reveal the actual lock code.

Confusion would be added were the code quadrants to be randomly oriented, however all of the iPad displays will be identically oriented relative to the bins.

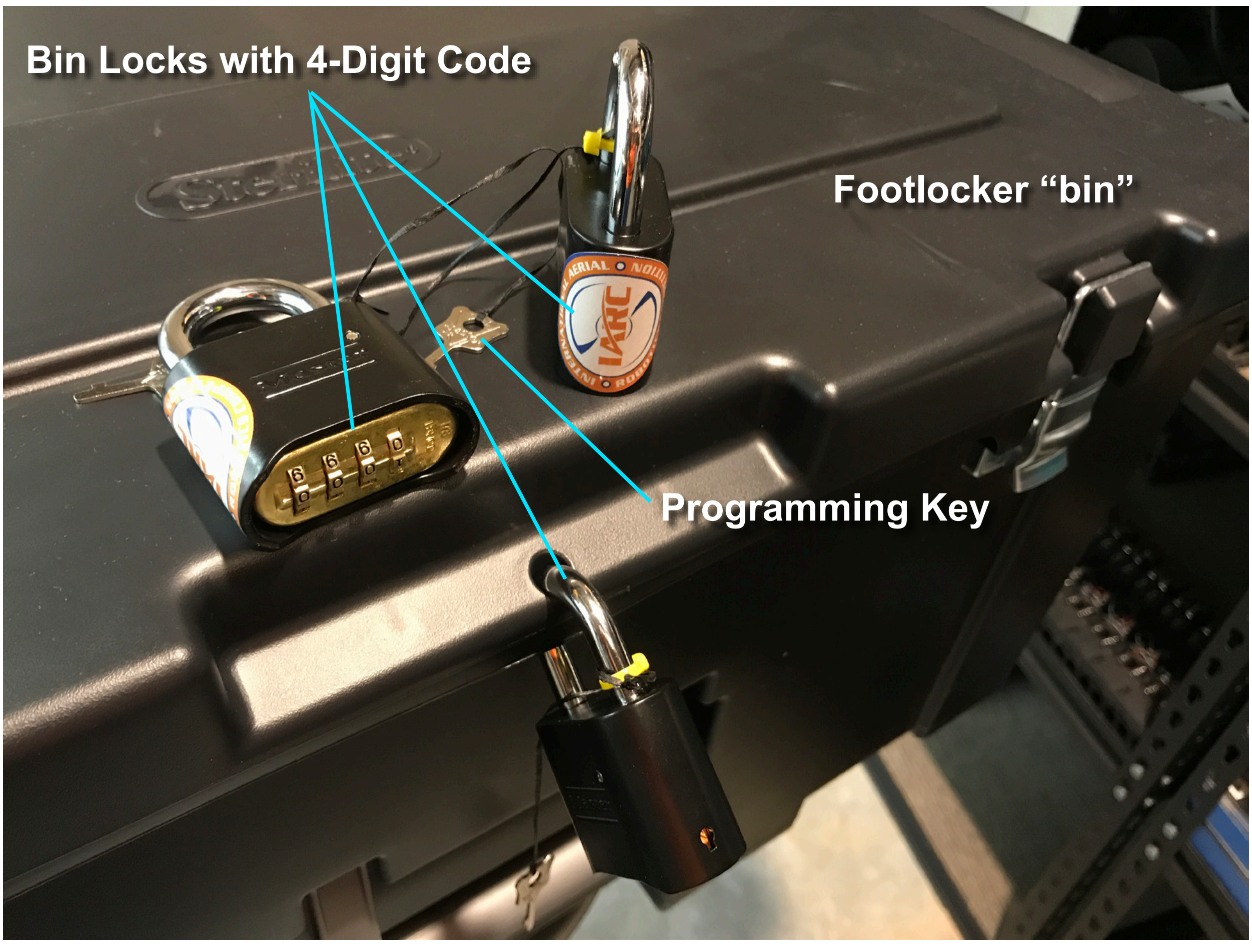
Bin Locks

The locks on each of the four bins are identical and will be encoded with the same 4-digit unlock code during each run (the unlock code will be changed between runs). The locks are conventional hasp locks with a 4-digit thumb-wheel. The locks are unlocked by entering the correct code and then squeezing the hasp toward the body of the lock and then releasing pressure.

Each of the locks has an associated key which is used to encode a new combination into the lock. This will be done by one of the Judges between each run, and the code will be entered (in binary) into the four toggle switches on the primary bin electronics box.

The bins can be any lockable container, but plastic lockable footlockers are recommended. When not in use between competition years, these footlocker bins can be used to store arena props for the subsequent year and the locks can be used to secure them.

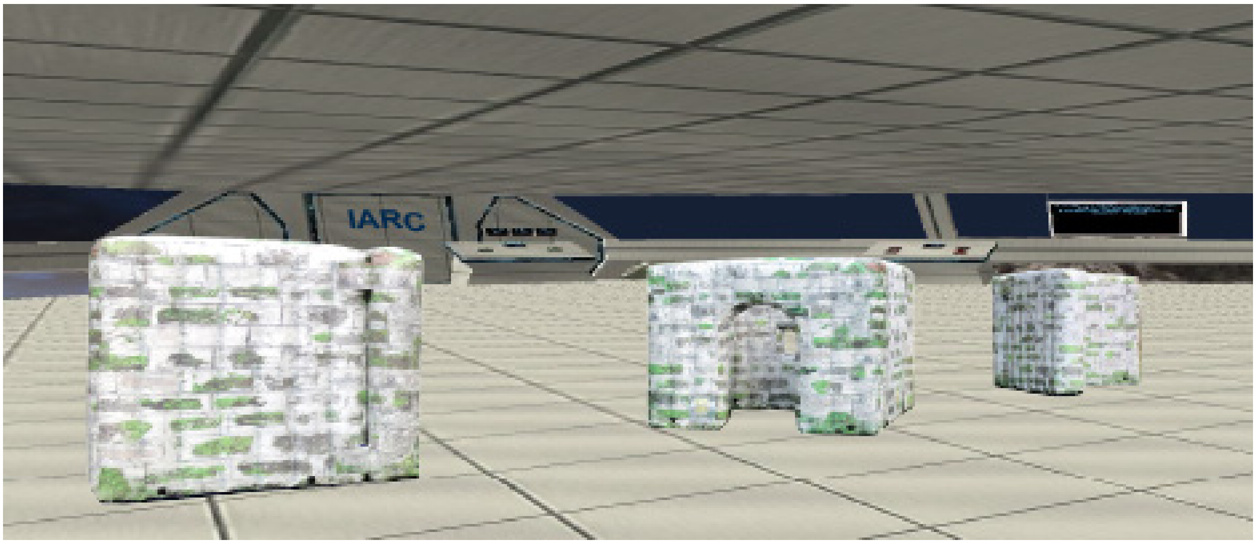
The bin display boxes will be secured to the tops of each of the bins, but between competition years, these bin display boxes should be removed and placed within the bins themselves.



Arena Barriers/Obstacles

Objects in the Arena will be the four bins and three barriers behind which a player can hide. The barriers are inflatable "walls" and a shelter. The shelter will be centrally located and there will be two 90° wall sections located on either side (but not adjoining) the centrally located shelter.

Each of these barrier types is shown in the following figures:



The barriers are available from http://www.mightypaintball.com/index.php?route=product/category&path=101_102. The various barrier shapes are created with items A, B, F, and I at this site. They are inflatable and store easily when not in use. The square shelter is configured to have a light-blocking tarp as a roof, a door, and a small window. Exact placement may vary from year-to-year. Repositioning of the barriers by the player is not allowed during any run.