

# Design of ECU Server Shelf

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# Problem Definition

An engineering research group at CSU is developing a remote vehicle network test platform. Continuous operation of electronic control units (ECUs), computers, servers, and other electrical hardware is expected. An organized means of mounting ECU equipment in standard 19-inch racks (server racks) is desired.



# Needs Analysis

**Primary Function:**

Support a vehicle ECU and its equipment on standard 19" racks

**Secondary Function(s):**

None

**Timeline:**

January 1<sup>st</sup> – January 30<sup>th</sup> 2021

**Where:**

Powerhouse Energy Institute Engine Control Room

**Who:**

SystemsCyber Research Group

# Requirements

## System Operational Requirements (SR)

- SR1 – System shall be securable to a standard 16U\* 19" two-post server rack.
- SR2 – System height shall not exceed 3U.
- SR3 – System weight shall not exceed 52.5 lb. (15% of rack weight capacity).
- SR4 – At minimum, the system shall support an ECU, 12V power adapter, and an SSS2 unit.

\*1U = 1.75 in.

## Key Figures of Merit (FOMs):

*Material Cost (Mc) – Dollars (\$)*

*Manufacturing Time (Mt) – Hours*

*Composite Failure Rate ( $\lambda$ ) – Likelihood a shelf is not made according to design*

*Total Design Cost (TC) – Per Shelf*

# Design Alternatives

## **Alternative 1:**

Acrylic-ABS Shelf and Display

**Description:** A desire for the shelf to doubly function as a project display board was considered but not included in the requirements. Alternative 1 attempts to satisfy this desire and the requirements by using laser cut 1/8" acrylic sheets, velcro, 3D-printed components, and available lab material.

### **Equipment Used:**

Laser Cutter, 3D Printer, Power Drill

## **Alternative 2:**

Wood-Steel Shelf

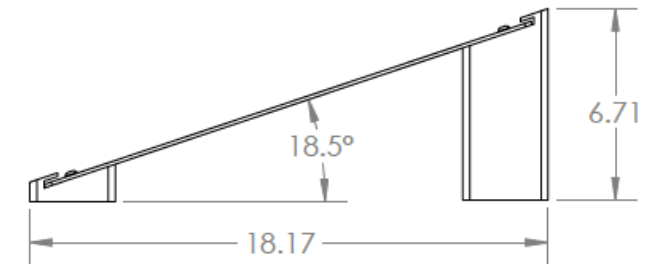
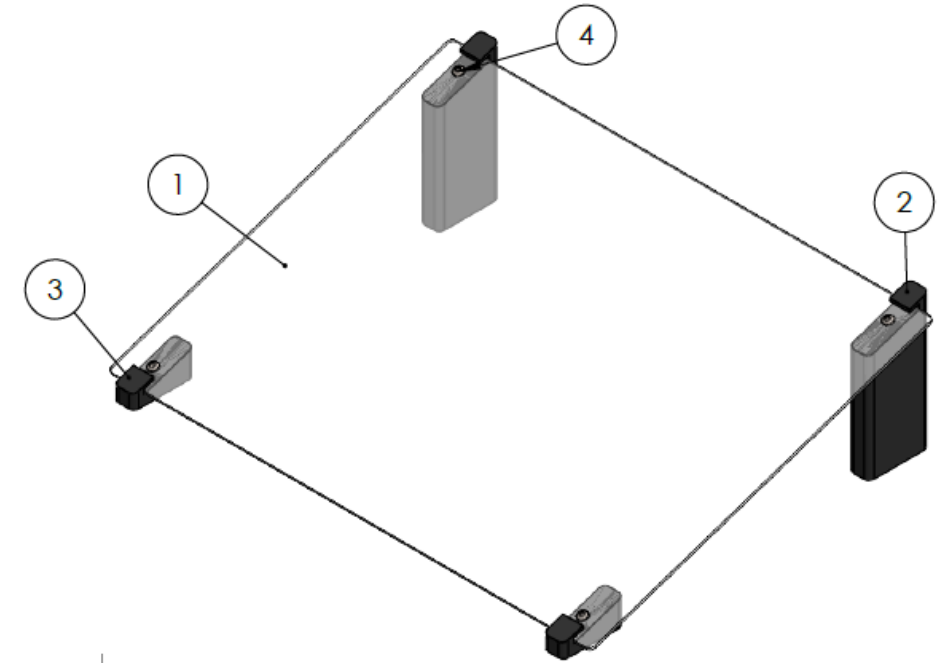
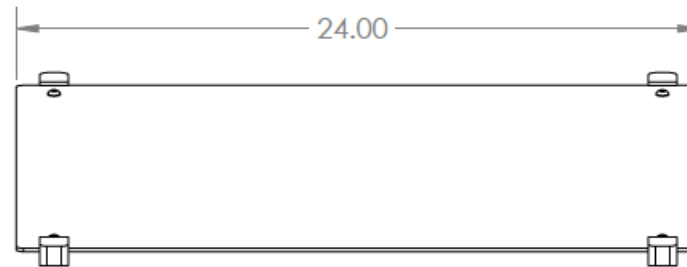
**Description:** Alternative 2 attempts to use welded 1/8 in. angle iron, screws, plywood, and available lab materials to satisfy the requirements.

### **Equipment Used:**

Mill, Welding Station, Metal Grinder, Horizontal Band Saw, Wood Saw, Power Drill

# Prototype CAD Drawing Alternative 1

ITEM NO.	PART NUMBER	QTY.
1	Display-Board-v1	1
2	Display-BackLeg-v1	2
3	Display-FrontLeg-v1	2
4	SBHCSCREW 0.25-20x0.25-HX-N	4



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UNLESS OTHERWISE SPECIFIED:		
DEC.PL	INCH	MM
X.X	± 0.050	± 1.25
X.XX	± 0.010	± 0.25
X.XXX	± 0.005	± .0127

MATERIAL  
FINISH  
DO NOT SCALE DRAWING

NAME	DATE
DRAWN DCN	12/23/2020
CHECKED	

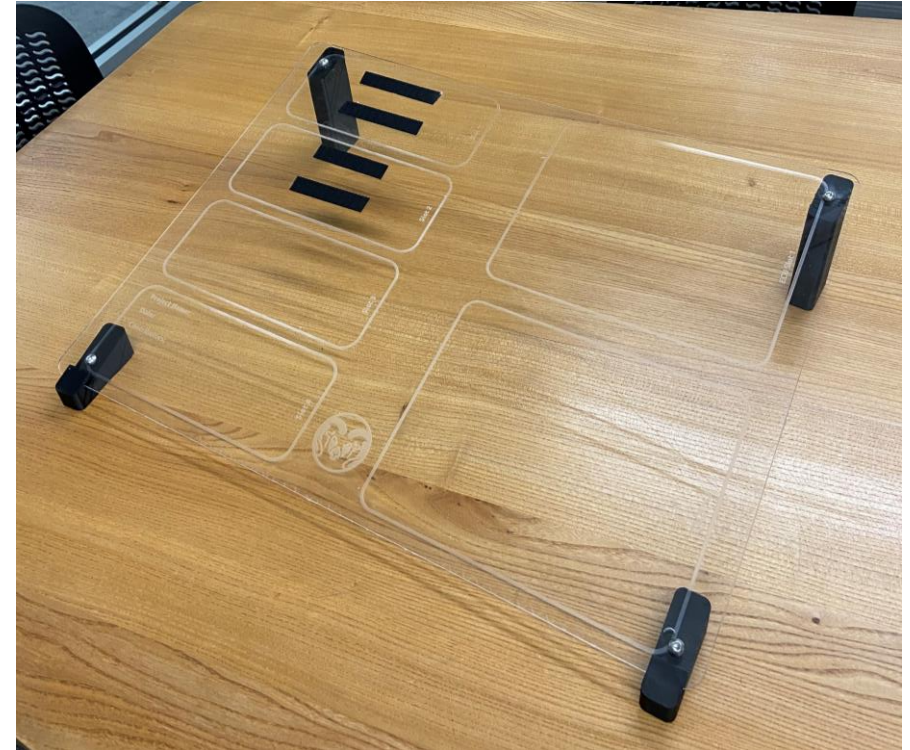
NNAJI ENGINEERING			
TITLE: General Purpose Display Assembly			
SIZE <b>A</b>	DWG. NO. Display-Board-Drawing-v1	REV <b>A</b>	
WEIGHT:			SHEET 1 OF 4

# Prototype Laser Design Alternative 1

<div>Slot 1</div>	<div>ECU Slot 1</div>
<div>Slot 2</div>	<div>ECU Slot 2</div>
<div>Slot 3</div>	
<div>Project Name: Date: Contributors:</div> <div>Slot 4</div>	<div></div>

# Issues: Alternative 1

- 3D printed components are difficult reliably produce.
- 3D printed components require 2-7 hours each to produce.
- Significant acrylic deflection observed when ECU components are mounted.
- Acrylic to ABS fastening is relatively weak.



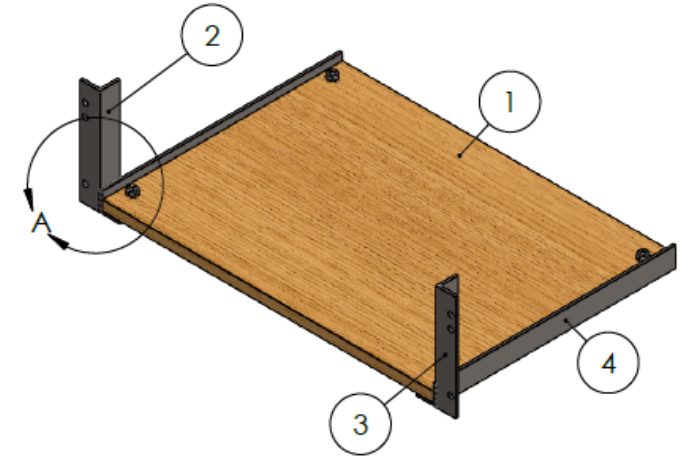
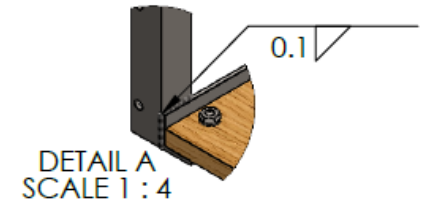
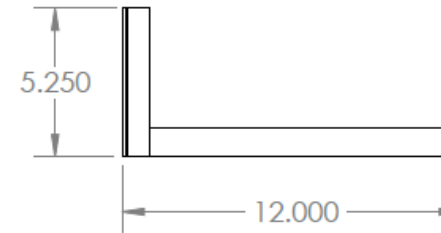
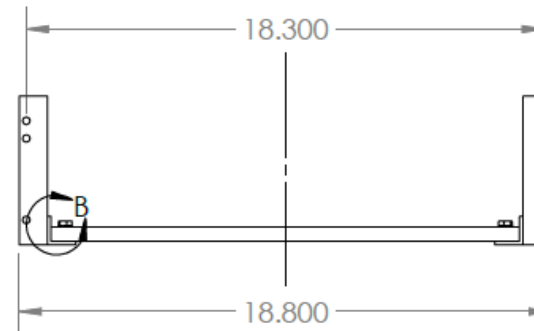
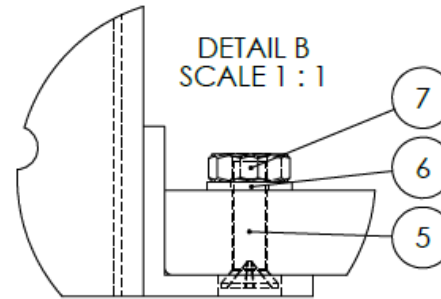


# Preliminary CAD Drawing Alternative 2

B

ITEM NO.	DESCRIPTION	QTY.
1	Baseboard	1
2	3-Hole 3RU Angle Iron (Left)	1
3	3-Hole 3RU Angle Iron (Right)	1
4	12" Angle Iron	2
5	10-32 Flat Head Screw, 3/4" Length	4
6	0.5" Flat Washer	4
7	10-32 Hex Jam Nut	4

A



CSU SYSTEMS CYBER			
TITLE:			
SIZE <b>A</b>	DWG. NO. ECU Server Rack Shelf	REV <b>A</b>	
WEIGHT:		SHEET 1 OF 4	

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	DEC.PL	INCH	MM			
	X.X	± 0.050	± 1.25			
	X.XX	± 0.010	± 0.25	FINISH	DRAWN	DCN 1/27/2021
				DO NOT SCALE DRAWING	CHECKED	

# Prototype for Wood

## **Manufacturing Processes**

Metal Cutting

Metal Grinding

Milling

Wood Cutting

Welding

Finishing

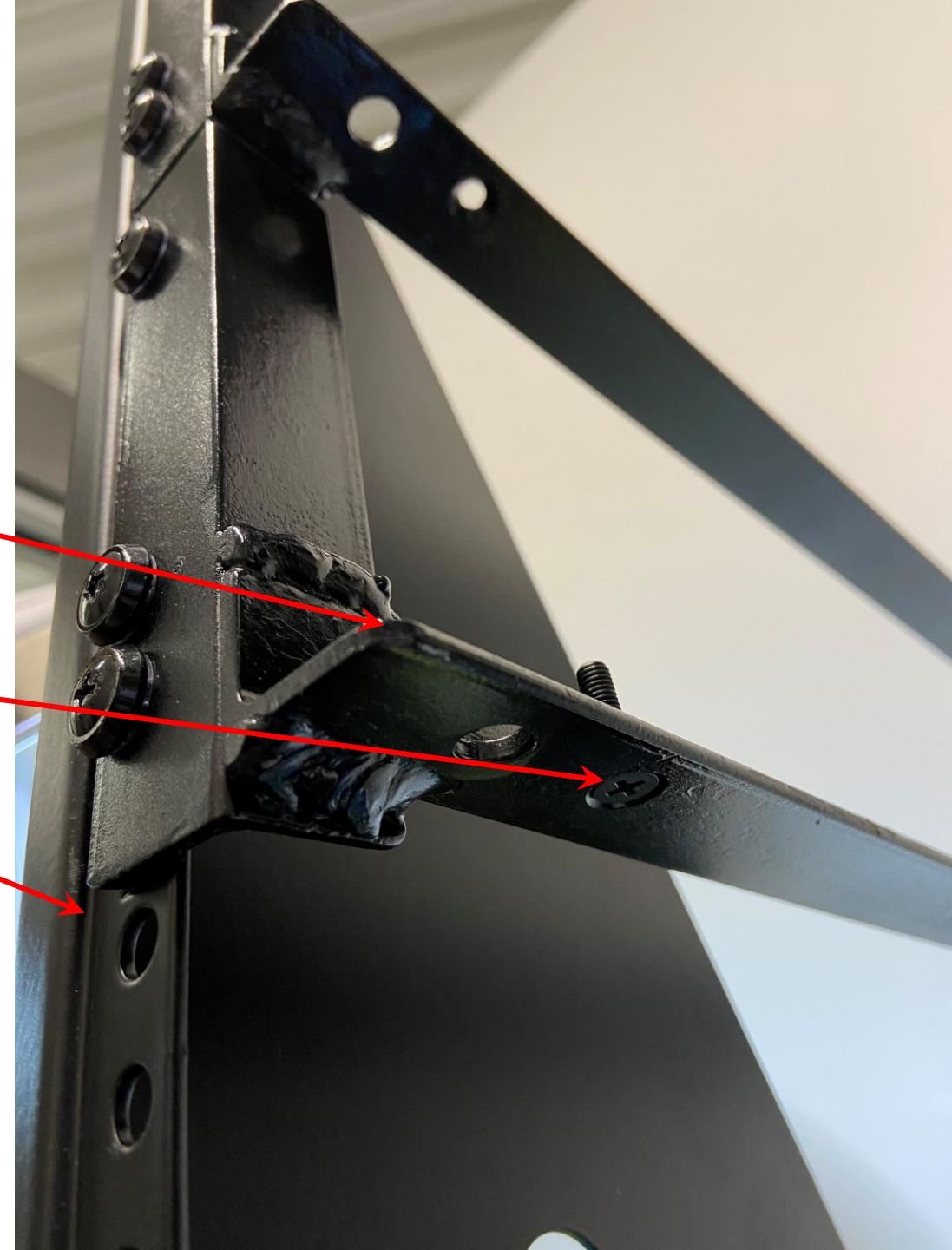
Painting

Assembly

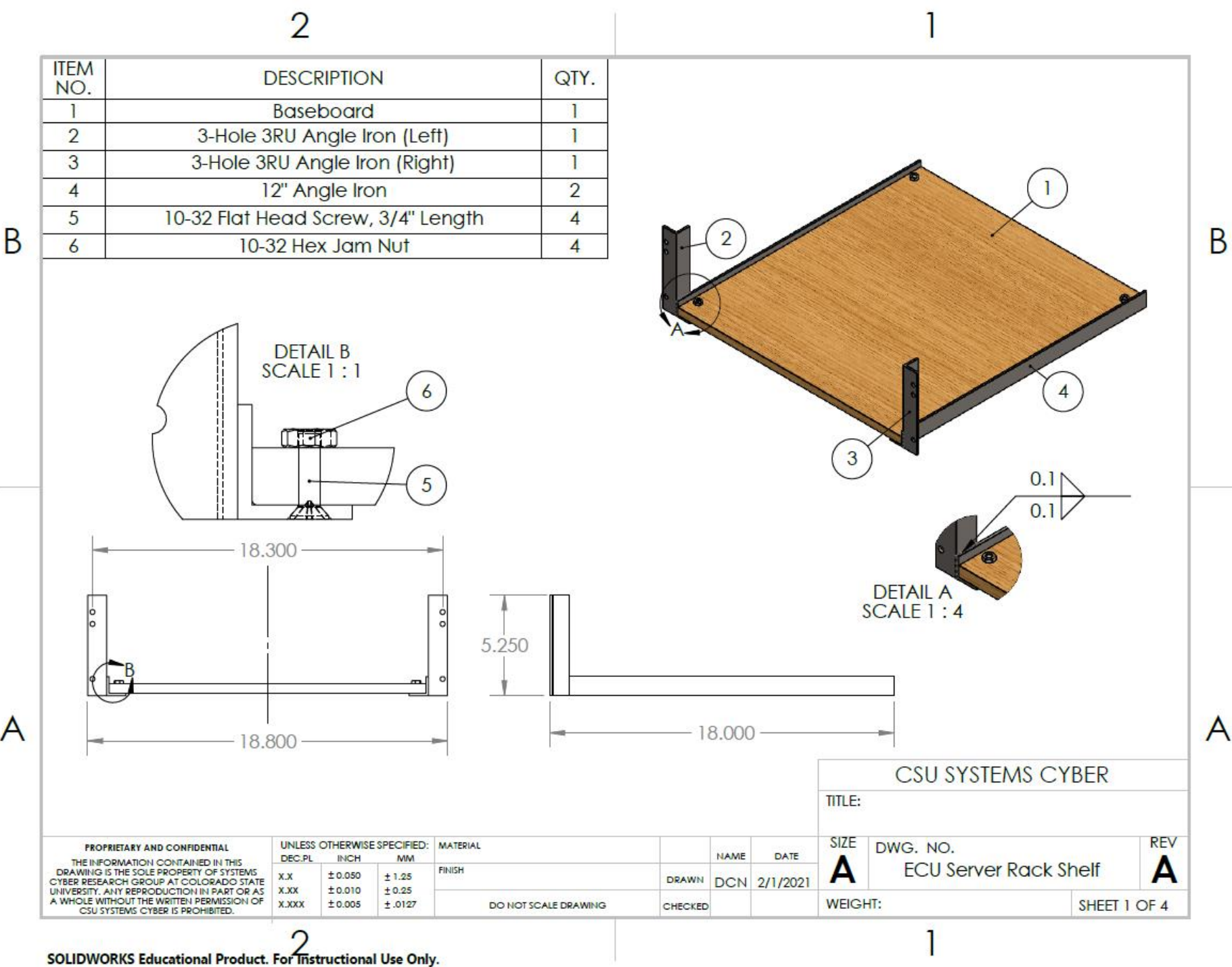


# Issues: Alternative 2

- Preliminary Design length was changed from 12" to 18"
- Preliminary Design did not include fillet features
- Preliminary design did not include countersink for long angle iron holes.
- Preliminary Design did not account for server ear shape
- Hole spacing and sizes were adjusted for multiple components.
- Washer nut replaced with flange locknut.



# Design-as-Built Drawing Alternative 2



# Trade-Off Study

*Engineering Cost (ENG C): \$30/hr*  
*Manufacturing Cost (MC): \$15/hr*

## Alternative 1

### Material Cost

19x24 Acrylic, \$13.29

136g of PLA, \$3.50

#10x0.75 Screw 50 Pack, \$9.00

*Total: \$16.79*

### Total Design Cost

$\$16.79 + 9h * \text{ENG C} + 17 * \text{MC} = \text{\$542}$

### Manufacturing Time

Laser Cut/Engraving, 0.5h

3D-Printing, 16h

Assembly, 0.5h

### Failure Rate

Baseboard, 0.05

Black legs, 0.4

Front legs, 0.2

**Composite: 54.4%**

## Alternative 2

### Material Cost

½" 19x18" Plywood, \$4.00

Paint, \$1

48" 1x1 Angle Iron from 10', \$14.40

#10x0.75 Fasteners 50 pack, \$16.16

*Total: \$35.56*

### Total Design Cost

$\$35.56 + 20h * \text{ENG C} + 9.1 * \text{MC} =$

**\$772**

### Manufacturing Time

Metal Cutting, 0.5h

Metal Grinding, 0.3h

Milling, 2h

Wood Cutting, 1h

Welding, 1h

Finishing, 1h

Painting, 3h

Assembly, 0.3h

### Failure Rate

Shelf Angle Iron, 0.15

Mount Angle Iron, 0.1

Baseboard, 0.05

**Composite: 27.3%**