

# ***Test Readiness Review: Remote Escalation/De-escalation and Surveillance System (REDSS)***

Team Pew^3 (Georgia Tech)

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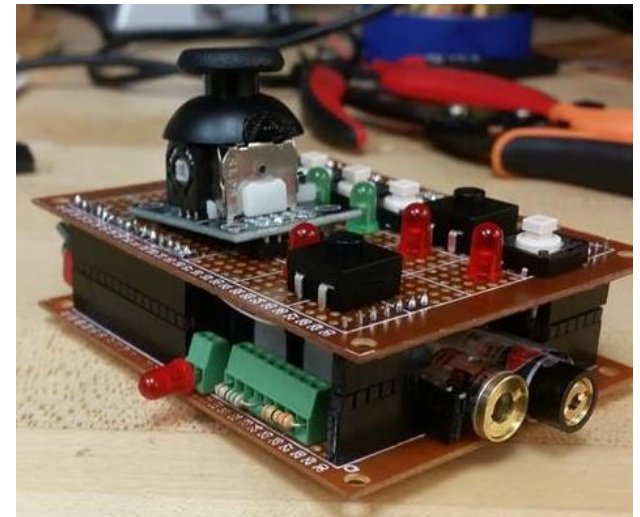
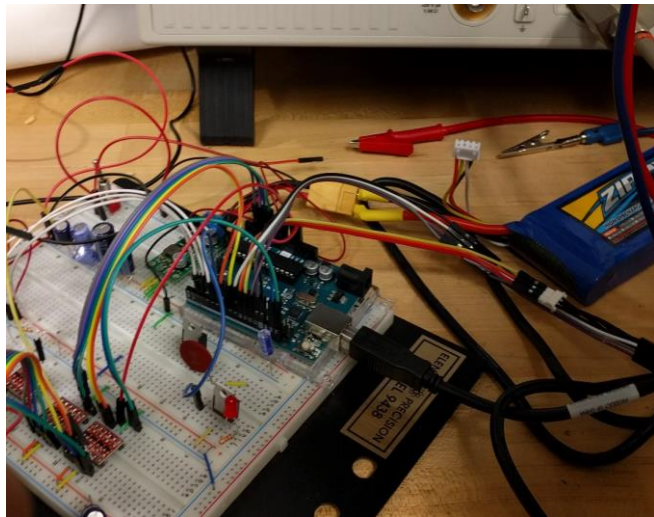
Satoshi Yuki

1. TRR Exit Criteria
2. TRR Scope
3. Current Disposition
4. Implementation Details
5. Test Plan
6. Performance Estimates
7. Action Items
8. Equipment List

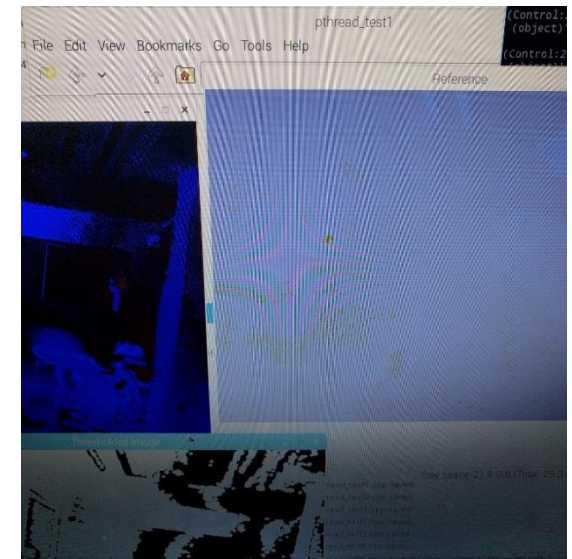
- Current disposition shown
- Subsystem implementation described
- Component list complete
- System behavior defined
- Estimate of system performance
- Test plans described

- Objectives and technical specifications
- Design details as implemented
- Estimate of performance metrics
- Decision criteria behind methods and parts
- Test plans

# Disposition



## Current Status Video

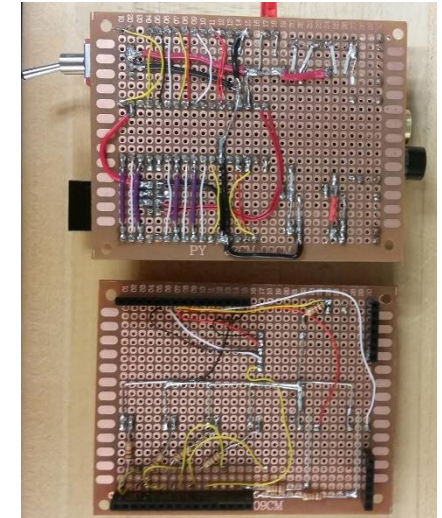
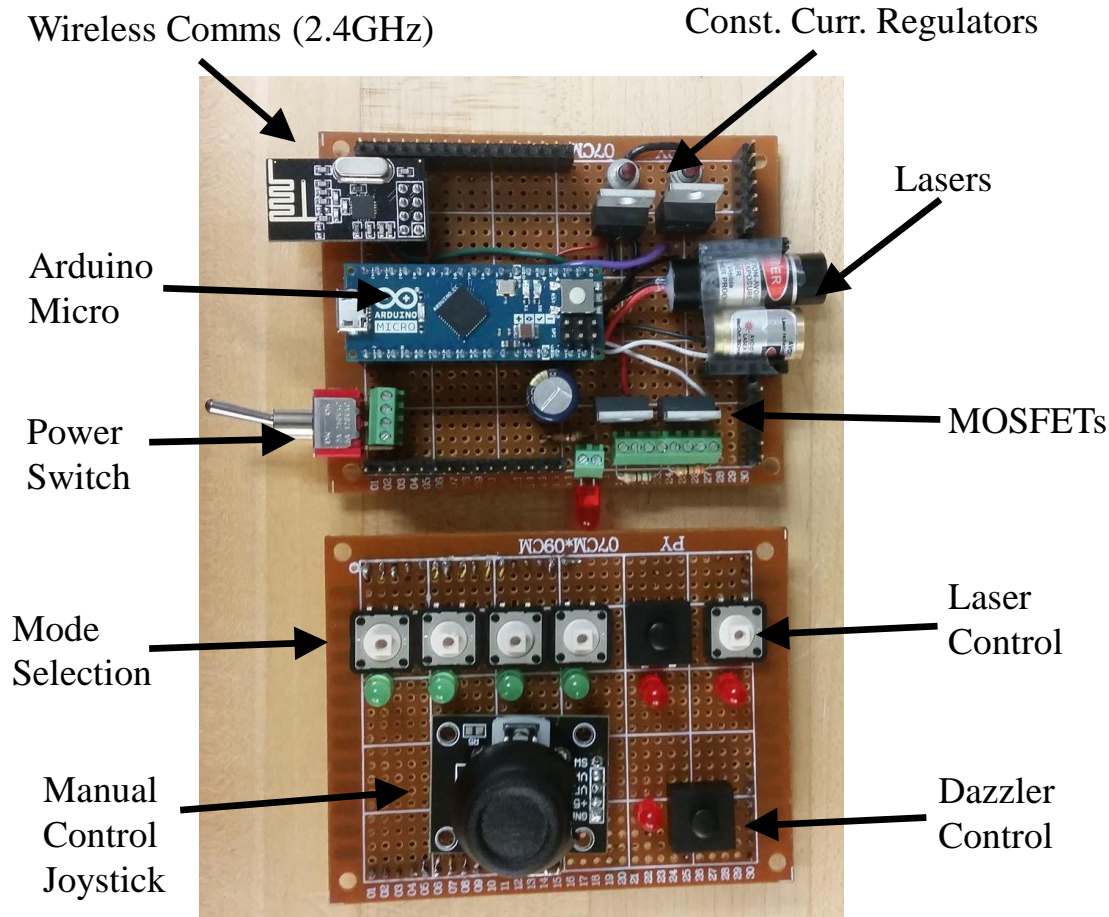


- The system is prepared for breadboard tests and refinement
- The physical assemblies are prepared, however, the remote's enclosure requires a re-print
- Approximately one day of work is required to integrate the electronics into the physical enclosures, pending 3D printer availability
- The mobile app is incomplete, however, the physical remote provides complete control over REDSS core functionality and can replace the mobile app for critical applications

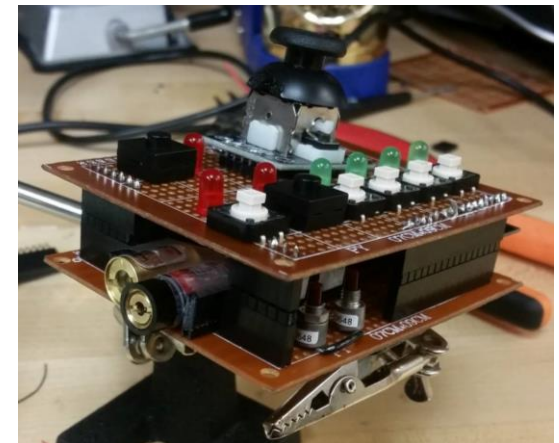
- Physical Remote: Complete
  - Communicates with REDSS Robot to cue laser tracking and control mode
  - Pulses laser to aid laser-tracking software
  - Will be rifle (nerf gun) mounted
- Android App: Ongoing. May be omitted from final product
  - Video feed functional
  - UDP message not implemented



# Disposition: Physical Remote



Underside of Remote



Assembled Remote without Housing

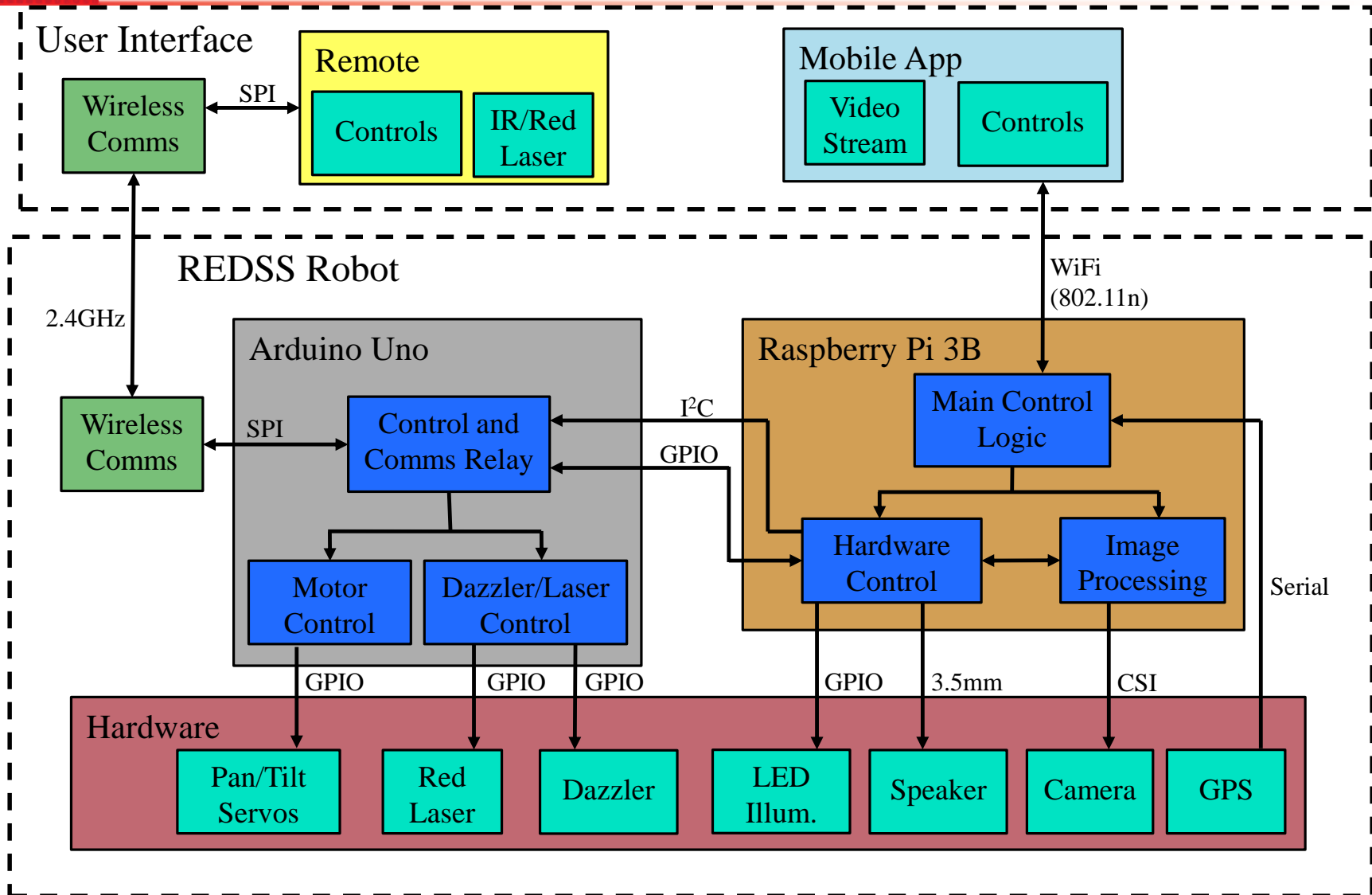


- System is complete and ready for testing on the breadboard
- Self-contained power tested and reliable
- Peripherals attached and controlled through the Arduino Uno or Raspberry Pi
- Physical housing prepared and ready to accept electronics

- Escalation Mode (Manual Control):
  - Allows manual control of all key functionality (pan/tilt, laser, dazzler)
  - Advanced functions (audio, camera stream) are not accessible without mobile app
- De-Escalation Mode (Laser Tracking):
  - Tracks laser accurately under ideal conditions
  - Image processing is tolerant to degraded environments but not vibration
  - Work ongoing to reduce effect of vibration
- Surveillance Mode (Automatic):
  - System defaults to an automatic pan routine
  - Motion detection not implemented

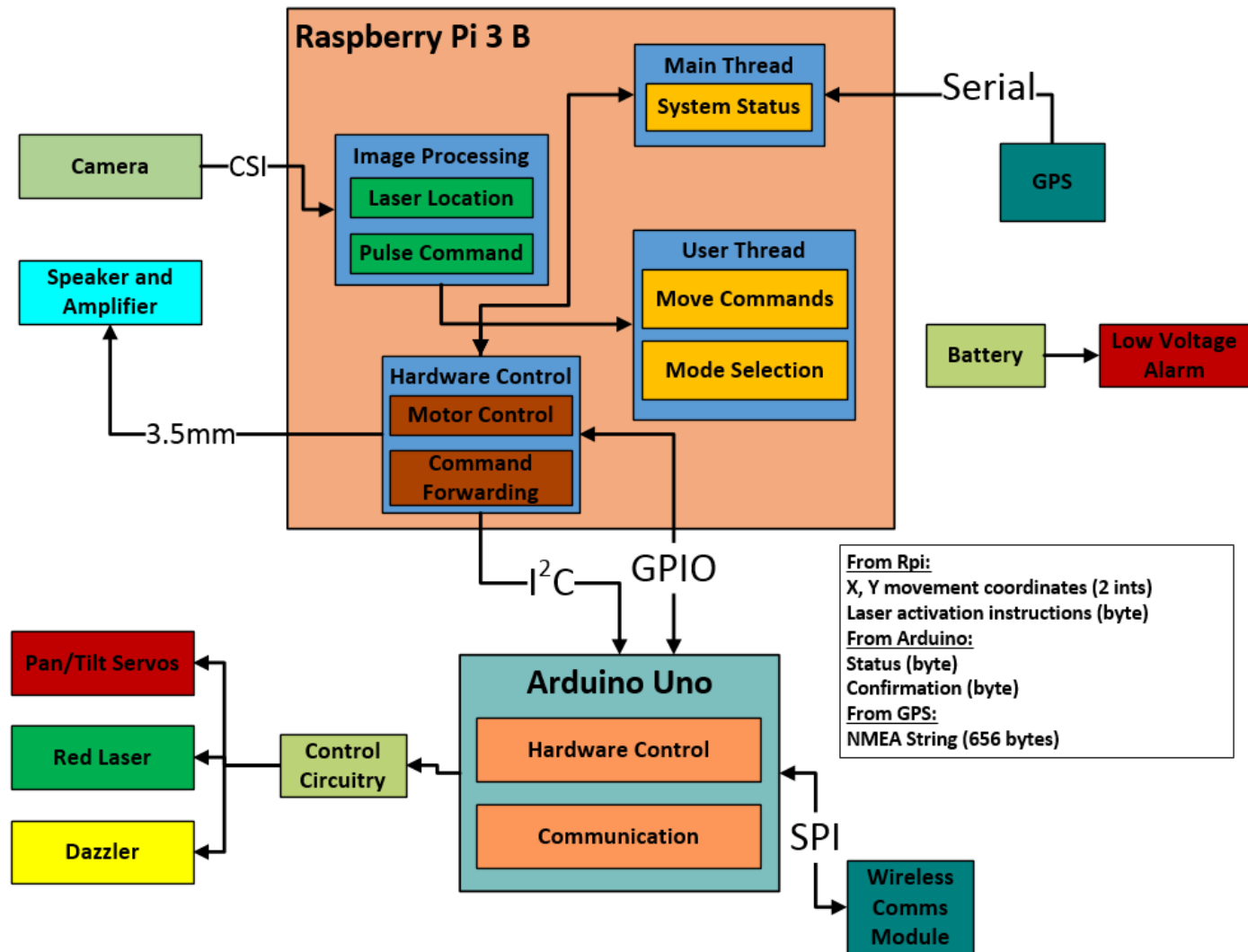
- All operation modes (Surveillance, Escalation, De-Escalation) are complete
  - Robot under manual control in Escalation mode
  - Automatic surveillance movement
  - No motion detection implemented
- Image processing and motor control are integrated
  - System tracks and moves to the laser location
  - When confused, the system pulses the laser to grab new reference frames
  - Ongoing refinement for vibration tolerance
- Arduino Uno handles the majority of the system control and communication

# Implementation



- Significant deviations from original design:
  - Arduino handles more processing and communication
  - I<sup>2</sup>C communication only used for Rpi -> Arduino communication, bidirectional accomplished using GPIO
  - 180 degree servos with a flip used in lieu of sailwynch servo
  - Multi-threading discarded
  - Bluetooth omitted in favor of Arduino->Arduino communication
  - Surveillance mode has automated movement and no motion detection
  - API difficult to define and not built out (communication libraries present and integrated)
- Physical specifications not a design objective
  - Approach dimension and weight requirements, but meeting specifications was lowest priority
- All peripherals attached
  - GPS not fully integrated
  - Red laser and illumination attached to robot per customer request

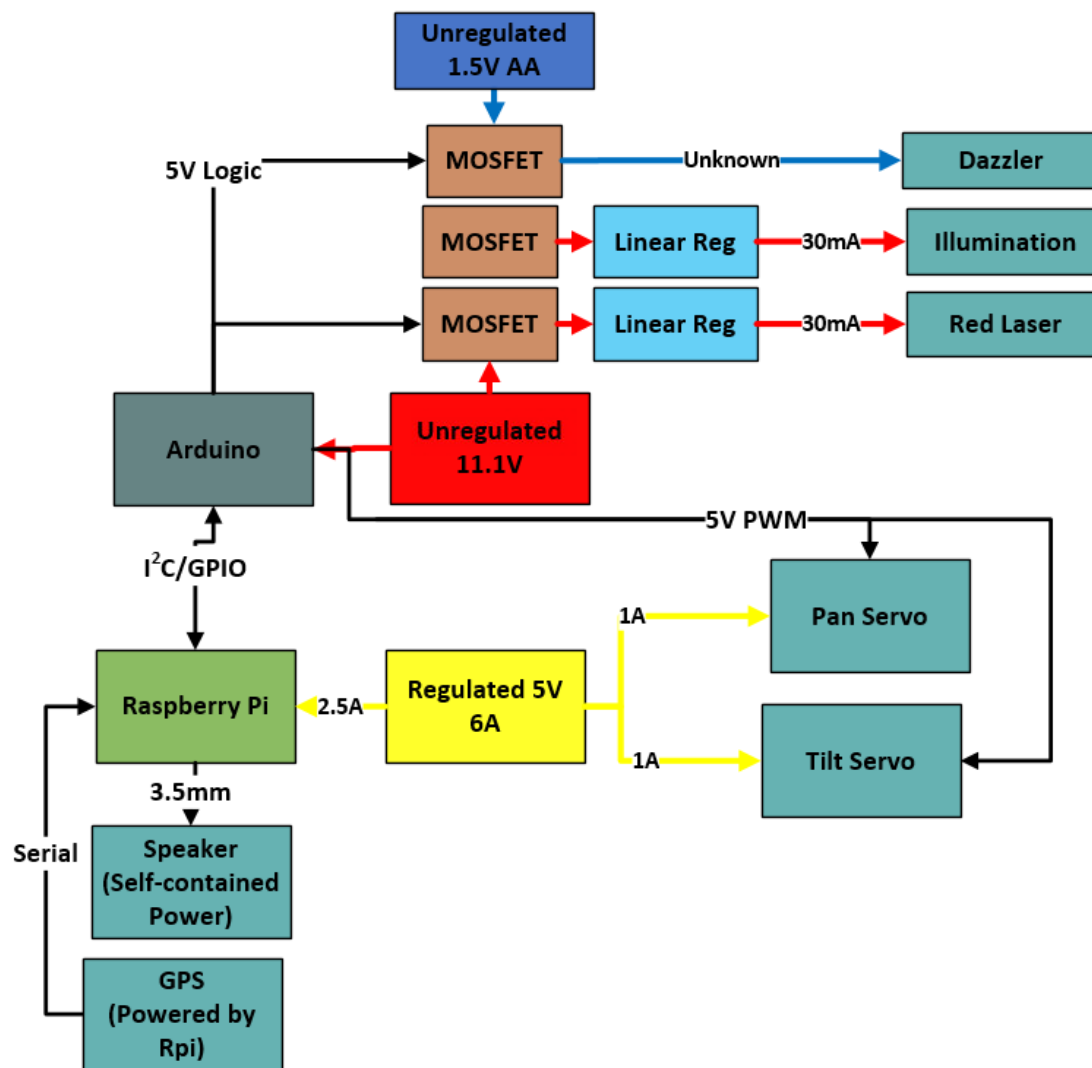
# Implementation: Robot





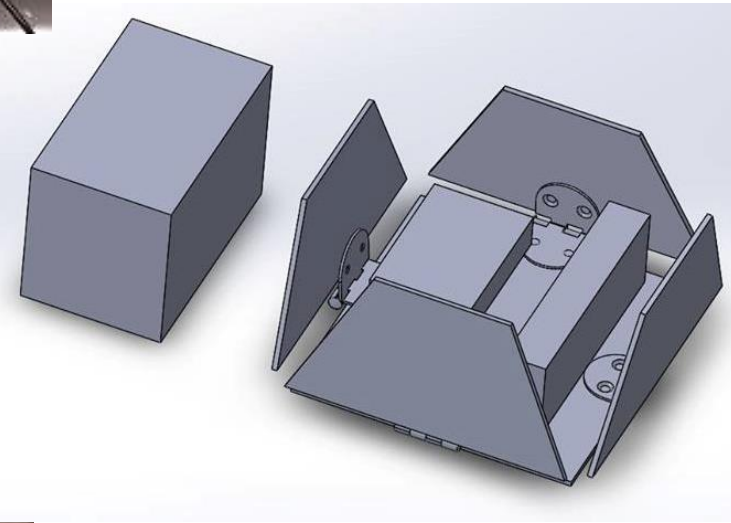
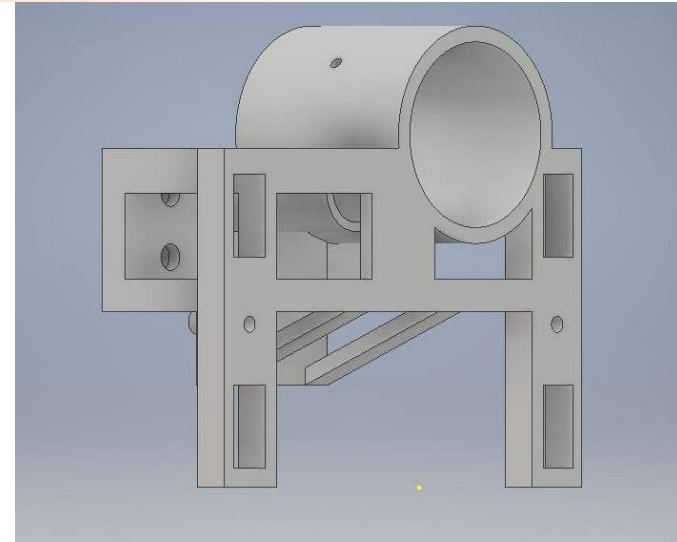
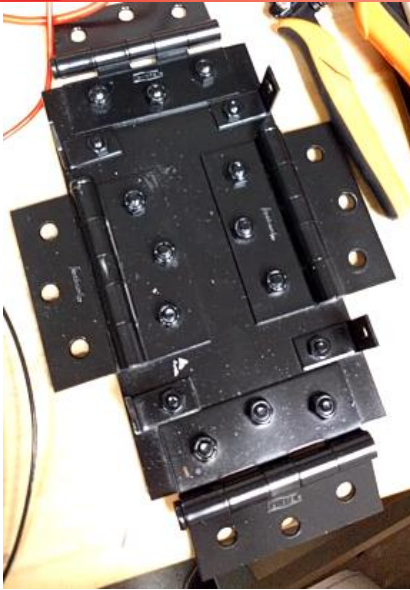
- Robot power provided by a 3 cell, 11.1V Lithium Ion battery
- Red laser is powered through a constant current regulator
- Dazzler has independent current control circuitry, and uses a 1.5V AA battery
- Illumination is current limited through a simple resistor
- Servo activation drops the 5V line to 4.58V and sets off a voltage alarm on the Raspberry Pi
- Extensive tests have not identified any voltage-related instability on the RPi

# Implementation: Power



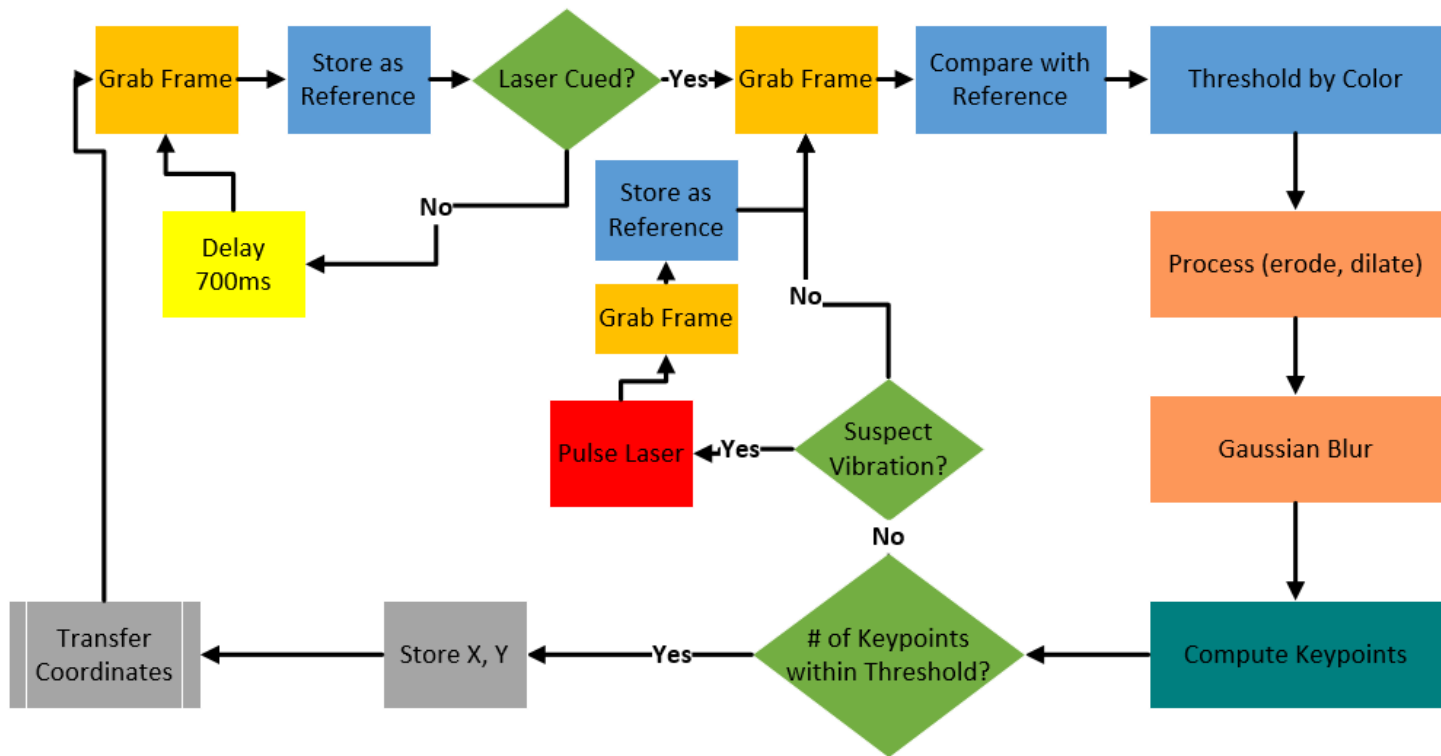
- Off-the-shelf pan/tilt module used to house servos
- Bracket for laser/LEDs/camera/dazzler custom manufactured on 3D printer
- Robot housing cut from aluminum using waterjet

# Implementation: Mechanical



- Image processing uses the RGB color space to resist the effects of lighting changes (indoor lighting pulses)
  - Differencing operation removes the effects of white lights
- Differencing operation reduces image to only deviations from reference
  - Color thresholding further reduces to deviations within the color region of the laser
- Keypoint detection translates objects into discrete points
  - Number of keypoints found used to judge quality of detection
  - Detections outside of a calibrated range are discarded
- If the processing software cannot detect the laser due to clutter, the remote's laser is shut off until a new reference frame is captured, then reactivated
  - The pulsing can be seen on the remote's status LED
- The system is still highly vibration sensitive

# Implementation: Image Processing



Integer Data

RGB

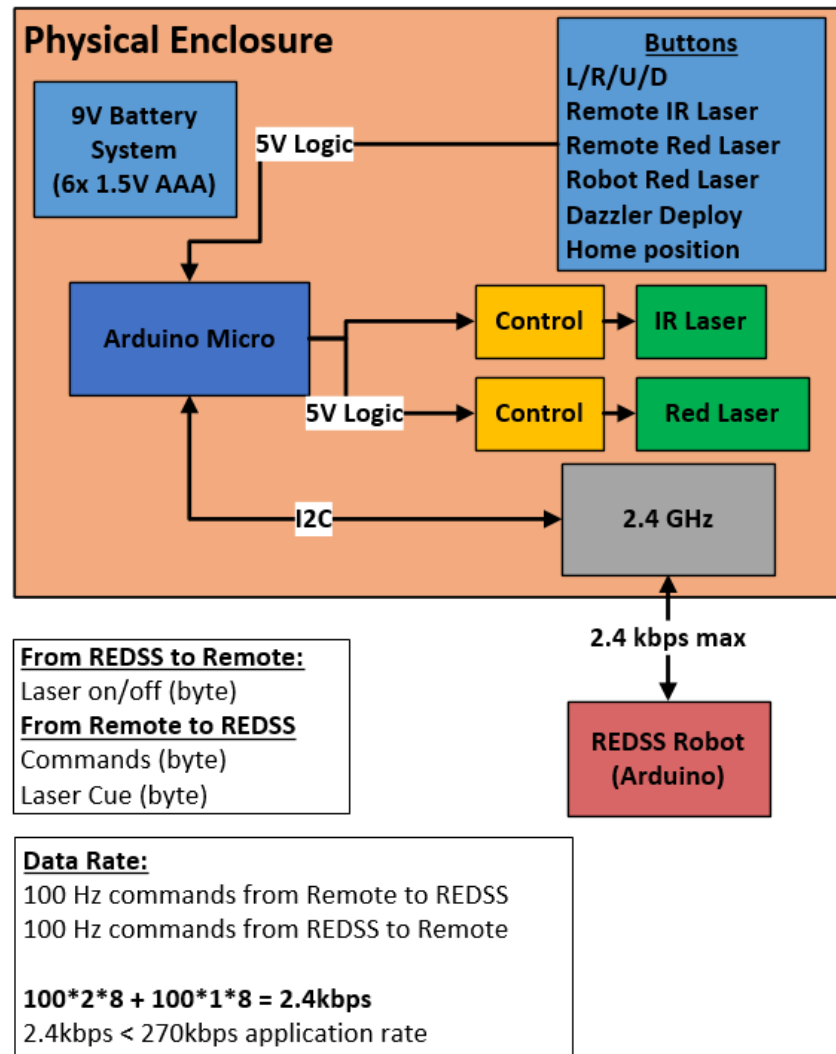
Binary or  
Grayscale



- Raspberry Pi (Back Seat):
  - Single thread operation
  - Processes image and transmits XY coordinates to Arduino
  - Controls audio output
  - Transmits video feed
  - GPS data
- Arduino (Front Seat):
  - Motor and peripheral control
  - Communication hub for remote and Raspberry Pi
  - Automatic surveillance and manual control

- Remote provides control over the following:
  - Mode selection: Surveillance, De-Escalation (Laser Tracking), Escalation (Manual Control), Standby
  - Robot red laser
  - Robot dazzler
  - Pan/Tilt and flip
  - Home position return
- Remote includes:
  - Red laser (Not tracked)
  - IR Laser

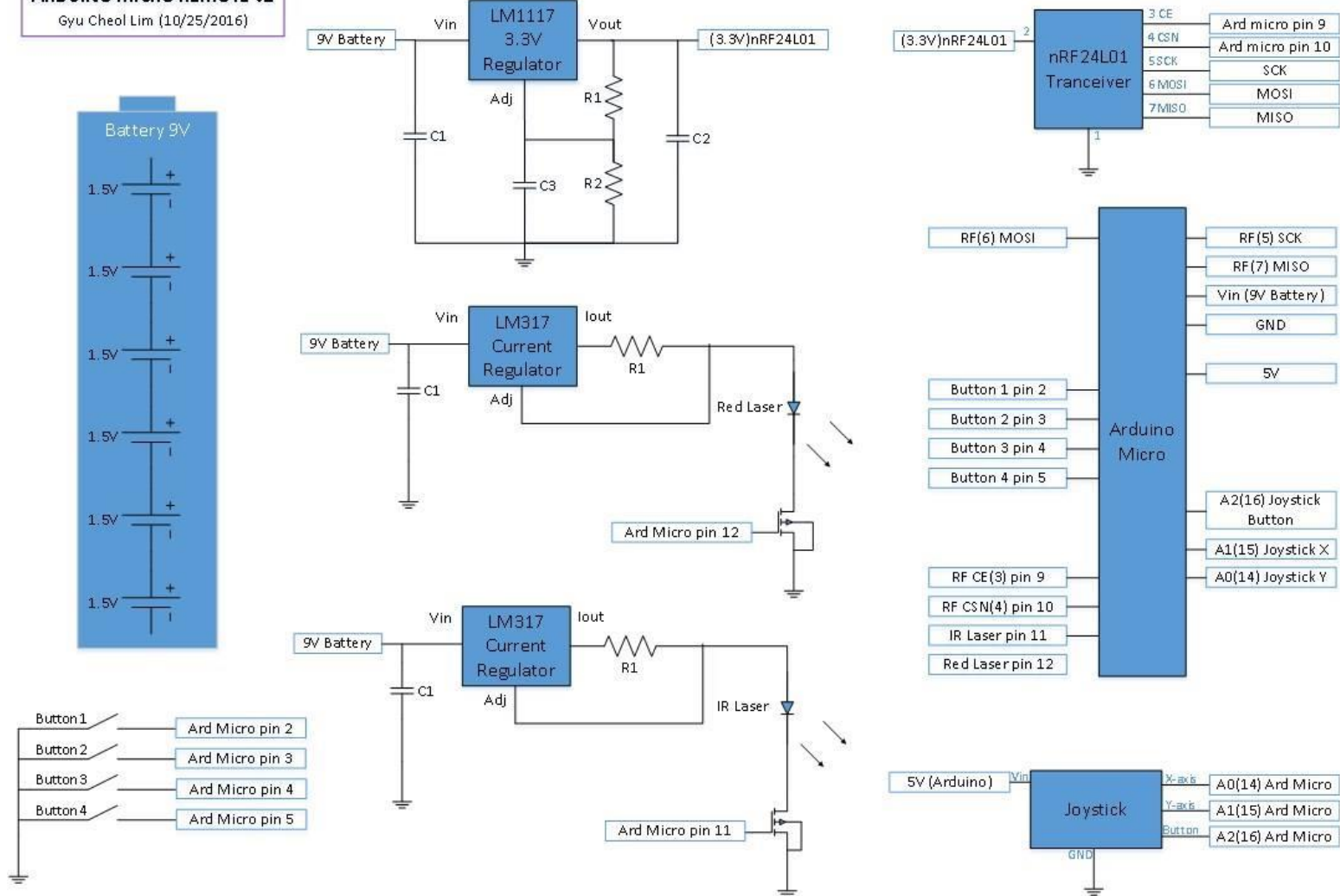
# Implementation: Physical Remote



# Implementation: Physical Remote

## ARDUINO MICRO REMOTE v2

Gyu Cheol Lim (10/25/2016)



**Environment:** Tests will be conducted in conditions which approximate battlefield environment

- Low light
- Moderate RF interference
- Varying ranges

**Standards:** The system will be expected to meet only the electronics standards (no weight or size specifications)

- Prototype laser is 1/5 power level of military laser (5mW vs 25mW), and failure to meet range specifications will not demonstrate design failure

**Methods:** The system will be tested in a manner similar to employment, specific to the CONOP

- Tests will be conducted sequentially and used to gauge battery performance

- Overall Success
  - Simple operation to permit a training time of less than one hour
  - Minimum impact on operator's situational awareness
- De-escalation Mode Success
  - Successful tracking of an IR laser to within 0.4 degrees of a target 50m away
  - Deploy an ultra-bright flashlight(dazzler) at the designated target with minimal operator workload
- Escalation Mode Success
  - Deploy the dazzler and announce audio instructions under remote command with a latency below 0.5 second at a range from the operator of 15m
- Surveillance Mode Success
  - Transmit an alarm signal when a man-sized object moves within 50m inside the REDSS visual coverage



# Test Plan: De-Escalation Mode



Specification	Method	Standard
Laser Track Range	Laser deployed in low-light environment at stationary white paper target*	20m (reduced from 50m)
Laser Track Accuracy	Robot red laser will be compared to remote laser location, after accounting for bore sighting errors	0.4 degrees
Laser Track Latency	System will be timed from laser activation to pan/tilt initiation	0.5 seconds
Noise/Clutter Tolerance	System will be tested with: 1. No street lights, no movement 2. Street lights, no movement 3. Street lights, periodic movement of personnel 4. Street lights, continuous movement 5. Differing target materials 6. Slowly moving target	Not specified, assumed standard (3), (5) and (6)
Dazzler/Red Laser Deployment	Dazzler activation under remote control with above test cases	Pass
Impact on Sit. Awareness	Team member will operate robot in above test cases and be watched for inattention	Does not remove eyes from target
Training Time	Unaffiliated person will be trained on system and run through a simple simulation	<1 hour
Endurance	Monitor battery voltage and extrapolate endurance	>5 Hours

\*Laser tracking cannot be tested on human target without safety lenses

# Test Plan: Escalation Mode



Specification	Method	Standard
Manual Control Range	System will be tested at varying ranges between remote and robot	15m
Speaker Range	Robot will announce instructions and team members will listen at varying ranges	25m
Dazzler Deployment	Dazzler activation under remote control with above test cases	Pass
Remote Control Through Brick Wall	System will be tested with a 10m range and brick wall between remote and robot	Pass
Movement Latency	Time to pan/tilt robot will be tested	40 degrees per second
Operator Cover	Team member will operate robot without line of sight and use mobile app video stream for feedback	Does not break cover
Training Time	Unaffiliated person will be trained on system and run through a simple simulation	<1 hour

# Test Plan: Surveillance Mode



Specification	Method	Standard
Video Stream Range	System will be tested at varying ranges between receiving platform and robot	50m
Motion Detection*	System will be view increasing levels of motion and monitored for alarm signal	Man-sized object
Operator Cover	Team member will operate robot without line of sight and use mobile app stream for feedback	Does not break cover
Training Time	Unaffiliated person will be trained on system and run through a simple simulation	<1 hour
Endurance	Monitor battery voltage and extrapolate endurance	>8 hours

\*Not implemented and will not be tested

# Performance Estimation: Overall



Specification	Standard	Estimate
Dimension	$< 17.8 \times 19 \times 10.1 \text{ cm}^3$ (Cargo pocket)	Not Targeted
Weight	500 g - 1 kg	Not Targeted
Operating Endurance	> 5 hours (Laser tracking mode) > 8 hours (Surveillance mode)	High likelihood of success (Battery loses <1V nominal after 3 hours)
Impact Endurance	> Survive drop from 3.2 m	Not Targeted
Aiming Accuracy	< 0.4 Degrees	<1 degree likely
Target Distance	> 50 m	~20m
Rotational Speed	> 40 Degrees per Second	> 40 Degrees per Second
Speaker Range	> 25 m	25 m
Camera Height	> 16 cm	> 16 cm
Interface	Hardware Remote and Android Mobile App with Video Stream	Hardware Remote and Android Mobile App with only Video Stream

# Performance Estimation: De-Escalation



Specification	Standard	Estimate
Laser Track Range	20m (reduced from 50m)	Success at 10m (lab tests), uncertain at 20m
Laser Track Accuracy	0.4 degrees	<1 degree, limitation of servo accuracy not image processing (Img. proc. successful at 10m)
Laser Track Latency	0.5 seconds	<1 second likely, frame rate jitter (lab experience)
Noise/Clutter Tolerance	Assumed standard (3), (5) and (6)	Pass with lights and periodic movement (3), Fail on moving target(5), Require calibration on different target material (6) (Lab experience)
Dazzler/Red Laser Deployment	Pass	Pass (Bench test)
Impact on Sit. Awareness	Does not remove eyes from target	Pass (Favorable remote design)
Training Time	<1 hour	Pass (Favorable remote design)
Endurance	>5 hours	Pass (Battery loses <1V nominal after 3 hours)

# Performance Estimation: Escalation



Specification	Standard	Estimate
Manual Control Range	15m	Pass at 50m (Lab experience)
Speaker Range	25m	Pass (Lab experience)
Dazzler Deployment	Pass	Pass (Bench tests)
Remote control through brick wall	Pass	Pass (Lab experience)
Movement Latency	40 degrees per second	Pass, but jerky movements
Operator Cover	Does not break cover	Uncertain, mobile app may not be finished
Training Time	<1 hour	Pass (favorable design)

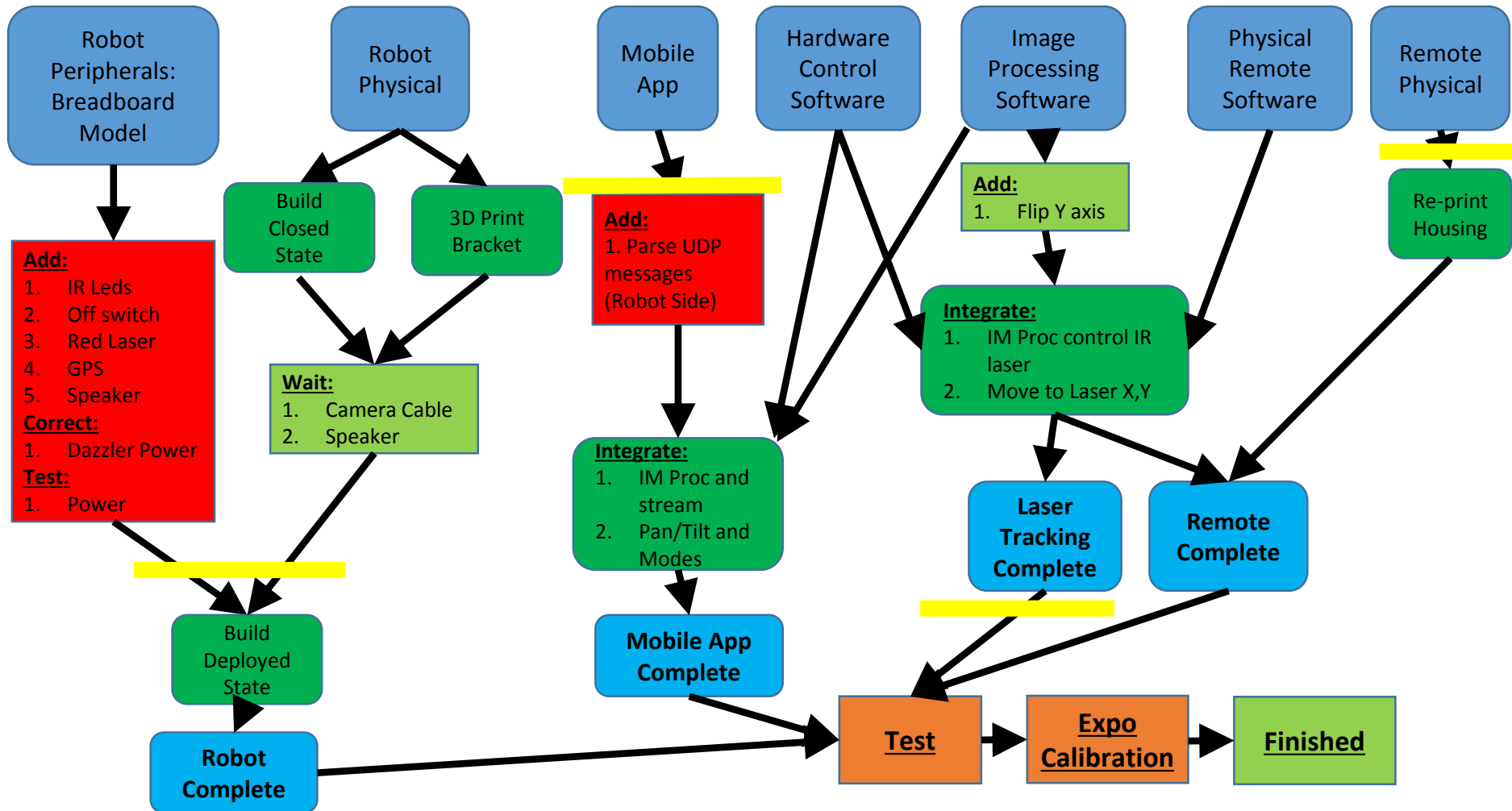


Specification	Standard	
Video Stream Range	50m	Pass (Within WiFi Range)
Motion Detection*	Man-sized object	Fail (Not implemented)
Operator Cover	Does not break cover	Pass (Favorable Design)
Training Time	<1 hour	Pass (Favorable Design)
Endurance	>8 hours	Pass with automatic pan disabled

\*Not implemented and will not be tested

1. Test electronics on breadboard
2. Refine laser tracking software (compensate for vibration)
3. Finish remote housing
4. Install electronics into housing
5. Calibrate and conduct test plan
6. Recalibrate for Expo

# Action Items: Final Steps



Current Position

# Prototype Equipment List



					quantity	price per part	total
Primary	1A	Amazon.com	B00V7T1YRQ	V1 Pro	1	\$13.95	\$13.95
Primary	1A	Hobbyking.com	Z50003S-25	Z50003S-25	1	\$27.62	\$27.62
Primary	2A	Hobbyking.com	9070000044-0	9070000044-0	1	\$21.61	\$21.61
Primary	3A	Hobbyking.com	9052000023-3	9052000023-3	1	\$15.05	\$15.05
Primary	4A	Adafruit	3006	3006	1	\$5.95	\$5.95
Primary	5A	Adafruit	1314	1314	1	\$1.95	\$1.95
Primary	1A	Sparkfun	BOB-12009	BOB-12009	3	\$2.95	\$8.85
Primary	2A	Robotshop.com	RB-Hit-53	HS-785HB	1	\$44.99	\$44.99
Primary	3A	Robotshop.com	RB-Sct-208	SPT-200	1	\$45.99	\$45.99
Primary	4A	Amazon	MB-MP32DA/AM	MB-MP32DA/AM	1	\$9.99	\$9.99
Primary	5A	Adafruit	2479	2479	2	\$17.50	\$35.00
Primary	6A	Adafruit	50	Arduino Uno R3	2	\$24.95	\$49.90
Primary	1A	Robotshop.com	RB-Lyn-77	RB-Lyn-77	1	\$9.95	\$9.95
Primary	5A	Pololu	2865	D24V60F5	1	\$19.95	\$19.95
Primary	1A	Adafruit	(adafruit) 1995	C688-9392	1	\$7.95	\$7.95
Primary	2A	Adafruit	(Adafruit) 2029	2029	1	\$6.95	\$6.95
Primary	3A	Adafruit	(Adafruit) 3055	(Adafruit) 3055	2	\$39.99	\$79.98
Primary	4A	Adafruit	(Adafruit) 2258	(Adafruit) 2258	1	\$7.95	\$7.95
Primary	5A	Adafruit	(Adafruit) 1086	1086	2	\$24.95	\$49.90
Alternative	6B	Emerging Tech Sales (amazon)	PiNoIR	(ASIN) B00KX3HS4K	1	\$23.99	\$23.99
Primary	7A	HobbyKing.com	SW5513-6MA	N/A	1	\$13.20	\$13.20
Primary	8A	Robotshop	RB-Hit-87	HS-485HB	1	\$14.99	\$14.99
Primary	9A	Digikey (US-Lasers Inc.)	38-1030-ND	D8505I	2	\$36.12	\$72.24
Primary	10A	Digikey (Adafruit Industries)	1528-1391-ND	1054	2	\$5.95	\$11.90
Primary	11A	Samsung (amazon)	MB-MP32DA/AM	MB-MP32DA/AM	1	\$9.99	\$9.99
Primary	1A	Amazon.com	B01E9HM7NC	B01E9HM7NC	1	\$6.99	\$6.99
Primary	2A	Adafruit	2077	2077	1	\$9.95	\$9.95
Primary	3A	Adafruit	2310	2310	1	\$4.95	\$4.95
Primary	4A	Digikey	38-1019-ND	M8505I	2	\$62.48	\$124.96
Primary	1A	Adafruit	1731	1731	1	\$2.95	\$2.95

- Total expenditure (including spares and unused parts):

**\$860**

- Cost as built:

**\$500** (Refinement ongoing)

# Thank You!



- Questions?

