

# Design of ECU Server Shelf

David Nnaji

# 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.



*Engine Control Module*

# 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:

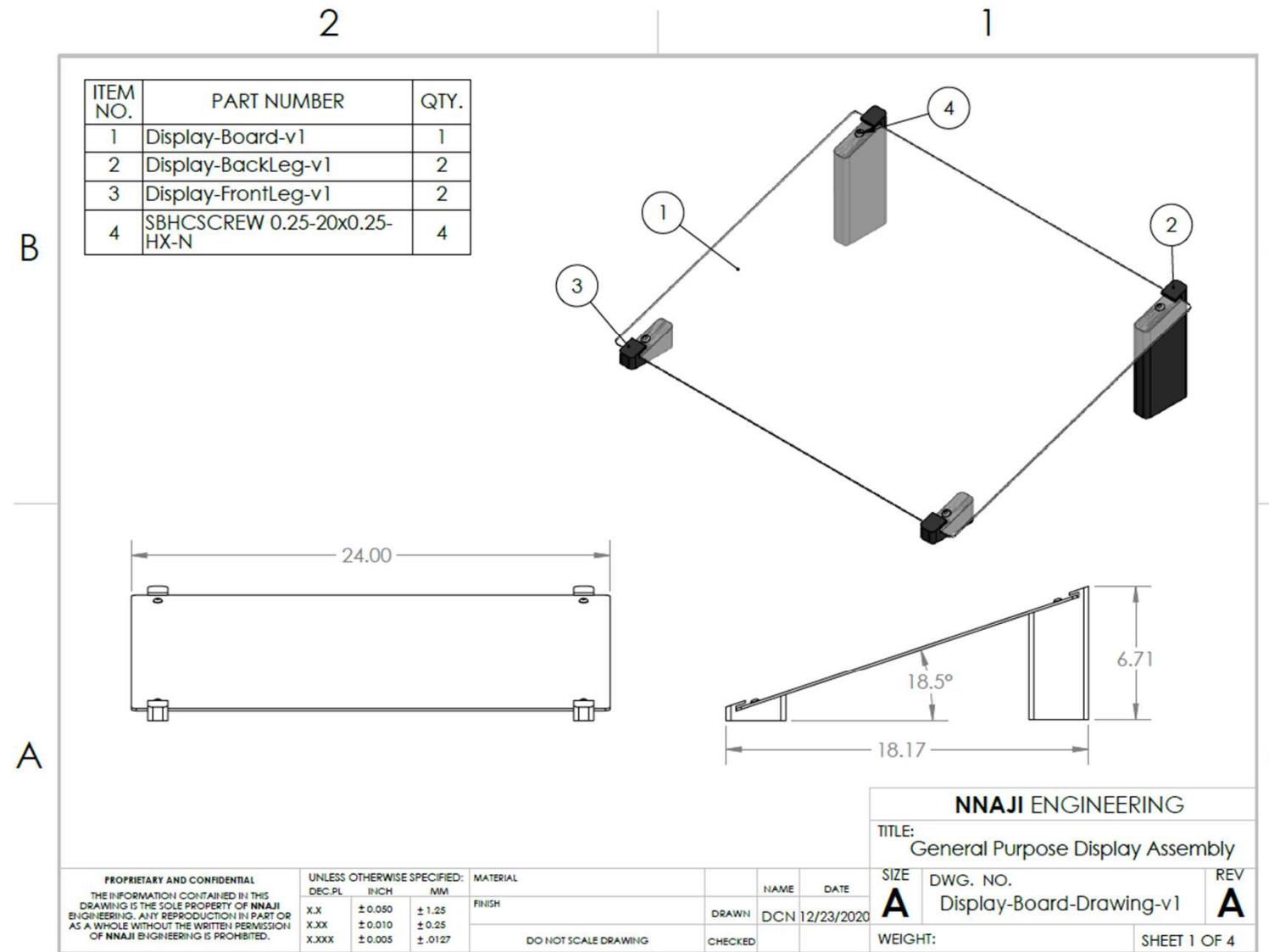
Wood-Steel Shelf

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

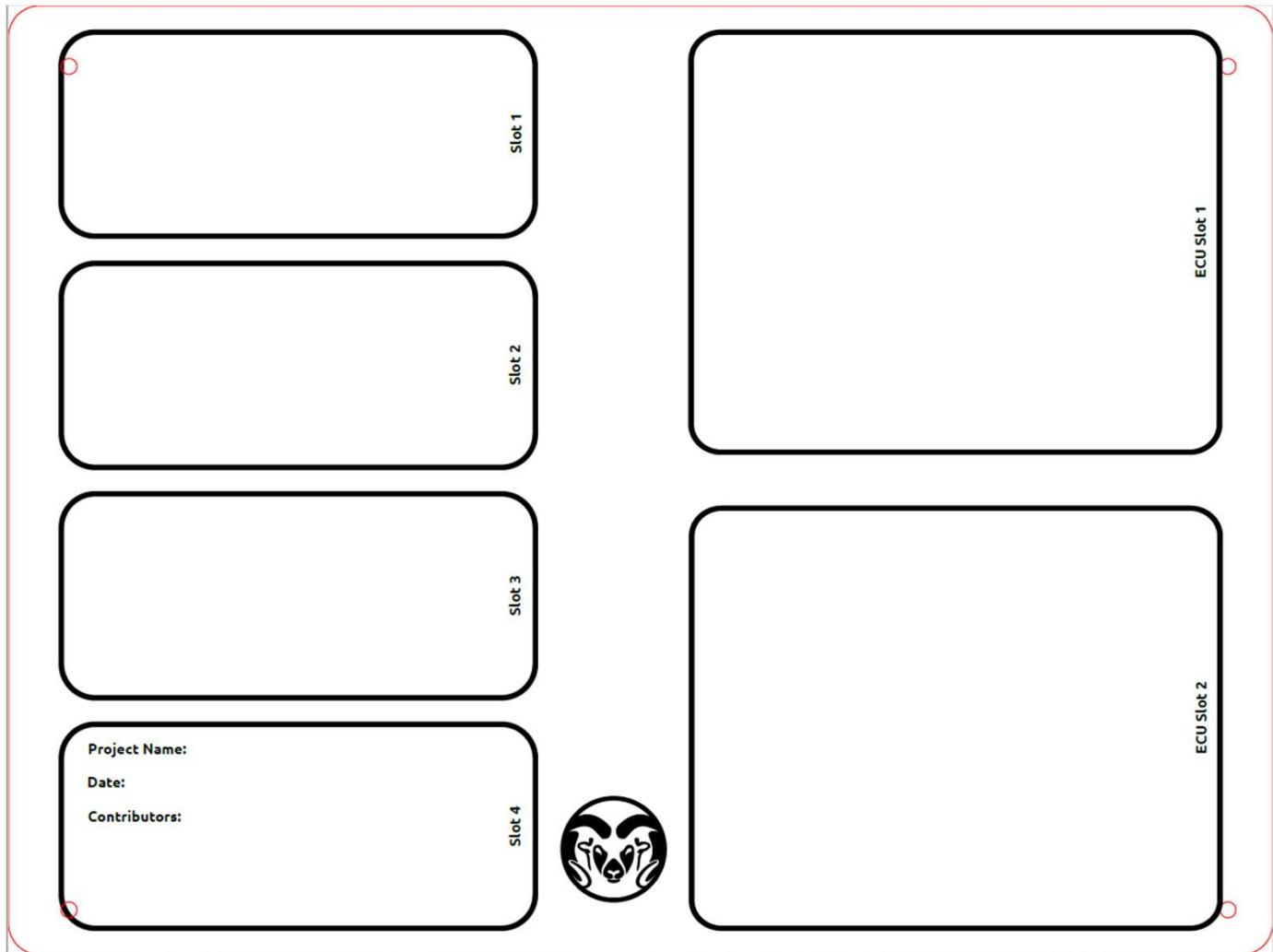
### **Equipment Used:**

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

# Prototype CAD Drawing Alternative 1

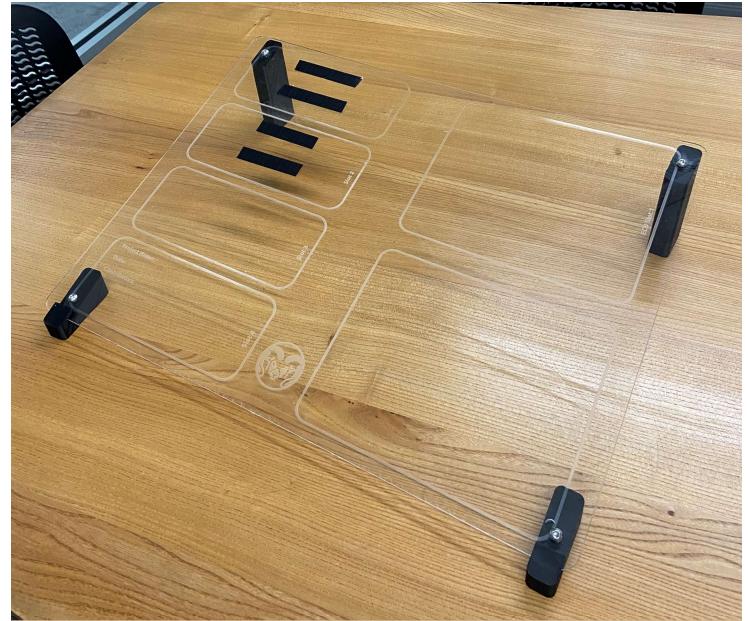


# Prototype Laser Design Alternative 1

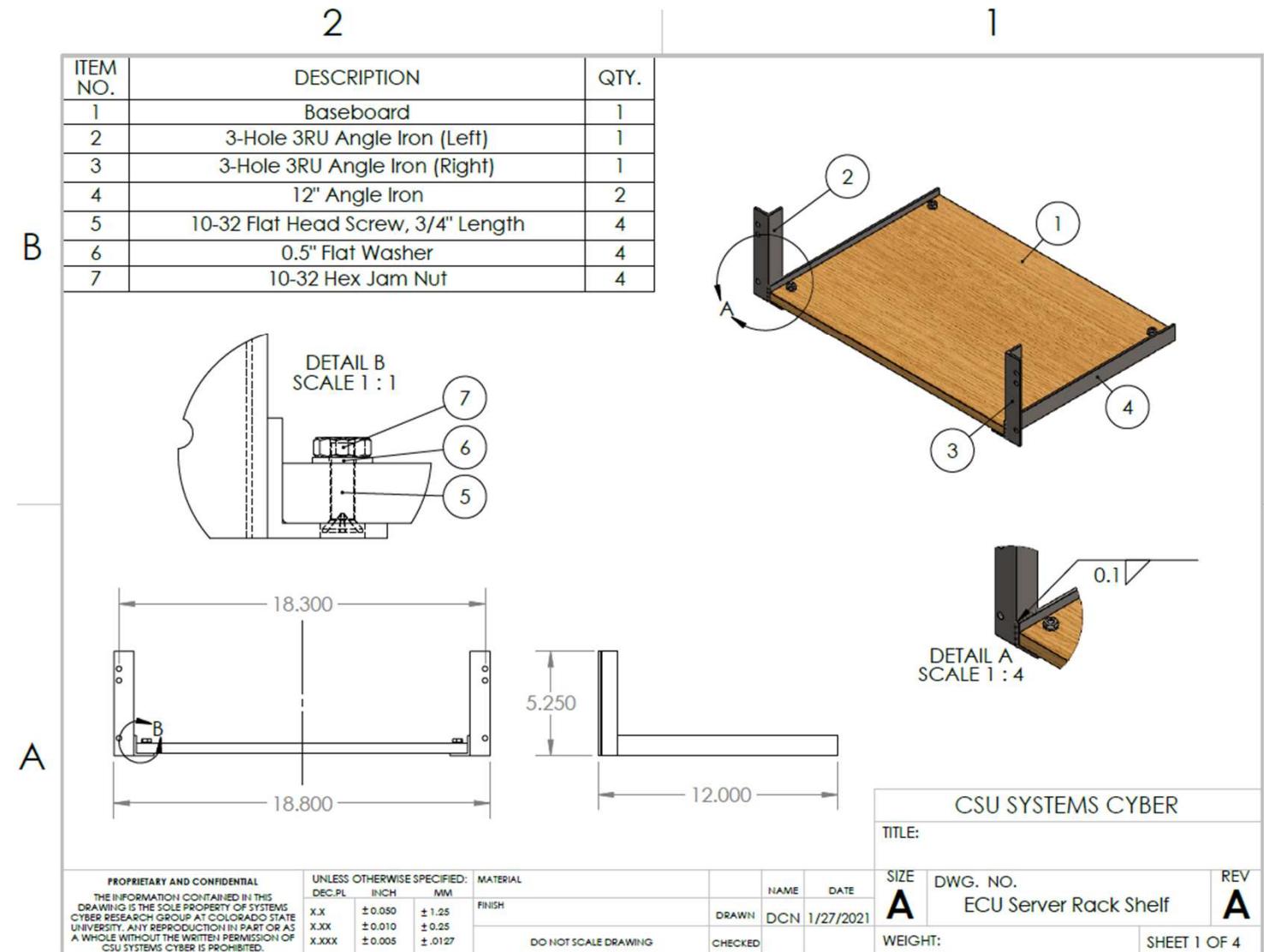


# Issues: Alternative 1

- 3D printed components are difficult to 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



2  
SOLIDWORKS Educational Product. For Instructional Use Only.

2

1

B

A

# Prototype for Wood

## **Manufacturing Processes**

Metal Cutting

Metal Grinding

Milling

Wood Cutting

Welding

Finishing

Painting

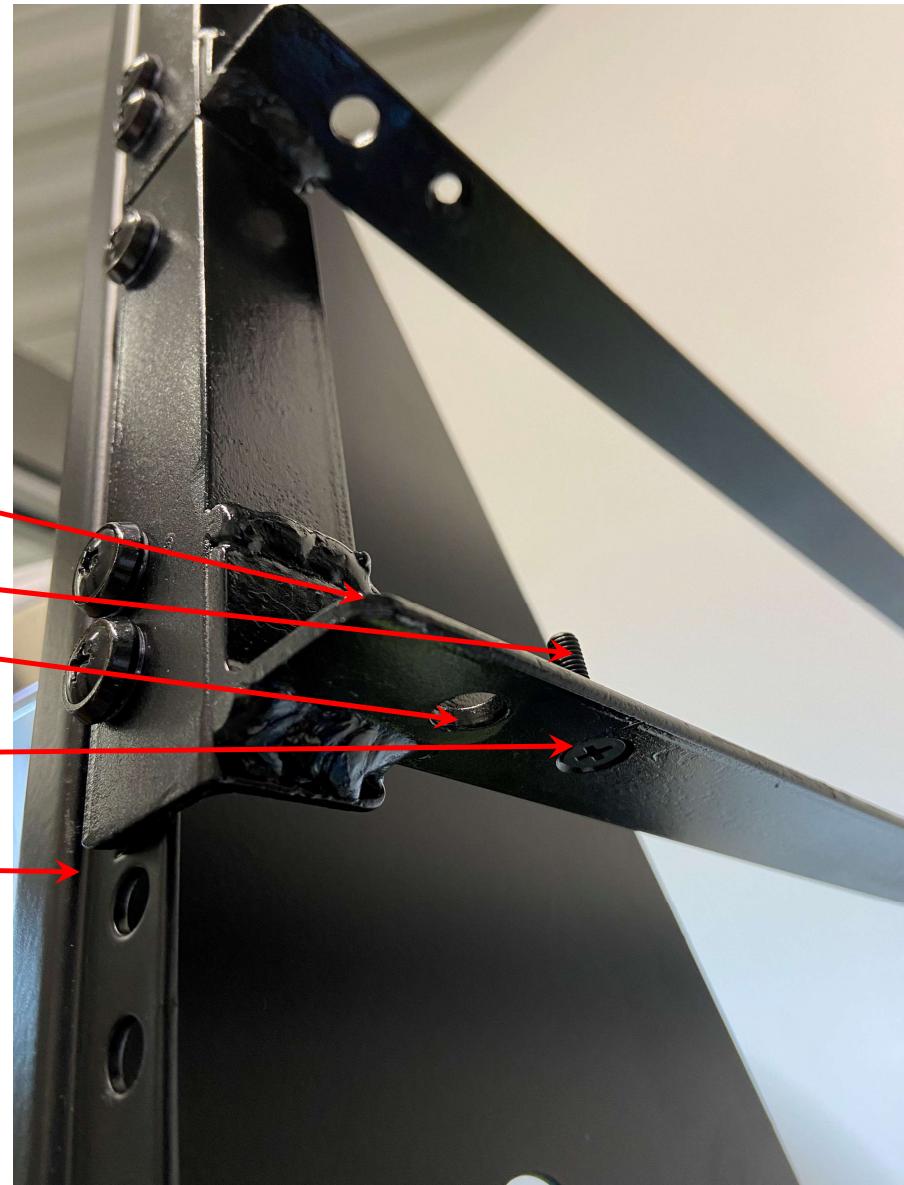
Assembly



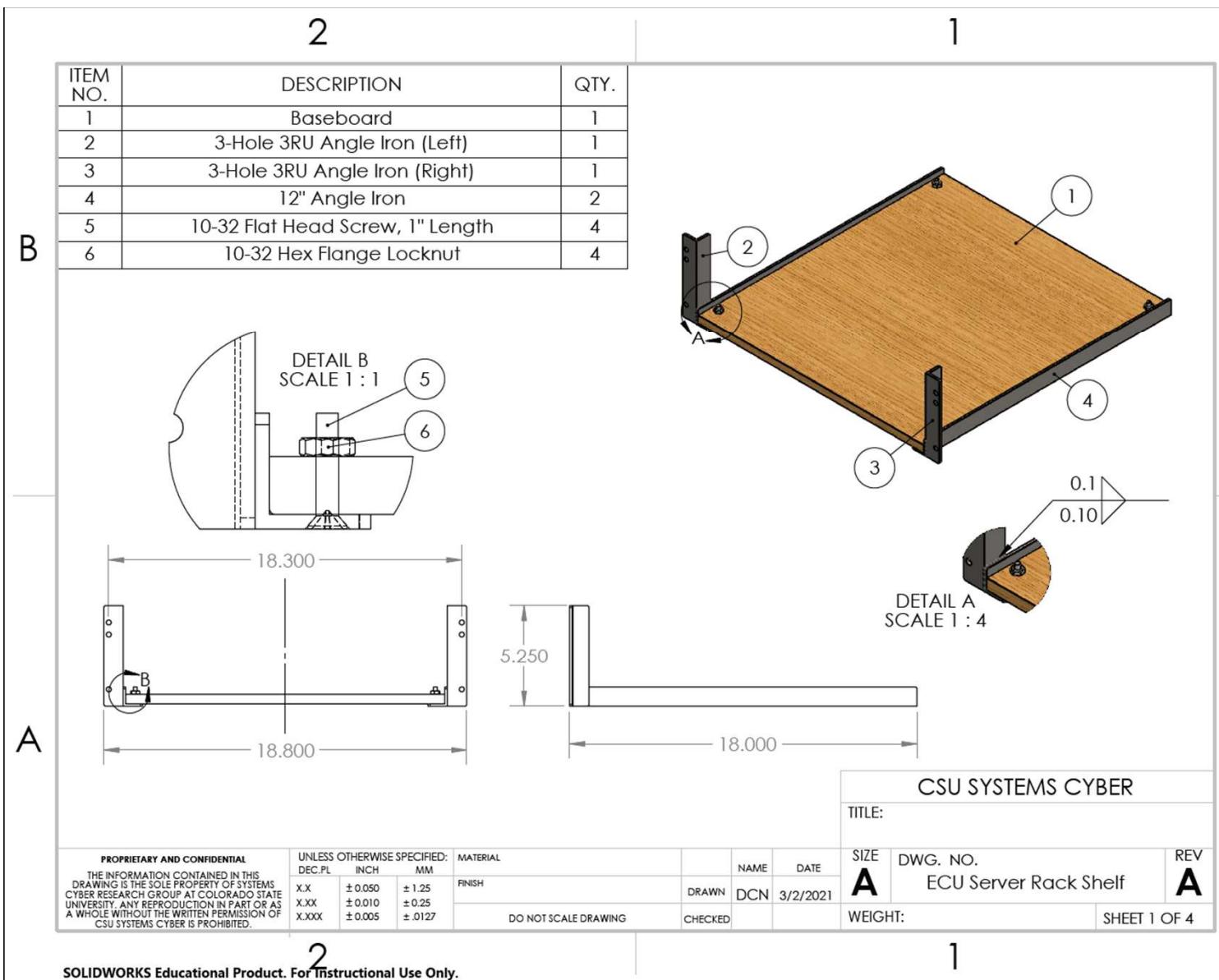
Server Rack Shelf

## Issues: Alternative 2

- Preliminary Design length was changed from 12" to 18"
- Preliminary Design did not include fillet features
- Screw length adjusted from  $\frac{3}{4}$ " to 1".
- Hole spacing and sizes were adjusted for multiple components.
- Preliminary design did not include countersink for long angle iron holes.
- Preliminary Design did not account for server ear shape
- Washer nut replaced with flange locknut.



# Design-as-Built Drawing Alternative 2



# Trade-Off Study

*Engineering Cost (ENGC): \$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\*ENGC + 17\*MC= **\$542**

### **Manufacturing Time**

Laser Cut/Engraving, 0.5h  
3D-Prining, 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', \$7.20  
#10x0.75 Fasteners 50 pack, \$16.16  
*Total: \$35.56*

### **Total Design Cost**

\$28.36 + 20h\*ENGC + 9.1\*MC= **\$764**

### **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%**

# COTS

Save time, money  
and energy

