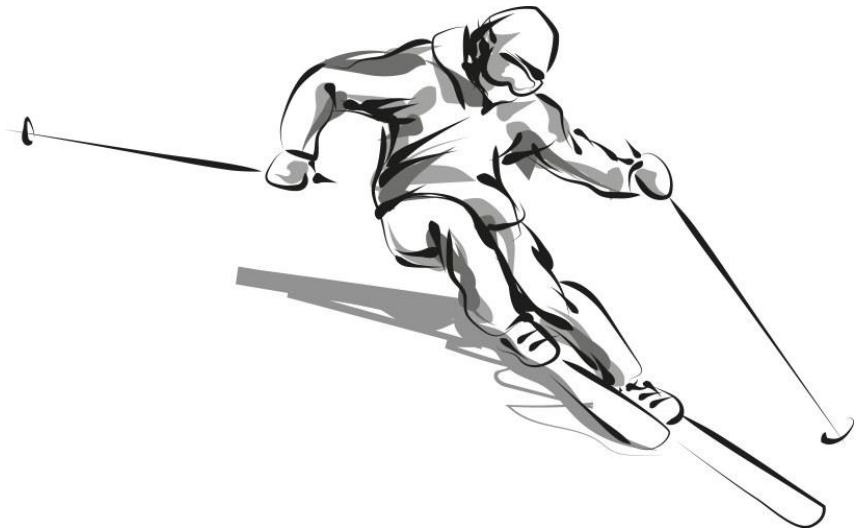
JumpGuard Preliminary Prototyping Demo



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Clients: Nick Hekker, Kade Borson, Tate Ellinwood, Tristan Tober

Advisor: Dr. Kevin Repasky

Date: 1/23/25

Problem Statement

Problem Motivation:

Many ski resorts today have terrain parks, which are collections of jumps and obstacles that can be ridden by athletes. Depending on the size of terrain park jumps, athletes can't always see the landing area before committing to the jump. So, if an athlete crashes on the bottom of a larger jump, athletes uphill may not be aware of the risk of collision awaiting them at the bottom of the jump.

Project Description:

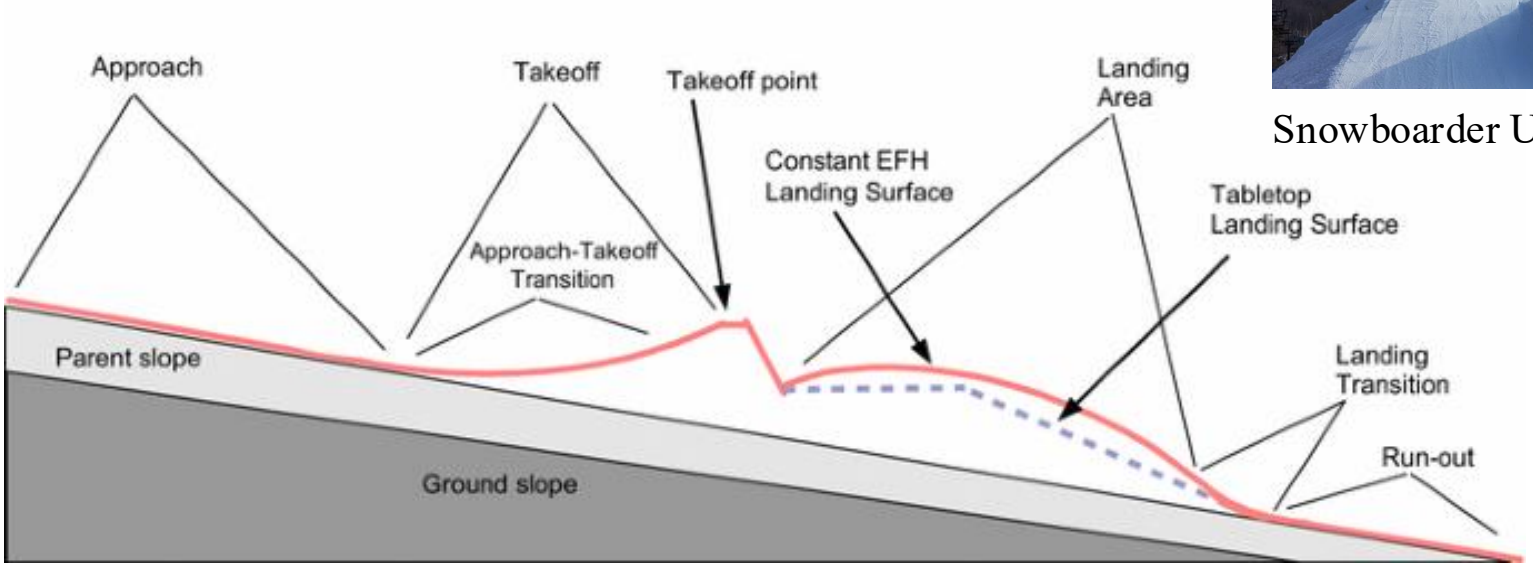
A system will be designed to detect when the landing area is clear before notifying the next athlete that it is safe to proceed from the top of the hill.

Objectives:

This system will determine whether the landing area below a jump is clear and then report the status to athletes uphill from the landing area. The system must operate in inclement weather throughout the ski-season. The system will operate on a stand-alone power system to avoid running power lines to the system, which could create unnecessary hazards.

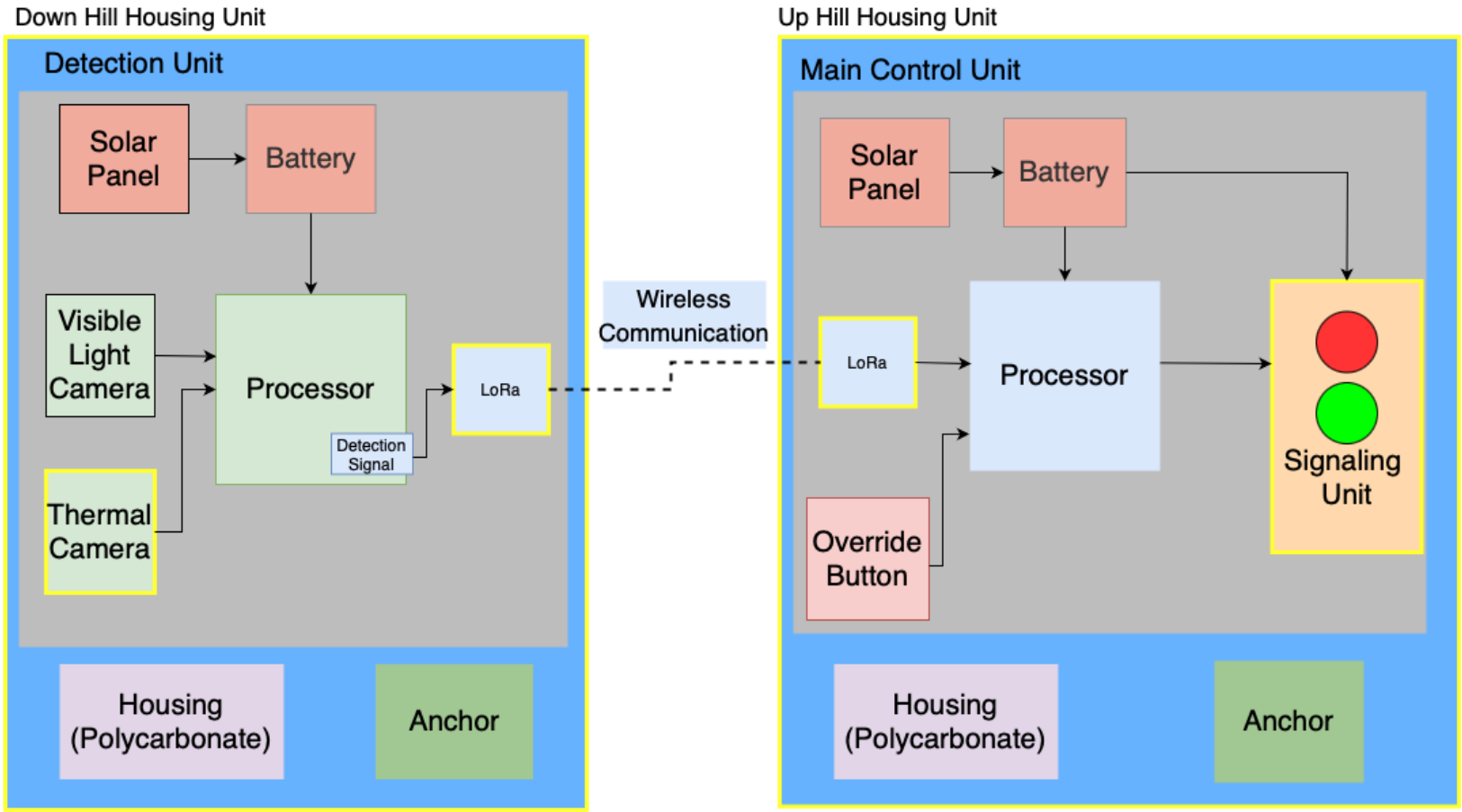
Necessary Background

Snowboarder Using Large Jump



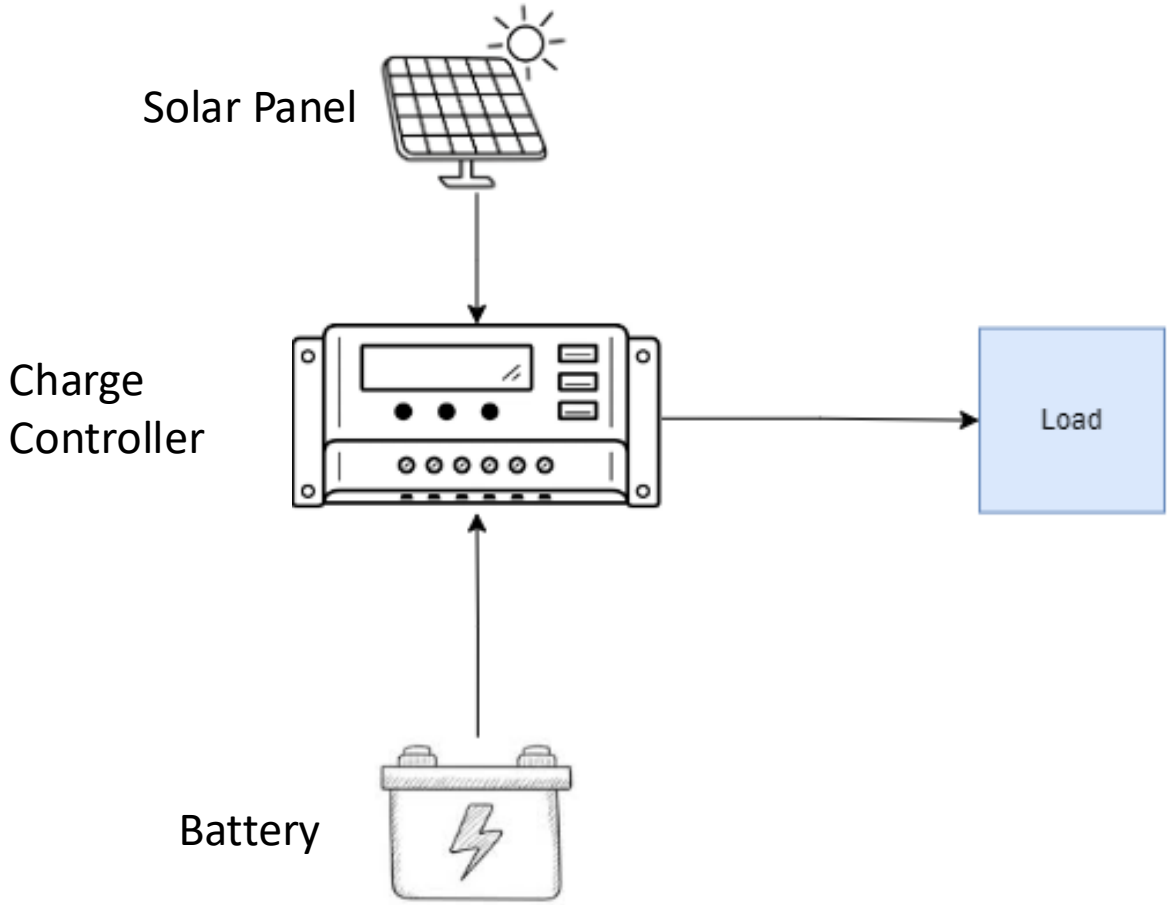
Terrain Park Jump Diagram

Project Design Concept

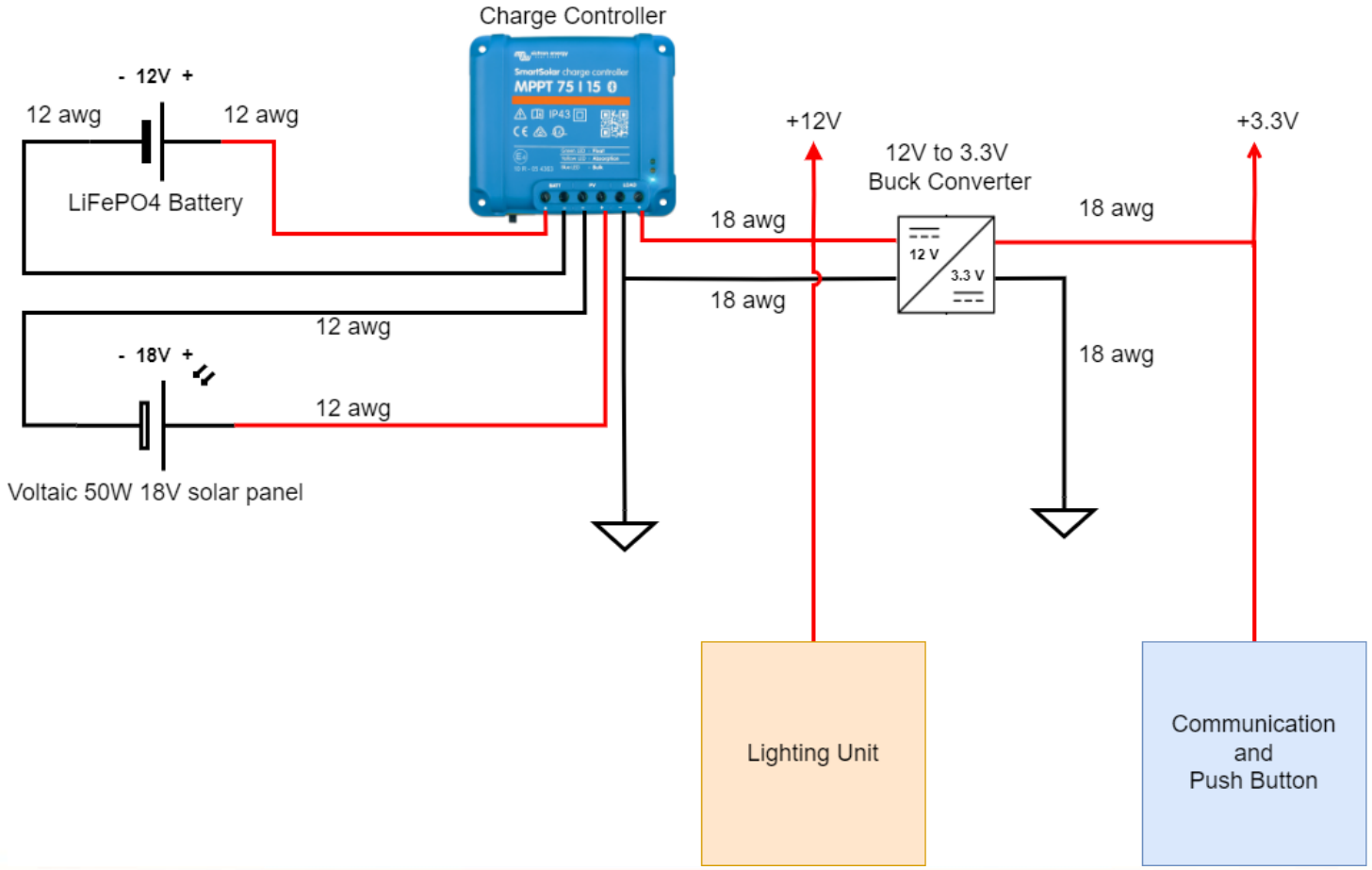


Conceptual Block Diagram

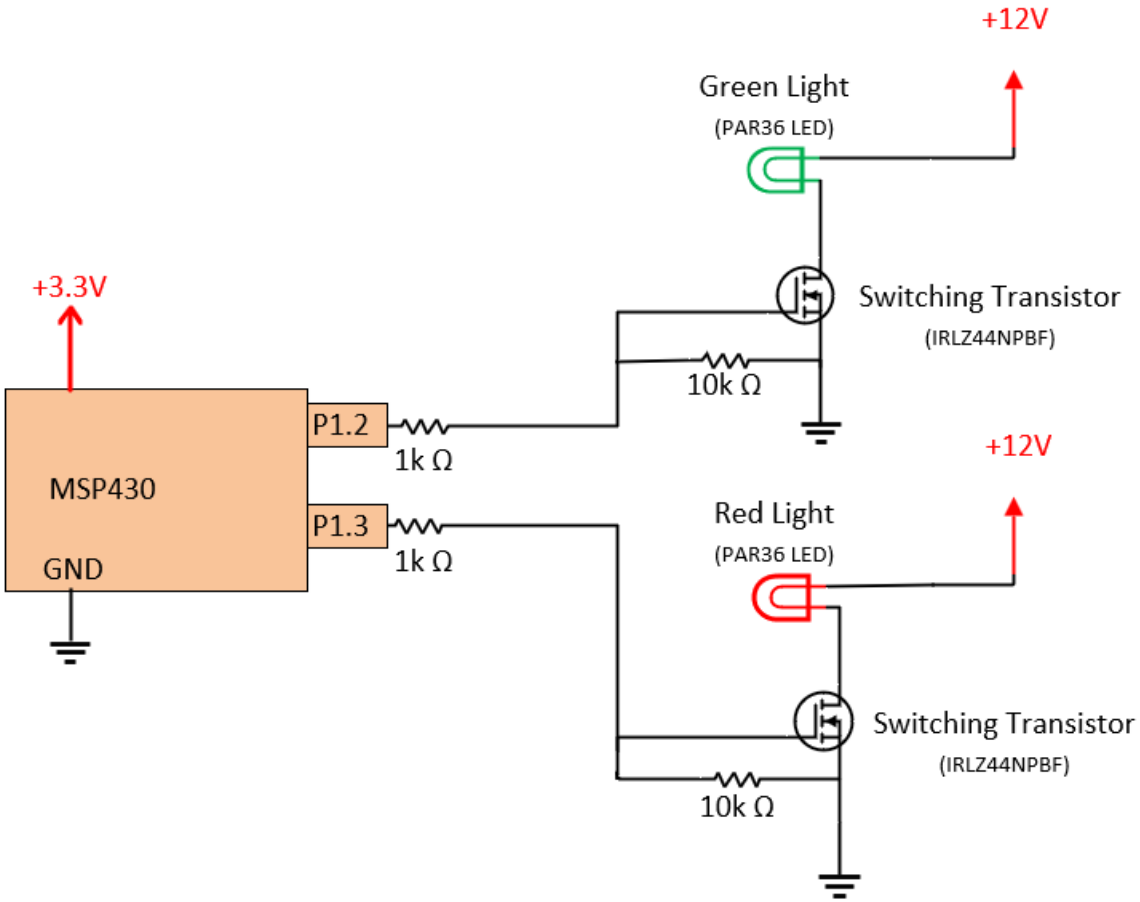
Simple Solar Power System



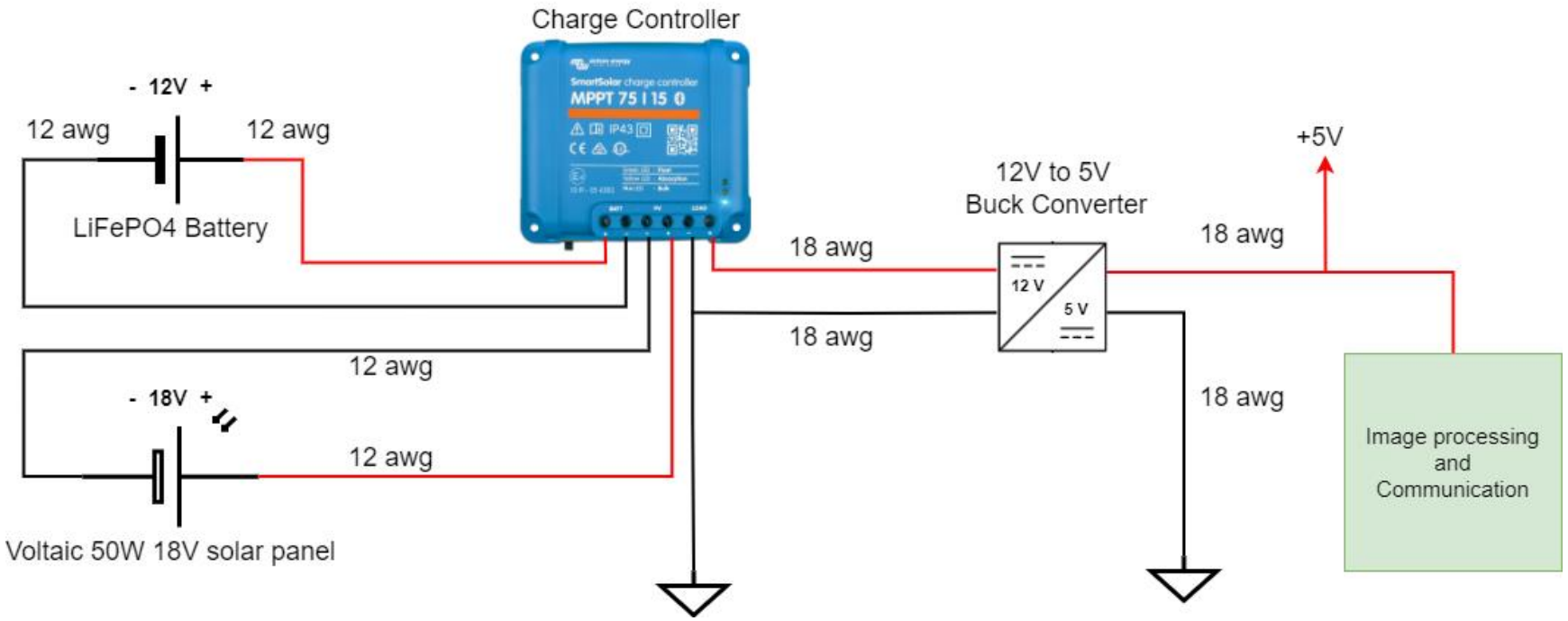
Design Solution: Solar Power System (Uphill)



Design Solution: Lighting Unit



Design Solution: Solar Power System (Downhill)



Design Solution: Solar Power System Component Selection

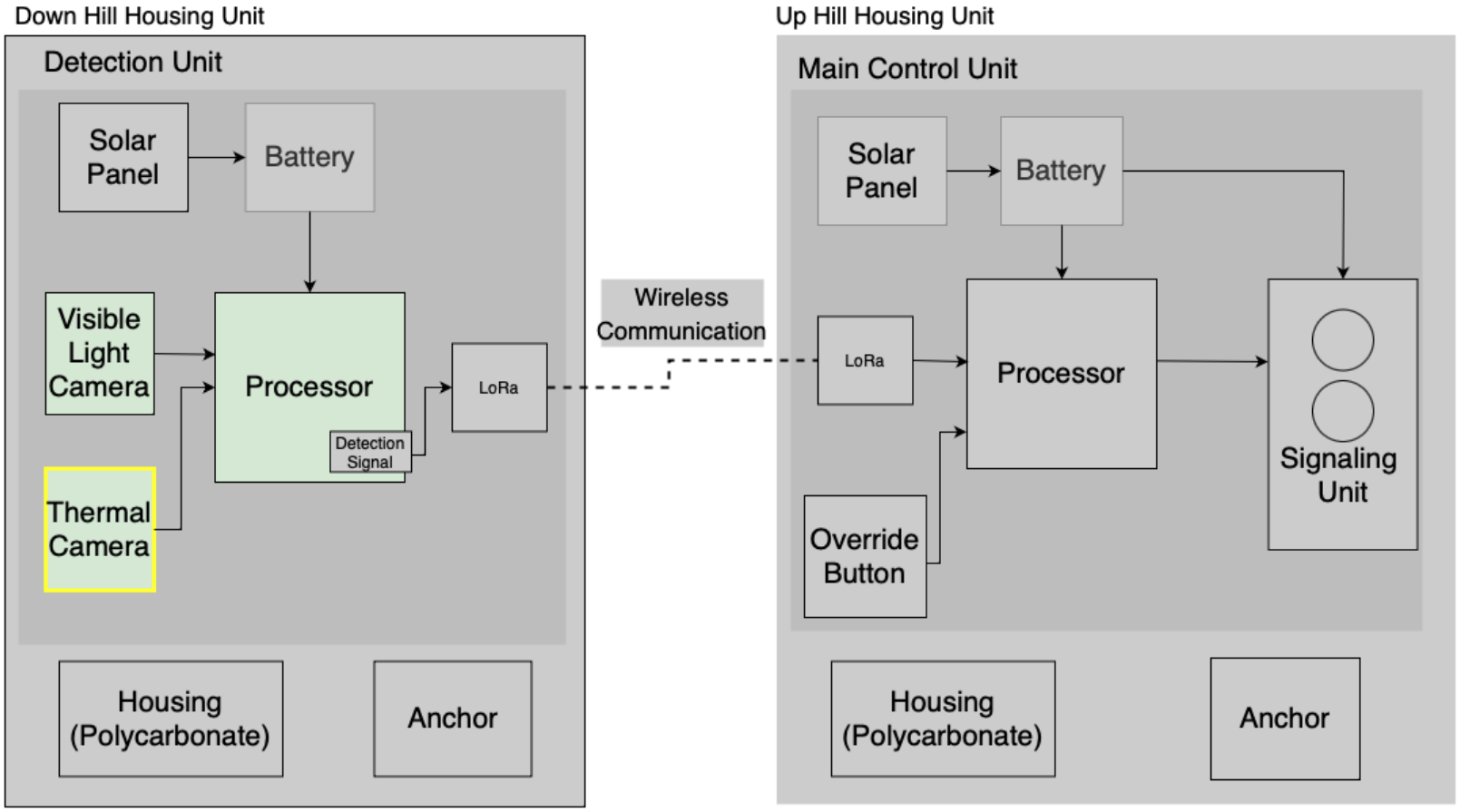
Uphill System

- LiFePO4 12V 10Ah Lithium Iron Phosphate Battery
- Voltaic 50W solar panel
- BlueSolar MPPT 75/15 Charge Controller
- 12V to 3.3V DC/DC converter

Downhill System

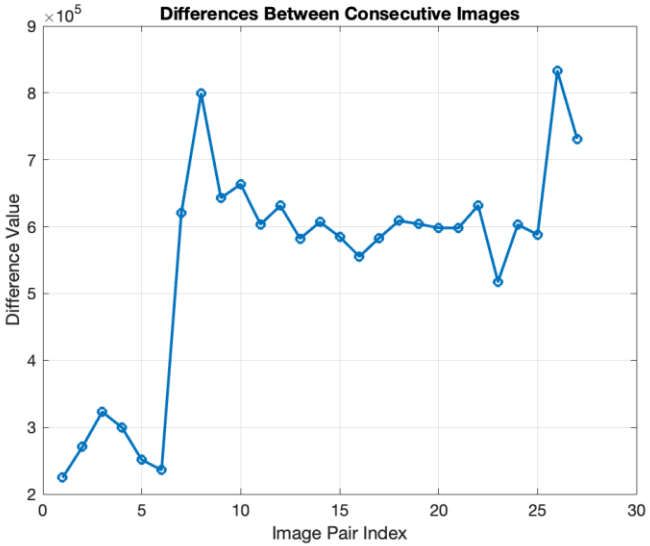
- LiFePO4 12V 30Ah Lithium Iron Phosphate Battery
- Voltaic 50W solar panel
- BlueSolar MPPT 75/15 Charge Controller
- 12V to 5V DC/DC converter

Block Diagram of Detection

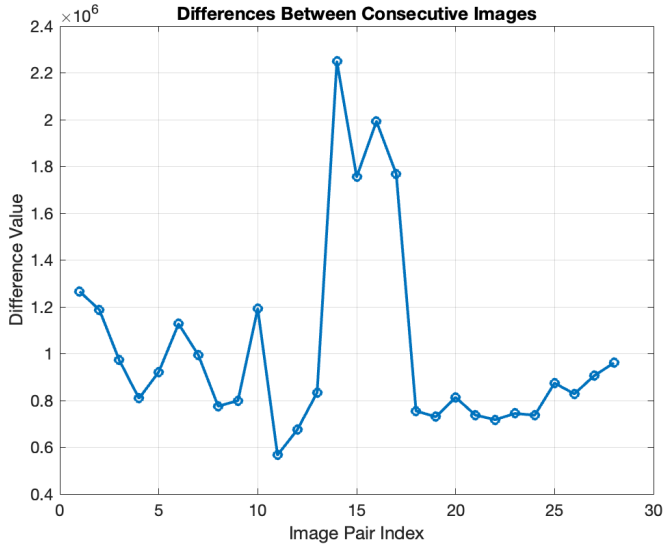


Design Solution: Detection Unit



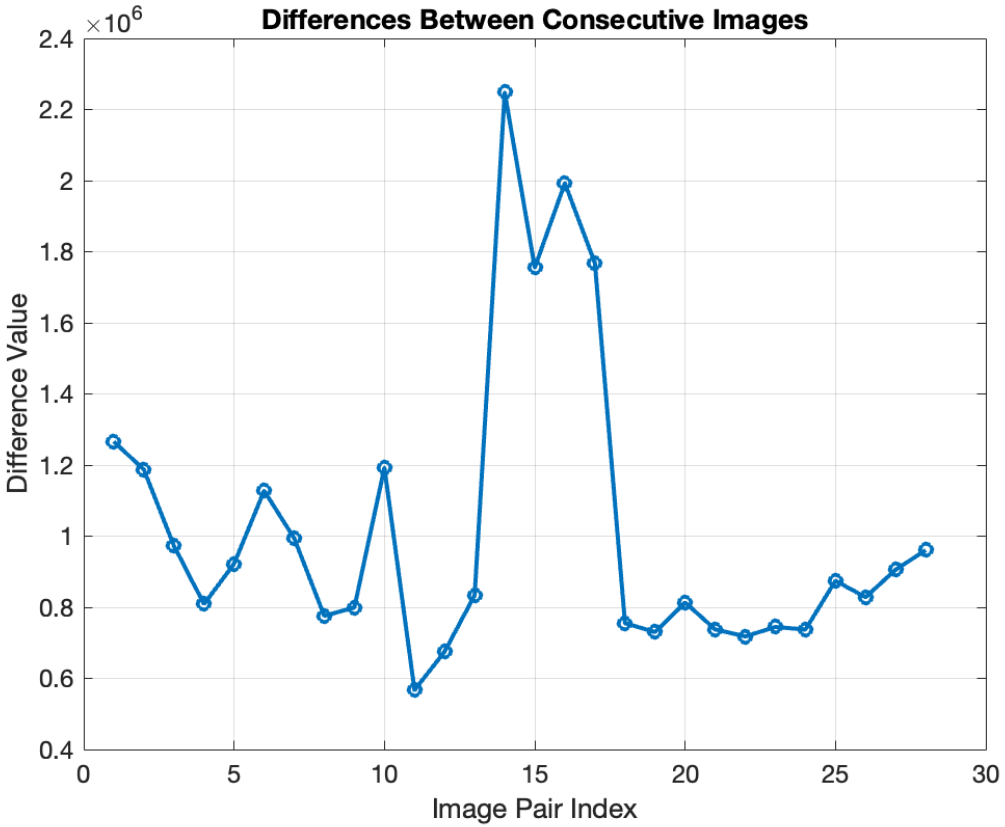
Data Set 1



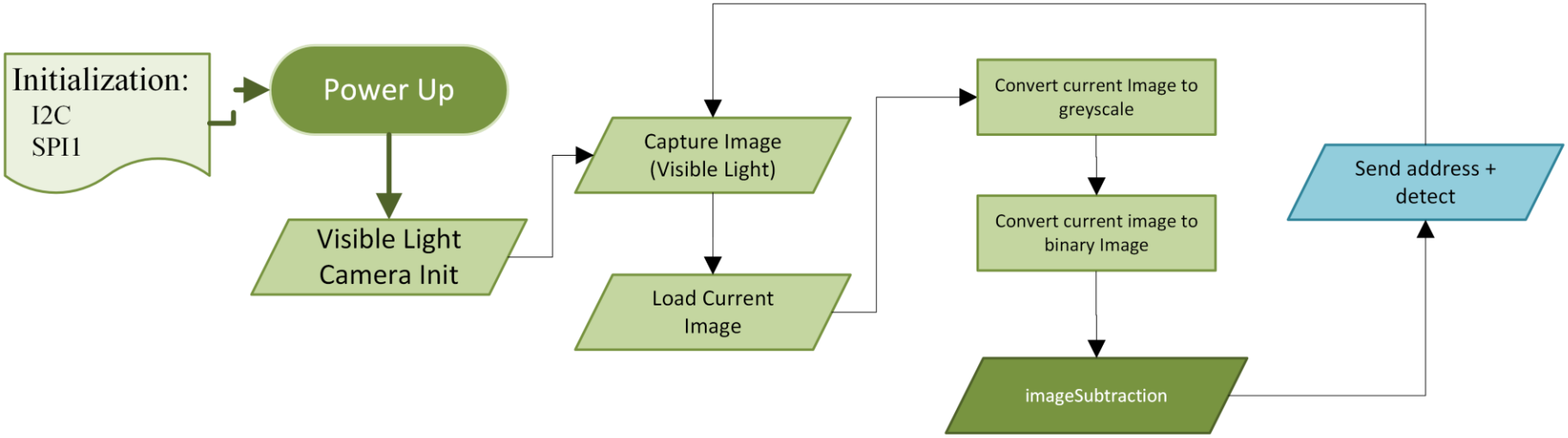
Data Set 2

Design Solution: Detection Unit

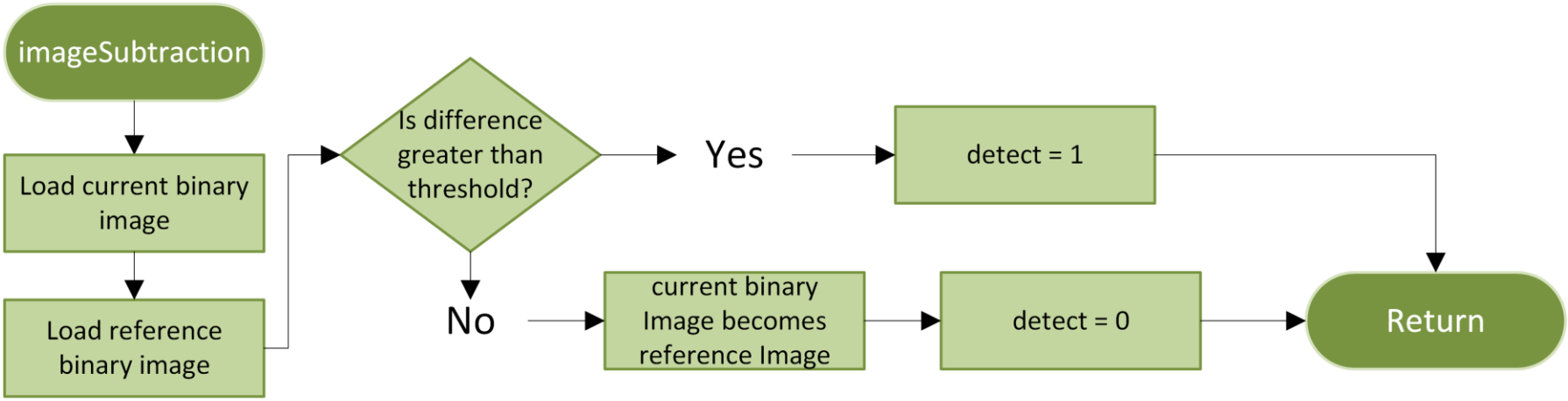
Difference Comparison for Data Set 2



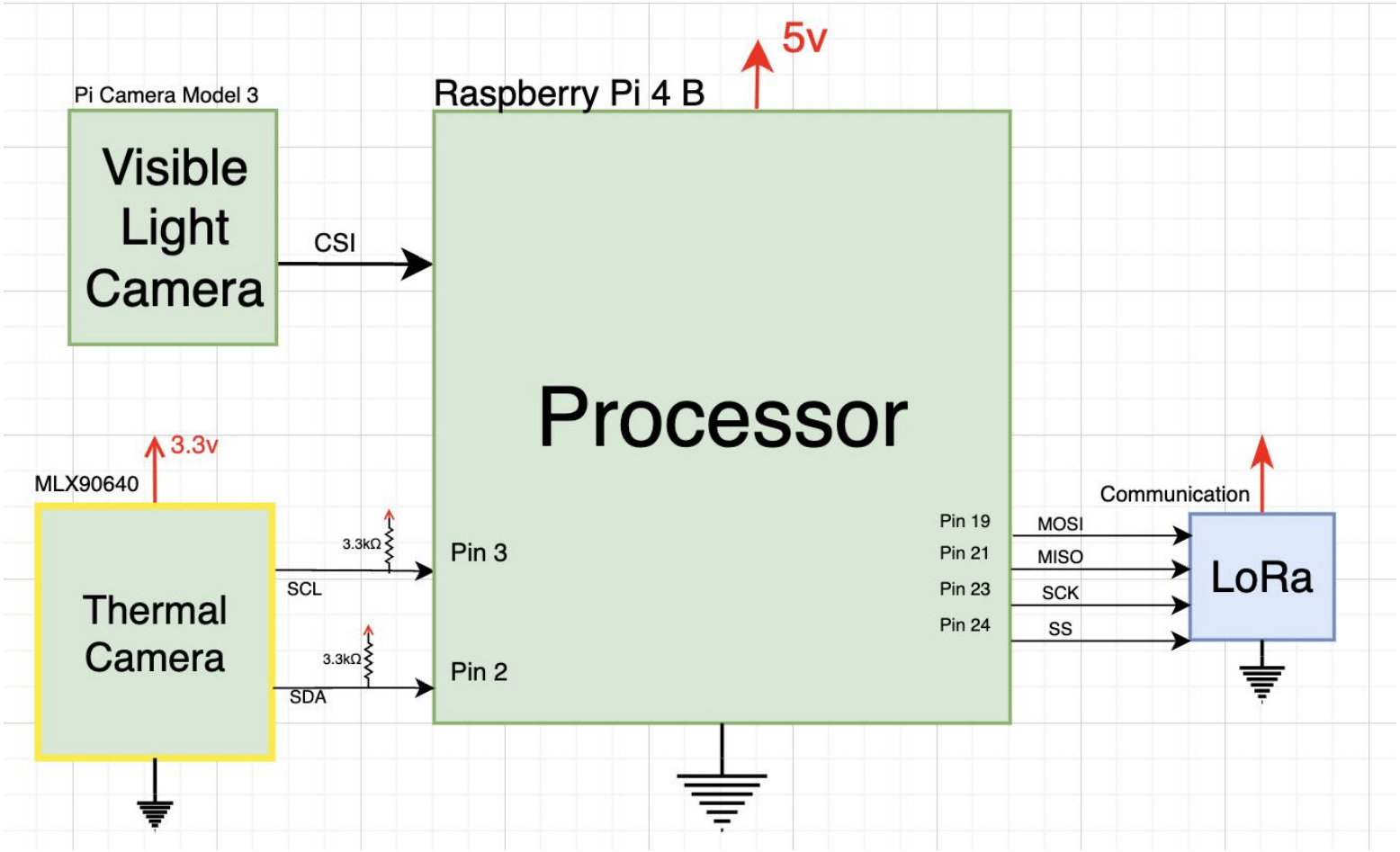
Design Solution: Detection Unit



Design Solution: Detection Unit

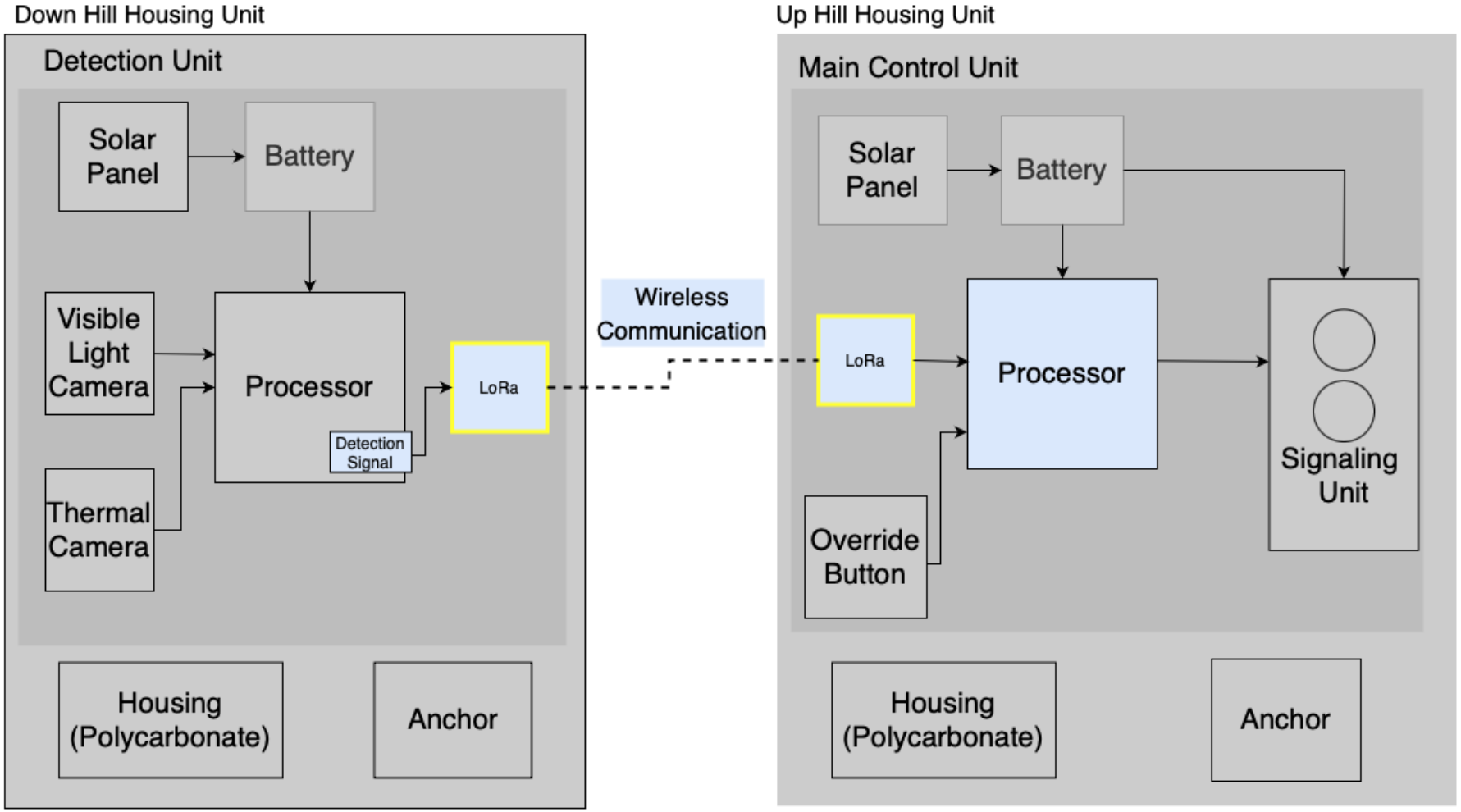


Design Solution: Detection Unit



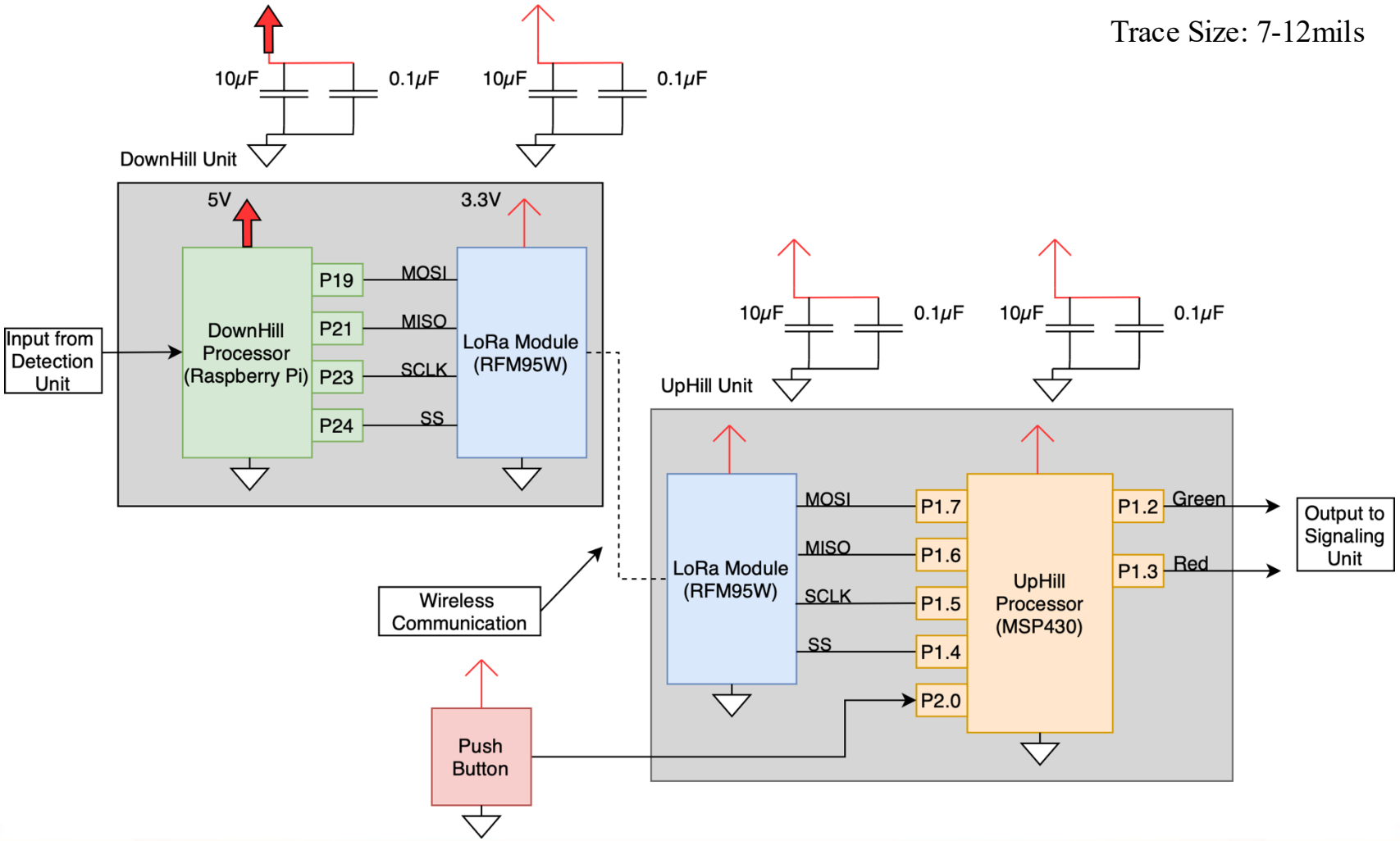
*trace sizes will be between 7-12 mils

Communication Unit

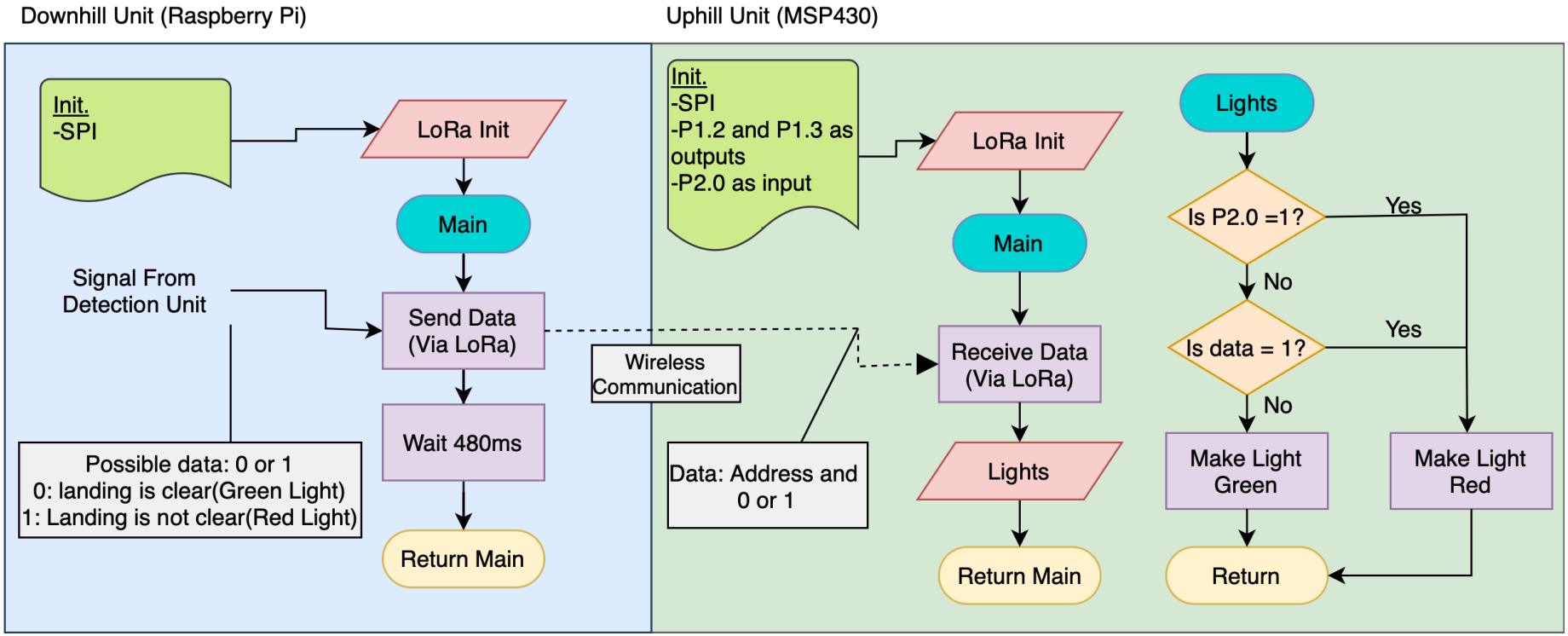


Design Solution: Communication

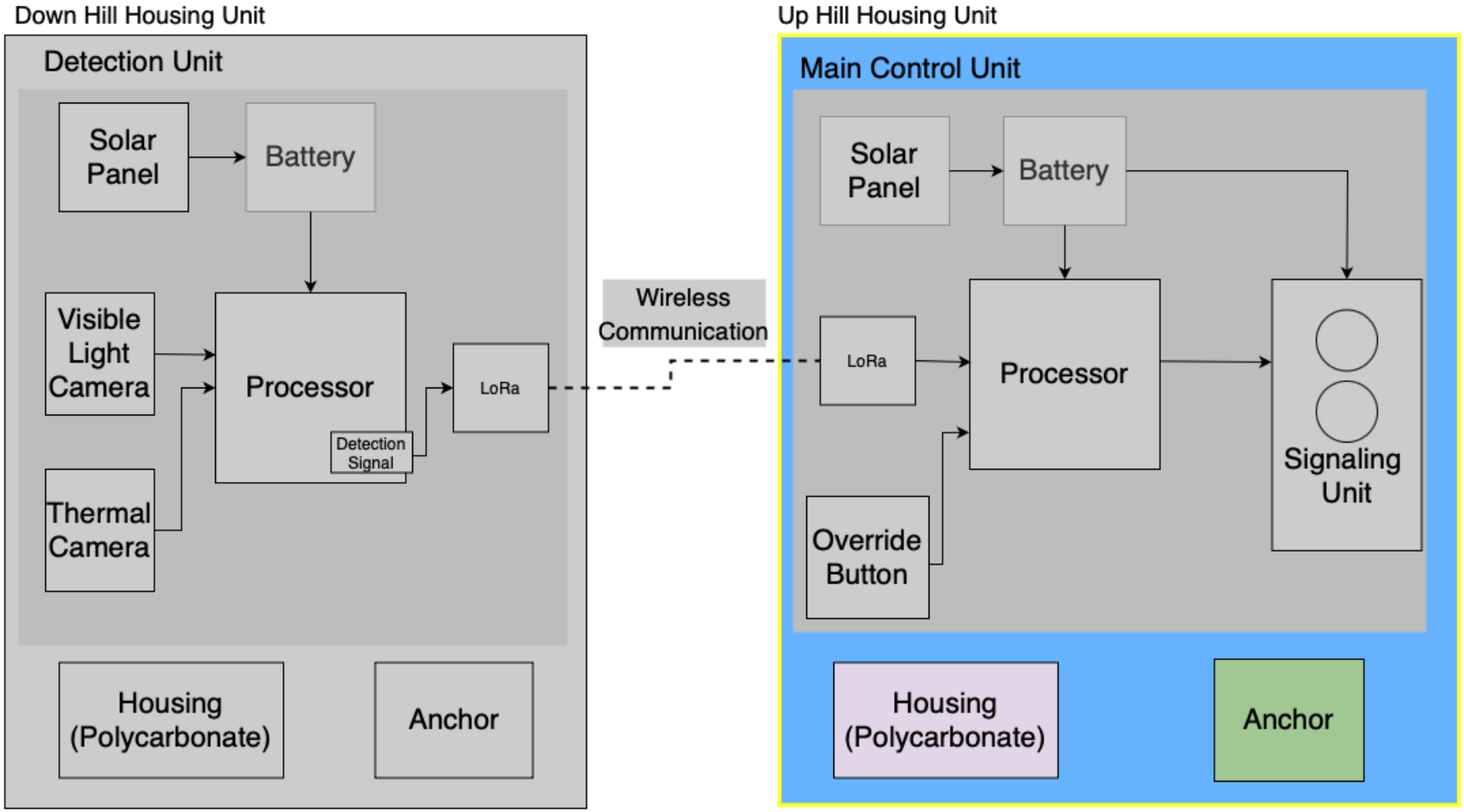
Trace Size: 7-12mils



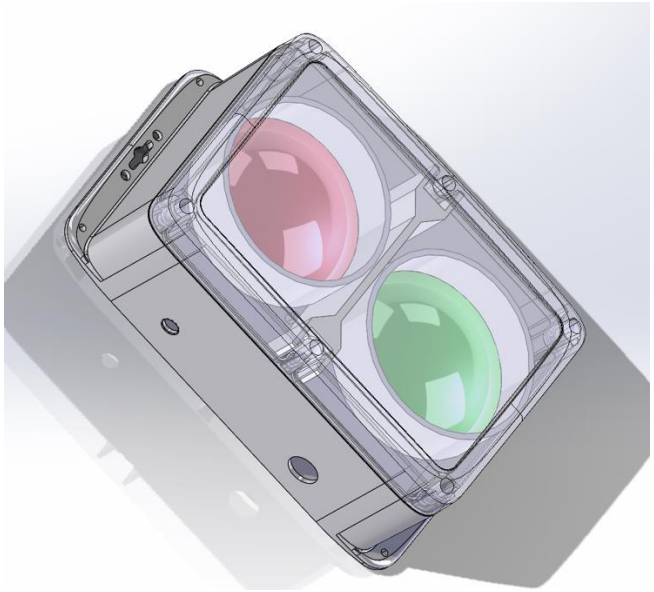
Design Solution: Communication



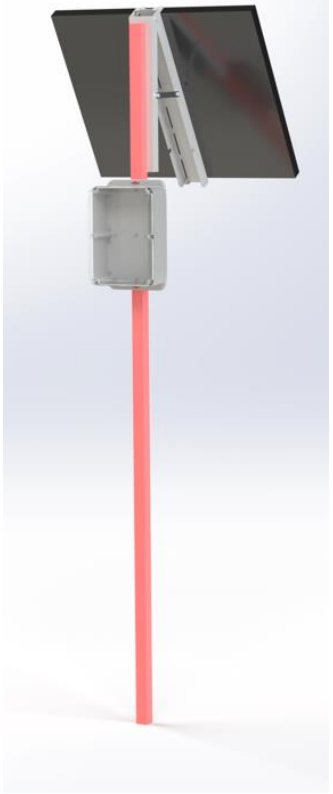
Uphill Housing Unit



Design Solution: Uphill Housing



Assembly of lighting unit with internal mounts and light divider



Render of solar panel and lighting housing mounted on stake

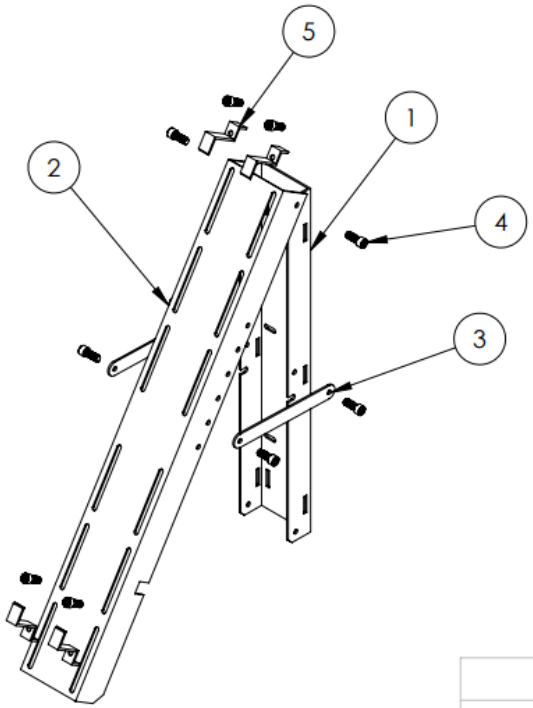
Wire gland used to keep wire inlets and outlets weatherproof

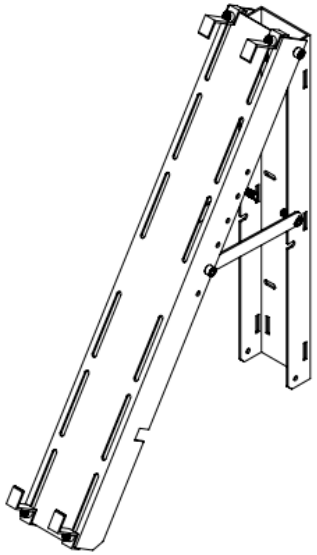
Lighting & battery case will be machined to allow for wire glands, U-bolt connections to the stake, and the emergency stop button

Note: Attaches to post with U-bolts (McMaster Carr #2936T36)

Material: 2.5mm Aluminum 5052

PART NUMBER	DESCRIPTION	QTY.
1	Post Mounting Plate	1
2	Solar Panel Plate	1
3	Support Bar	2
4	Black-Oxide Alloy Steel Socket Head Screw (90044A203)	10
5	Solar Panel Clamp	4





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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16"
ANGULAR: MACH ± .5 BEND ± 1
TWO PLACE DECIMAL ± 0.03"
THREE PLACE DECIMAL ± 0.005"
INTERPRET GEOMETRIC TOLERANCING PER:
COMMENTS:
NEXT ASSY
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Trevor J	10/23/24
CHECKED		
ENG APPR.		
MFG APPR.		
MATERIAL	VARS	

MSU M.& I.E. DEPT.

TITLE: Solar Panel Mount

SIZE A | DWG. NO. 1 | REV

SCALE: 1:5 | WEIGHT: 1.52 | SHEET 1 OF 1

5 4 3 2 1

SOLIDWORKS Educational Product. For Instructional Use Only.

Battery Selections

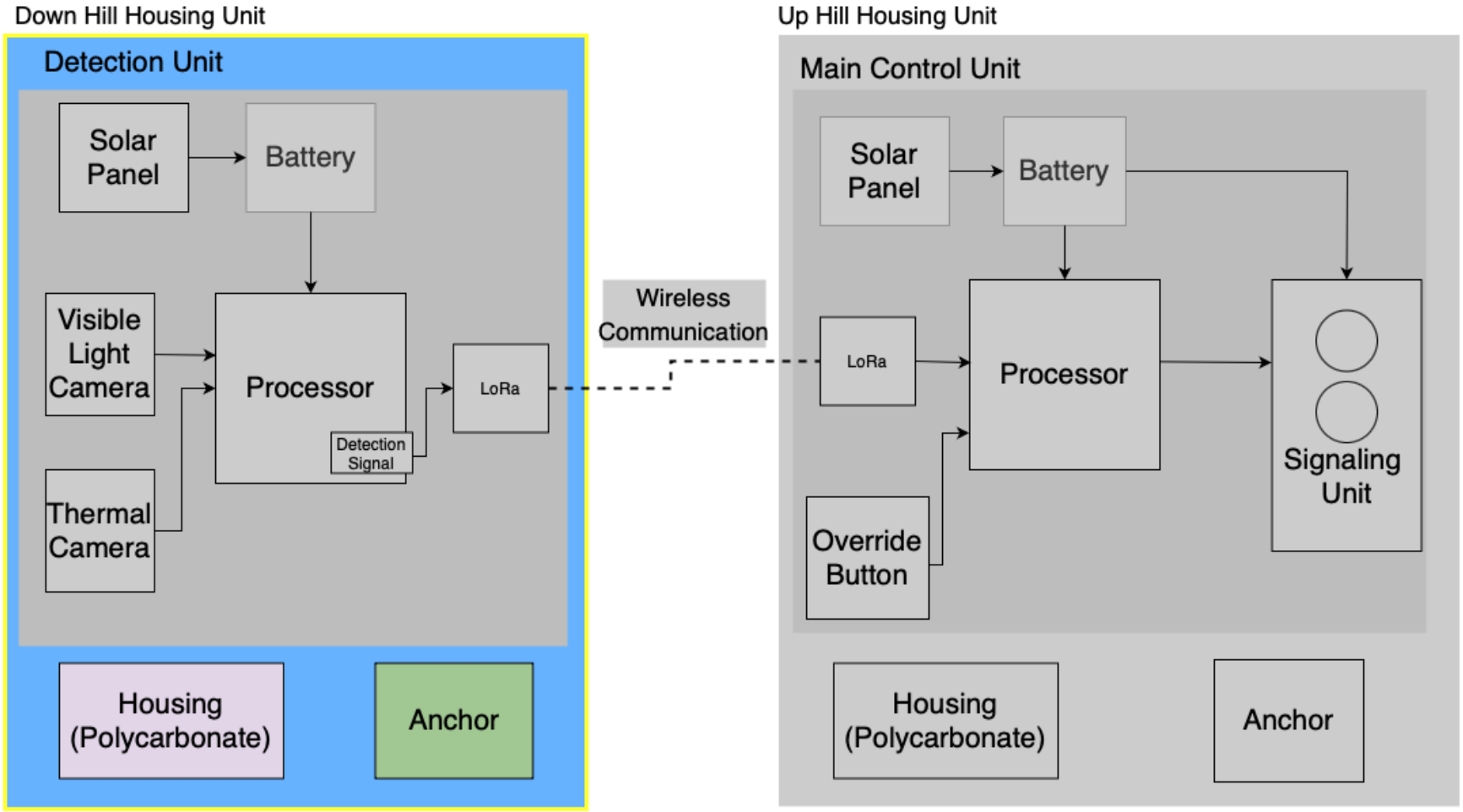
Uphill

- Dimensions: 5.9*3.7*2.6 in
- Battery Weight: 2.43 lbs

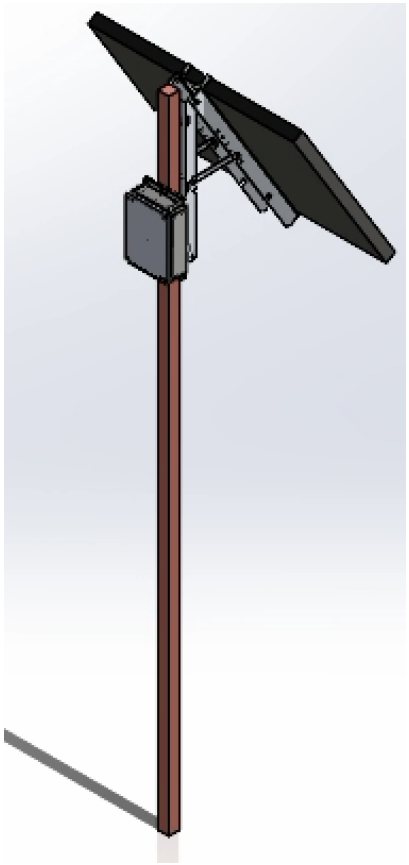
Downhill:

- Dimensions: 7.2*6.9*3.2 in
- Downhill Battery Weight: 7.82 lbs

Downhill Housing Unit



Design Solution: Downhill Housing



3D model of the downhill components mounted on the Polystake

Downhill housings from PolyCase

- Weatherproof
- Fully adjustable on the stake

Cable glands will be used to waterproof holes for cable connections

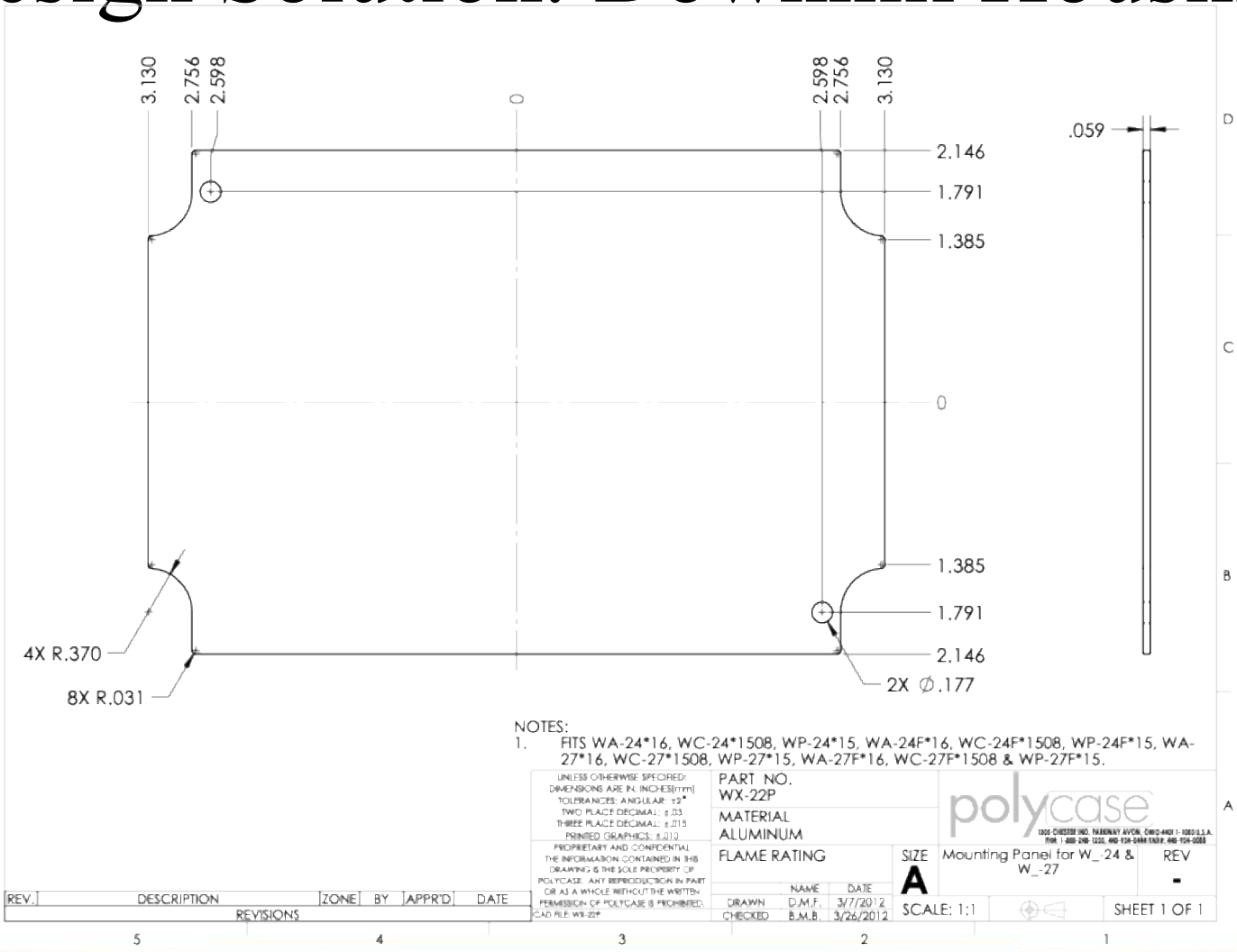
Detection Unit housing
6.7x4.7x2.1 in

Battery housing
10x8.4x7.2 in

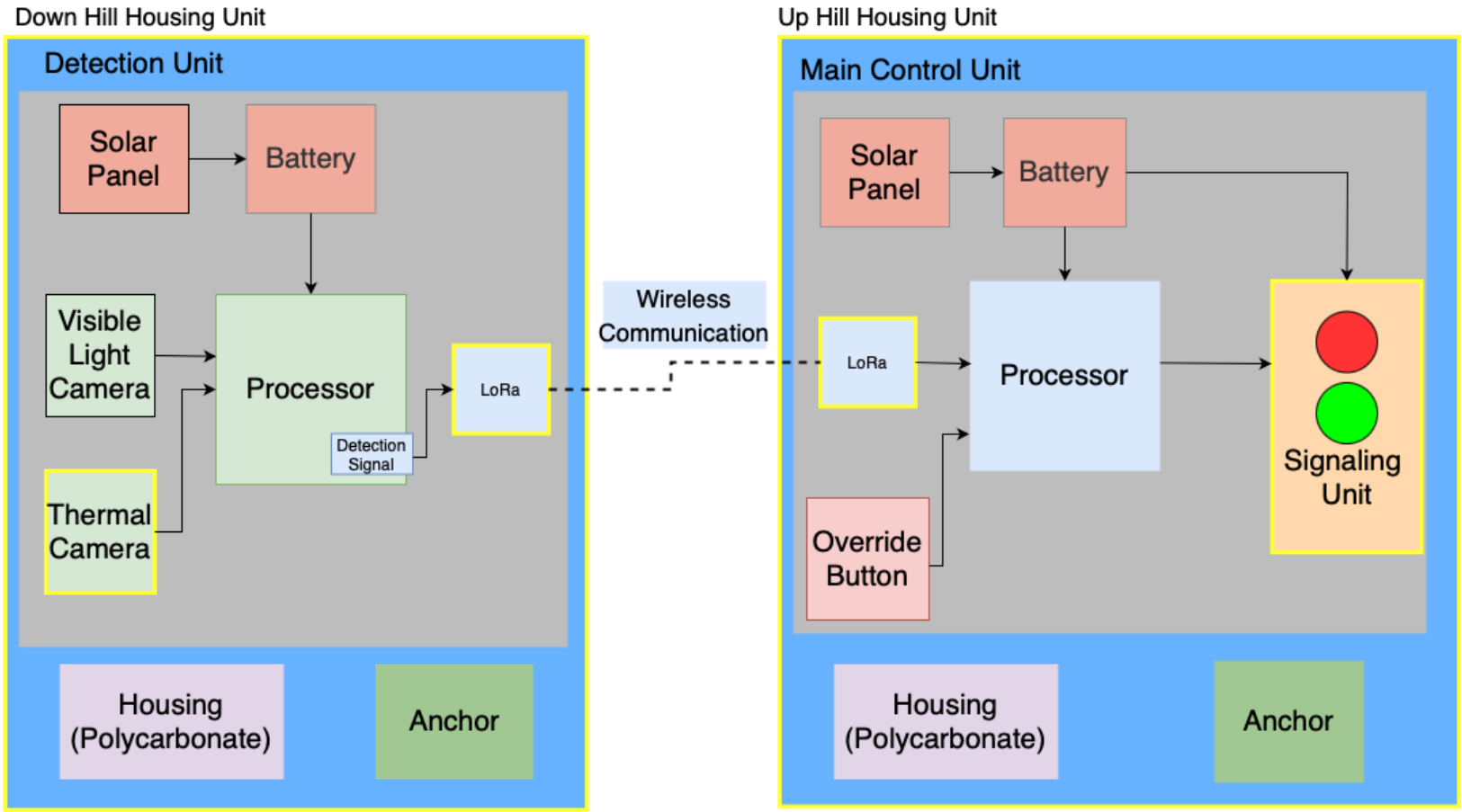
PolyStakeXL from FallLine

- Same stakes used for marking at resorts such as Bridger Bowl
- Made to bend if ran into by a skier or snowboarder

Design Solution: Downhill Housing

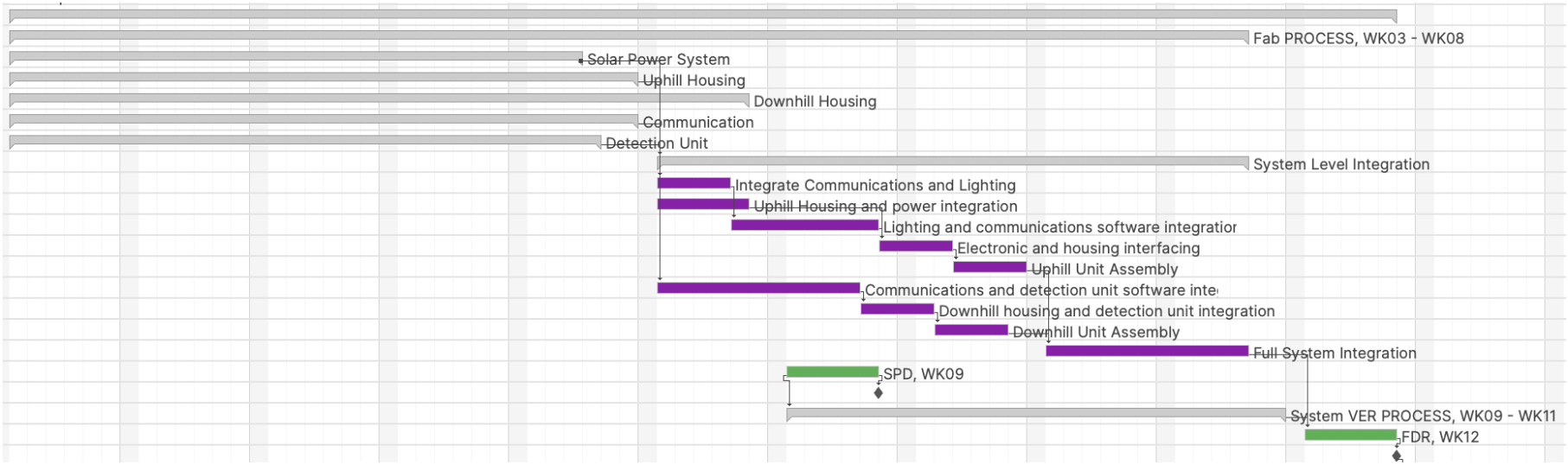


Design Solution: System Integration

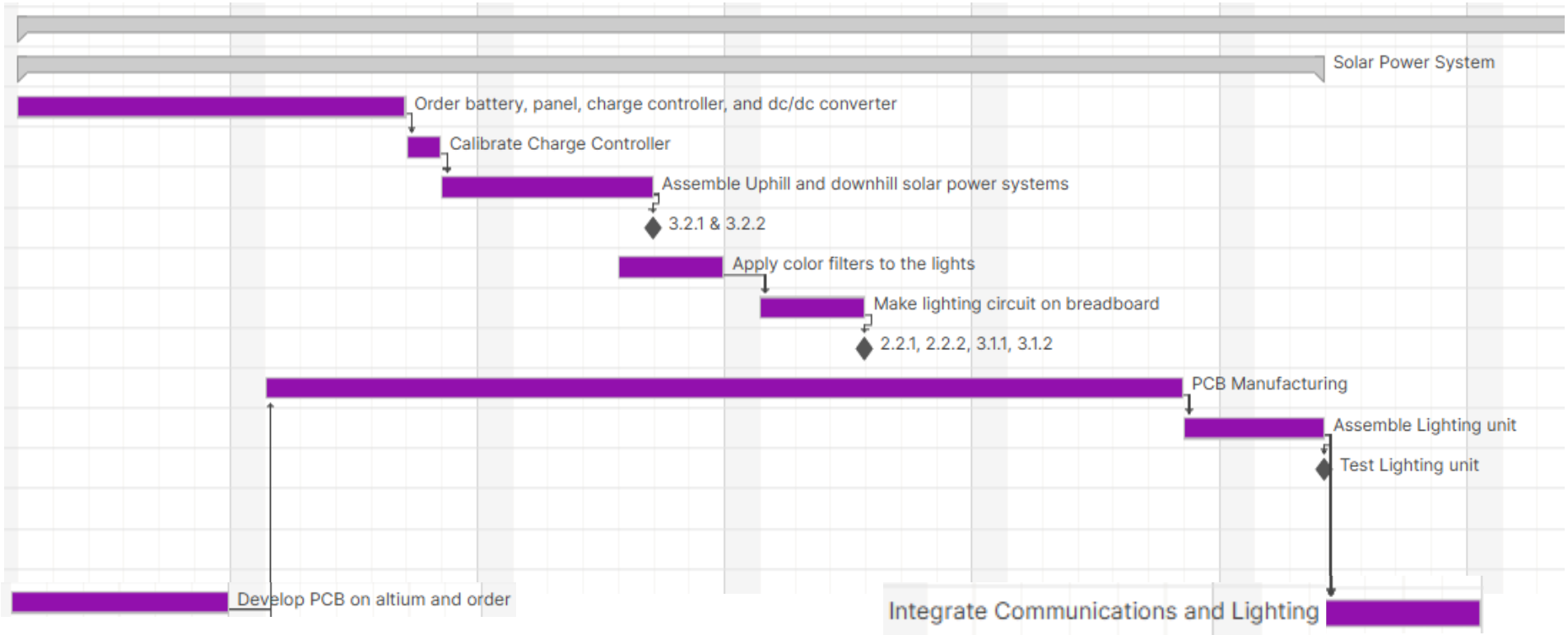


Conceptual Block Diagram

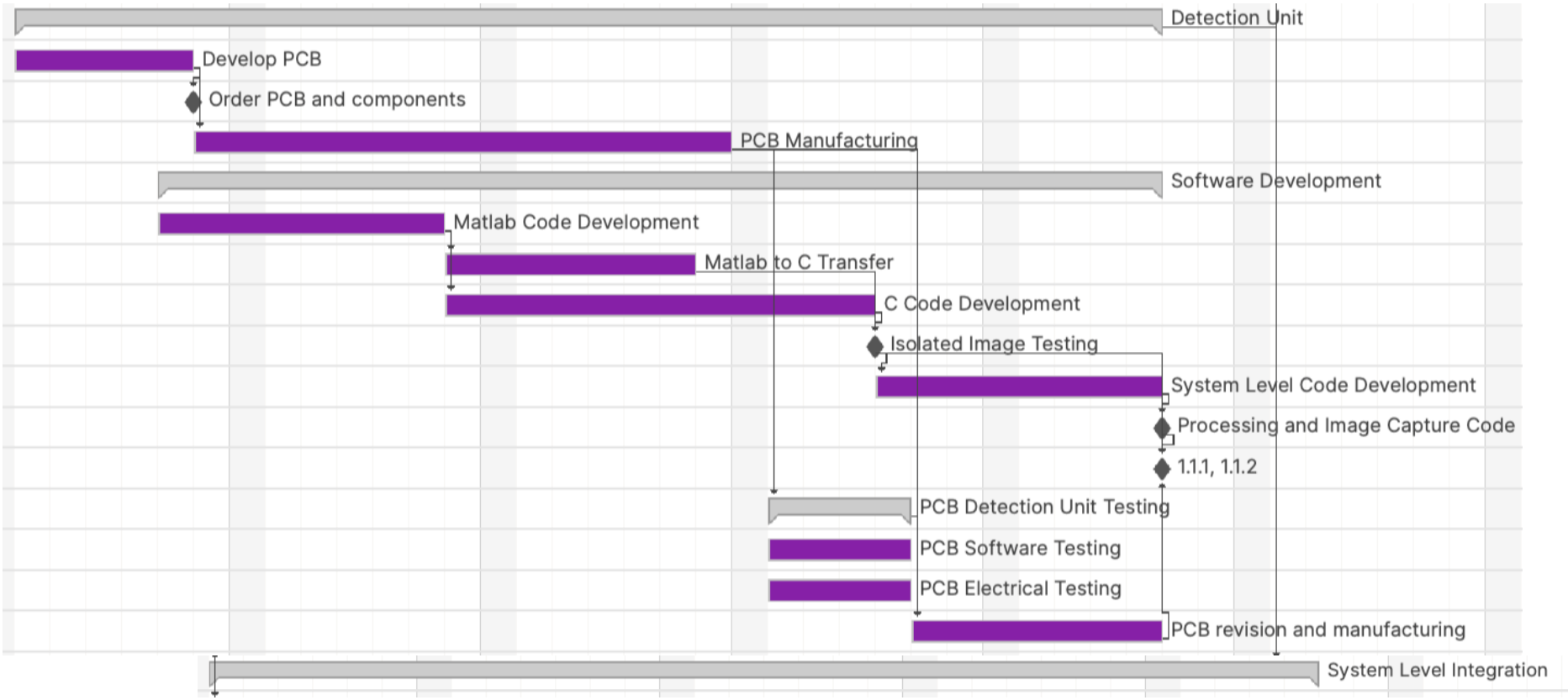
Fabrication Plan Overview



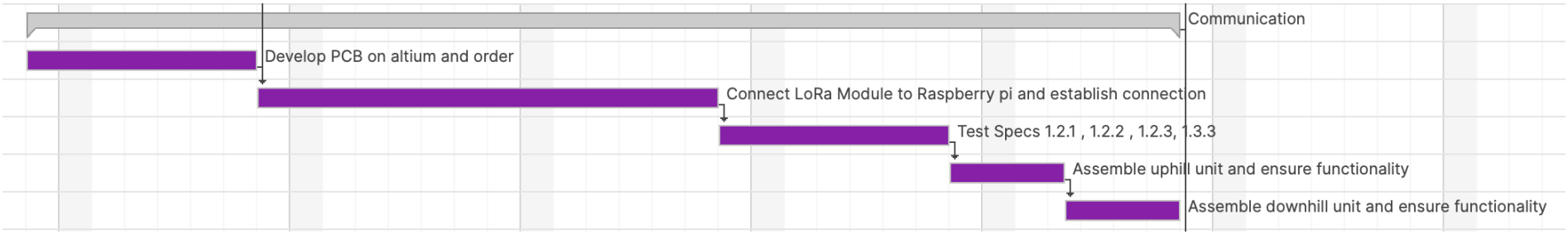
Fabrication Plan: Solar Power



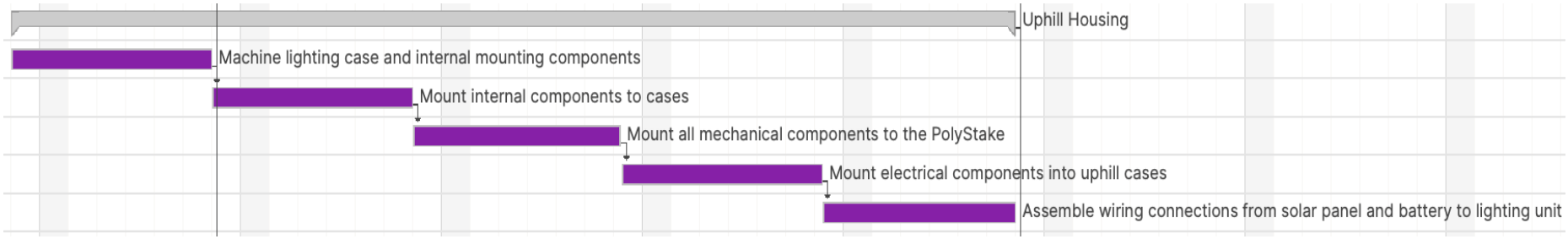
Fabrication Plan: Detection Unit



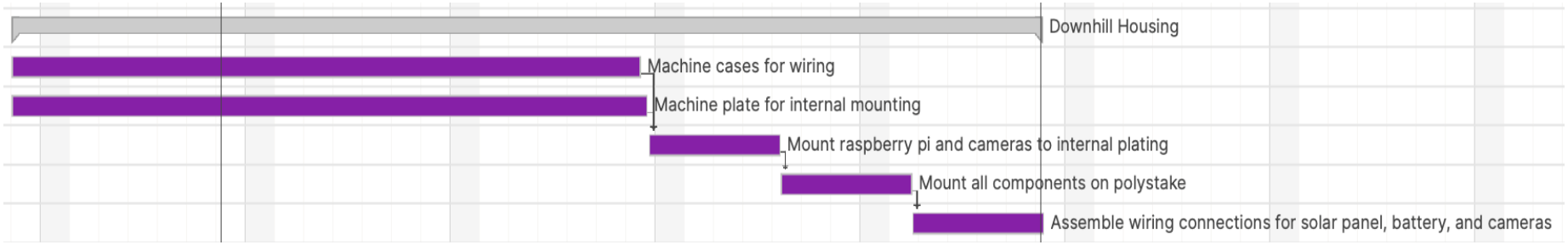
Fabrication Plan: Communication



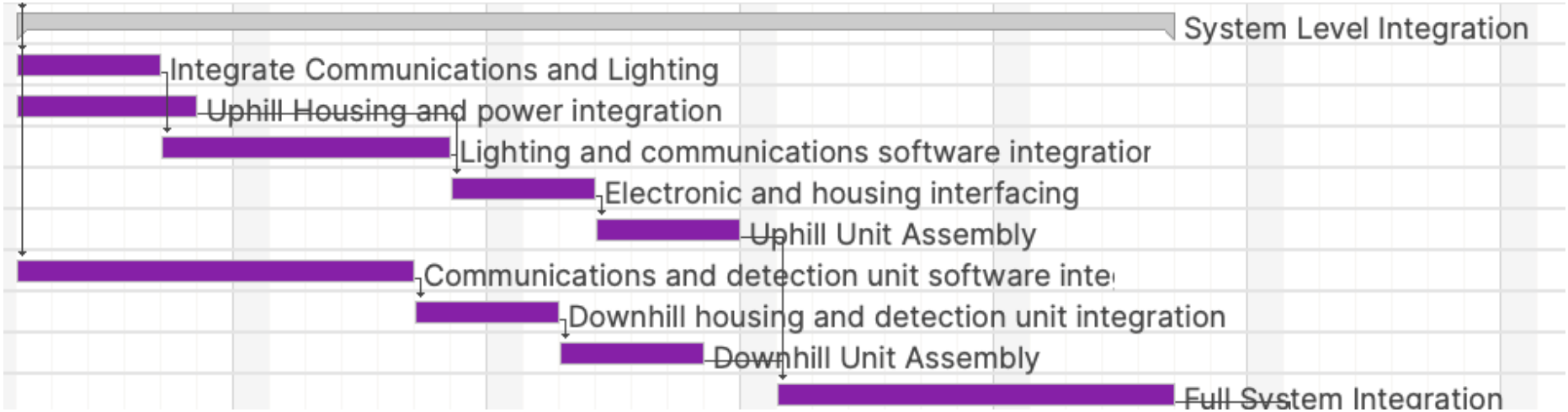
Fabrication Plan: Uphill Housing



Fabrication Plan: Downhill Housing



Fabrication Plan: System Integration



Project Risks

- PCB manufacturing time may take longer than we would like, causing delays for other aspects of fabrication.
- Any errors in PCB development would heavily delay the fabrication of the project.
- Time period for testing will coincide with the end of the season that the system is designed for.
- Current Issues with the thermal camera and its ability to communicate with the Raspberry Pi.

Project Budget

Team 13 - JumpGuard										
#	Date of purchase	Date of Reimbursement	Purchased by	Expense	Expected Expense (PLANNING)		Actual Cost (EXECUTION)			
					Expected Cost	Savings	Supplier	Quantity	Item Cost	Total Cost
					Expected Budget:	$1,750			Actual Budget Provided:	$1,750.00
				Wirless Commuication						
1	10.31.2024	12.08.2024	Riley	LoRa Module (RMF95W)	$75.00	$23.68	Adafruit	2	$25.66	$51.32
2	10.14.2024	12.08.2024	Riley	MSP430 launchpad	$25.00	$0.00	Adafruit	1	$25.36	$25.36
3	12.12.2024		Riley	Emergency stop push button(CWI28	$30.00	$26.51	Digikeey	2	$9.76	$18.26
4	mm.dd.yy			MSP430FR2111	$4.00	$0.00	DigiKey			$0.00
				Detection System						
5	11.03.2024	12.08.2024	Emily	Thermal Camera (Adafruit MLX90640 24x32 IR Thermal Camera Breakout - 110 Degree FoV)	$74.95	-$3.81	Adafruit	1	$78.76	$78.76
6	11.03.2024	12.08.2024	Emily	Visible Light Camera (Raspberry Pi Camera Module 3 Standard - 12MP Autofocus)	$35.00	-$3.81	Adafruit	1	$38.81	$38.81
8	11.03.2024	12.08.2024	Emily	Processor (Raspberry Pi 4 Model B)	$75.00	-$3.81	Adafruit	1	$78.81	$78.81
9				Wires (STEMMA Cable - 4 Pin JST-PH 2mm Cable–Female/Female - 150mm/6" Long)	$0.75	$0.00	Adafruit	1	$0.00	$0.00
				Stoplight System						
9	11.05.2024	12.08.2024	Ben	Lights	$27.98	$0.00	Amazon	2	$13.99	$27.98
10	11.05.2024	12.08.2024	Ben	Transistors	$18.10	-$8.80	DigiKey	10	$2.69	$26.90
11	11.19.2024	12.08.2024	Ben	Color filters (Red and Green)	$16.97	$0.00	Amazon	2	$8.99	$16.97
				Uphill Housing						
13	01.23.2025		Johnny	PolyStakeXL	$21.00	-$39.33	FallLine	1	$60.33	$60.33
14	11.04.2024	12.08.2024	Johnny	ML-70F Plastic NEMA Enclosure	$45.00	$0.00	PolyCase	1	$49.20	$49.20
15				Solar Panel Mounting	$50.00	$0.00	Voltaic	1		$0.00
				On/Off Switch						$0.00
16				Battery Mount	$15.00	$0.00	Amazon	1		$0.00
				Downhill Housing						
17	01.23.2025		Johnny	PolyStakeXL	$21.00	-$39.33	FallLine	1	$60.33	$60.33
18	11.04.2024	12.08.2024	Johnny	WC-24F Outdoor Enclosure with Cle	$35.00	$7.64	PolyCase	1	$27.36	$27.36
				ZQ-100806 Outdoor Electrical Junct	$63.00		PolyCase			$0.00
				WX-22 Panel for WA/WP/WC Series	$11.00		PolyCase			$0.00
				On/Off Switch						$0.00
19				Solar Panel Mounting	$50.00	$0.00	Voltaic	1		$0.00
				Power						
21				Solar Panel	$89.00	$0.00	Voltaic	1		$0.00
22				Solar Battery	$119.00	$0.00	Voltaic	1		$0.00
				OTHER SYSTEM LEVEL COMPONENTS (these might include bulk wiring, shipping, PCB manufacturing)						
				Cable Glands	$15.00					$0.00
										$0.00
				Electrical Wiring						$0.00
25				Custom PCB for downhill Unit	$200.00	$0.00				$0.00
	Summary			Planned Budget Remaining:	$633.25	$556.36			Actual Budget Remaining:	$1,189.61
				Planned Total Cost:	$1,116.75	$556.36			Actual Total Cost:	$560.39

Summary

- This project aims to enhance skier safety by providing real-time information about the landing zone's clarity, reducing collision risks and promoting smoother traffic flow in terrain parks. With the planning phase complete, we are preparing to begin the executing phase.
- Our progress is supported by our expertise, resources, and commitment to improving safety. We have designed a robust system that integrates thermal and visible light imaging technologies for accurate monitoring of the landing area.
- The potential to significantly reduce accidents makes this project valuable. As we move forward, building and verifying the system, we believe it will effectively prevent collisions, and we will make necessary adjustments to optimize its performance in real-world conditions.

QUESTIONS?

ADDITIONAL SUPPORT SLIDES

Objective 1: Determine whether the landing area below a jump is clear, and then report the status to athletes uphill from the landing area

Req 1.1) System must detect when the landing area is clear

Spec 1.1.1) Detection system must be able to detect athletes within a 30x30 ft area within the landing area

Spec 1.1.2) Must have ≥ 95% detection rate

Req 1.2) System must communicate detection results to uphill athletes

Spec 1.2.1) Latency from when the sensor triggers, to when the signaling unit triggers, must be ≤ 0.5s

Spec 1.2.2) Dropout rate of information must be ≤ 2%

Spec 1.2.3) Sensors must communicate with signaling unit from a maximum distance of 60 ft away with a direct line of sight

Req 1.3) System must notify the next athlete it is safe to proceed

Spec 1.3.1) Signal must produce a green light when the landing area is clear

Spec 1.3.2) Signal must produce a red light when the landing area is not clear

Spec 1.3.3) The latency of the light changing states after a signal is received must be ≤ 0.5 seconds

Spec 1.3.4) Must have a manual override to send the system to the "stop" state in case of emergencies or other events

Objective 2: The system must operate in inclement weather throughout the months of December through April

Req 2.1) Must have housing material capable of protecting electronics while ensuring operation in varying weather conditions

Spec 2.1.1) Must be able to withstand and function in temperatures $\geq 0°F$

Spec 2.1.2) Must be able to operate in winds up to 20 mph

Spec 2.1.3) System is not meant to operate in visibility lower than 30 ft or when the terrain park is not operational

Req 2.2) Signaling Unit must be visible to athletes in varying weather conditions

Spec 2.2.1) Must be able to see signaling unit from 30 ft away uphill

Spec 2.2.2) Lights on the signaling unit must produce at least 1000 Lumens

Spec 2.2.3) Adjustable between 0 - 5 feet with height increments by ± 6” for every adjustment

Objective 3: The system will operate on a standalone power system to avoid running power lines to the system which could create unnecessary hazards

Req 3.1) Power source must be reliable in varying winter conditions

- Spec 3.1.1) Must operate continuously for 7.5 hours
- Spec 3.1.2) Must have sufficient backup power to operate normally for 21 operational hours

Req 3.2) The system must have the ability to recharge both primary and secondary power sources

- Spec 3.2.1) Can recharge for a 7.5 hour operational day with 3.5 hours of peak sunlight
- Spec 3.2.2) Backup power can be recharged through an external source in 8 hours for the system to operate for 21 operational hours

Battery Comparison

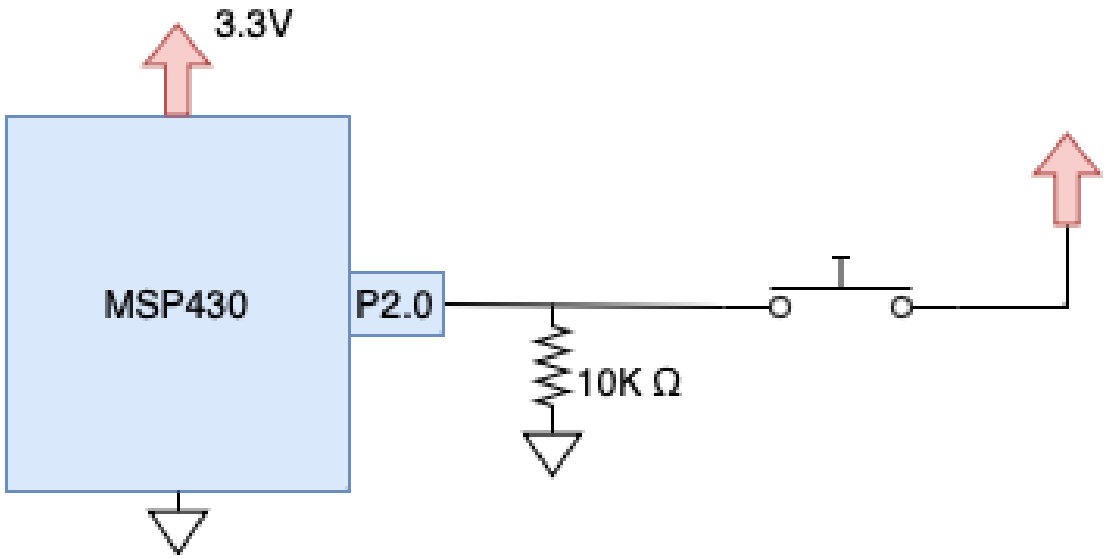
21 Hours

- Battery would cost around $159.99 for the uphill unit and around $219.99 for the downhill unit
- Uphill Dimensions: 9.1*5.3*7.1 in
- Uphill Battery Weight: 12.65 lbs
- Downhill Dimensions:10.2*6.6*8.4 in
- Downhill Battery Weight: 23.15 lbs

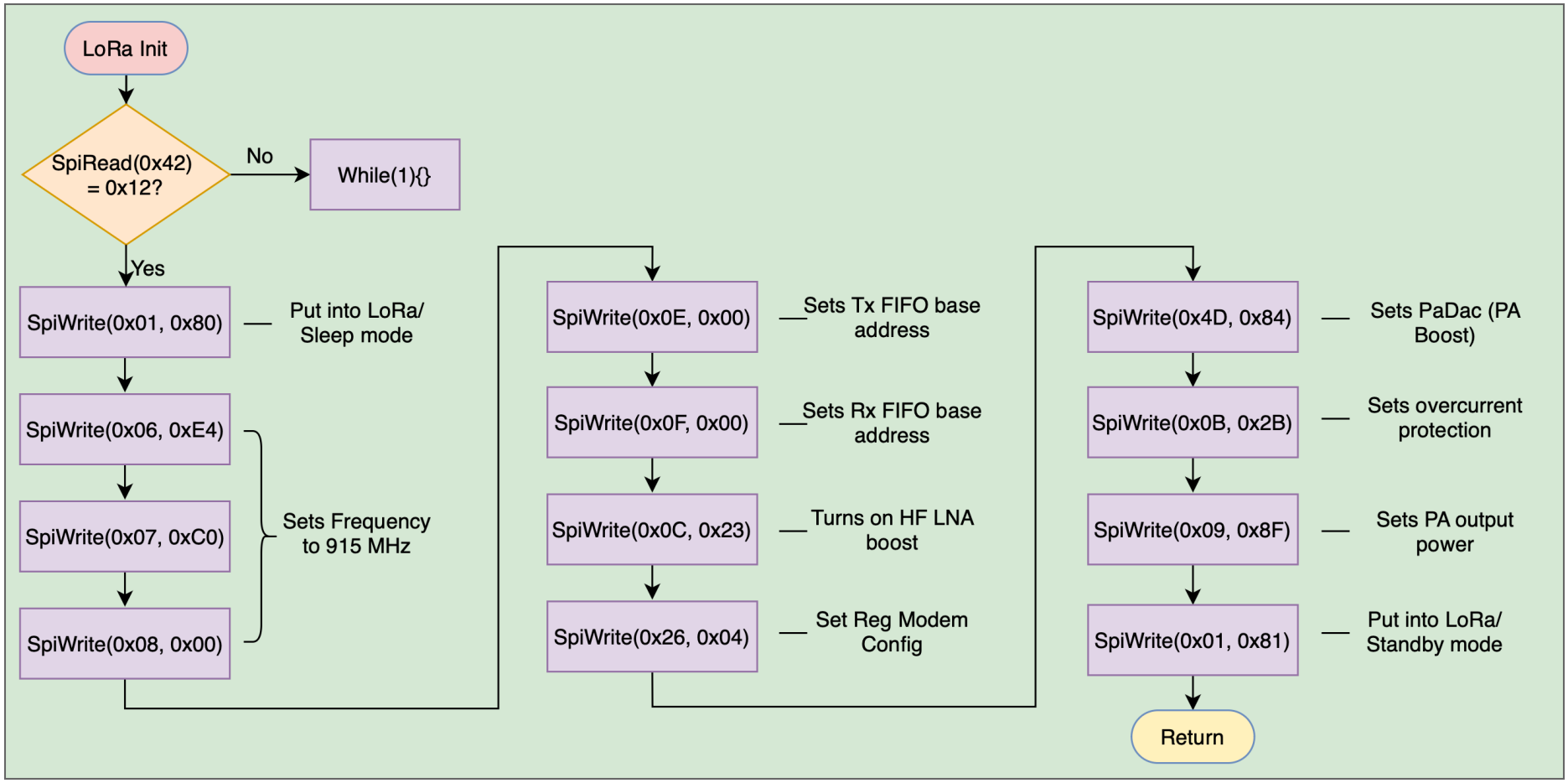
7 Hours

- Battery would cost around $39.99 for the uphill unit and around $89.99 for the downhill unit
- Uphill Dimensions: 5.9*3.7*2.6 in
- Uphill Battery Weight: 2.43 lbs
- Downhill Dimensions: 7.2*6.9*3.2 in
- Downhill Battery Weight: 7.82 lbs
- Much more reasonable weights to mount onto stake (fits within 25 lb limit)

Design Solution: Push Button

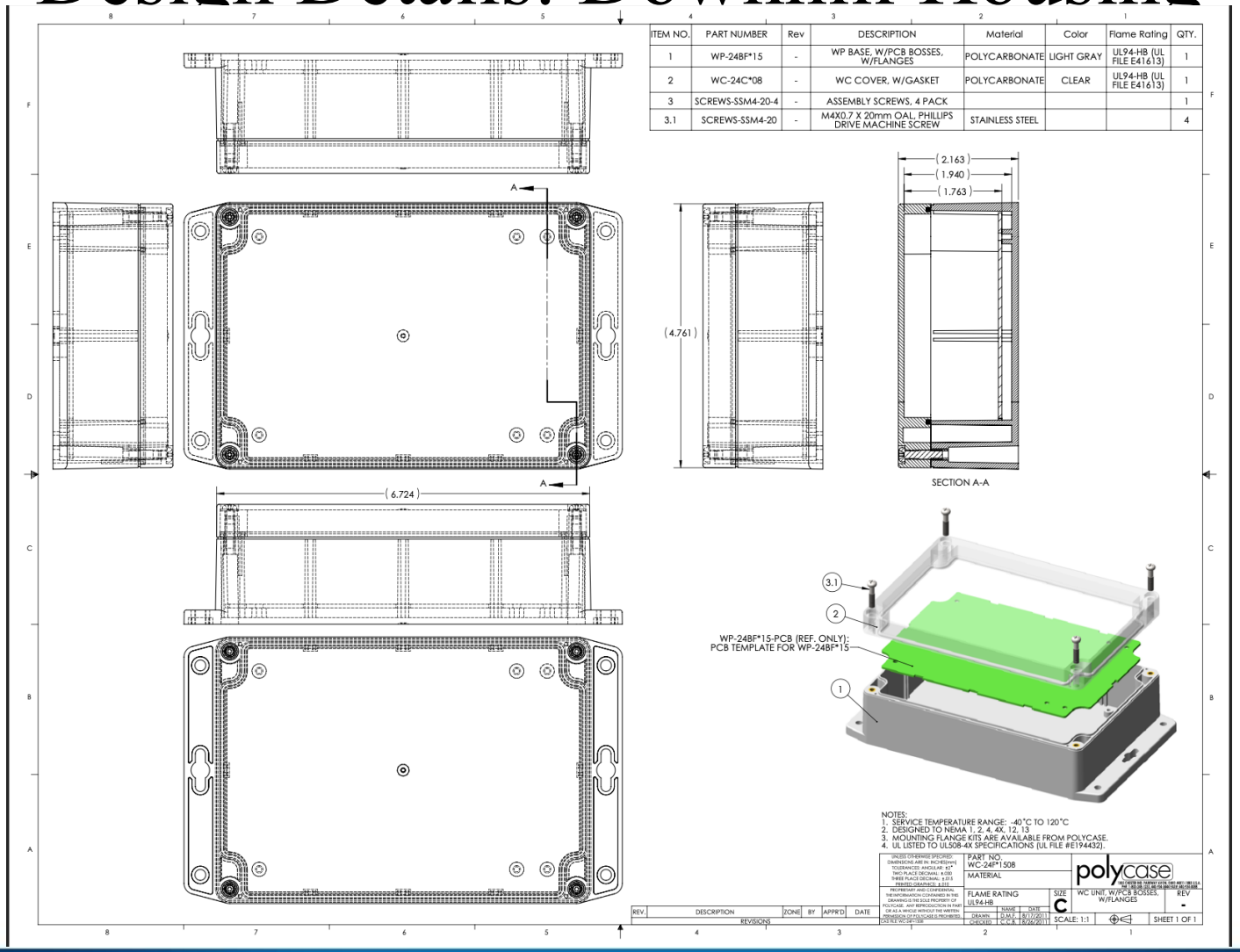


LoRa Init function



*Referenced on slide 15

Design Details: Downhill Housing



ITEM NO.	PART NUMBER	Rev	DESCRIPTION	Material	Color	Flame Rating	QTY.
1	WP-24BF*15	-	WP BASE, W/PCB BOSSES, W/FLANGES	POLYCARBONATE	LIGHT GRAY	UL94-HB (UL FILE E41613)	1
2	WC-24C*08	-	WC COVER, W/GASKET	POLYCARBONATE	CLEAR	UL94-HB (UL FILE E41613)	1
3	SCREWS-SSM4-20-4	-	ASSEMBLY SCREWS, 4 PACK				1
3.1	SCREWS-SSM4-20	-	M4X0.7 X 20mm OAL, PHILLIPS DRIVE MACHINE SCREW	STAINLESS STEEL			4

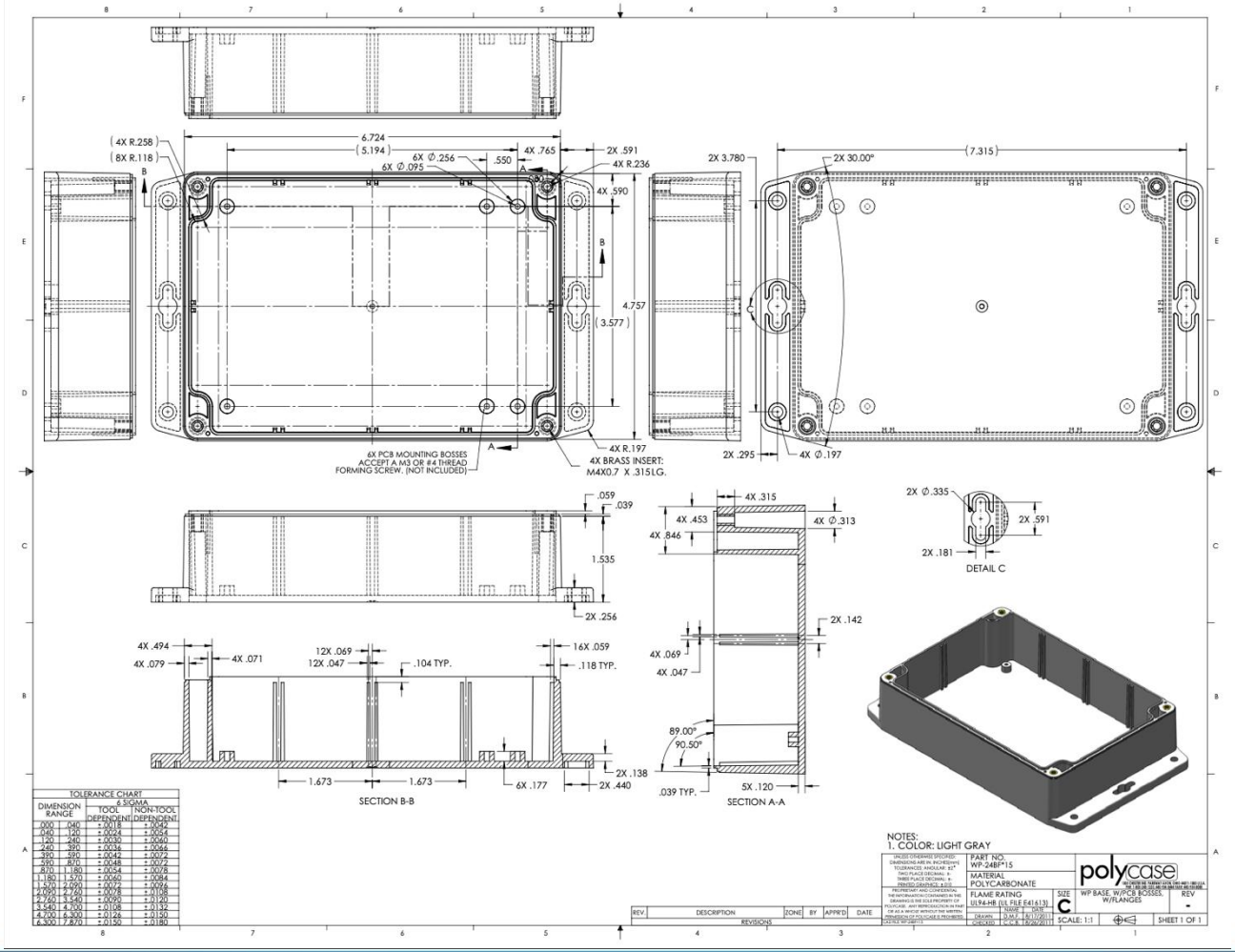
NOTES:
1. SERVICE TEMPERATURE RANGE: -40°C TO 120°C
2. DESIGNED TO NEMA 1, 2, 4, 4X, 12, 13
3. MOUNTING FLANGE KITS ARE AVAILABLE FROM POLYCASE.
4. UL LISTED TO UL508-4X SPECIFICATIONS (UL FILE #E194432).

REV.	DESCRIPTION	ZONE	BY	APPR'D	DATE

REVISIONS

PART NO. WC-24F*1508
MATERIAL
FLAME RATING UL94-HB
SIZE C
WC UNIT, W/PCB BOSSES, W/FLANGES
REV -
DRAWN D.M.F. 8/17/2011
CHECKED C.W.B. 8/26/2011
SCALE: 1:1
SHEET 1 OF 1

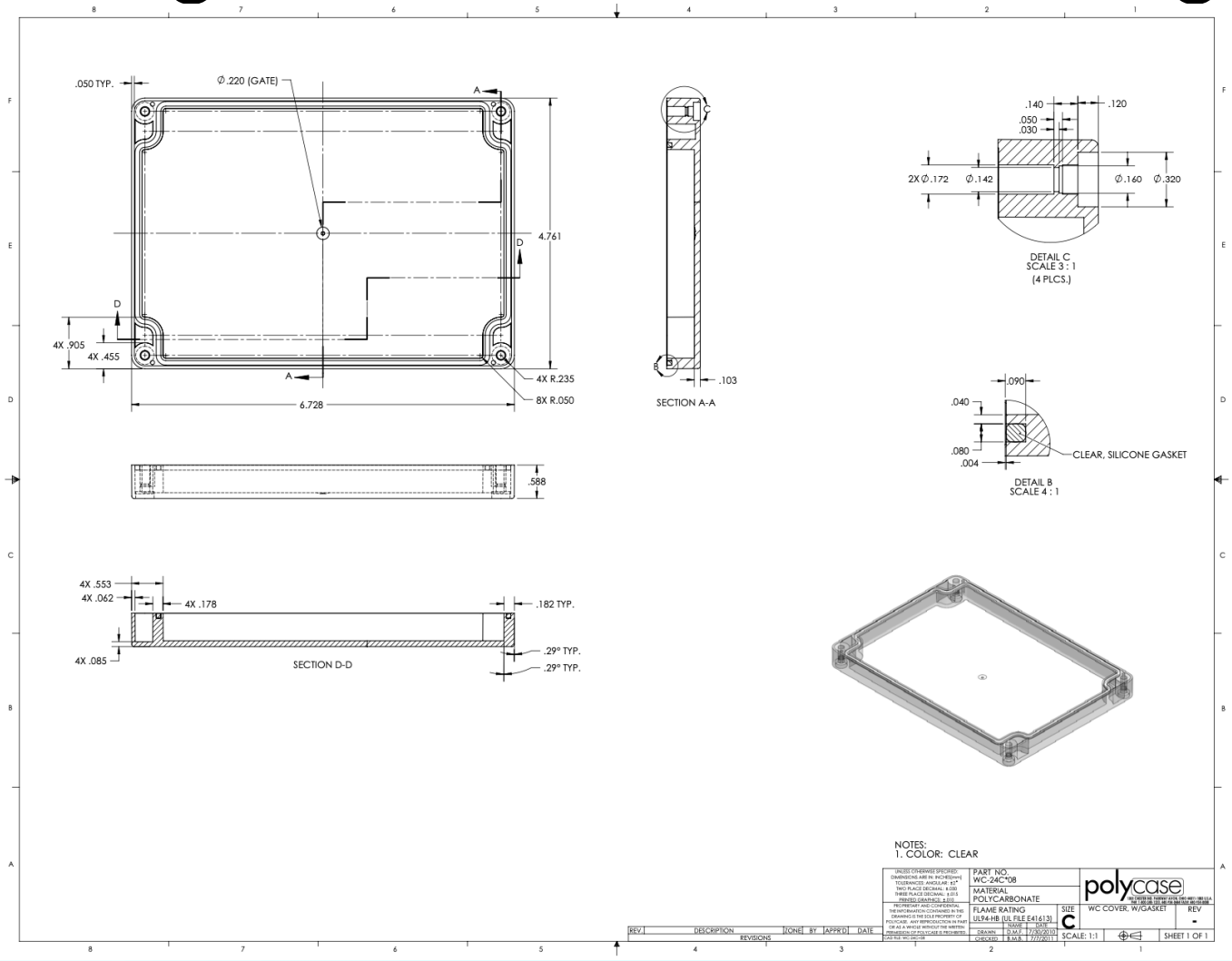
Design Details: Downhill Housing



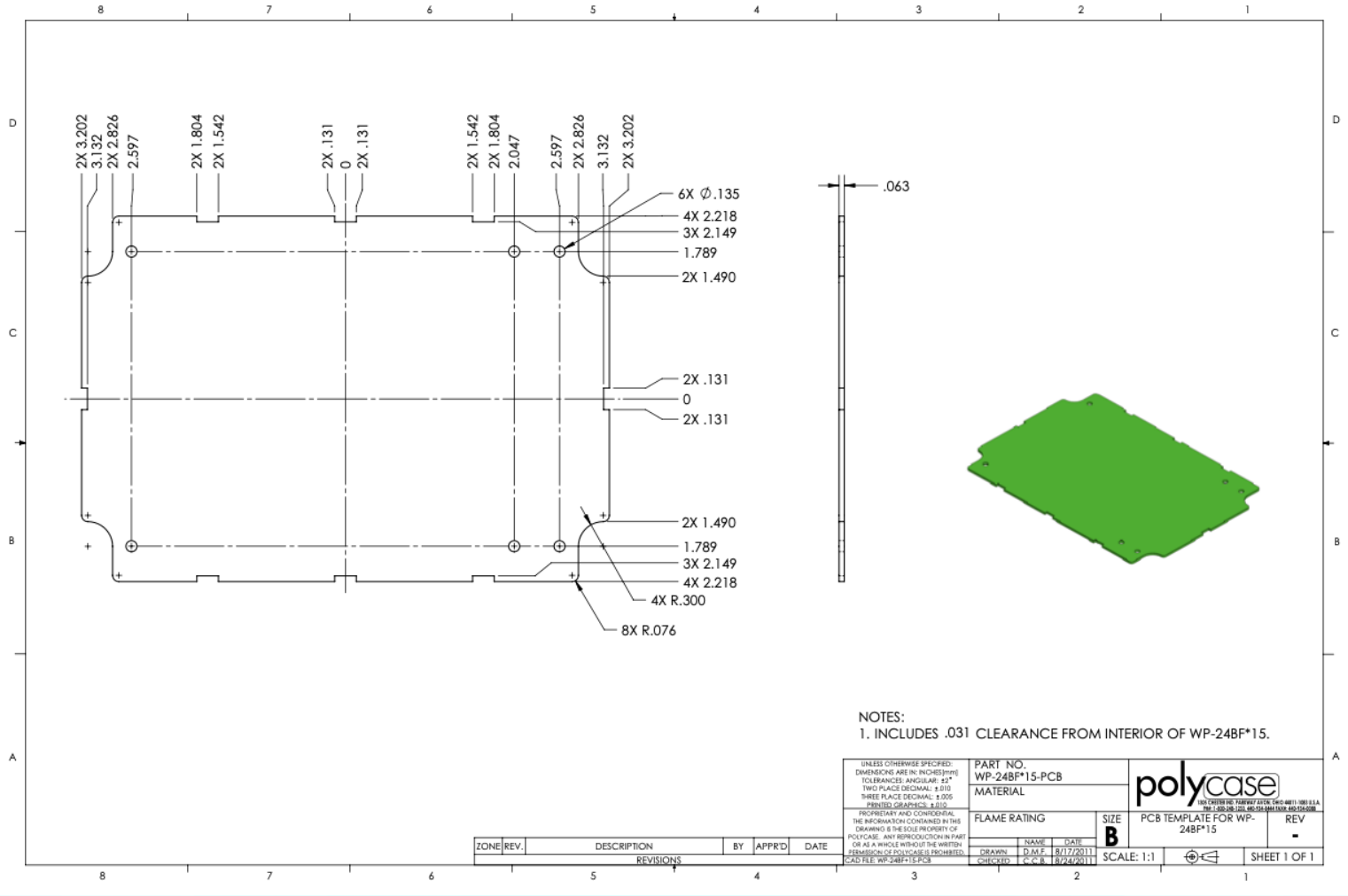
TOLERANCE CHART

DIMENSION RANGE		6 SIGMA TOOL DEPENDENT	6 SIGMA NON-TOOL DEPENDENT
.000	.040	±.0018	±.0042
.040	.120	±.0024	±.0054
.120	.240	±.0030	±.0060
.240	.390	±.0036	±.0066
.390	.590	±.0042	±.0072
.590	.870	±.0048	±.0072
.870	1.180	±.0054	±.0078
1.180	1.570	±.0060	±.0084
1.570	2.070	±.0068	±.0078
2.070	2.760	±.0075	±.0108
2.760	3.540	±.0090	±.0120
3.540	4.700	±.0108	±.0132
4.700	6.300	±.0126	±.0150
6.300	7.870	±.0150	±.0180

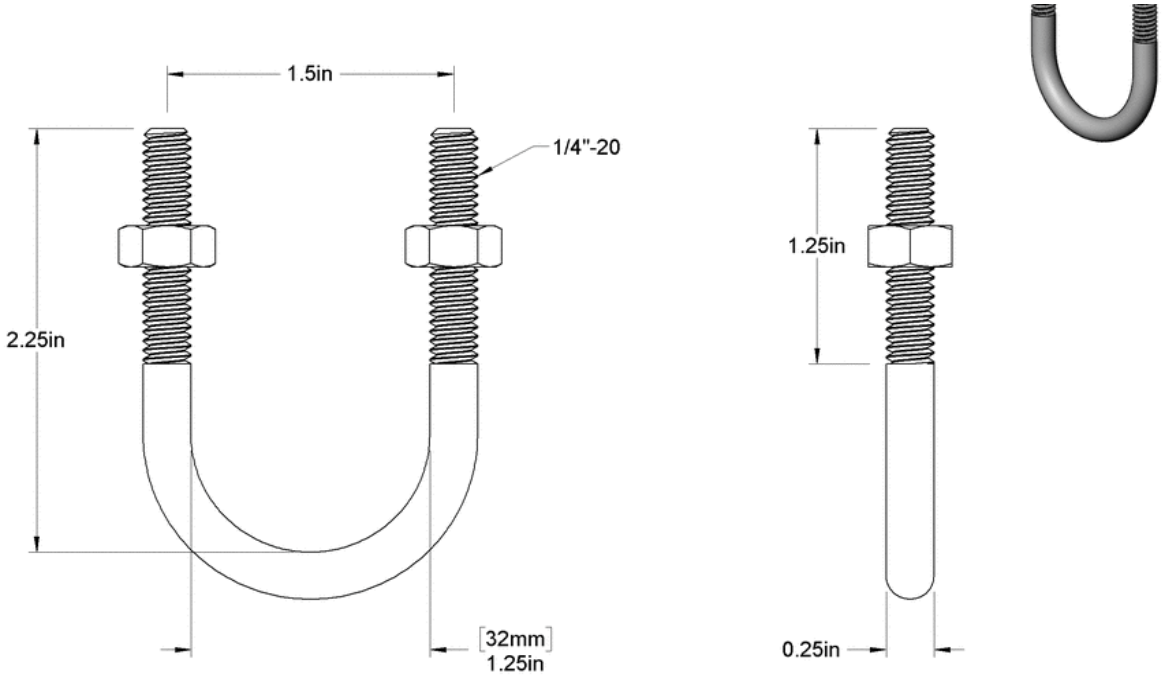
Design Details: Downhill Housing



Design Details: Downhill Housing



U bolt for mounting components to PolyStake



For EMT Conduit Trade Size: 1
For Copper Tube Size: 1

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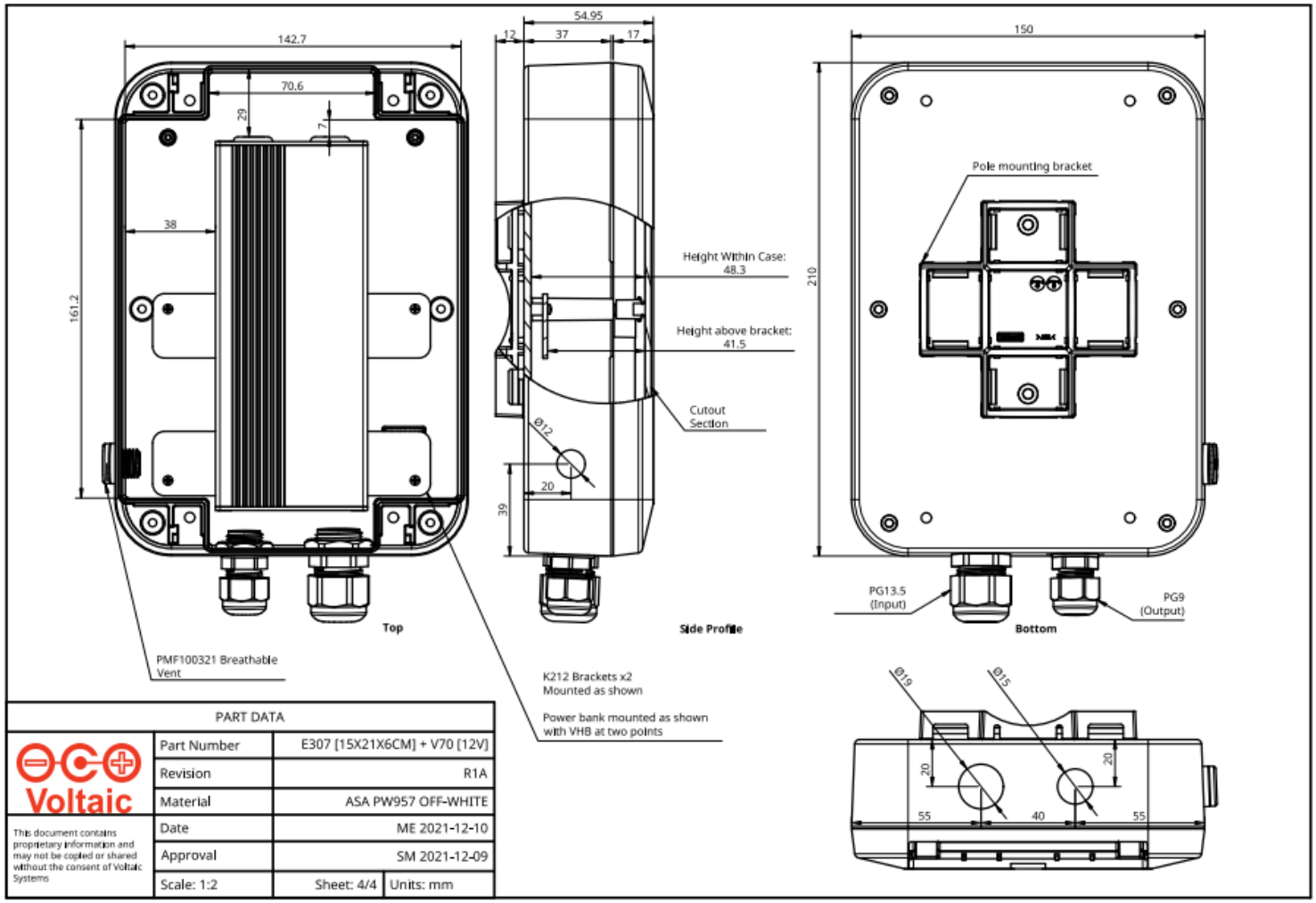
Information in this drawing is provided for reference only.

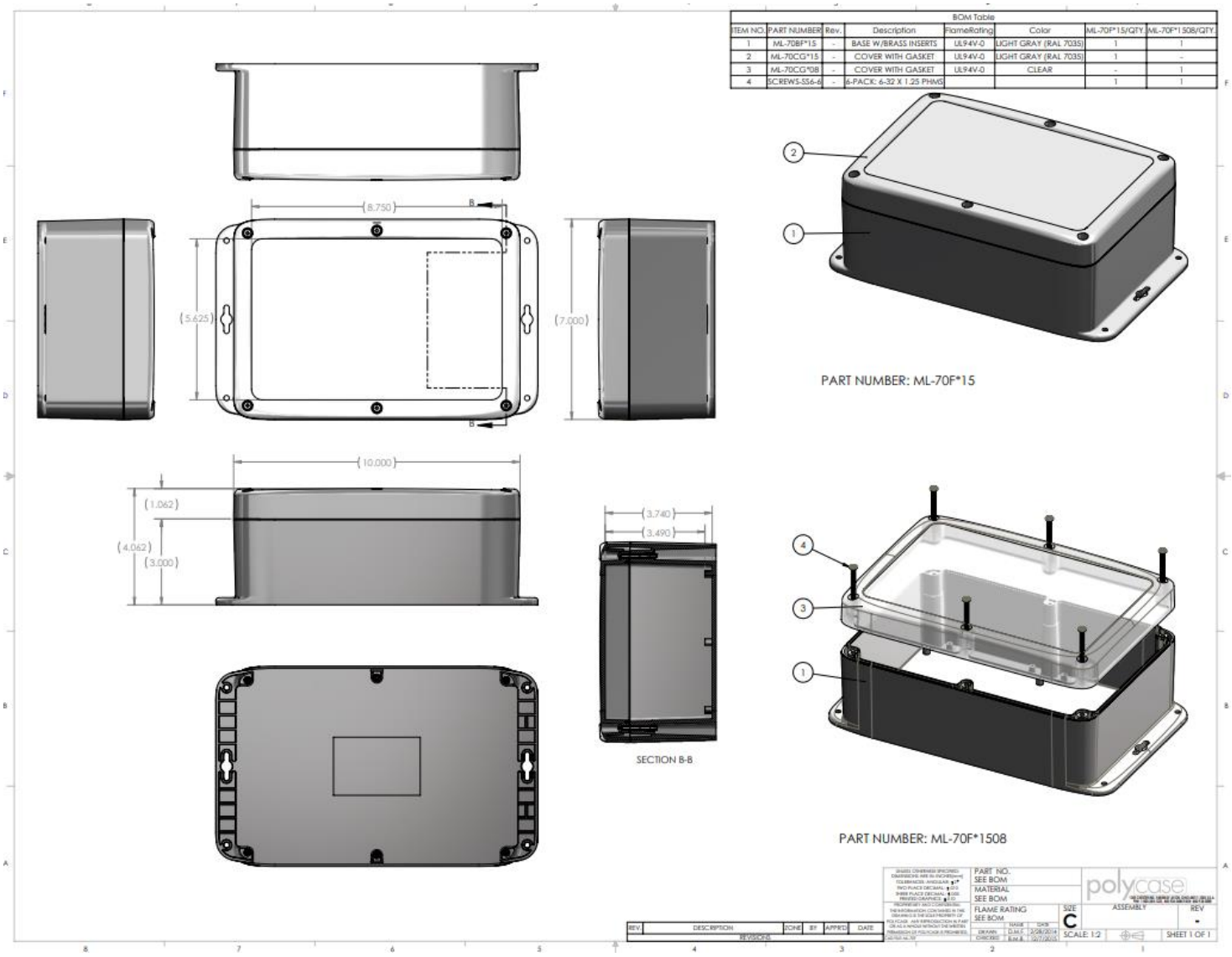
PART NUMBER 2936T36

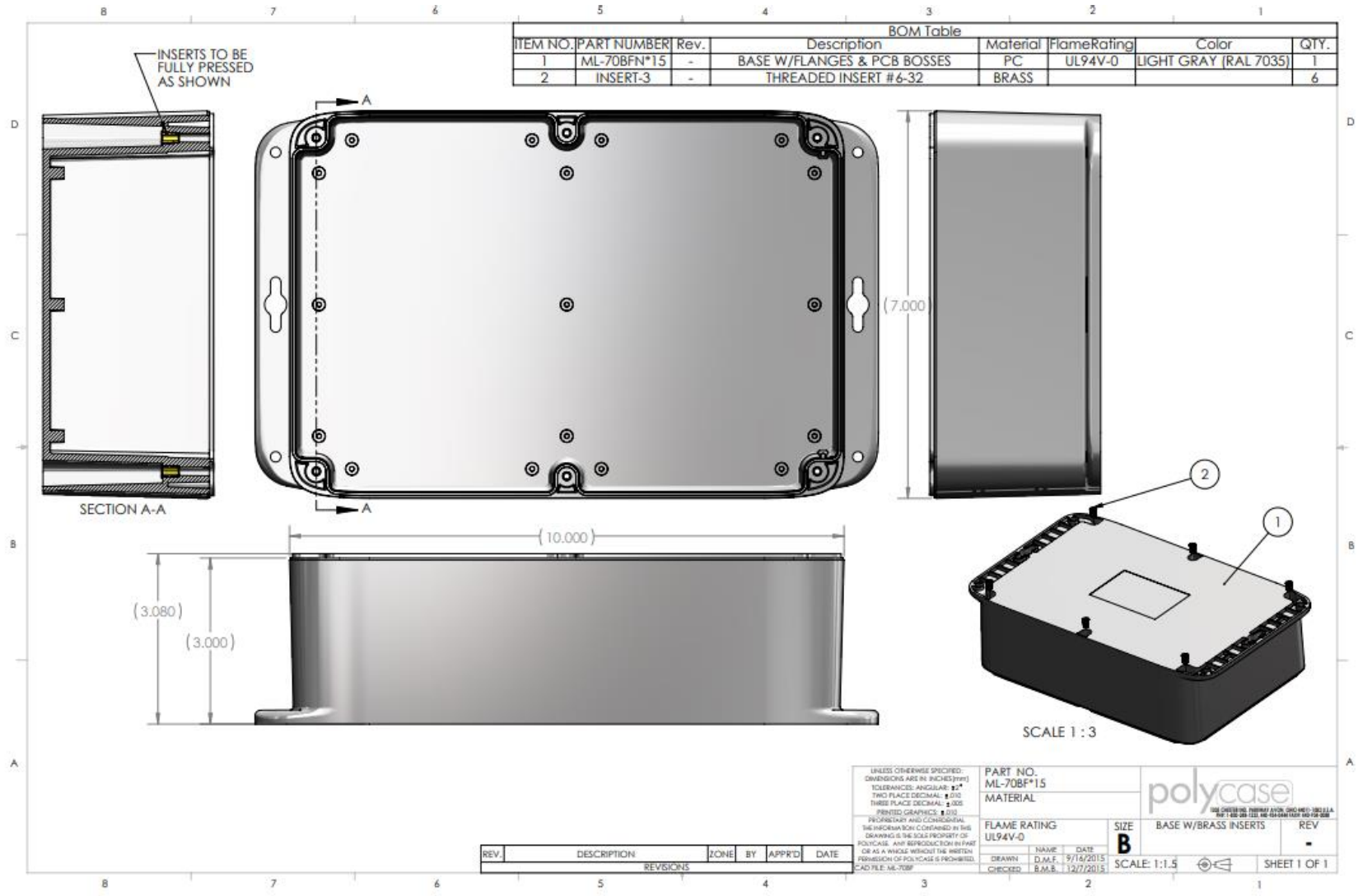
Galvanized Steel U-Bolt

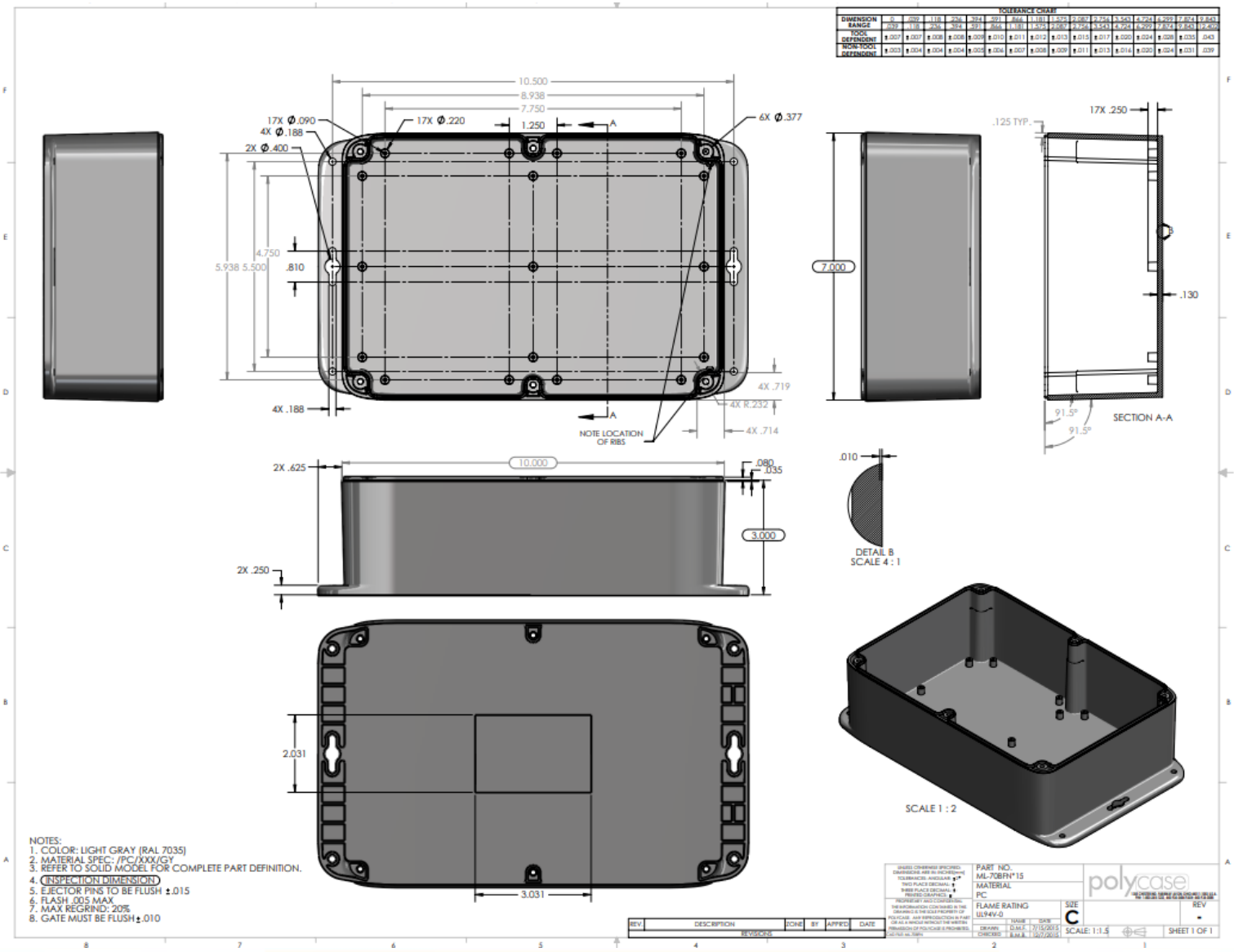
Solar panel battery case Drawing



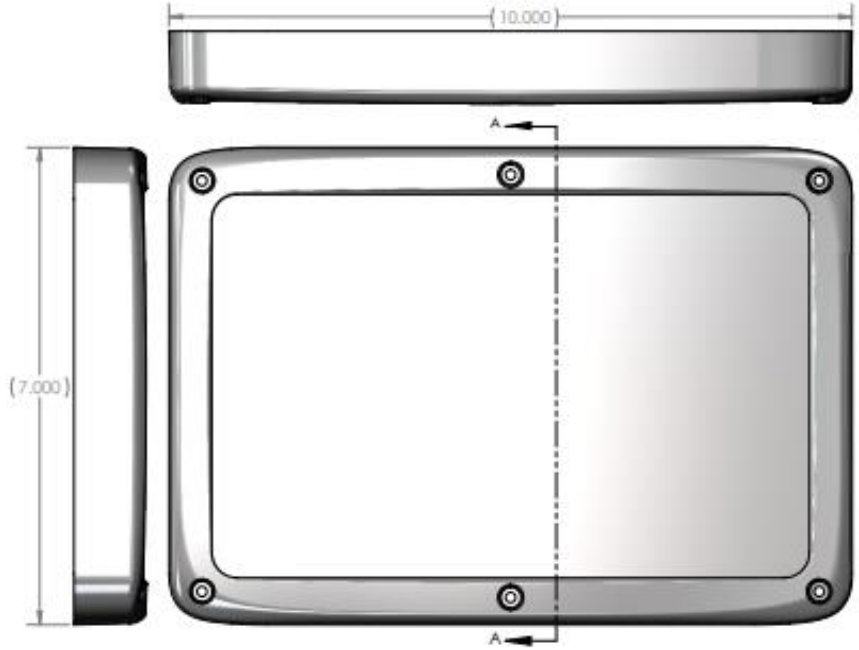
PART DATA			
Voltaic	Part Number	E307 [15X21X6CM] + V70 [12V]	
	Revision	R1A	
	Material	ASA PW957 OFF-WHITE	
This document contains proprietary information and may not be copied or shared without the consent of Voltaic Systems	Date	ME 2021-12-10	
	Approval	SM 2021-12-09	
	Scale: 1:2	Sheet: 4/4	Units: mm


BOM Table
ITEM NO. | PART NUMBER | Rev. | Description | FlameRating | Color | ML-70F*15/QTY | ML-70F*1508/QTY
1 | ML-70BF*15 | - | BASE W/BRASS INSERTS | UL94V-0 | LIGHT GRAY (RAL 7035) | 1 | 1
2 | ML-70CG*15 | - | COVER WITH GASKET | UL94V-0 | LIGHT GRAY (RAL 7035) | 1 | -
3 | ML-70CG*08 | - | COVER WITH GASKET | UL94V-0 | CLEAR | - | 1
4 | SCREWS-SS6-6 | - | 6-PACK: 6-32 X 1.25 PHMS | | | 1 | 1
8.750
5.625
7.000
10.000
1.062
4.062
3.000
3.740
3.490
SECTION B-B
PART NUMBER: ML-70F*15
PART NUMBER: ML-70F*1508
polycase
SEE BOM
SEE BOM
C
SCALE: 1:2
SHEET 1 OF 1


BOM Table
ITEM NO. | PART NUMBER | Rev. | Description | Material | FlameRating | Color | QTY.
1 | ML-70BFN*15 | - | BASE W/FLANGES & PCB BOSSES | PC | UL94V-0 | LIGHT GRAY (RAL 7035) | 1
2 | INSERT-3 | - | THREADED INSERT #6-32 | BRASS | | | 6
INSERTS TO BE FULLY PRESSED AS SHOWN
SECTION A-A
A
A
(7.000)
(10.000)
(3.080)
(3.000)
2
1
SCALE 1 : 3
PART NO. ML-70BF*15
MATERIAL
FLAME RATING UL94V-0
SIZE B
BASE W/BRASS INSERTS
REV -
DRAWN D.M.F. 9/16/2015
CHECKED R.M.B. 12/7/2015
SCALE: 1:1.5
SHEET 1 OF 1
REV. DESCRIPTION ZONE BY APPR'D DATE
REVISIONS


TOLERANCE CHART
10.500
8.938
7.750
17X Ø.090
4X Ø.188
2X Ø.400
17X Ø.220
1.250
6X Ø.377
4.750
5.938 5.500
.810
4X .188
4X .719
4X R.232
4X .714
NOTE LOCATION OF RIBS
7.000
17X .250
.125 TYP.
.130
91.5°
91.5°
SECTION A-A
2X .625
10.000
.080
.035
3.000
2X .250
.010
DETAIL B
SCALE 4 : 1
2.031
3.031
SCALE 1 : 2
NOTES:
1. COLOR: LIGHT GRAY (RAL 7035)
2. MATERIAL SPEC: /PC/XXX/GY
3. REFER TO SOLID MODEL FOR COMPLETE PART DEFINITION.
4. (INSPECTION DIMENSION)
5. EJECTOR PINS TO BE FLUSH ±.015
6. FLASH .005 MAX
7. MAX REGRIND: 20%
8. GATE MUST BE FLUSH±.010
PART NO.
ML-70BFN*15
MATERIAL
PC
FLAME RATING
UL94V-0
polycase
SIZE
C
REV
-
SCALE: 1:1.5
SHEET 1 OF 1
REVISIONS
REV.
DESCRIPTION
ZONE
BY
APPRD.
DATE

BOM Table								
ITEM NO.	PART NUMBER	Rev.	Description	Material	FlameRating	Color	ML-70CG*15/QTY.	ML-70CG*08/QTY.
1	ML-70C*15	-	COVER	PC	UL94V-0	LIGHT GRAY (RAL 7035)	1	-
2	ML-70C*08	-	COVER	PC	UL94V-0	CLEAR	-	1
3	GASKET-10	-		SILICONE		CLEAR	1	1



SECTION A-A

SCALE 1 : 2

SCALE 1 : 2

REV.	DESCRIPTION	ZONE	BY	APP'D	DATE

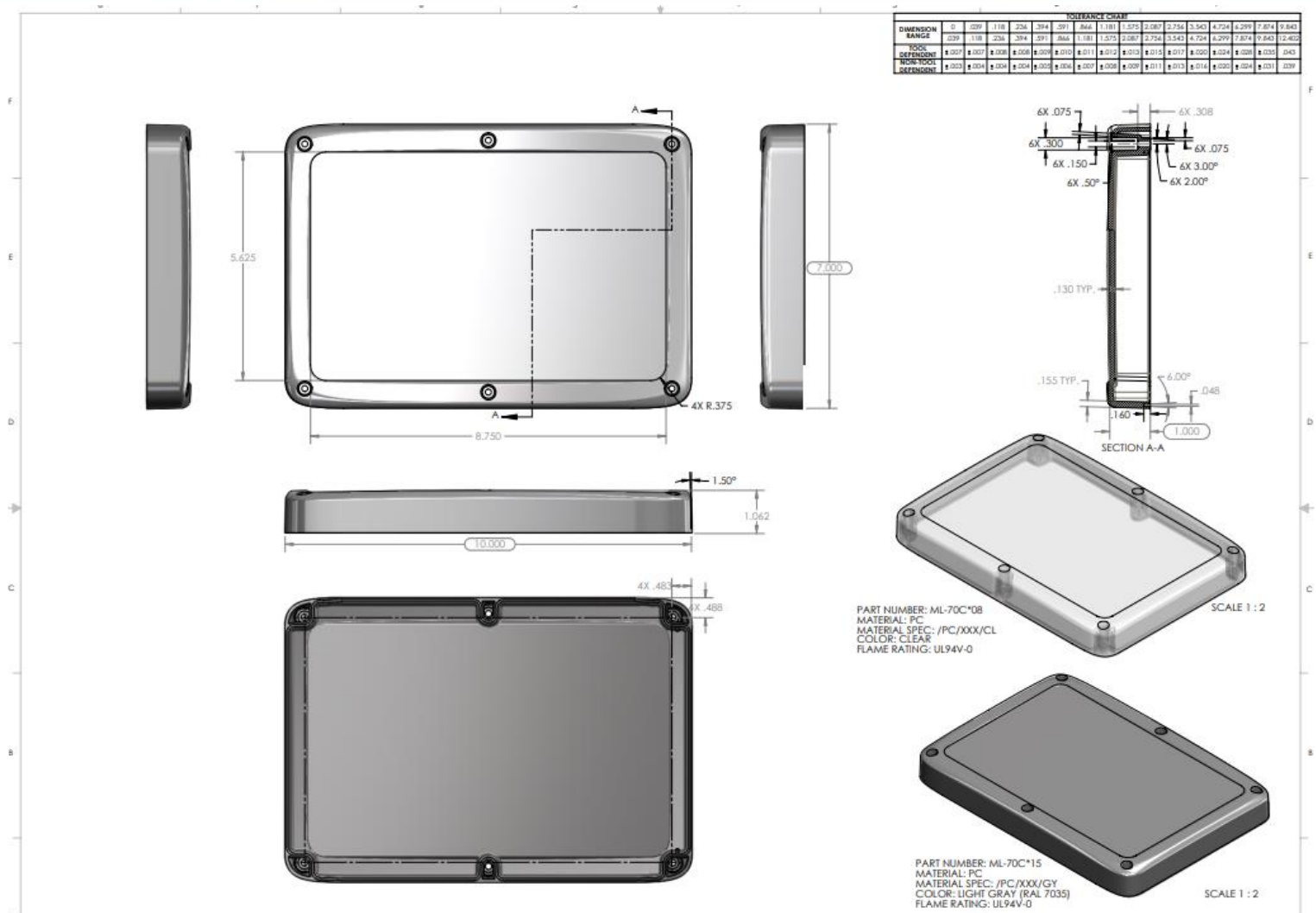
REVISIONS

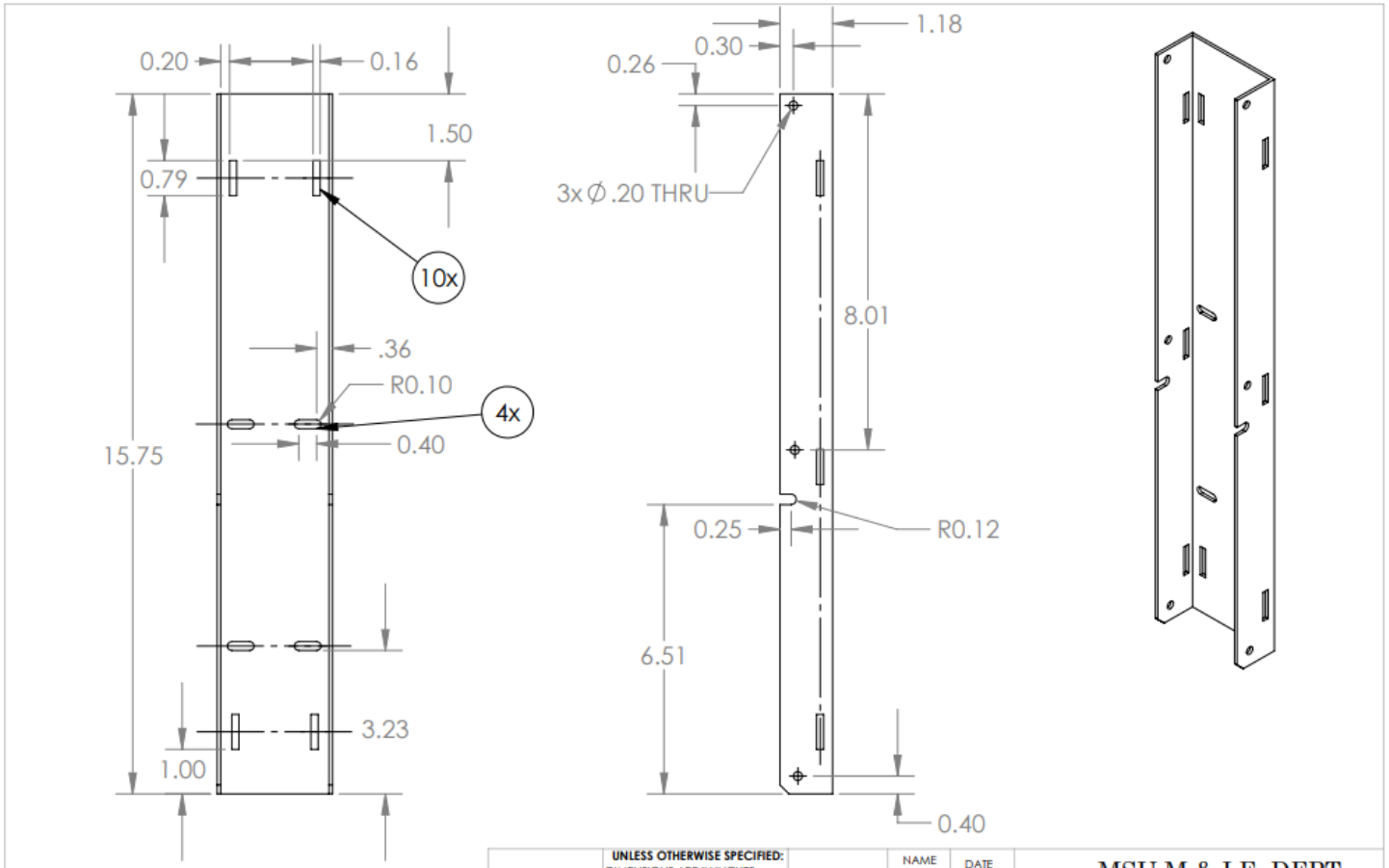
PART NO.
SEE BOM
MATERIAL
SEE BOM
FLAME RATING
SEE BOM

polycase

SIZE B | COVER WITH GASKET | REV -

SCALE: 1:1.5 | SHEET 1 OF 1


TOLERANCE CHART
5.625
7.000
4X R.375
8.750
1.50°
1.062
10.000
4X .483
4X .488
6X .075
6X .308
6X .300
6X .075
6X .150
6X 3.00°
6X .50°
6X 2.00°
.130 TYP.
.155 TYP.
6.00°
.048
.160
1.000
SECTION A-A
PART NUMBER: ML-70C*08
MATERIAL: PC
MATERIAL SPEC: /PC/XXX/CL
COLOR: CLEAR
FLAME RATING: UL94V-0
SCALE 1 : 2
PART NUMBER: ML-70C*15
MATERIAL: PC
MATERIAL SPEC: /PC/XXX/GY
COLOR: LIGHT GRAY (RAL 7035)
FLAME RATING: UL94V-0
SCALE 1 : 2
NOTES:
1. REFER TO SOLID MODEL FOR COMPLETE PART DEFINITION.
2. FINISH: DIAMOND POLISH
3. (INSPECTION DIMENSION)
4. FLASH CANNOT EXCEED .005
5. MAX REGRIND: 20%
6. GATE MUST BE FLUSH ±.015
PART NO.
AS NOTED
MATERIAL
AS NOTED
FLAME RATING
AS NOTED
polycase
SIZE
C
REV
-
SCALE: 1:1.5
SHEET 1 OF 1
REVISIONS
DESCRIPTION
ZONE
BY
APP'D
DATE



	UNLESS OTHERWISE SPECIFIED:		NAME	DATE
	DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/16" ANGULAR: MACH ± .5 BEND ± 1 TWO PLACE DECIMAL ± 0.03" THREE PLACE DECIMAL ± 0.005"	DRAWN	Trevor J	10/23/24
		CHECKED		
		ENG APPR.		
	INTERPRET GEOMETRIC TOLERANCING PER:	MFG APPR.		
	COMMENTS:	MATERIAL 2 mm Aluminum 5052		
NEXT ASSY	DO NOT SCALE DRAWING	-		

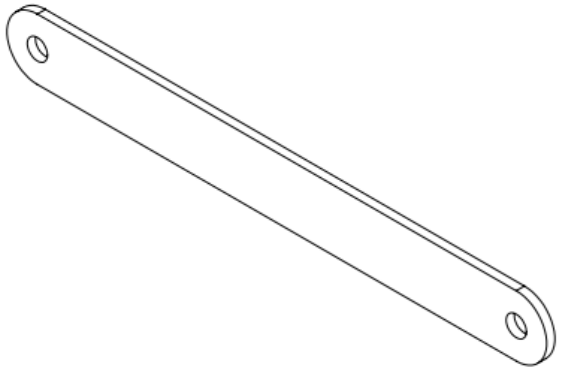
MSU M.& I.E. DEPT.

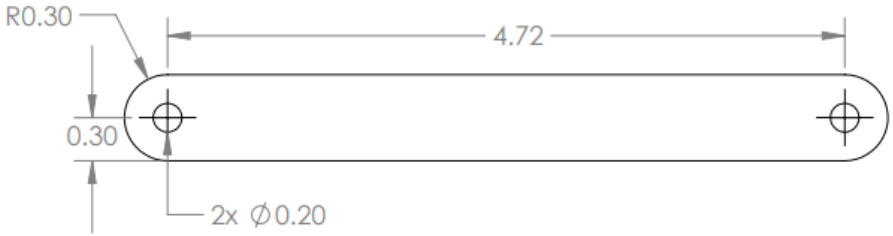
TITLE: Post Mount Plate

SIZE	DWG. NO.	REV
A	2	

SCALE: 1:4 | WEIGHT: 0.57 | SHEET 1 OF 1

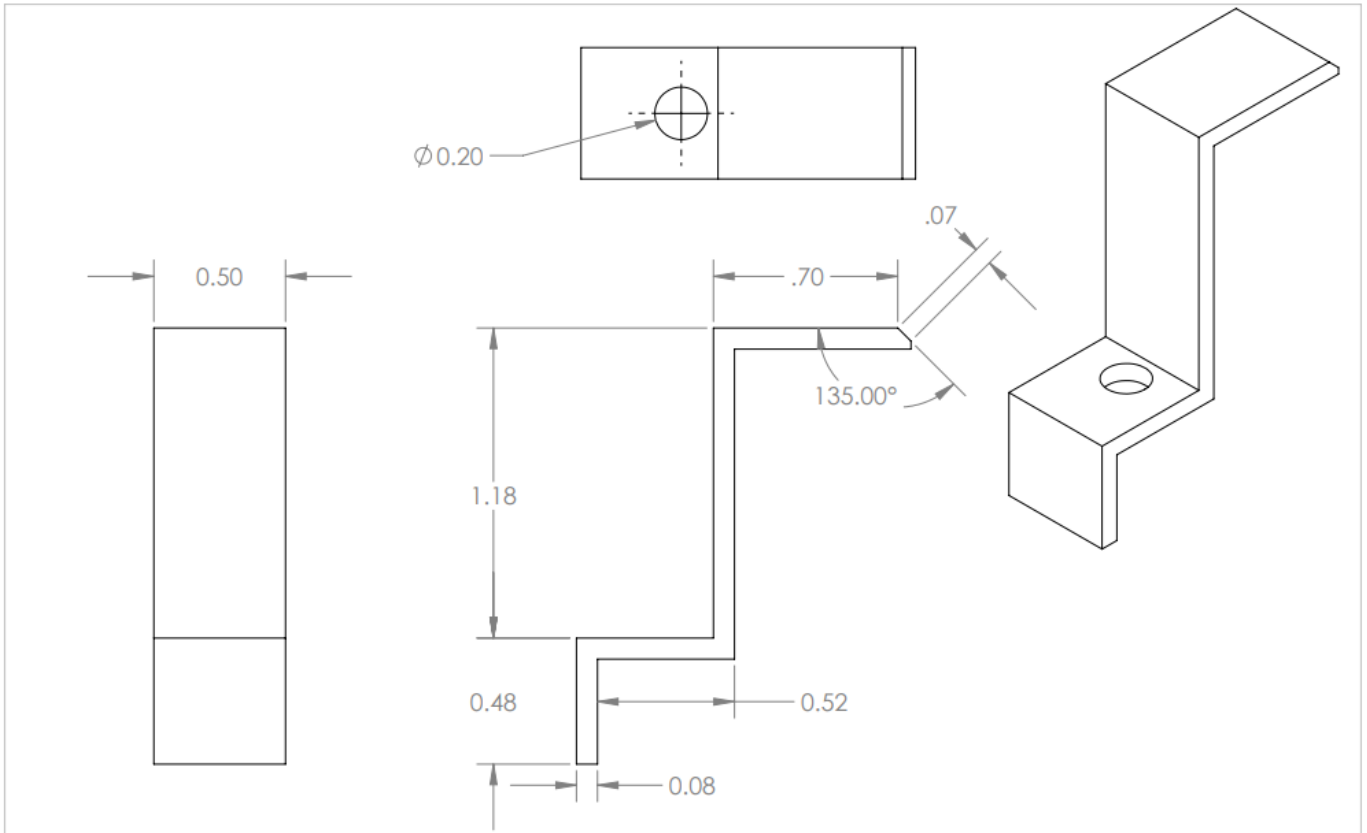
5 4 3 2 1





	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/16" ANGULAR: MACH ± 5 BEND ± 1 TWO PLACE DECIMAL ± 0.03" THREE PLACE DECIMAL ± 0.005"		NAME	DATE	MSU M.& I.E. DEPT.
		DRAWN	Trevor J	10/23/24	TITLE: Support Bar
		CHECKED			
		ENG APPR.			
	INTERPRET GEOMETRIC TOLERANCING PER:	MFG APPR.			SIZE A | DWG. NO. 4 | REV
	COMMENTS:	MATERIAL 2 mm Aluminum 5052			
NEXT ASSY	DO NOT SCALE DRAWING	-			SCALE: 1:1 | WEIGHT: 0.02 | SHEET 1 OF 1

5 4 3 2 1



	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/16" ANGULAR: MACH ± .5 BEND ± 1 TWO PLACE DECIMAL ± 0.03" THREE PLACE DECIMAL ± 0.005"		NAME	DATE
		DRAWN	Trevor J	10/23/24
		CHECKED		
		ENG APPR.		
	INTERPRET GEOMETRIC TOLERANCING PER:	MFG APPR.		
	COMMENTS:	MATERIAL 2 mm Aluminum 5052		
NEXT ASSY	DO NOT SCALE DRAWING	-		

MSU M.& I.E. DEPT.

TITLE: Solar Panel Clamp

SIZE	DWG. NO.	REV
A	5	

SCALE: 2:1 | WEIGHT: 0.00 | SHEET 1 OF 1

5 4 3 2 1