# **OpenPit** 2024



# **LELAND** ROBOTICS **OUIXIVER** 644



**Background / Requirements** 

# **OpenPit** Background

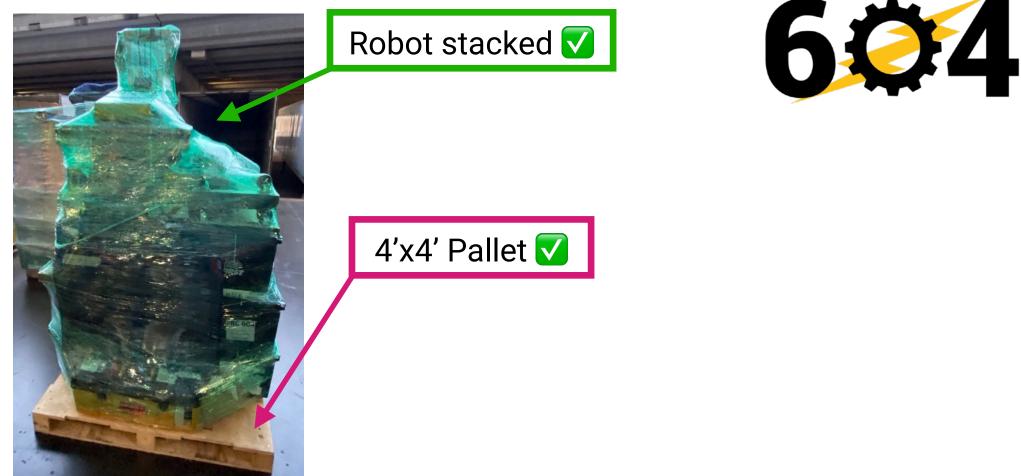
## **Motivation**

- Packing for competition was AWFUL for every competition in 2022/2023
  - Time to pack + chaos of filling totes
- Organizing transport was difficult for regionals
  - difficult to avoid losing stuff in various cars
- Pit setup was painfully slow
- Pit was disorganized (particularly finding tools / spare parts)
- Pit changed every competition
- Moving pits at champs was a major pain

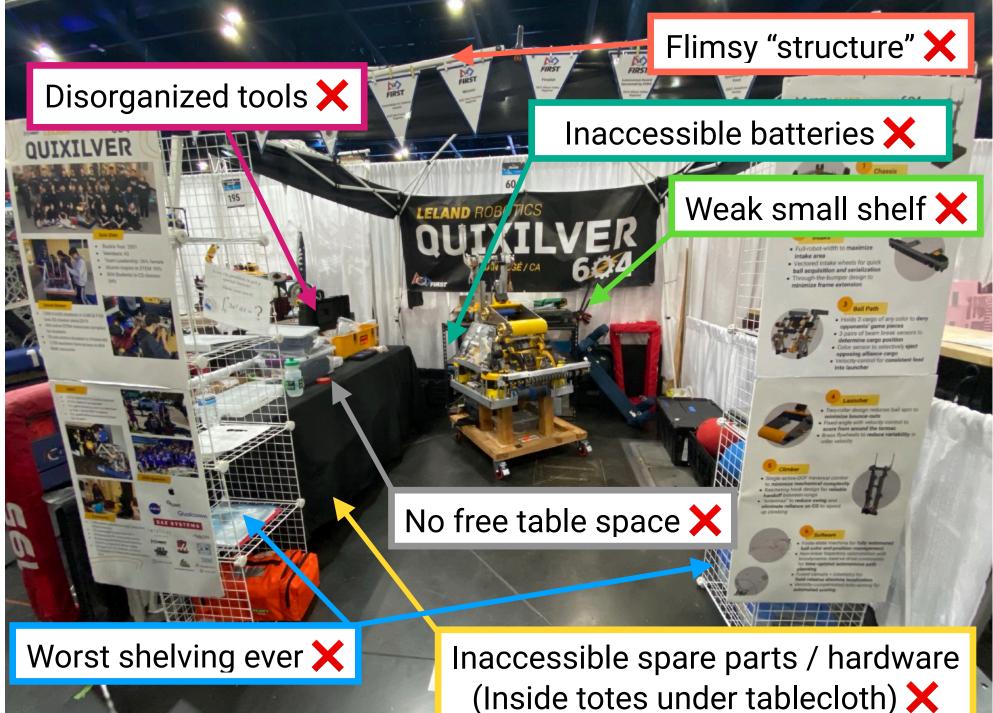
## Goals

- Provide better organization of tools / hardware
  - Throughout build <u>AND</u> competition
- Simplify / speed-up packing for competition
- Simplify / speed-up pit setup/teardown/move
- Simplify shipping to champs (including Robot)

#### **Champs Shipping**



2022 Champs Pit





## **OpenPit** Requirements

## **Portability**

- Fit in common small SUV (ex: RAV4, CRV, etc...)
  - Max dimension 2'x3'x4'
  - Cannot require trailer / truck for transport
- Can be lifted into cars
  - Max weight ~300lbs (4 students to lift)
- Combine to form 4'x4' platform for shipping to champs
  - Robot can be secured to platform

## Functionality

- Hold and organize ALL items required for competition
  - Batteries / Chargers
  - Hardware (bearings, screws, rivets, etc...)
  - Tools (Vacuum, drill, hand tools, etc...)
  - Spare parts (electronics, gears, robot specific, etc...)
- Provide additional workbench / table for pit
- Work out of pit throughout the season
  - No need to pack everything you need is already in the pit



#### "Super Pit"

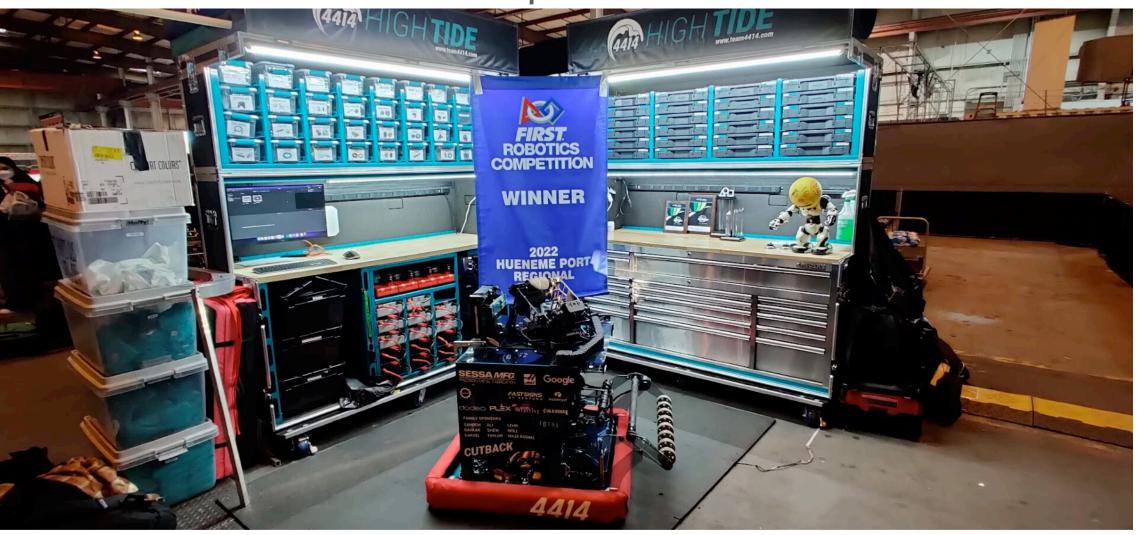


Photo pulled from CD thread: https://www.chiefdelphi.com/t/team-4414-hightide-pit-writeup/411862

### **Super Pit Drawbacks:**

- Large / Heavy
  - Requires trailer / truck for transport
- Expensive
  - ~\$8k / Case



# Cratelet Concept

# **OpenPit** Concept

## Concept

- Emulate "Super Pit" style roadcases
  - Avoid the high cost + transport challenges

### Implementation

- Split "Super Pit" roadcase into modular "Cratelets"
- Limit cratelet size to 18"x18"x48"
  - Ensures at least 2 can fit in a small SUV
  - Ensures weight doesn't get excessive
- Cratelets stack to form work surfaces + maximize storage volume per floor area
- Built from plywood (no road-case hardware)
  - Cheap and easy to source

## Why "OpenPit"?





• Modular design enables upgrading / repurposing of cratelets New designs can be shared and easily implemented by others



# **OpenPit Cratelet Modular Components**

## **Base Cratelet**

- Basic cratelet structure
- All cratelets share the same base cratelet
- <u>Cratelet differentiation is through inserts</u>

### Insert

- Internal structure to hold specific items
  - Example: shelves to hold parts bins

## **Face Cover**

- Structure added to the cratelet to keep contents inside for shipping
  - Example: cabinet doors

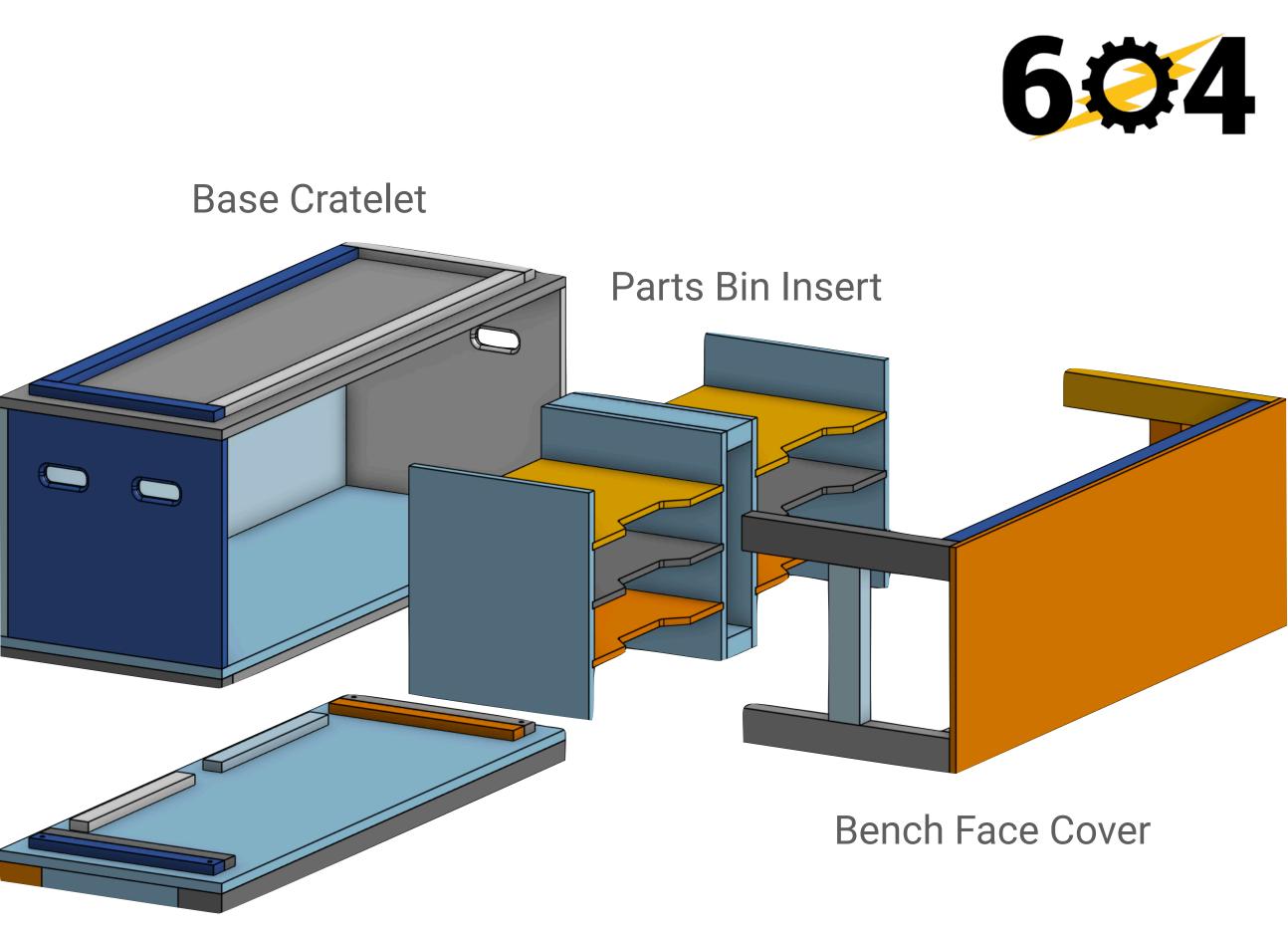
## Accessories

- External items assembled in pit
  - Example: poster poles

## **Transportation Aids**

- Items to help transport cratelets
  - Example: cart





Cart

Components for upgrades / new designs (Interchangeable within Base Cratelets)

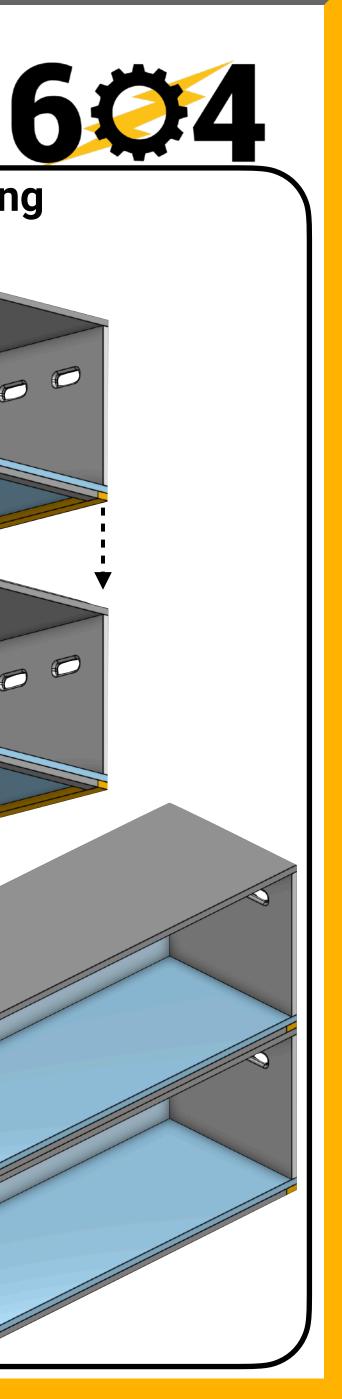
## **OpenPit** Base Cratelet

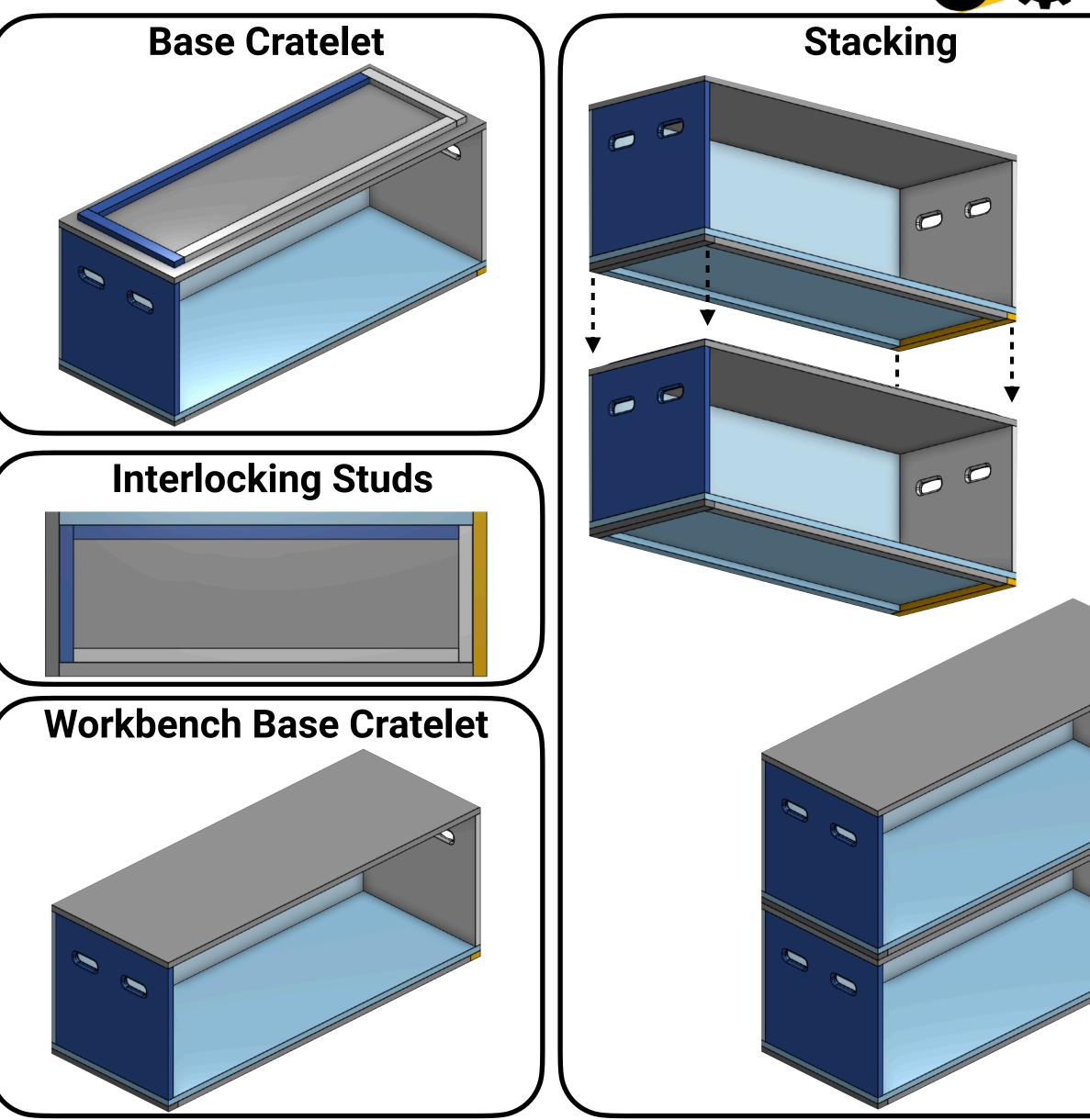
### **Base Cratelet**

- Single design
  - Makes building cratelets easier
  - Allows for changing/upgrading in the future
- Handles
  - Easy lift points
  - Potential mounting locations for accessories
- Interlocking studs on top/bottom surfaces
  - Similar function to "Lego"
  - Allows stacking of cratelets
    - Prevents cratelets from sliding off

## Workbench Base Cratelet

- Provides a table/work surface for the pit
- Same build as base cratelet
  - Don't add the stud feature on the top surface
- Intended to be used as top cratelet in a stack





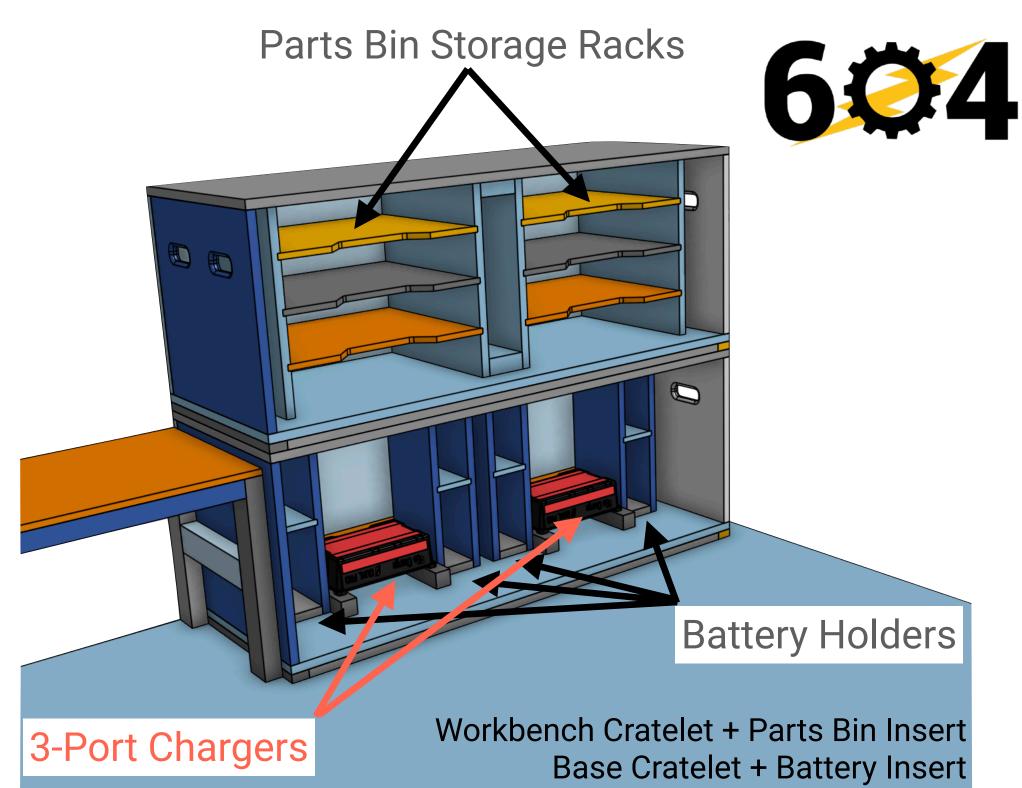
## **OpenPit Parts Bin and Battery Inserts**

### **Parts Bin Insert**

- Holds up to 8 Sortimo parts bins
  - Rivets
  - Screws
  - Bearings
  - Spacers
  - Crimps
  - Etc...

### **Battery Insert**

- Holds up to 8 FRC batteries
  - Velcro straps to secure batteries during transport
- Holds (2x) 3-port chargers
- Holds container for battery spill kit





# **OpenPit** Bench Face Plate

## Use

- Seats up to 3 people per bench
  - Only 1 if taking a nap
- Can be used as additional work surface if needed
- Bumpers / backpacks store underneath

## Storage

- Benches pack into Parts Bin and Battery Cratelets
  - Easy way to pack benches
  - Prevents items falling out during shipping







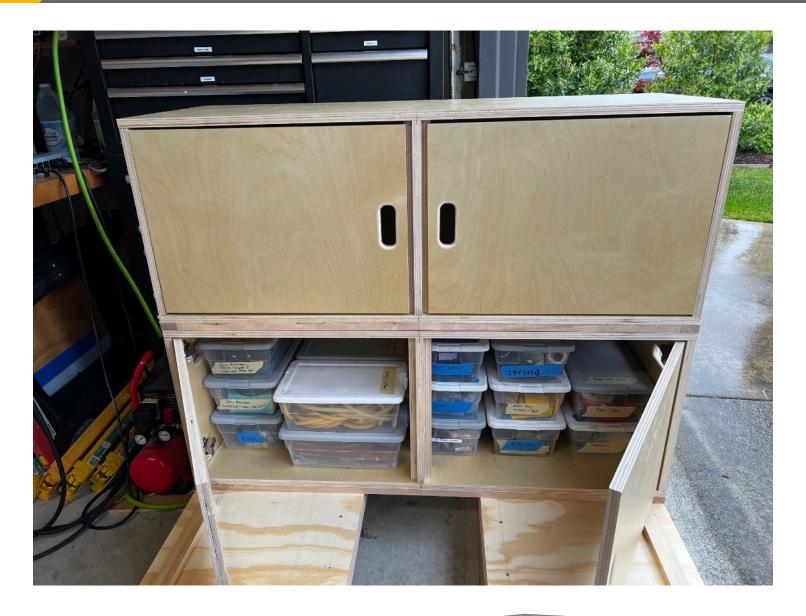
## **OpenPit Cabinet Door Face Plate**

### **Cabinet Doors**

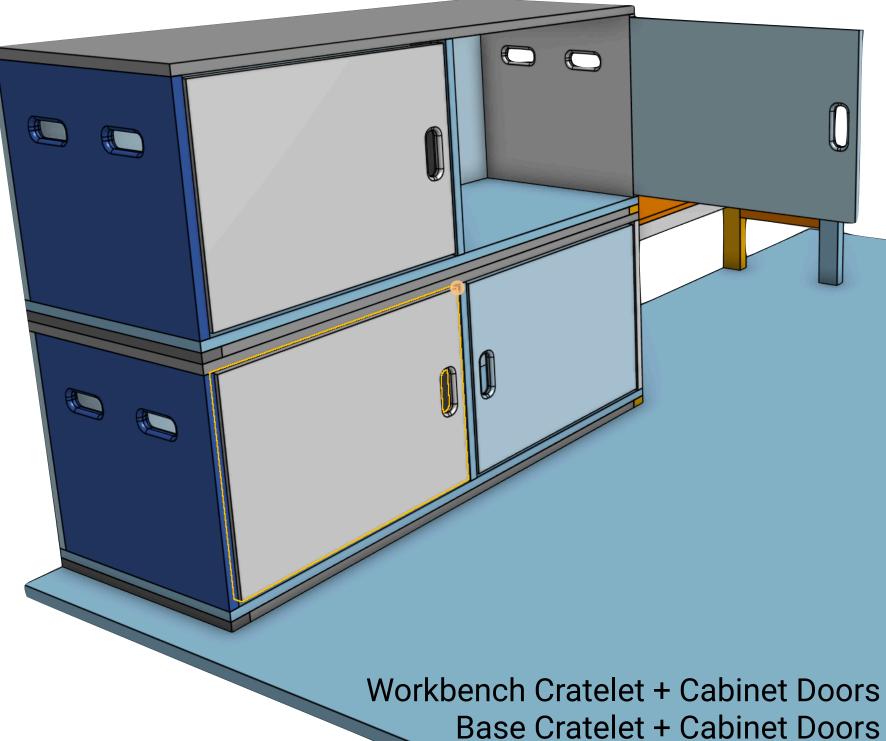
- Doors can be merged with inserts
  - Example: swap bench for doors on battery or parts bin cratelets

### **Cabinet Cratelet**

- Generic storage cabinet
  - No need for specific insert
  - Intended for plastic shoebox type bins
  - Can hold up to 18 standard 8x14x5" bins
- Not intended for small loose components
  - Option to add shelf at later time if needed
- Doors secured for transport with velcro loops
  - Ties door handles to center column









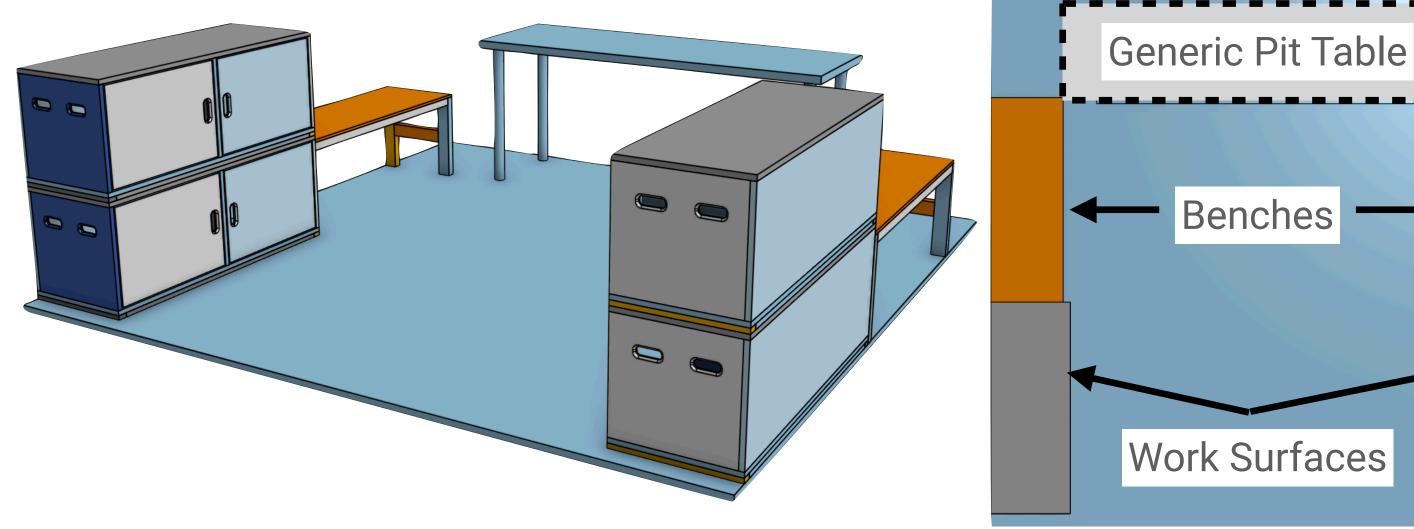
# **OpenPit** Pit Layout: 10' x 10' Pit

### **Suggested Cratelets**

- Base Cratelet + Battery Insert + Bench Face Cover
- Workbench Cratelet + Parts Bin Insert + Bench Face Cover
- Base Cratelet + Cabinet Doors
- Workbench Cratelet + Cabinet Doors

## Layout

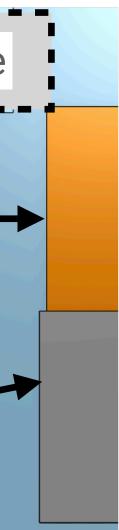
- Cratelet stacks at front of pit
  - Allows for mounting posters
  - Defines pit boundary
- Benches in back
  - People sitting are out of the way
- Keep supplied pit table
  - Extra work area
  - Can store carts underneath











# **OpenPit Carts / Palletizing**

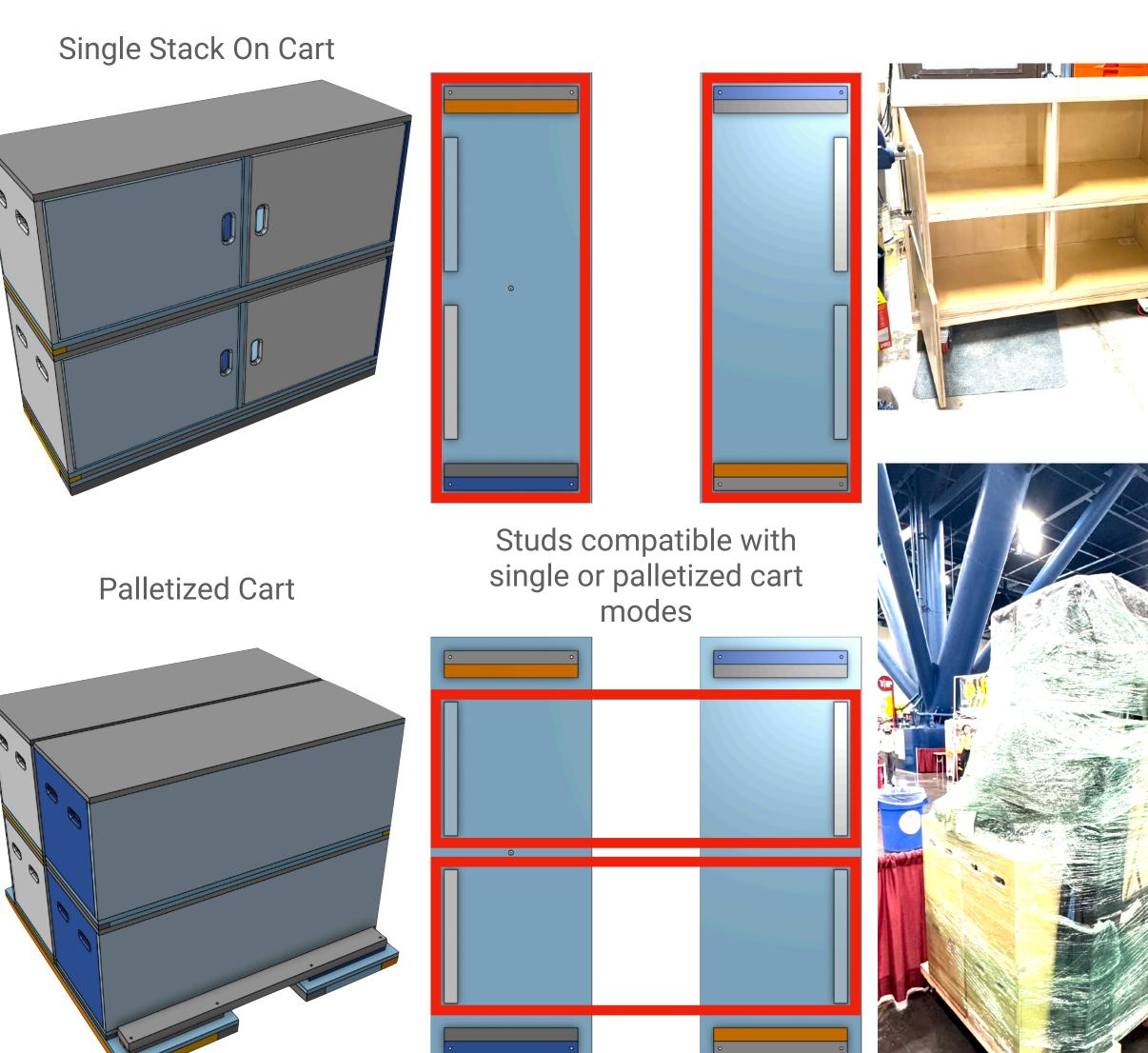
## Cart

- Holds single stack of cratelets
- Can be left on cart in pit, but suggest placing • cratelets on floor
  - Better workbench height
- Easy to move around competition

## **Palletized Cart**

- Combines two carts to form a 4'x4' pallet
  - Connected by 2x4 braces
  - Interlocking studs compatible in both cart ulletand palletized cart modes
  - Can be lifted by forklift
- Stacks crates + flat surface for stacking robot
  - Easy shipping by truck





Note: 2x4 braces not shown







# **OpenPit** Transport

## **Car requirements**

- Cratelets can be loaded into most small SUVs
- Suggest adding some hard material to surface before loading cratelets
  - Helps cratelets slide in
  - Protects car from damage
- Strongly suggest strapping cratelets to tie-down points in car (don't want them sliding around)

## Sled

- Easy to load structure for trunk of car
- Keeps cratelets from sliding during transport
- Makes loading easier
  - Slides in easily
  - Ensures space for 2 cratelets
- Design may need to vary depending on vehicle



I

Plywood Cutting

# OpenPit **Plywood Tips**

Note:

## **Table Saw Cutting Order:**

- 48" long dimensions use existing edge of 4'x8' sheet
- For parts with the same dimensions, keep the same fence position
  - Matching is more important than the exact dimension
  - Cut tables are color coded to help highlight dimensions that should be cut at the same time
    - Grey means unique to that part, other colors are dimensions shared between parts
    - Color code is consistent between cut lists
- If making multiple cratelets, cut all parts at the same time

### **Plywood Selection**

- Cratelet designs assume nominal dimensions
  - If plywood is less than nominal (eg 0.7" instead of 3/4") you may want to adjust some dimensions to keep edges aligned and cratelet height consistent
- Highly suggest sanded plywood
  - Comes with smooth, aesthetically pleasing surfaces + surface layers are thick
- Avoid pre-finished / thin veneer

  - Makes glueing more challenging (need to sand away finish on glue surfaces) • The thin veneer seems to be bonded worse to the rest of the plywood (makes for a weaker crate)



Plywood cut list layouts are for what 604 built for the 2024 season Layouts are specific to the combinations of inserts / face covers

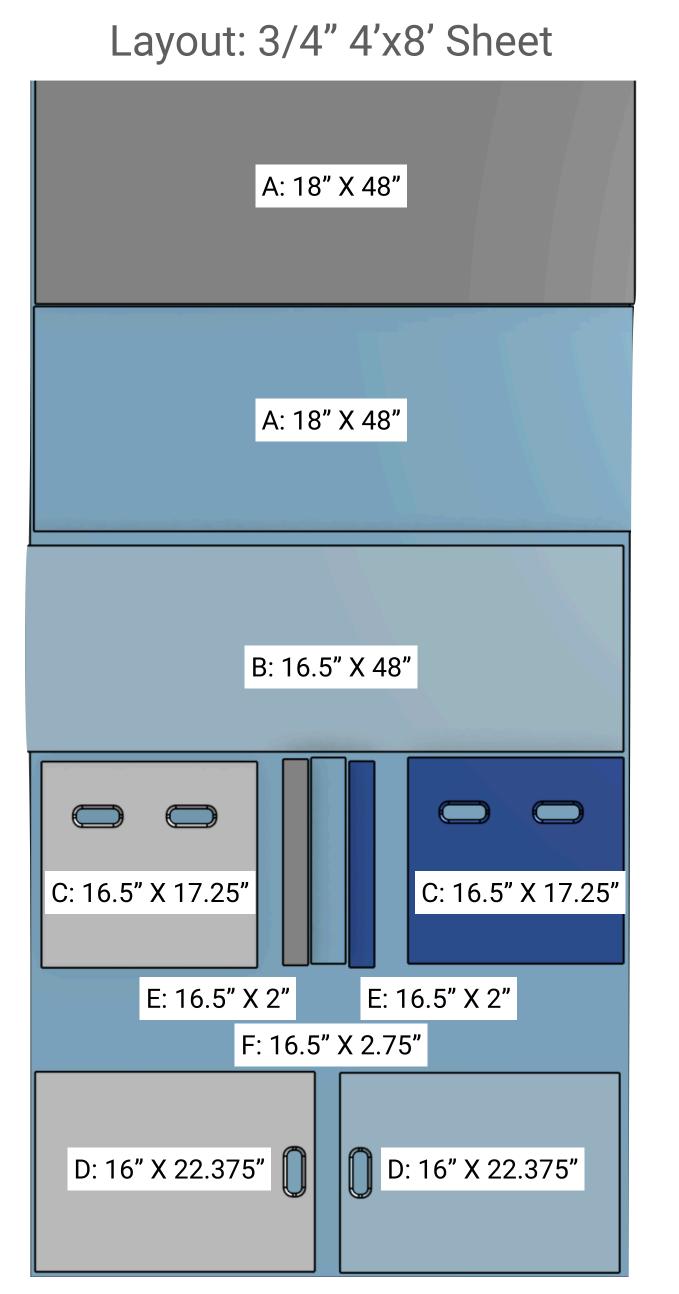
## **OpenPit** Cabinet Cratelet 3/4" Sheet Layout

## **Required Material:**

 One 4'x8' sheet of 3/4" plywood is required for each cabinet cratelet

### Tips:

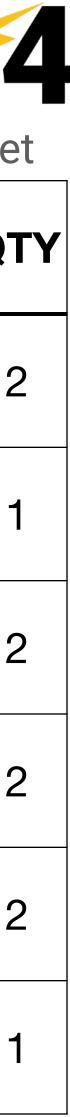
 Cabinet doors (D) may need dimensions changed depending on what hinges are used





#### Cut List: 3/4" 4'x8' Sheet

| Part | L     | W       | Q |
|------|-------|---------|---|
| Α    | 18"   | 48"     |   |
| В    | 16.5" | 48"     |   |
| С    | 16.5" | 17.25"  |   |
| D    | 16"   | 22.375" |   |
| Ε    | 16.5" | 2"      |   |
| F    | 16.5" | 2.75"   |   |



## **OpenPit** Parts Bin / Battery Cratelet 3/4" Sheet 1 Layout

## **Required Material:**

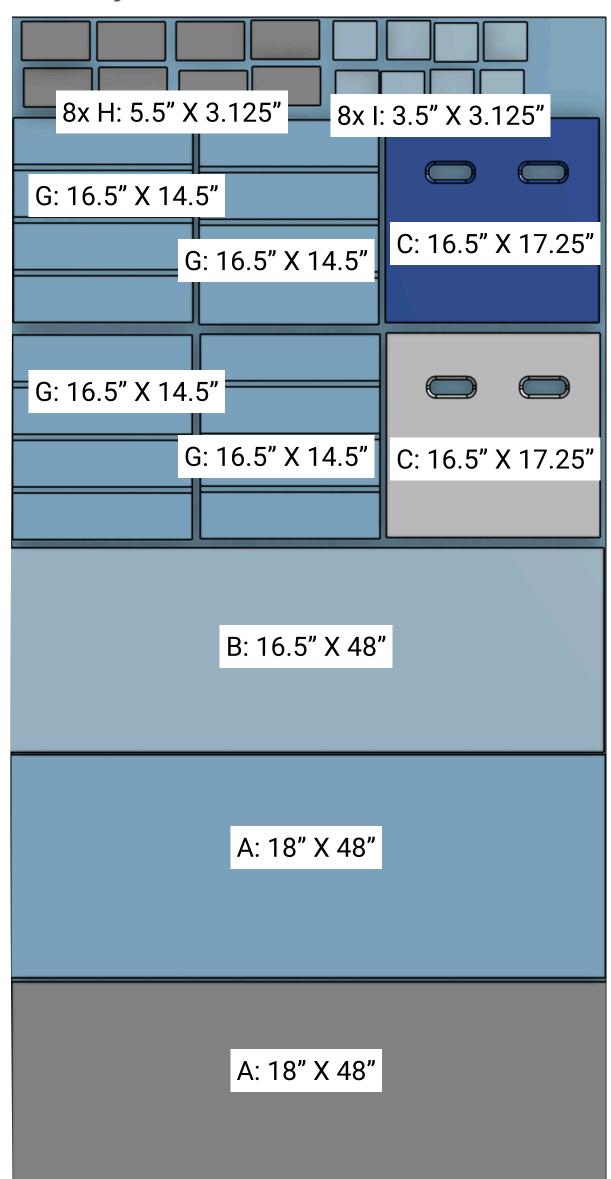
- Two 4'x8' sheets of 3/4" plywood
- One 4'x8' sheet of 1/2" plywood
- (Parts don't cleanly split between crates, need some mix/match to make both + inserts)

## Tips:

- Parts bin insert side plate (G)
  - May be desirable to make thinner than 16.5" so it can be easier to insert into the base cratelet post assembly
  - Slot spacing for the may be dependent on the exact model of parts bin
  - Sizing of the slots should be adjusted to have a snug fit with the 1/2" plywood shelves

• 3.125" dimensions are critical to keep identical

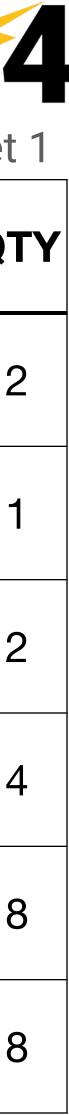
#### Layout: 3/4" 4'x8' Sheet 1





### Cut List: 3/4" 4'x8' Sheet 1

|      |       |        | 1 |
|------|-------|--------|---|
| Part | L     | W      | Q |
| Α    | 18"   | 48"    |   |
| В    | 16.5" | 48"    |   |
| С    | 16.5" | 17.25" |   |
| G    | 16.5" | 14.5"  |   |
| н    | 5.5   | 3.125  |   |
|      | 3.5   | 3.125  |   |



## **OpenPit** Parts Bin / Battery Cratelet 3/4" Sheet 2 Layout

## Tips:

- Battery holder side plate (J) and Battery holder back plate (K) may be desirable to make thinner than 16.5" so they can be easier to insert into the base cratelet post assembly
- 3.125" dimensions are critical to keep identical with those in "Sheet 1"

| La | ayout:  | 3/4"              | 4'x8      | ' Shee    | t 2      |  |
|----|---------|-------------------|-----------|-----------|----------|--|
|    |         |                   |           |           |          |  |
|    |         |                   | 4x K: 3.1 | 25" X 16. | 5"       |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           | C: 16.5"  | X 17.25" |  |
|    | 8x J: 1 | ы<br>б.5" Х 7     | //        |           |          |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           | C: 16.5"  | X 17.25" |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           |           |          |  |
|    |         | B <sup>.</sup> 16 | 5" X 48"  |           |          |  |
|    |         | <b>D</b> . 10.    | 0 / 10    |           |          |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           |           |          |  |
|    |         | A: 18             | 8" X 48"  |           |          |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           |           |          |  |
|    |         | A: 18             | 8" X 48"  |           |          |  |
|    |         |                   |           |           |          |  |
|    |         |                   |           |           |          |  |



#### Cut List: 3/4" 4'x8' Sheet 2

| Part | L     | W      | Q |
|------|-------|--------|---|
| Α    | 18"   | 48"    |   |
| В    | 16.5" | 48"    |   |
| С    | 16.5" | 17.25" |   |
| J    | 16.5" | 7"     |   |
| κ    | 16.5" | 3.125" |   |

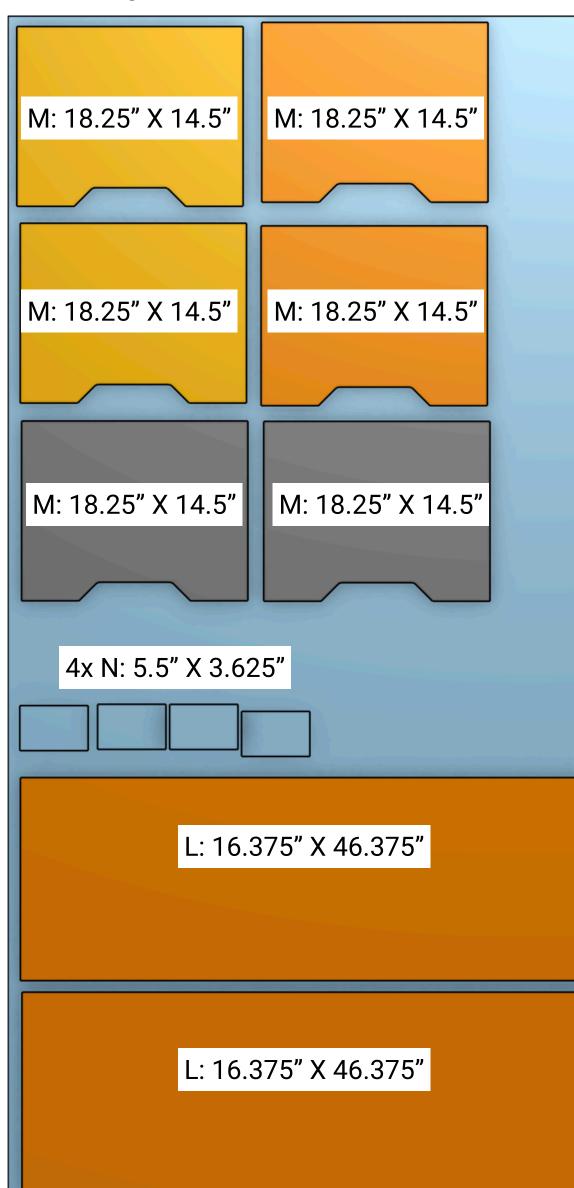


## **OpenPit** Parts Bin / Battery Cratelet 1/2" Sheet Layout

Tips:

 Dimensions for the Parts Bin Shelves (and quantity of shelves) may be dependent on the exact model of parts bin

#### Layout: 1/2" 4'x8' Sheet





#### Cut List: 1/2" 4'x8' Sheet

| Part | L       | W       | Q. |
|------|---------|---------|----|
| L    | 16.375" | 46.375" |    |
| Μ    | 18.25"  | 14.5"   | (  |
| Ν    | 5.5"    | 3.625"  | 2  |



# Assembly

# **OpenPit Assembly Requirements**

## **Required Fixtures for Assembly**

- (2x) Right Angle Panel Clamps
- (1x) Pocket Hole Jig
- (4x) Wood Clamps (>18" capacity)

### **Required Power Tools for Assembly**

- 18ga Nailgun
- Hand Drill

### **Required Consumables for Assembly**

- Wood Glue
  - We used: Titebond III
- 18 ga Nails (1.5", 1.25", and 1" Long)
- #10 Wood Screws (1.5", 2", and 1.5" Long)
- Some form of sealant (water proof)
  - We used: Polyurethane (water based Varathane)













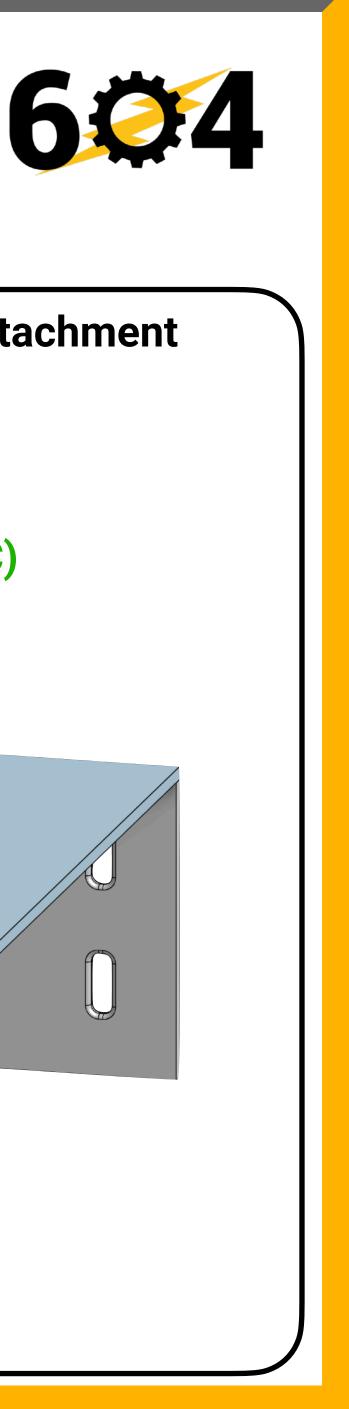
## **OpenPit** Base Cratelet Frame Assembly

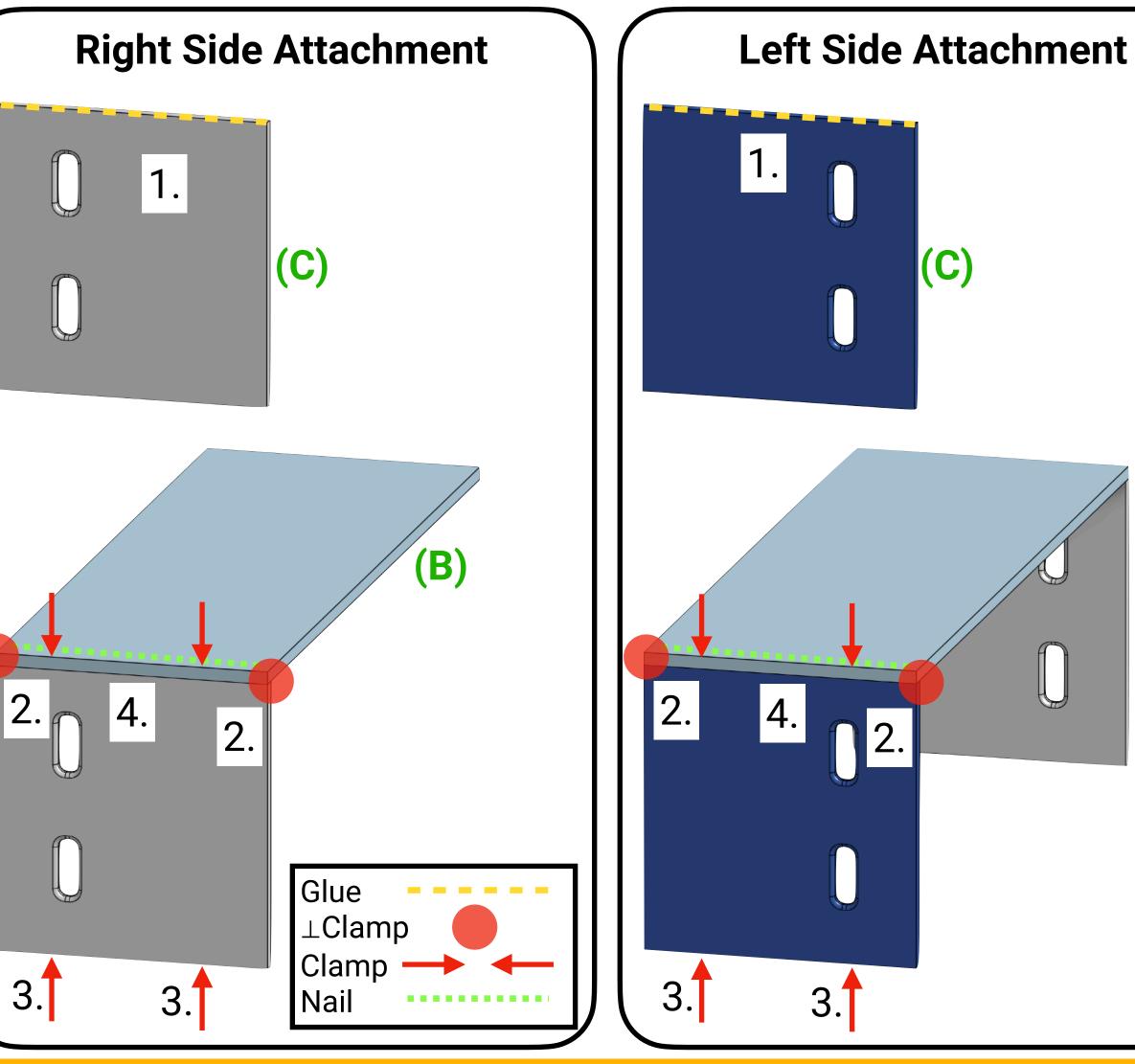
### **Attach Sides to Back**

- Apply glue to edge of side (C)
  NOTE: handles are not symmetric to the part, check CAD orientation to ensure correct assembly
- 2. Use right angle panel clamps to hold flush with back (B)
- 3. Squeeze joint together with wood clamps
- 4. Nail in place
- 5. Remove all clamps
- 6. Repeat for second side (C)

### Notes:

- Use 1.5" long nails for all specified joints
- Nail on centerline of plywood edge every 1.5" 3"





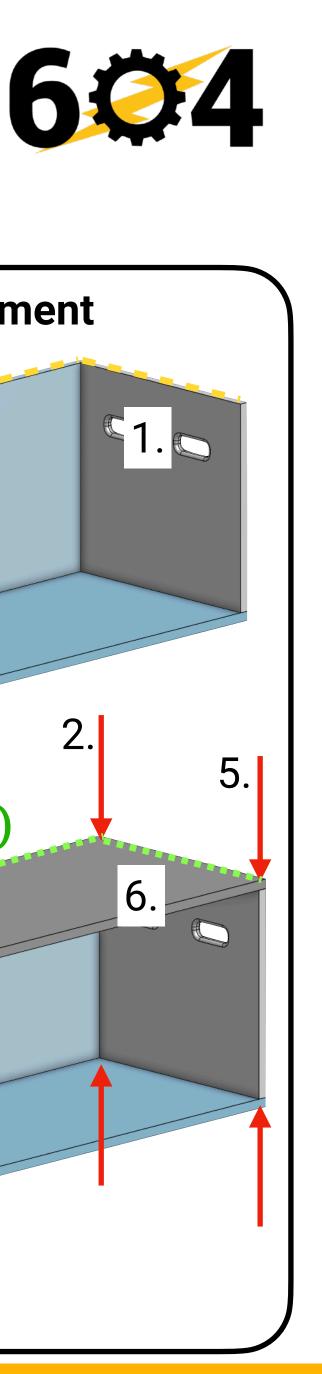
# **OpenPit Base Cratelet Frame Assembly (Continued)**

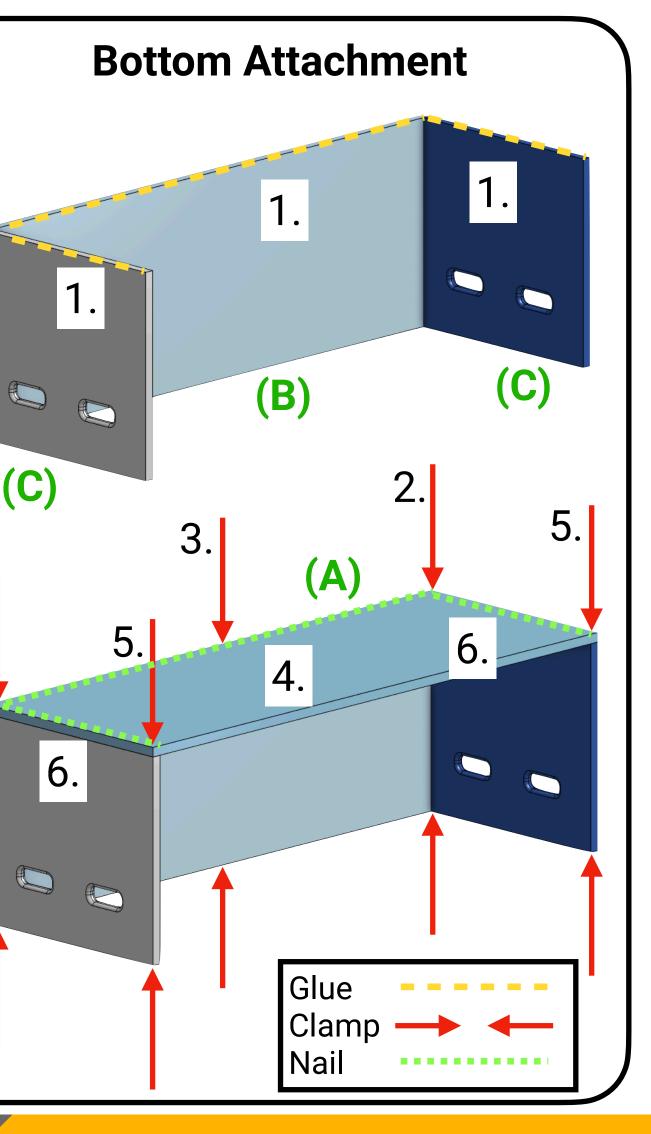
### Attach Top / Bottom

- 1. Apply glue to edge of sides (C) / back (B)
- 2. Align back corners to keep flush with bottom (A), clamp corners in place
- 3. Bend back to keep flush with bottom, clamp in place
- 4. Nail back edge (can remove clamps when nailed)
- 5. Bend sides to make flush with bottom, clamp in place
- 6. Nail sides (can remove clamps when nailed)
- 7. Repeat process for top (A)

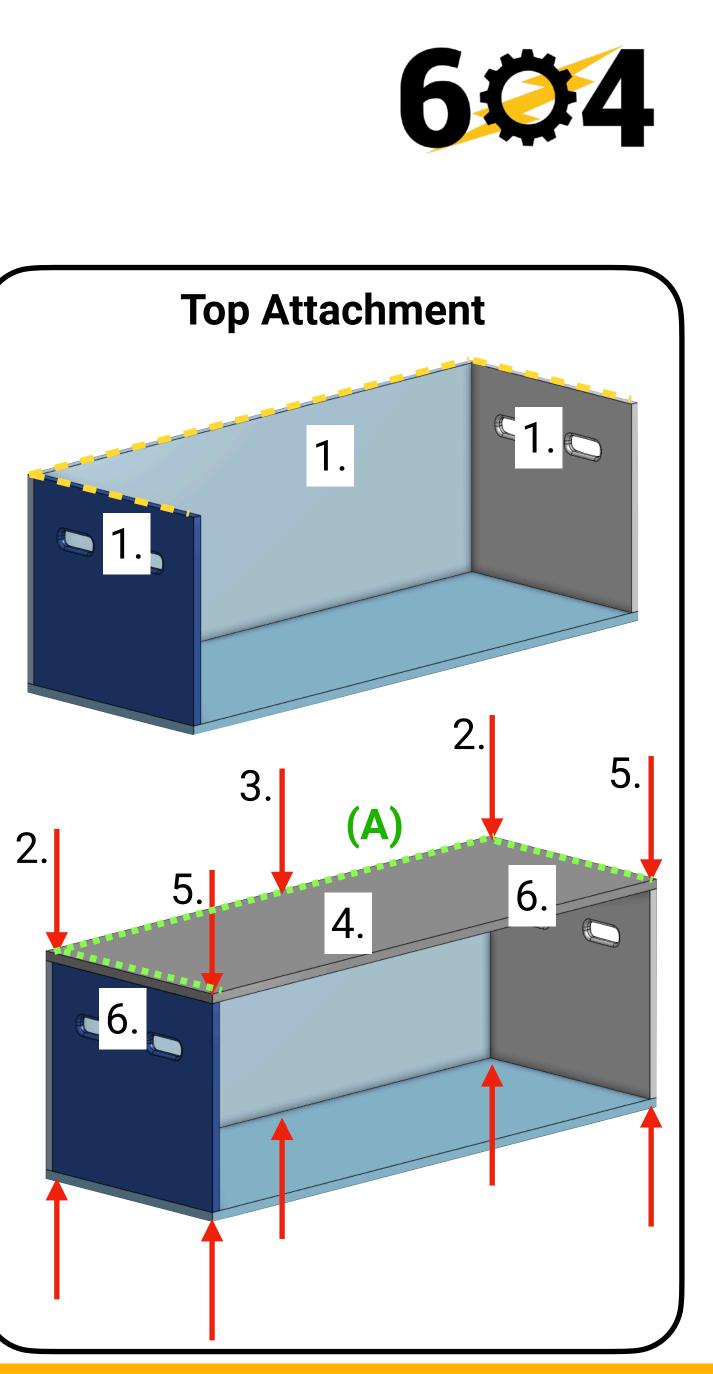
### Notes:

- Use 1.5" long nails for all specified joints
- Nail on centerline of plywood edge every 1.5" 3"





2.



## **OpenPit** Base Cratelet Studs

### Material

- Made from 1x2 wood (1x2 is nominally 0.75" x 1.5")
  - Dimensions are not exact (may be oversized)
  - Must use hardwood for durability

### Sizing Interlocking Stud Segments

- Need Cratelets to interlock easily
- Nominally designed with 1/16" clearance all around (1/8" total) - adjust parts to ensure clearance

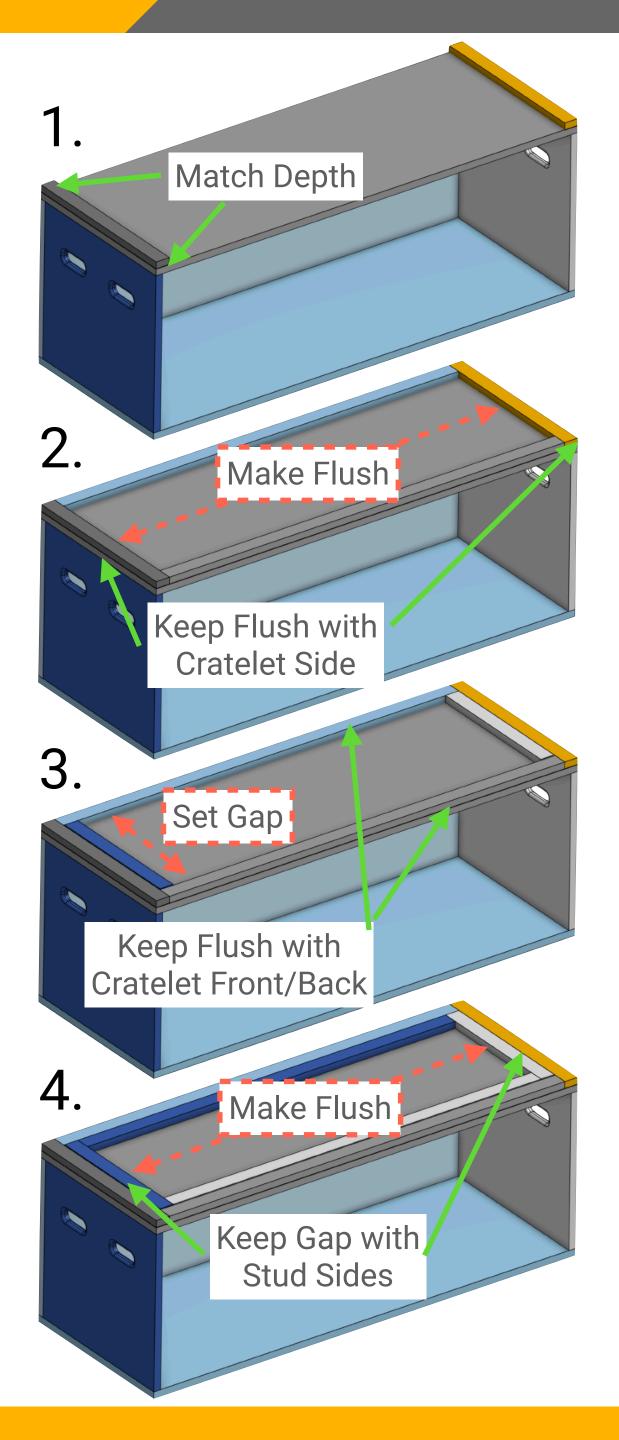
#### Method

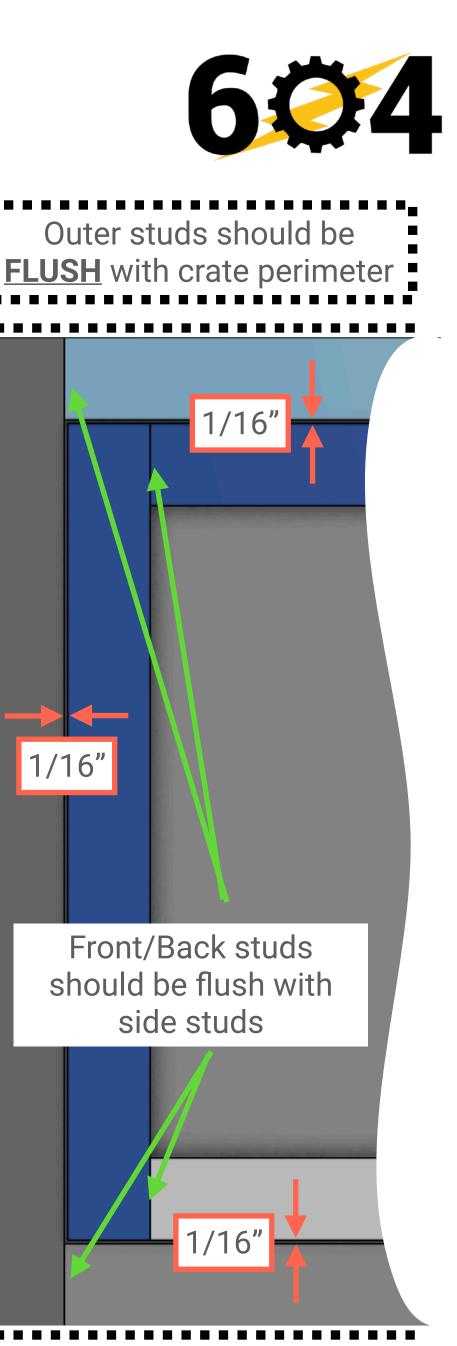
### **DO NOT GLUE PARTS TO CRATELET YET**

- 1.Cut outer side studs to match cratelet depth
- 2.Cut outer front/back studs to fit gap
  - Assumes outer side studs are flush with cratelet width

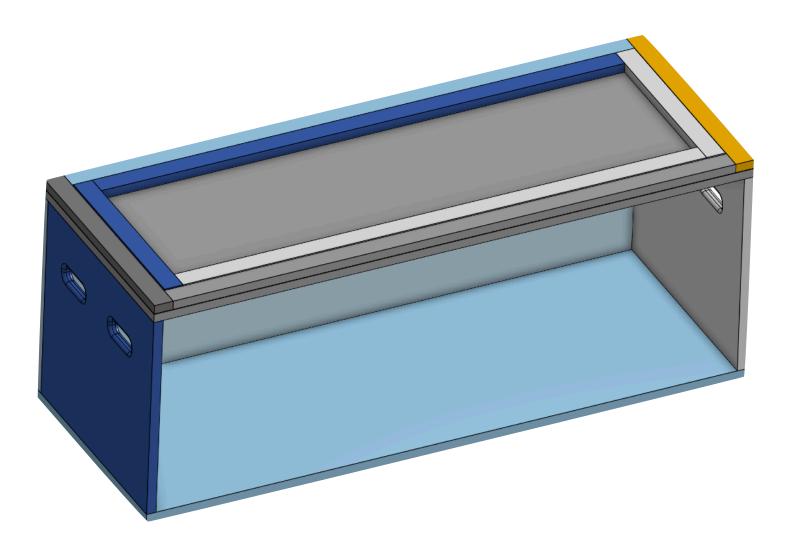
3.Cut inner side studs to have 1/16" gap 4.Cut inner front/back studs to have 1/16" gap

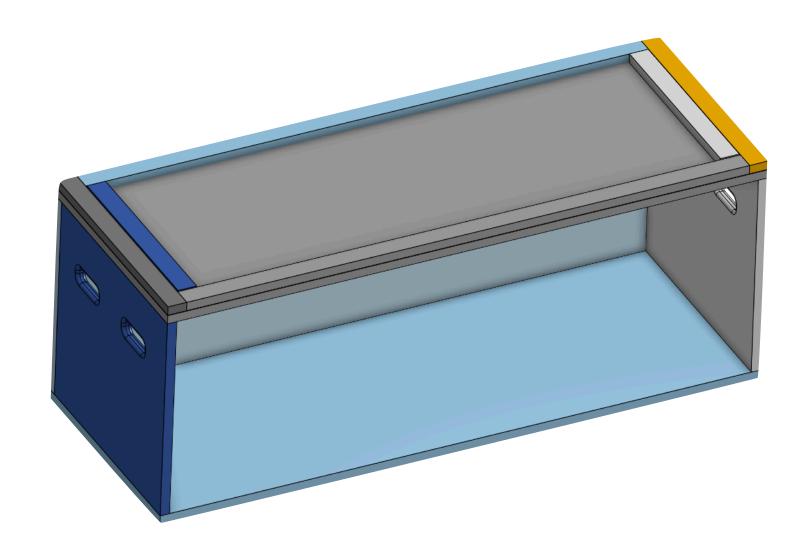
• Assumes inner side studs have 1/16" gap





## **OpenPit** 624 **Base Cratelet Top Stud Assembly (Skip for Workbench Base Cratelets)**





### 1. Layout parts on cratelet **TOP**

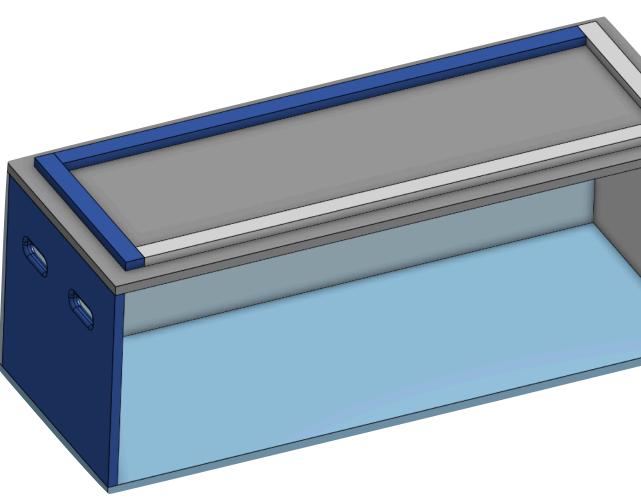
 Clamp spare material to cratelet (suggest using the outer stud material)

#### 2. Attach Sides

• Ensure inner stud segments have even gaps

#### Notes:

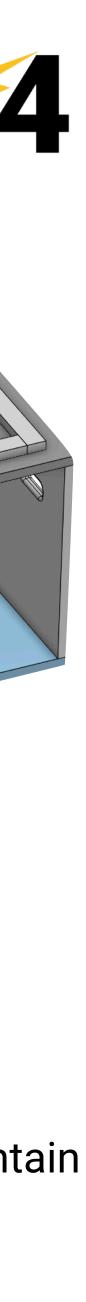
- Use 1.25" long nails to hold stud segments to crate
- Nail on centerline of segments every 1.5" 3"



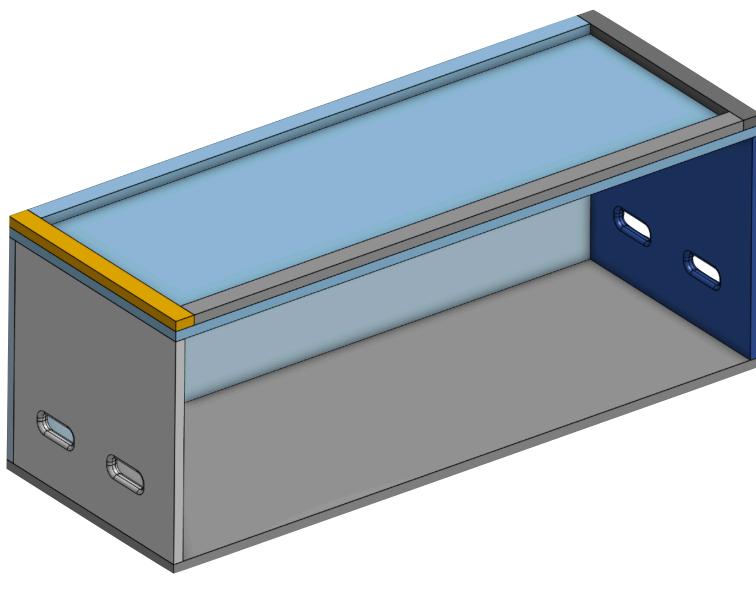
• Glue + Nail side segments while outer segments are still clamped • Keep outer stud segments clamped

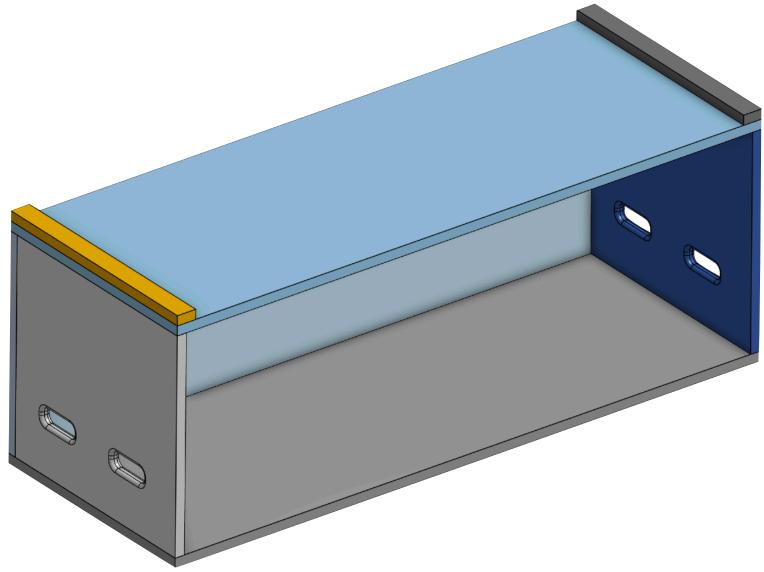
#### **3. Attach Front/Back**

- Glue + Nail long segments
- Nail outer edge first while maintaining gap from outer stud segments
- Flex segments as needed to maintain gap, nail remainder of segments
- Remove outer stud segments



# **OpenPit Base Cratelet Bottom Stud Assembly**





- 1. Layout parts on cratelet **BOTTOM**
- Ensure short segments are flush with cratelet edges
- Use clamps to secure long segments
  - Ensures long segments will fit

#### 2. Attach Sides

- segments are still clamped

### Notes:

- Use 1.25" long nails to hold stud segments to crate
- Nail on centerline of segments every 1.5" 3"



• Glue + Nail side segments while long • Clamp side segments in place until nails are driven in (prevents sliding) Can remove all clamps after nailing

### **3. Attach Front/Back**

- Glue one long segment at a time
- Clamp long segment in place (may need multiple clamps to fix warped wood)
- Nail in place
- Remove clamps, repeat for second segment







# **OpenPit** Bench Assembly

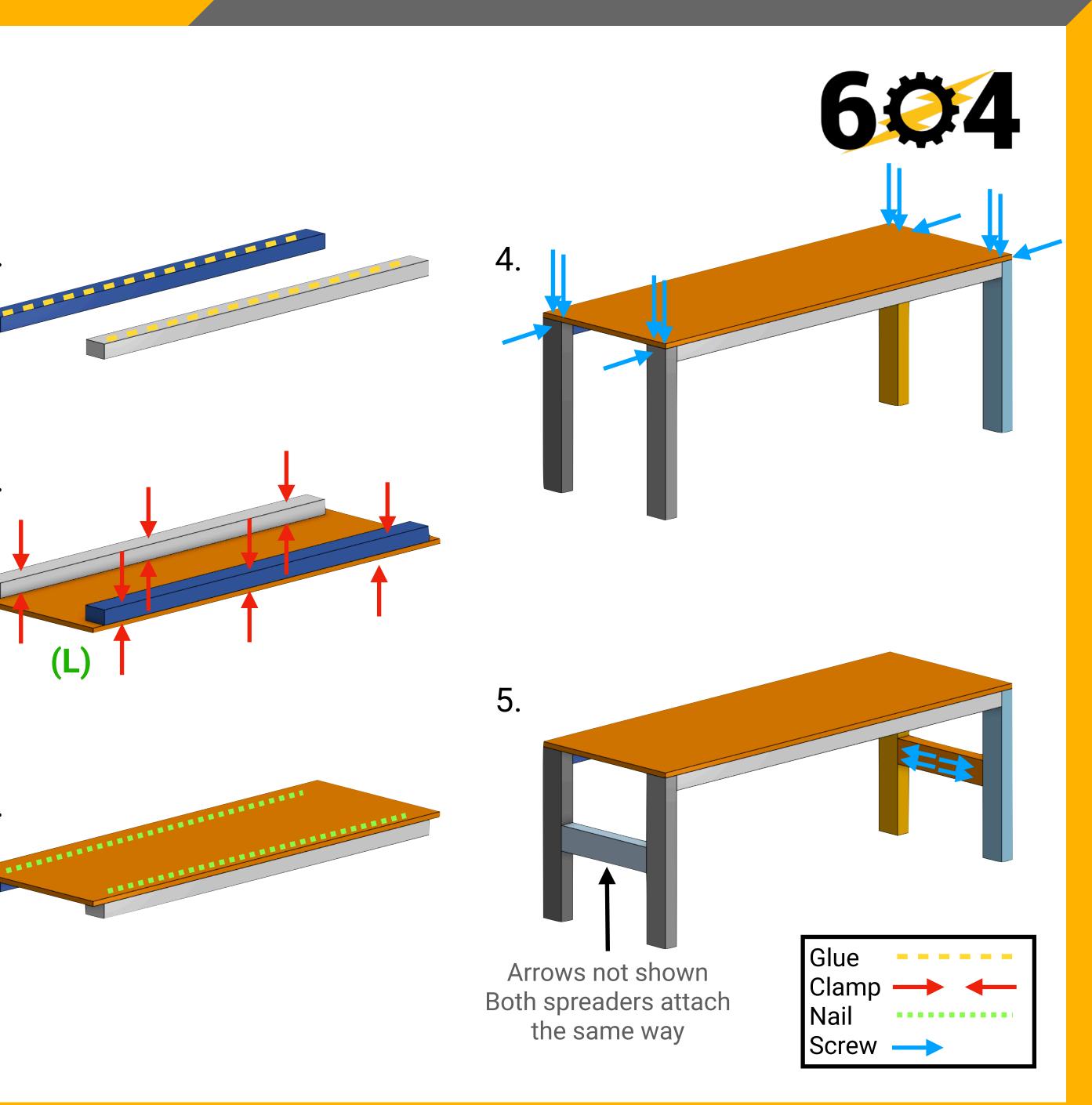
### **Assemble Bench**

- 1. Apply Glue to 2x3 frame
- 2. Clamp 2x3 frame onto bench top (L)
  - Ensure frame is flush with bench edge
- 3. Nail from bench top to attach
  - Avoid placing nails where screws in step 4 will go
- 4. Attach legs by screws
- 5. Attach leg separators by pocket screws
  - Position is critical to make sure separators don't interfere with cratelet handles when stored

### Notes:

- Use 1.25" long nails for specified joints
- Nail on centerline of 2x3 every 1.5" 3"
- Use 3" long deck screws for legs
  - Pre-drill holes to avoid splitting

3.



# **OpenPit** Cabinet Cratelet Assembly

### **Assemble Cabinet Door Support**

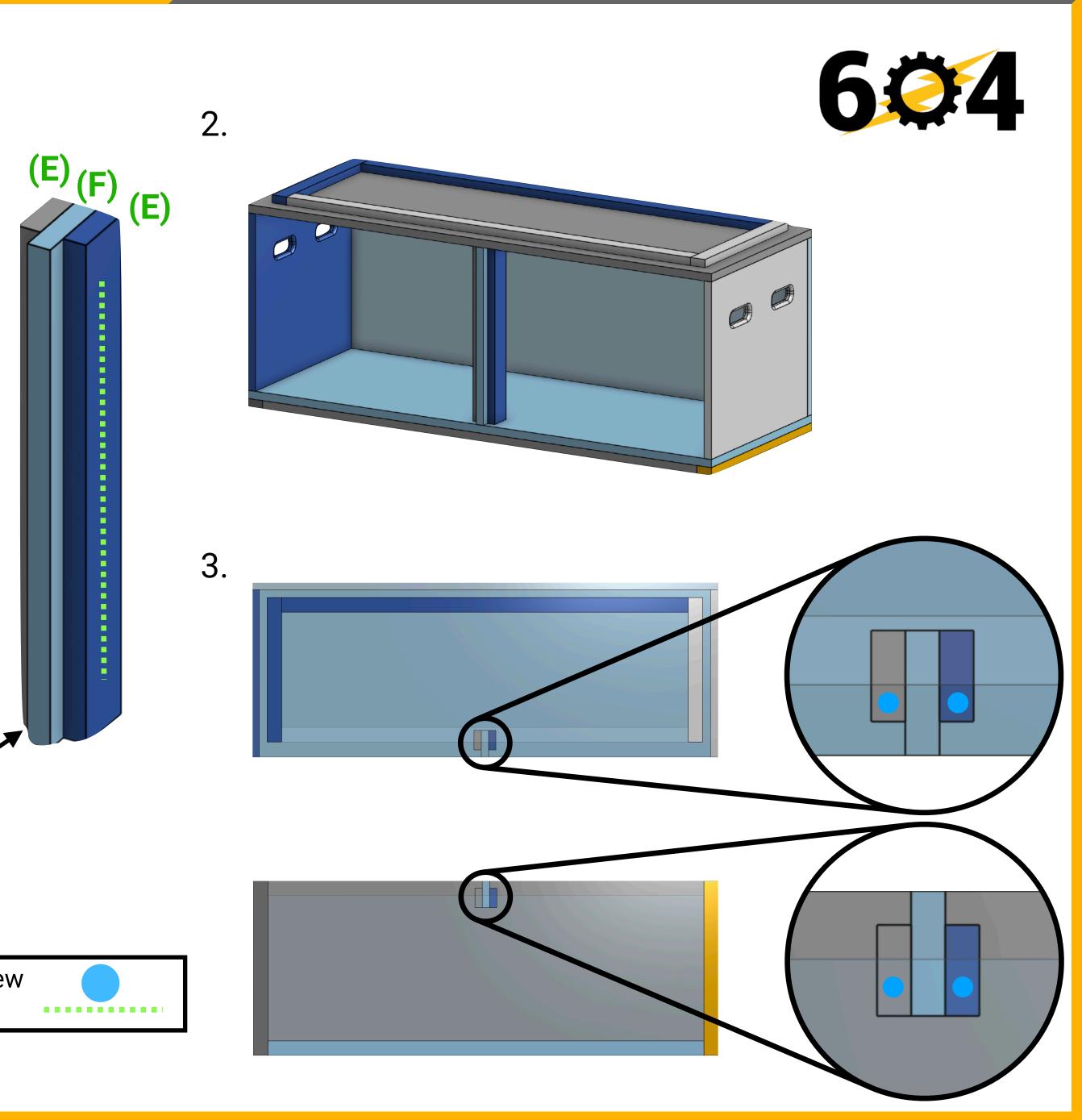
- 1. Glue + nail door support together (E)(F)
  - Avoid placing nails where screws in step 3 will go
- 2. Insert door support into base cratelet
  - Glue optional (we did not glue ours)
    - Provides much better strength, but cannot disassemble
- 3. Attach support with screws
  - Avoid interlocking studs when placing screws

Nails not shown on left side Both **(E)** attach the same way to **(F)** 

### Notes:

- Use 1.25" long nails for all specified joints
- Nail on centerline of plywood face every 1.5" 3"
- Use 2" long screws for cabinet door support
  - Pre-drill holes to avoid splitting plywood





# OpenPit **Cabinet Cratelet Assembly**

### **Cabinet Door Hinges**

- Requires "Inset Door" hinges
- Must be compatible with 3/4" thick doors
- Strongly suggest soft close

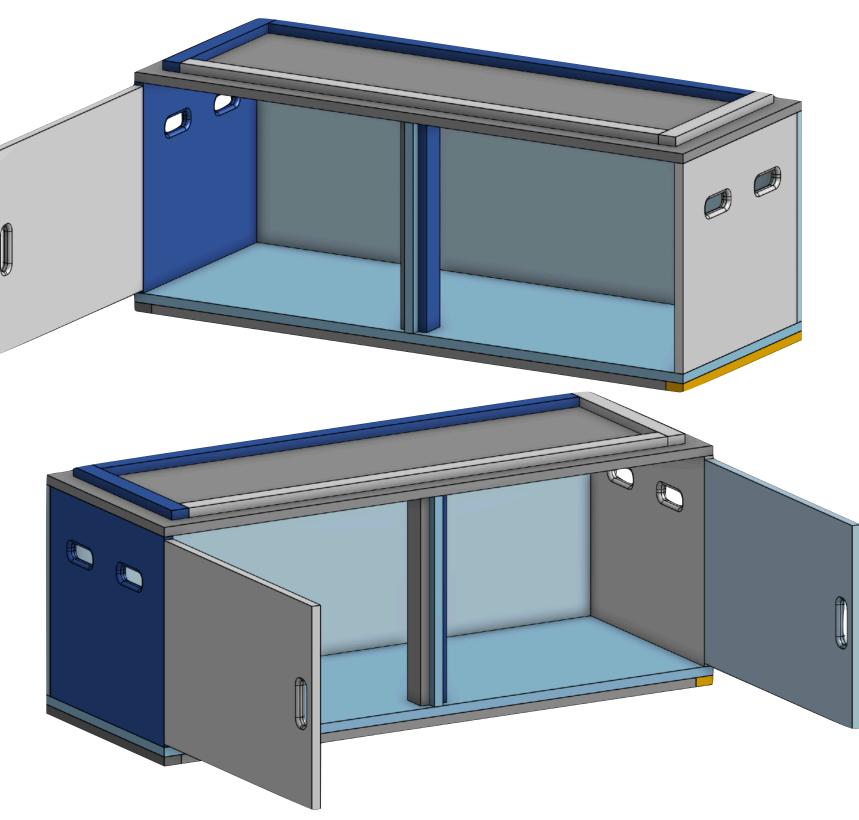
### **Assemble Cabinet Doors**

- Follow installation instructions for chosen hinges
- Will likely need to screw hinges directly to cratelet sides
- May require cutting a pocket into cabinet door











## **OpenPit** Battery Insert Assembly

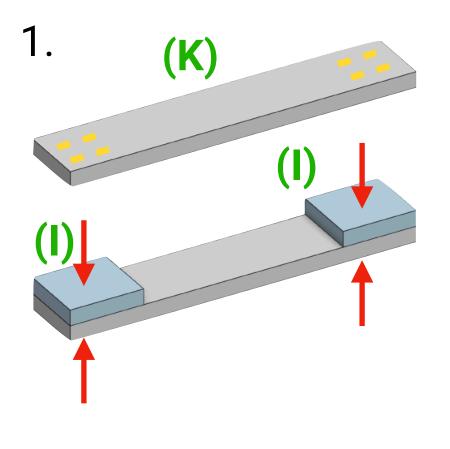
### **Assemble Battery Holder**

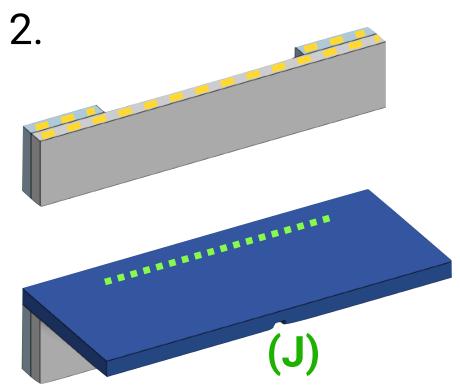
- Glue doublers (I) to back plate (K) (clamp until dry)
  No nails (future screw clearance)
- 2. Glue back assembly to side plate (J), nail in place
  - Ensure doubler is flush with side plate
  - Avoid nails in doublers (future screw clearance)
- 3. Glue top / bottom plates (H) and center divider (N), nail in place
  - Ensure top/bottom plates are flush with side plate
- 4. Glue final side plate (J) to assembly, nail in place
  - Ensure all edges are flush
  - Avoid nails in doublers (future screw clearance)

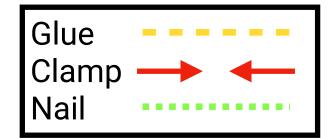
### Notes:

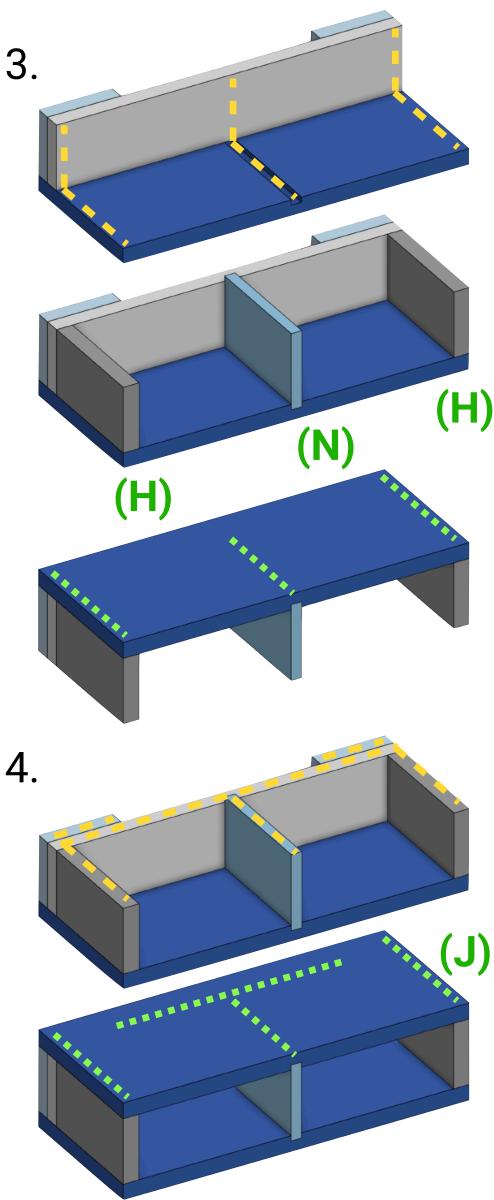
- Use 1.25" long nails for all specified joints
- Nail on centerline of plywood edge every 1" 1.5"











## **OpenPit** Battery Insert Assembly

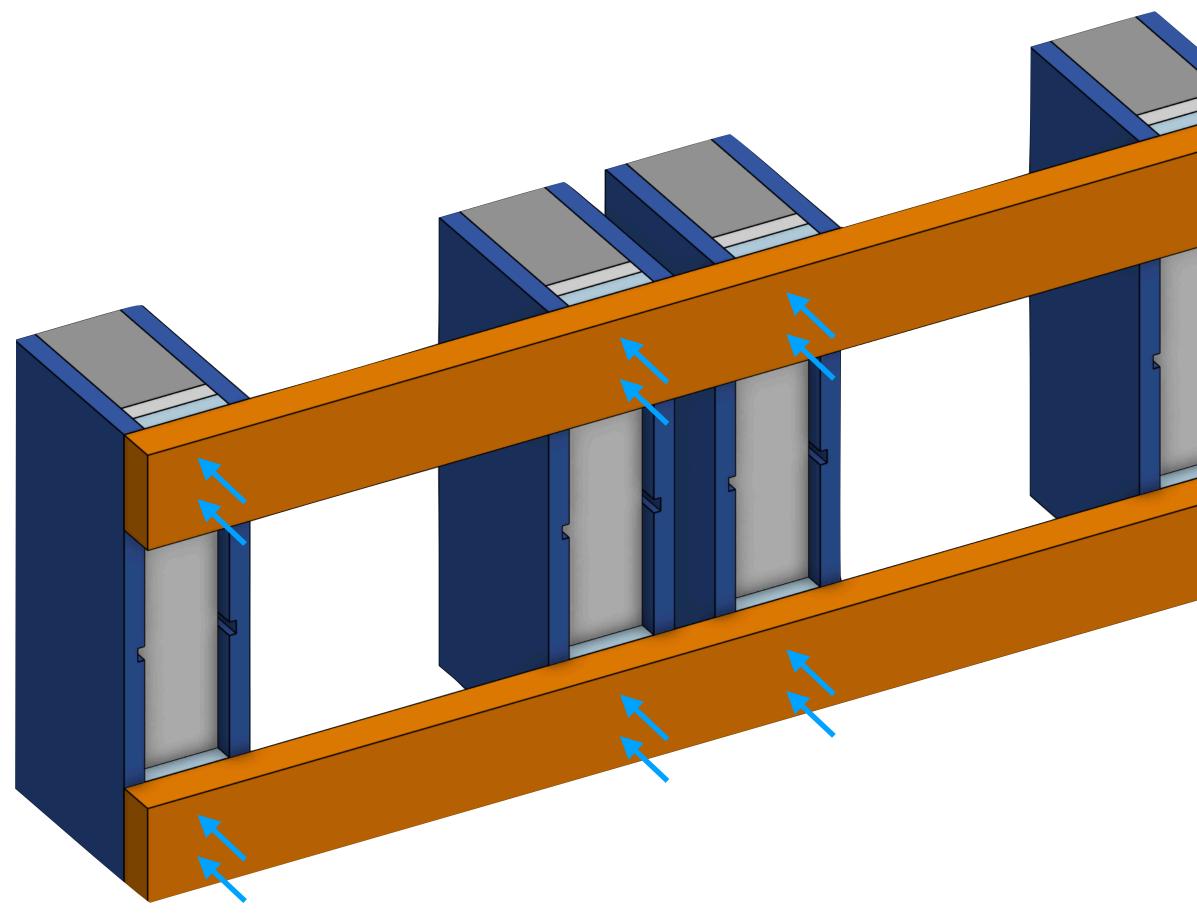
### **Assemble Battery Insert**

- 1. Screw battery holders to 2x4 braces
  - Ensure brace is flush with top/bottom
  - ENSURE SCREW DOES NOT POKE THROUGH INTO BATTERY COMPARTMENT

#### Notes:

- Use 2.5" screws for attaching braces
  - Pre-drill holes to avoid splitting plywood









# **OpenPit Battery Cratelet Assembly**

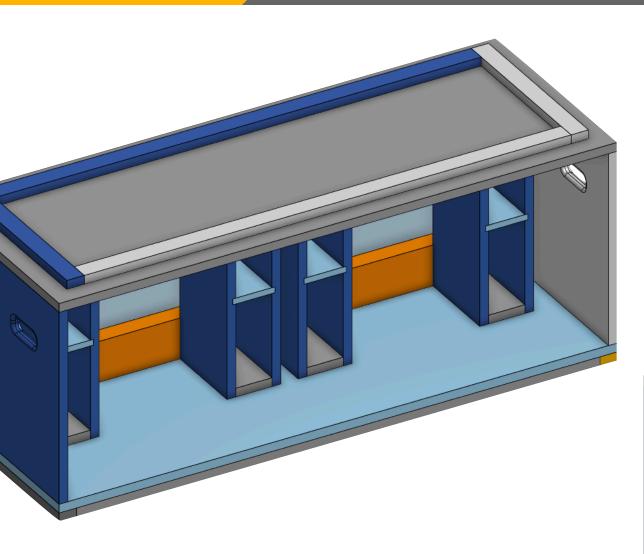
### **Assemble Battery Cratelet**

- 1. Place battery insert into base cratelet
  - Maintain gap behind insert
- 2. Add screws to top / bottom
  - Ensure screws are in 2x4s and miss any of the screws already in the 2x4s
  - Avoid placing screws in top/bottom stud segments
- 3. Mount battery chargers
  - Design will vary depending on charger
  - Make sure screws are used to attach mounts to base cratelet
    - Keeps design modular can change/upgrade

#### 3.

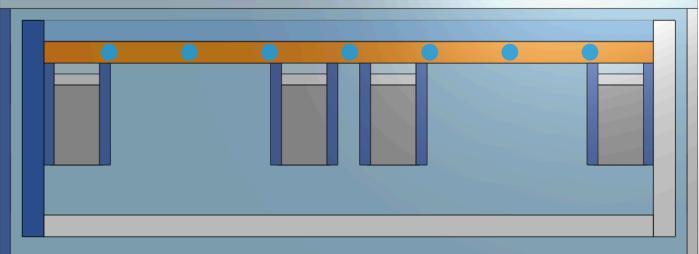
### Notes:

- Use 2" screws for attaching braces
  - Pre-drill holes to avoid splitting 2x4s

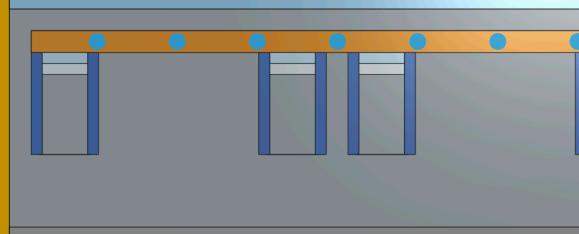




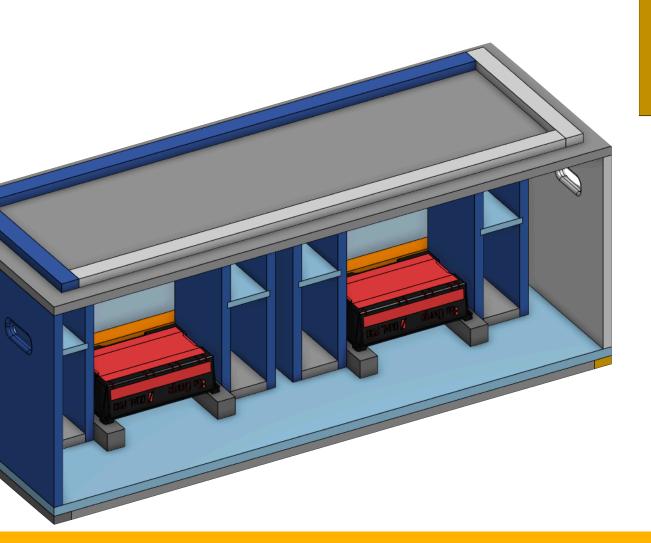
2. Top (cratelet top is transparent)



#### Bottom (cratelet bottom is transparent)



Screw



## **OpenPit** Parts Bin Insert Assembly

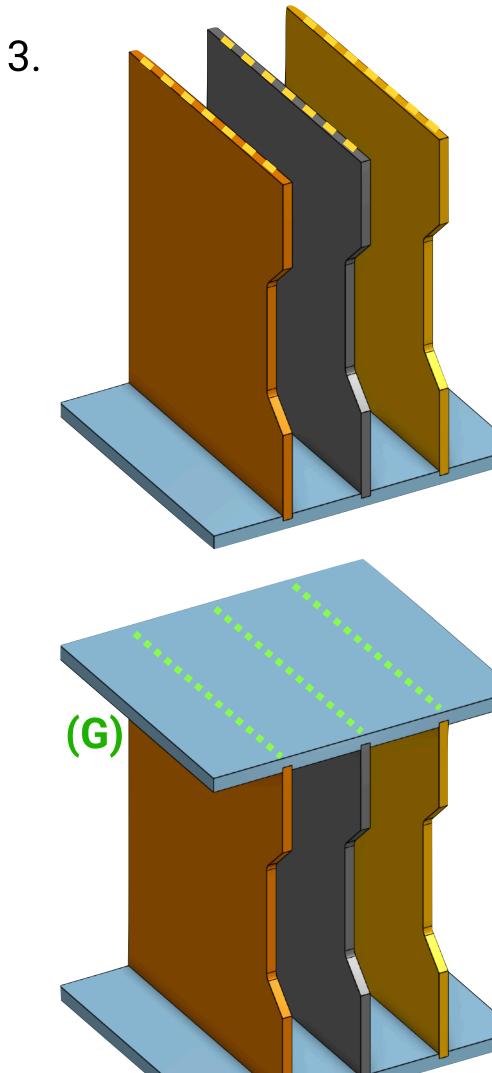
### **Assemble Parts Bin Shelf**

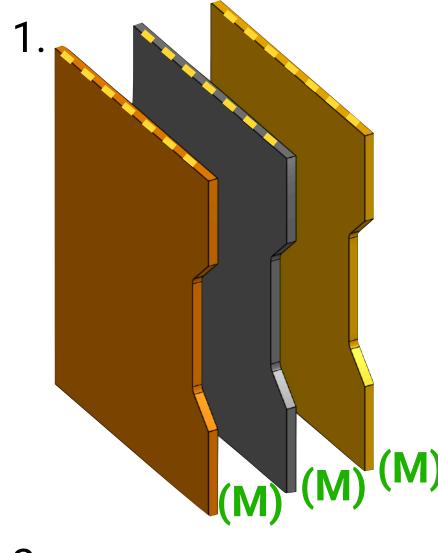
- 1. Apply glue to shelf (M) edges
- 2. Nail shelves to side plate (G)
  - Ensure shelves are flush with back edge
- 3. Repeat for second side plate (G)

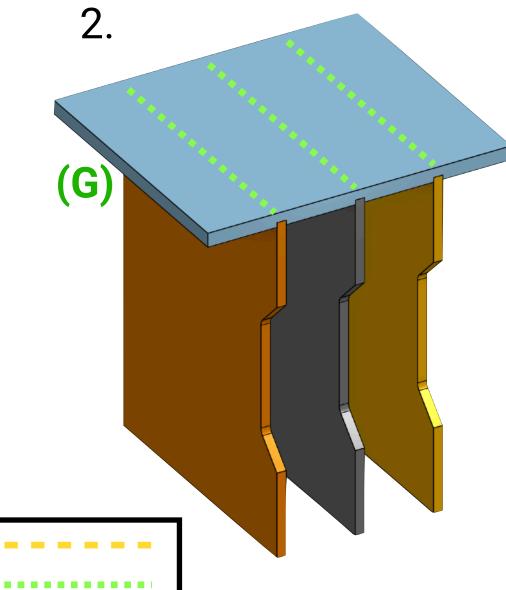
#### Notes:

- Use 1" long nails for all specified joints
- Nail on centerline of plywood edge every 1.5" 3"









Glue

Nail

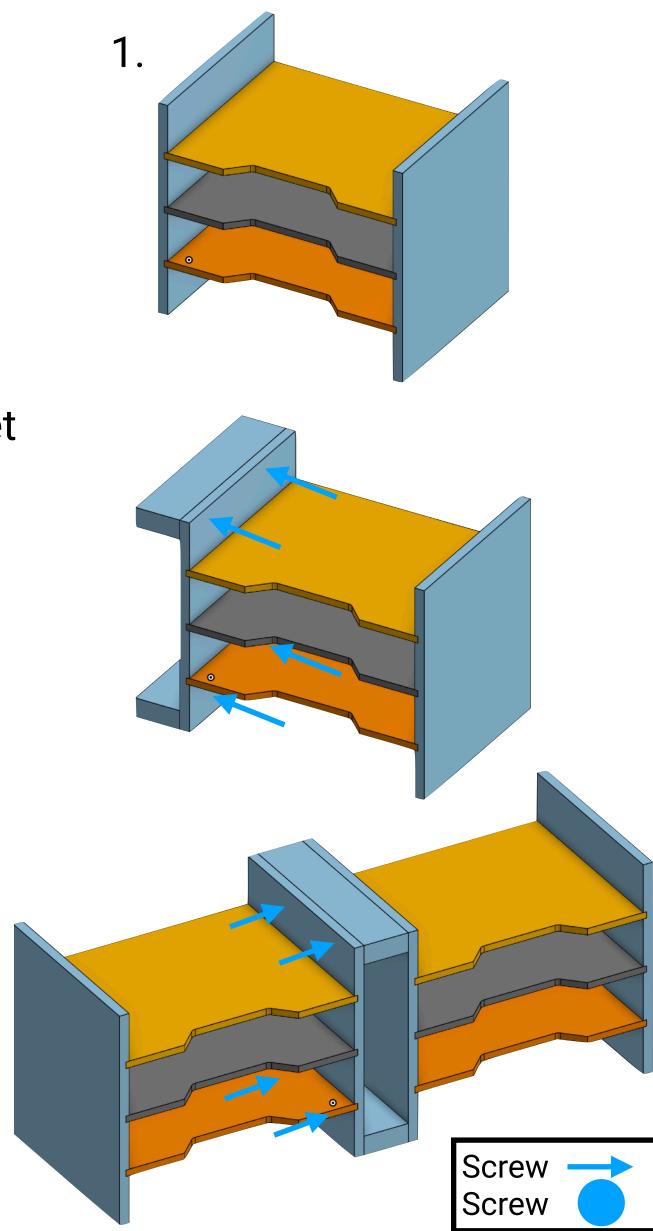
## **OpenPit Parts Bin Cratelet Assembly**

### **Assemble Parts Bin Insert + Parts Bin Cratelet**

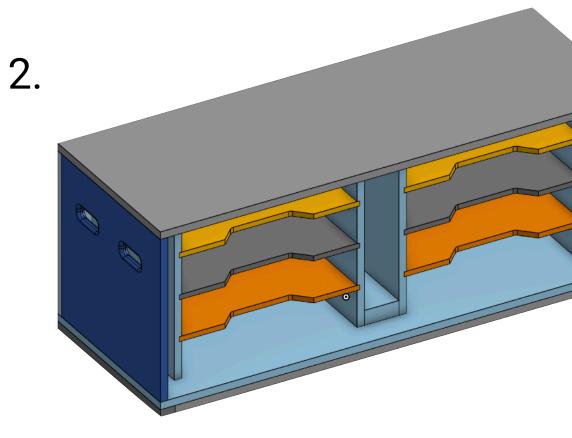
- 1. Attach parts bin shelf assemblies together
  - Screw to 2x4 braces
  - Ensure 2x4s are flush with top/bottom of insert
- 2. Place parts bin insert assembly into base cratelet
  - Assembly is centered
- 3. Add screws to top / bottom in 2x4s
  - Avoid screws already in 2x4s
  - Avoid placing screws in top/bottom stud segments

### Notes:

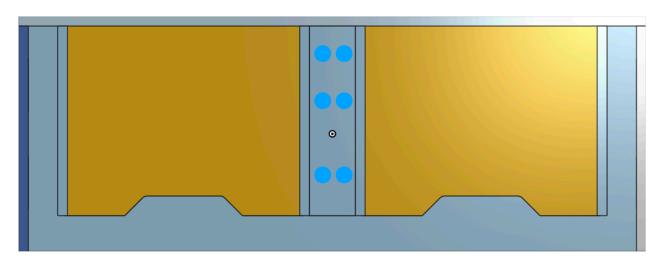
- Use 1.5" screws for attaching braces
  - Pre-drill holes to avoid splitting 2x4s

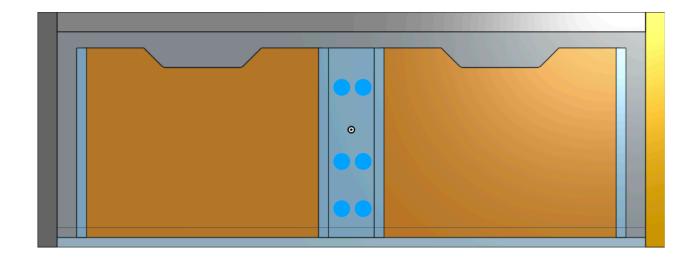






3.









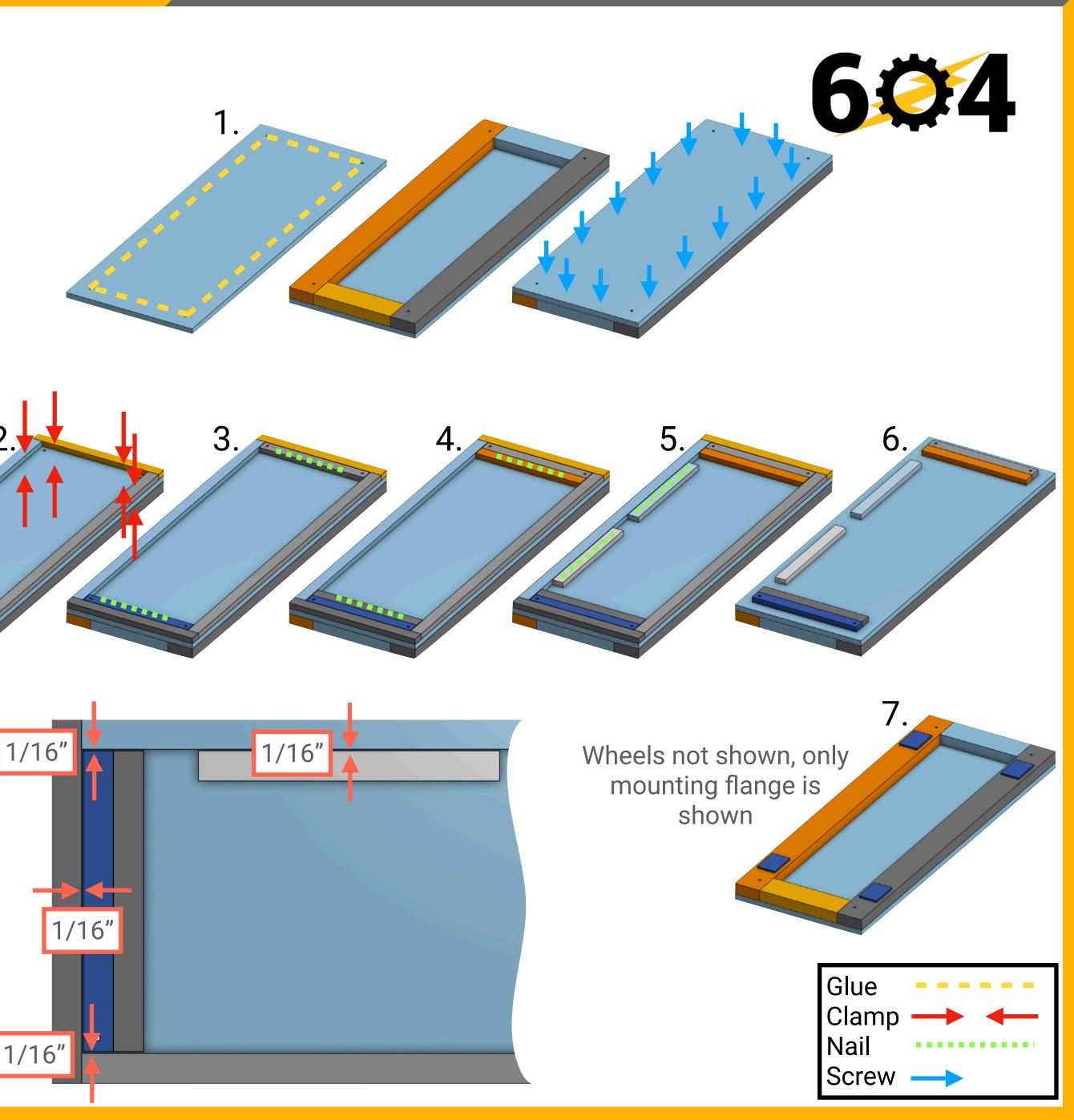
# **OpenPit Cart Assembly**

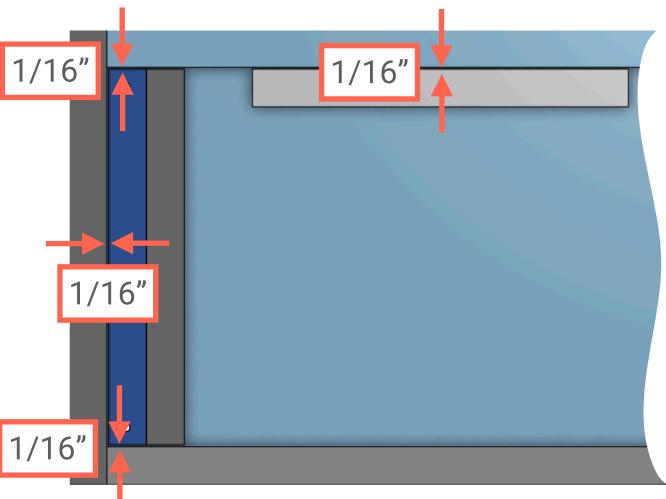
### **Assemble Cart**

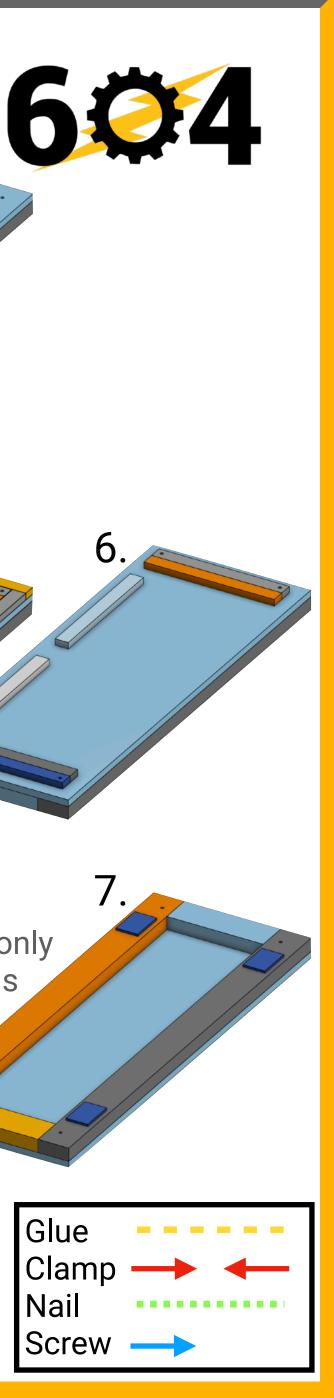
- 1. Glue and mount 2x4 braces by screw to base
- 2. Temporarily clamp spare 1x2 stud material to perimeter of cart (emulate cratelet bottom studs)
  - Needed to ensure studs can interlock with cratelets
- 3. Attach inner side studs by glue and nail
  - Ensure 1/16" gap with temporary studs
- 4. Add second inner side studs by glue and nail
- 5. Attach side studs by glue and nail
  - Ensure 1/16" gap with temporary studs
  - Follow spacing from CAD to ensure crates don't interfere
- 6. Remove temporary 1x2 stud material
- 7. Attach caster wheels
  - Use lag bolts into 2x4s

### Notes:

- Use 1.5" screws for attaching braces
  - Pre-drill holes to avoid splitting 2x4s
- Use 1.25" long nails to hold stud segments to cart
- Nail on centerline of segments every 1.5" 3"







# **OpenPit Pallet Cart Assembly**

### **Assemble Pallet Cart**

- 1. Clamp 2x4 braces to two carts
  - Ensure cart spacing and squareness
- 2. Match drill holes for bolts
  - Can remove clamps once everything is drilled

1.

- 3. Oversize cart hole for threaded insert + hammer in threaded insert
- 4. Bolt 2x4 braces to attach carts into pallet mode
- 5. Unbolt braces to return to individual cart mode
  - Keep braces and bolts/washers safe for future use

#### Notes:

- Use 4.5" bolts for attaching braces
  - Include large fender washers
  - Use threaded inserts in cart



