



IPI Kicker PFL Installation at ESB

Preliminary Design & Planning Report

Daniel R. MacLean
FAST Facility / IOTA
Friday, 1100
5-April-2024

Overview

- Upgrade IOTA Vertical Kicker Pulse-Forming Network (PFN) for p⁺ running
- Use Pulse-Forming Lines (PFLs) re-allocated from Main Injector kicker system
 - Currently housed in F17 service building
- Relocate 3x PFL spools to **ESB** for permanent installation, termination by EE Support
 - Dennis Barak & Co.
- Significant engineering / logistical challenge
- Will require careful review & coordination between FAST Facility Department, Safety, MSD, and EE Support
- Today: showing **preliminary** design concept for review & suggestions
 - **Not** a finished-product
 - Execution will take time

Kicker PFL Spools

- PFN cables [AA5966 / RG-220] are wound into spools and supported by large Aluminum plates & tie-down shoes
- 3 spools in total required for IOTA PFN upgrade
- Full assembly [Width X Height X Depth]: [102" X 78" X 2.875"]
 - Controlled 3D model + drawing exists for square 78" X 78" version...
 - 9506.000–ME–305626 (Rev. A)
 - Unable to locate up-to-date model of *our* 102" X 78" spool assemblies beyond single uncontrolled drawing provided by EE Support
- ~1,500 lbs per spool (including ~580 feet of cable per assembly)
- **Total weight of 3x PFL assemblies: ~4,500 lbs**
- EE Support uses hydraulic A-frames to relocate assemblies
 - Will not work for our purposes (explanation forthcoming)



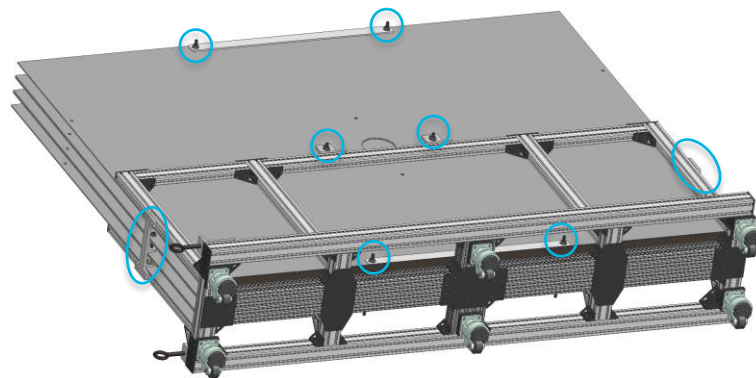
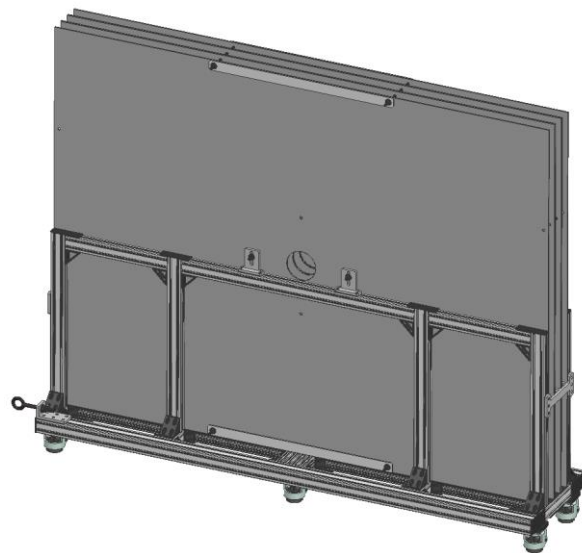
Target Destination in ESB



- Southern wall of Laser Room, between East & West Unistrut assemblies
 - Gap width: ~112" (approx., ± 2 ")
 - Spool assembly width: 102"
- IOTA Horizontal Kicker (N:IKPSH) rack & Resonant Charging Chassis/XFMR are currently obstructing; will require relocation
- For the Plan I will discuss today, should be no need to remove 480 Vac / 120 Vac breakers & junction boxes on Eastern Unistrut assembly
- These spools are typically installed *perpendicular* to the face of a wall; cannot afford to lose ~1,000" square of floor space in the middle of ESB – *cable pulls, relay rack access, etc.*
- **The challenge becomes: find a way to move & secure the spools into position *parallel* to the wall safely, w/o interfering w/any electrical infrastructure**

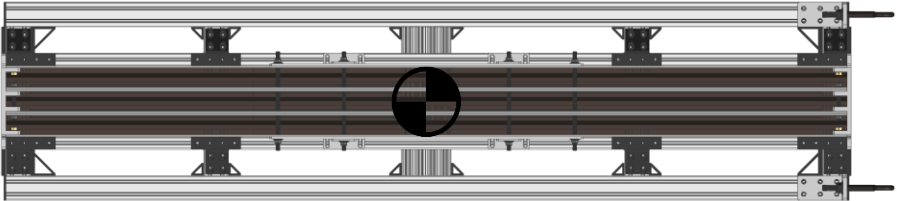
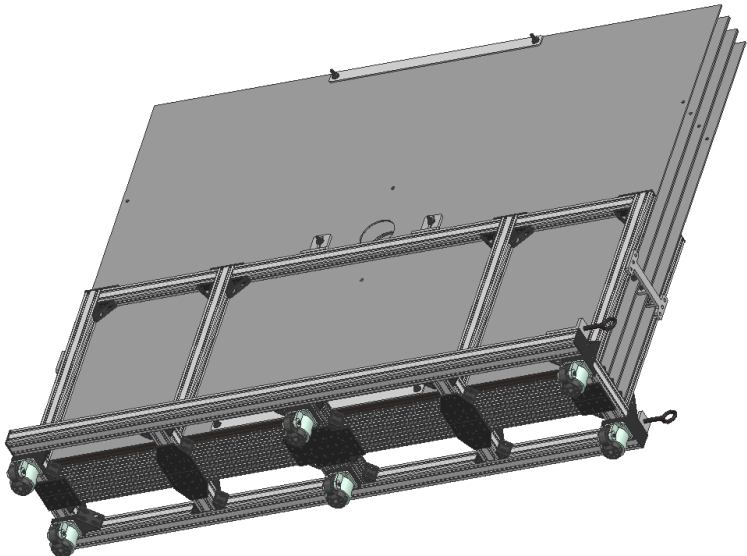
Spool Platform: Mechanical Design (1/2)

- Engineered solution: construct mobile (caster-supported) 8020 platform w/machined fixtures for fastening spool assemblies together into single body, secured to platform
- Casters spec'd to bear well-beyond the weight of 3x PFL spools
 - Rated load capacity **per-caster**: 2,200 pounds
 - 6x casters in total, placed along load-bearing rails – *distributed evenly*
 - Lower leveling feet to ground after final position is reached
 - 8020 Part #: 2717
- PFL spools mated face-to-face & fastened at multiple **points**
 - Existing PFL face plates have redundant/unused $\text{Ø}1/2$ " clearance holes along surface; plan to use for fastening – *will verify these holes are non-critical*
- Main support beams are 3060 profiles of t-slotted framing, secured to outer 3030 beams on which the swivel casters are installed
- Vertical railing @ ~midplane to provide support along long axis of spools + mount spool fastening fixtures



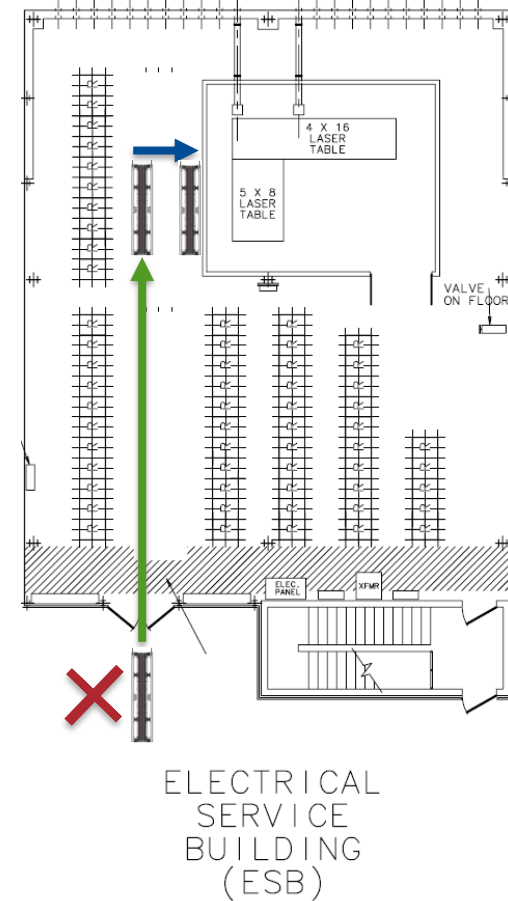
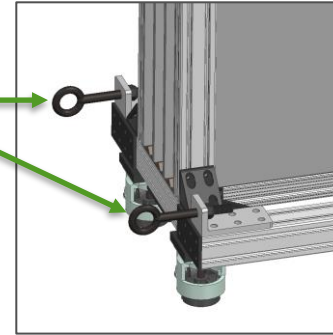
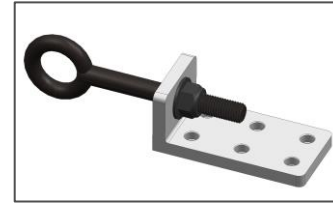
Spool Platform: Mechanical Design (2/2)

- Will fabricate new wheel guide / track assembly based on existing
 - Current track **not** designed for face-to-face mating of spools (small gaps)
 - Weld 3x 90° A36 steel angles to 1/16" thick 4130 (Chromoly) base sheet
- Assembly is axisymmetric; COM should be close to dead-center of the spool sub-assemblies
 - Will tend to tip towards vector normal to face of support plates
 - Tip-analysis ongoing
- Will likely add a few additional features for platform movement (more details on forthcoming slide)
- See backup slides for prints of machined fastening components



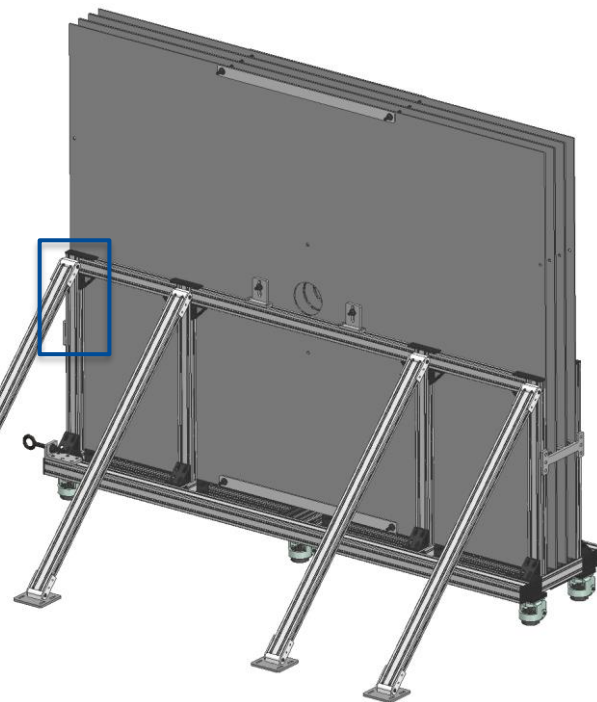
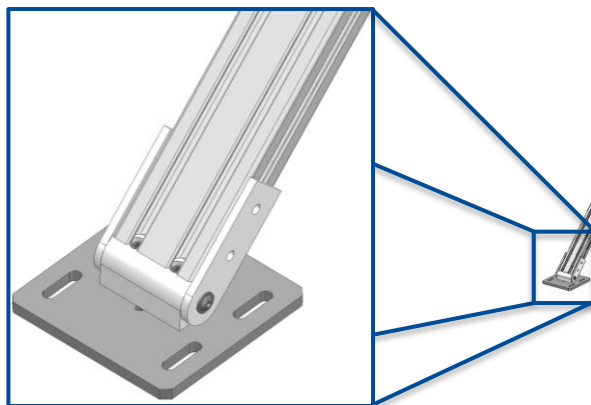
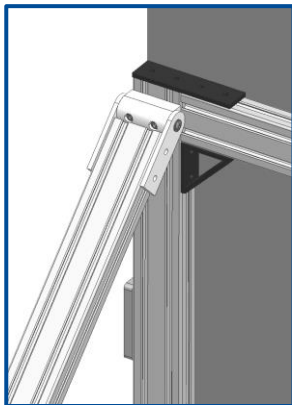
Relocation Plan

- Due to its weight and geometry, moving PFL spool assembly into position will require extreme care
- **Crane** PFL spools off delivery flatbed directly onto platform & **fasten together**
 - Stationed on sidewalk leading into ESB
 - Will likely need to remove ESB door temporarily (barely too short; 83" vs. 86.5" assembly height)
- Ideally: use a ratcheting winch ('come-along') to slowly pull PFL spool platform into ESB towards Laser Lab wall
 - Anchor fixed points to ESB floor
 - Eyebolt fixture plates already designed for **Westward** pull
 - Still working on e.g. pulley system for final **Northward** move into final position; tight quarters, wall obstructing...
 - Avoiding all direct hand-contact w/assembly by personnel during move



Spool Platform: Final Configuration

- Once platform is in final position, fasten to anchored Unistrut beams suspended down from ceiling
- Still working on interface w/Unistrut along Laser Lab wall
- Leveling casters: drop down static feet if necessary
- Optional: add support arms extending at 45° that can be anchored to floor
 - *Not ideal as this would take up significantly more floor space*
 - Have made alternate version of assembly w/supports included
 - Option is available if required by e.g. Safety



Cost Estimates & Manufacturing Pipeline

- Machined components: **~\$4,000*****
 - e.g. Xometry, Center Tool Co., WPA Works (?)
 - Alternatively: Village Shop - *lead-times can be punishing*
- 8020 platform kit: **~\$5,000**
 - Via distributor e.g. Steiner Electric Co.
- Assembly hardware: **~\$300 - \$500**
 - e.g. McMaster-Carr, Grainger
- Come-Along / Winch system: borrow internally ?
 - Otherwise: **~\$500** (max.) from e.g. MSC Industrial, McMaster-Carr + anchoring components
- Steel stock for wheel guide / track: **~\$200 + fabrication**
 - Current plan is to source raw stock, bring to FNAL Weld Shop for fabrication
 - e.g. OnlineMetals, MSC Industrial



**** Save roughly ~\$1,000 by machining components w/simpler geometry in-house e.g. upper/lower tie-down brackets, main beam joining plate*

Summary & Current Status

- Have done a fair amount of design work, however still addressing several open items
- Main issues / unaddressed items at present:
 - Logistics of relocation – *coordinate w/EE Support, Safety, MSD*
 - Tip-analysis / final verification of load-bearing ability for OTS components
 - Final northward move up to South Laser Lab wall – *e.g. pulley system*
 - Plan for securing platform assembly in place @ final position in ESB – *Unistrut sub-assembly, design underway*
 - Removal of ESB door frame temporarily for the move?
- Despite being incomplete, felt that design was developed enough for internal review
- Still fluid: can easily make changes to assembly / edits to components (no hardware nor components ordered)
- **Please feel free to comment & give suggestions – thank you.**

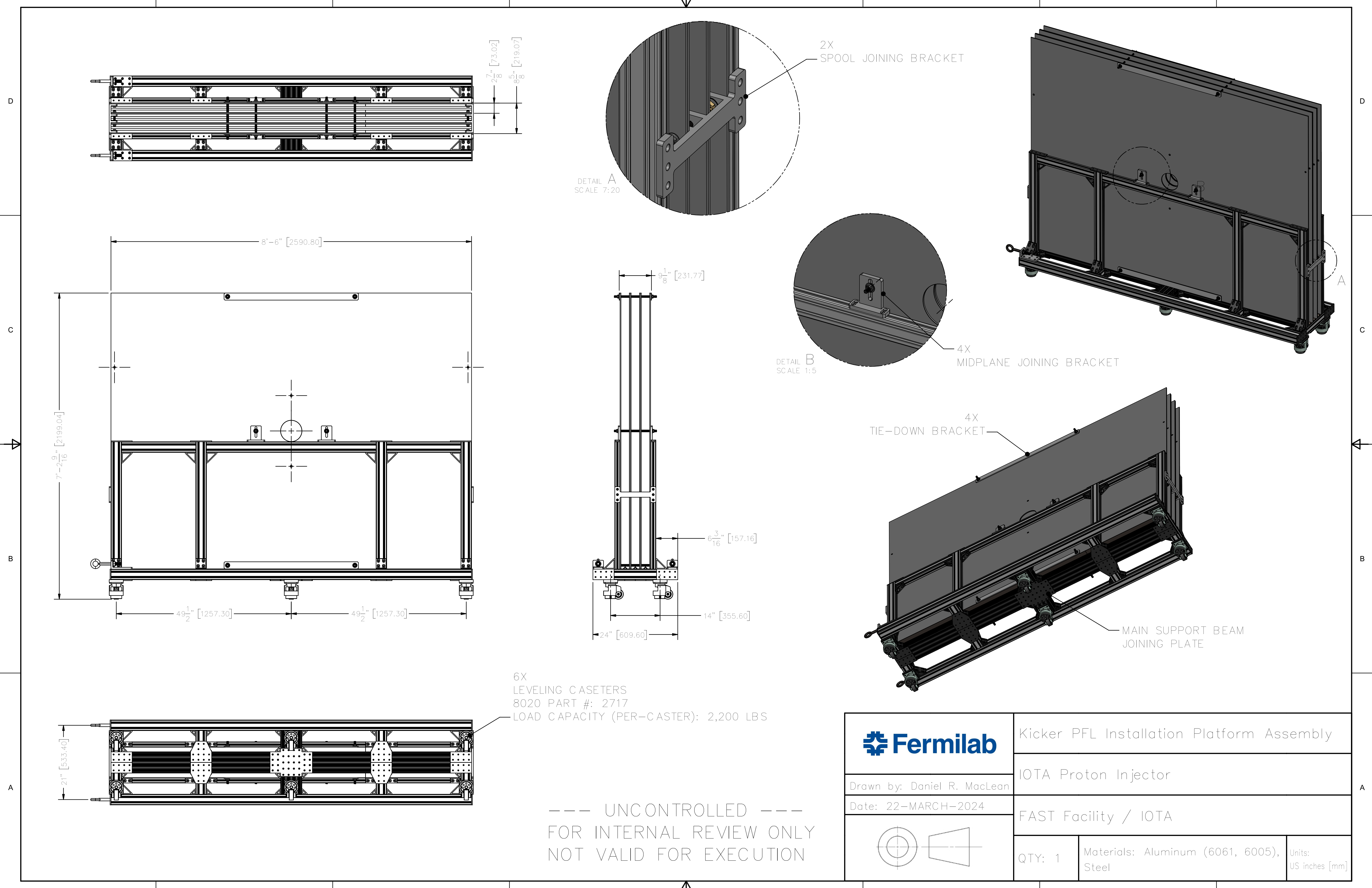
--- Backup Slides ---

Bill of Materials (1/2)

- 8020 Components (all parts are 15-Series):
 - #2717: leveling caster --- **6x**
 - #2409: leveling caster baseplate --- **6x**
 - #3030-S: solid t-slotted profile, 3" x 3" x 102" --- **2x**
 - #3030-S: solid t-slotted profile, 3" x 3" x 18" --- **2x**
 - #3030-S: solid t-slotted profile, 3" x 3" x 6" --- **4x**
 - #3060: t-slotted profile, 3" x 6" x 45" --- **2x**
 - #3060: t-slotted profile, 3" x 6" x 18" --- **1x**
 - #1530: solid t-slotted profile, 1.5" x 3" x 36" --- **8x**
 - #1530: solid t-slotted profile, 1.5" x 3" x 21" --- **4x**
 - #1530: solid t-slotted profile, 1.5" x 3" x 48" --- **2x**
 - #4325: 12-hole T-plate --- **4x**
 - #4305: 4-hole straight plate --- **8x**
 - #4338: 8-hole gusseted inside corner bracket --- **12x**
 - #4334: 4-hole gusseted inside corner bracket --- **28x**
 - #4336: 4-hole tall gusseted inside corner bracket --- **12x**
 - #4365: 8-hole rectangular plate --- **12x**
 - #3330: 5/16"-18 UNC x 0.6875" button head socket cap screw --- **516x**
 - #3278: 5/16-18 UNC slide-in economy T-nut --- **516x**

Bill of Materials (2/2)

- Machined Components:
 - Modified PFL track sub-assembly --- **1x**
 - 102" x 0.75" x 0.75" x 0.125" ASTM A36 angles --- **3x**
 - 72" x 8.625" x 0.063" 4130-Chromoly track base --- **1x**
 - 30" x 8.625" x 0.063" 4130-Chromoly track base --- **1x**
 - Main support beam joining plate --- **1x**
 - Midplane joining brackets --- **4x**
 - Upper & lower tie-down brackets --- **4x**
 - Side-mounted joining brackets --- **2x**
 - Pulley / come-along fixture plate --- **2-4x**
- Additional Assembly Hardware:
 - High-strength (ASTM grade BD) steel threaded rod: ½"-13 UNC x 12" [3314N725] --- **6x**
 - High strength (ASTM grade BD) steel threaded rod: ½"-13 UNC x 4" [90322A299] --- **2x**
 - High-strength (ASTM grade 8) steel serrated flange locknut [95922A140] --- **16x**
 - 316L stainless steel washer: 0.531" ID, 1.25" OD [90107A033] --- **16x**
 - Galvanized steel eyebolt: ¾"-10 UNC x 3" thread, 6" long shank [3016T63] --- **2-4x**
 - High-strength (ASTM grade G) steel flanged locknut: ¾"-10 UNC thread, nylon insert [92018A116] --- **2-4x**
 - ZnCr plated steel (ASTM grade 8) hex bolt: ½"-13 UNC x ¾" [92620A709] --- **4x**



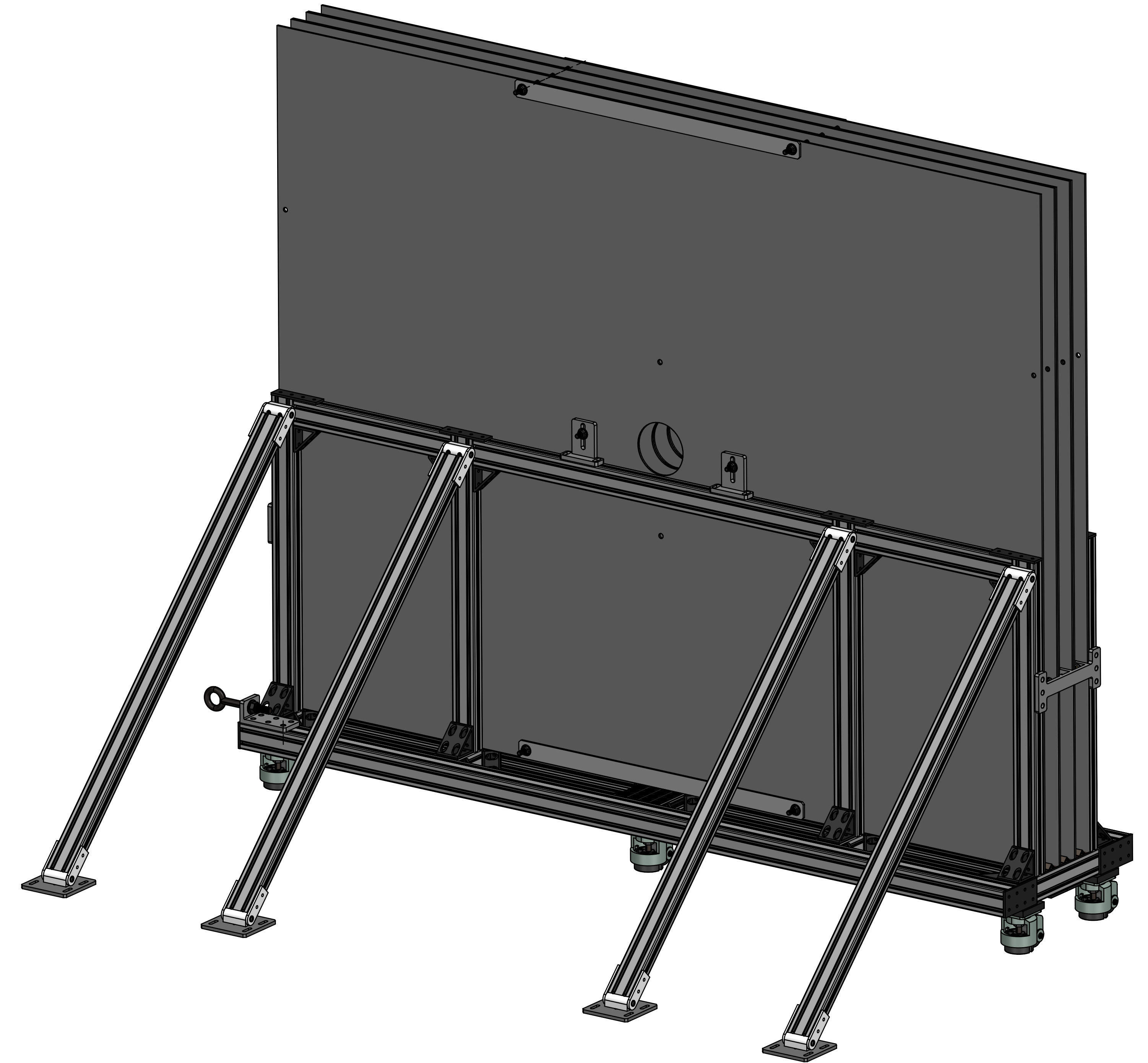
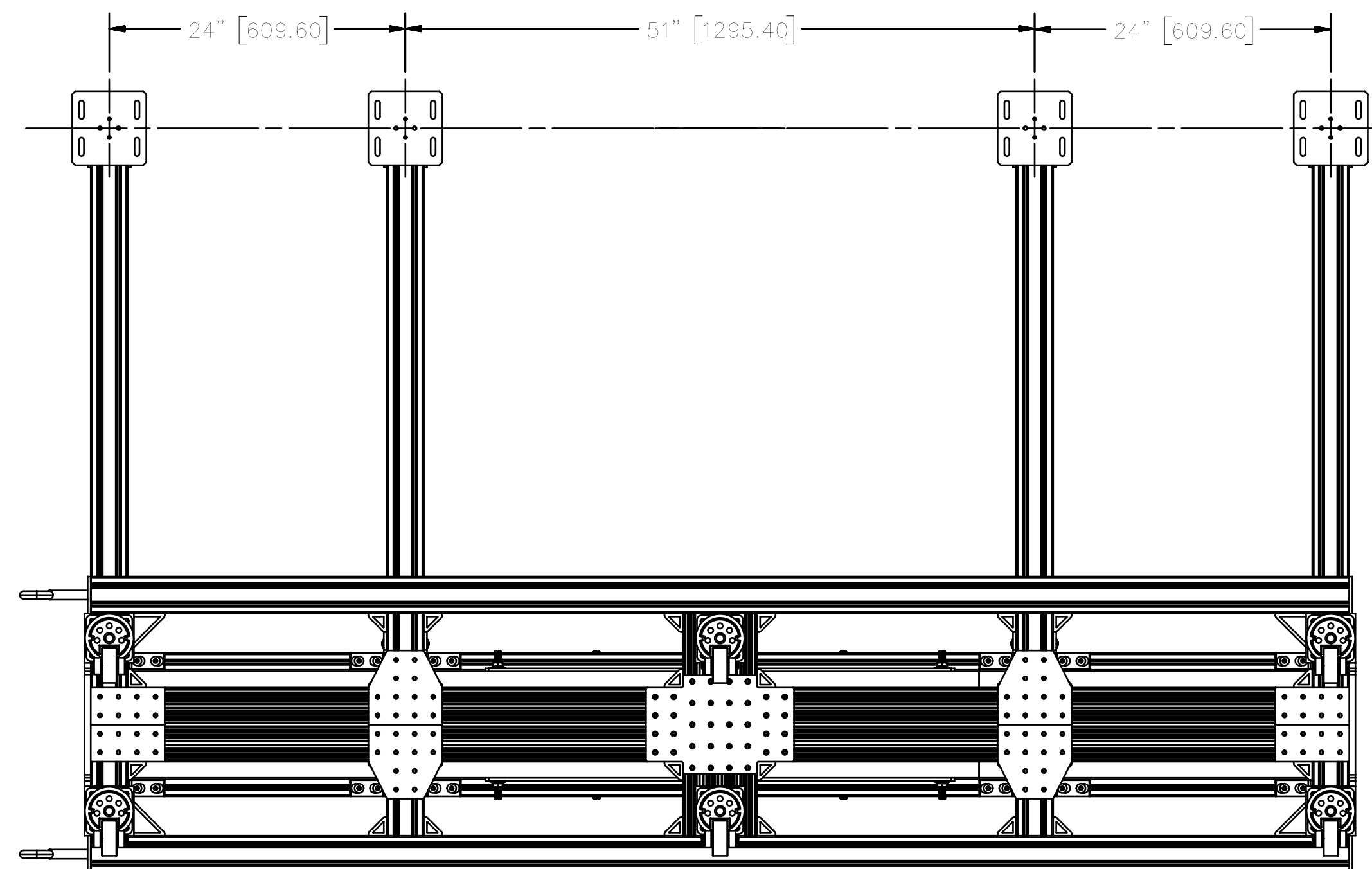
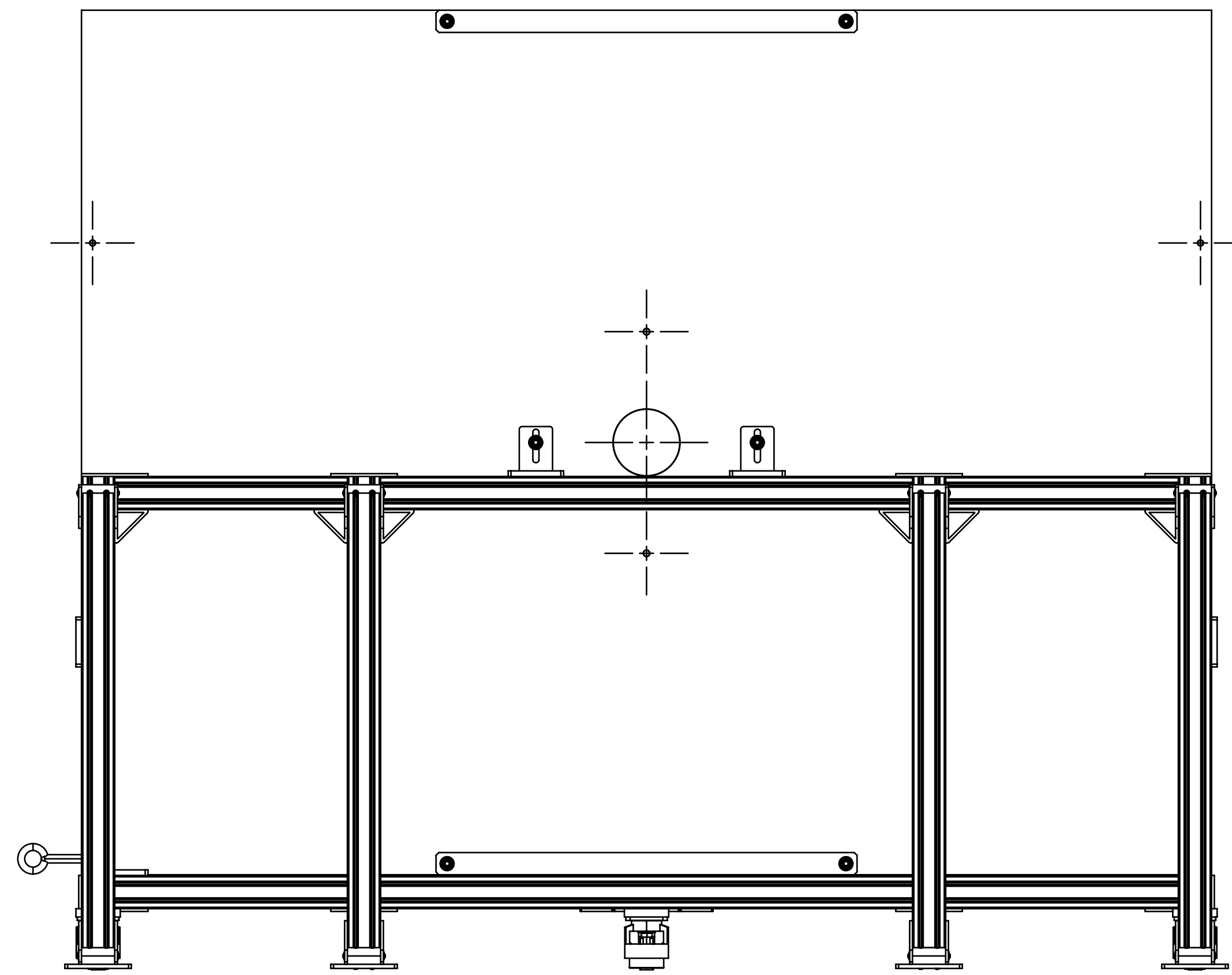
DETAIL A
SCALE 7:20

DETAIL B
SCALE 1:5

6X
LEVELING CASERS
8020 PART #: 2717
LOAD CAPACITY (PER-CASTER): 2,200 LBS

--- UNCONTROLLED ---
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	Kicker PFL Installation Platform Assembly	
	IOTA Proton Injector	
Drawn by: Daniel R. MacLean Date: 22-MARCH-2024	FAST Facility / IOTA	
	QTY: 1	Materials: Aluminum (6061, 6005), Steel
		Units: US inches [mm]



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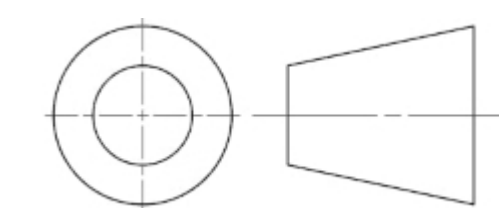
Kicker PFL Installation Platform Assembly
 + Floor-Anchoring Components

Drawn by: Daniel R. MacLean

IOTA Proton Injector

Date: 22-MARCH-2024

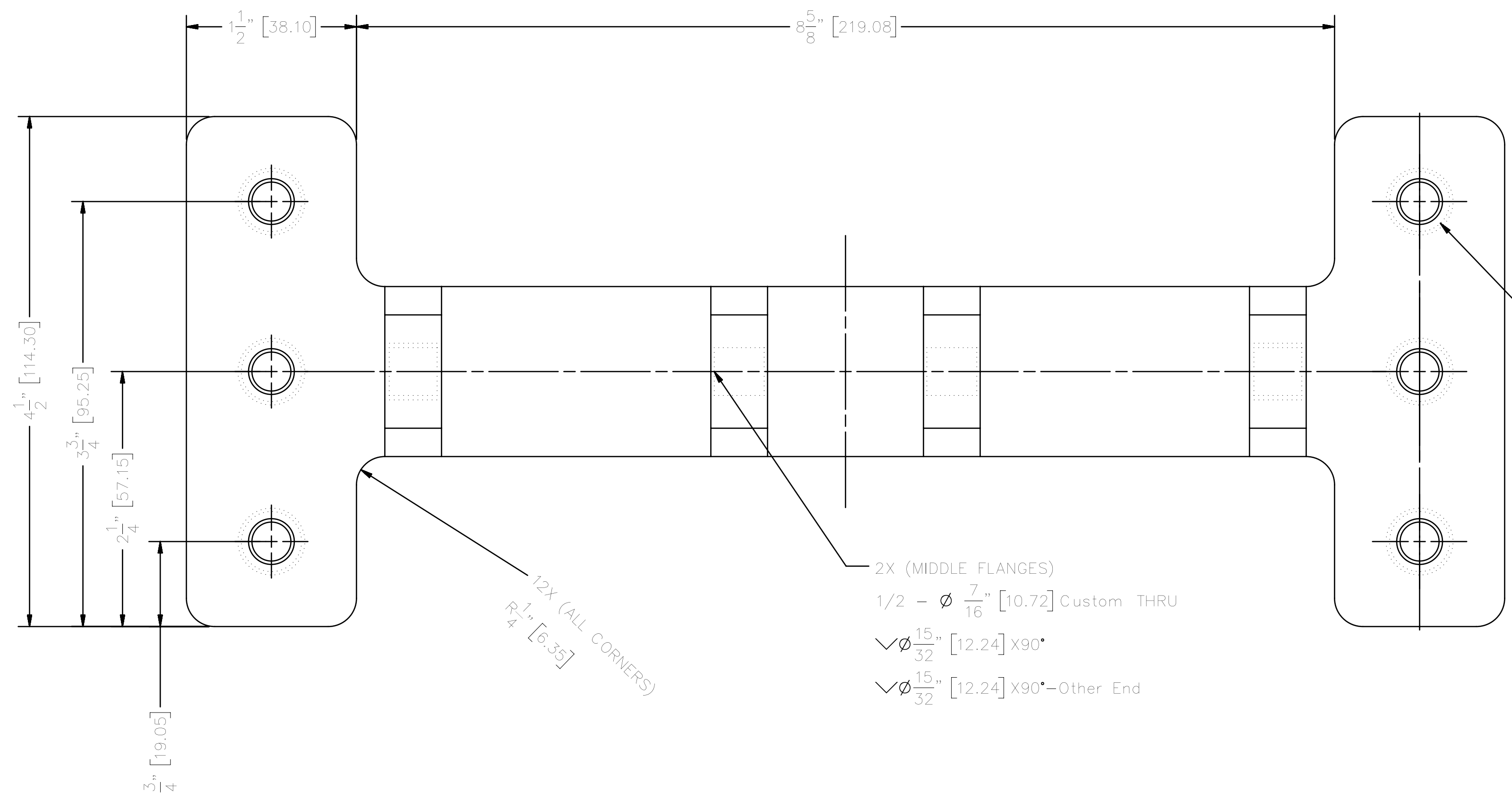
FAST Facility / IOTA



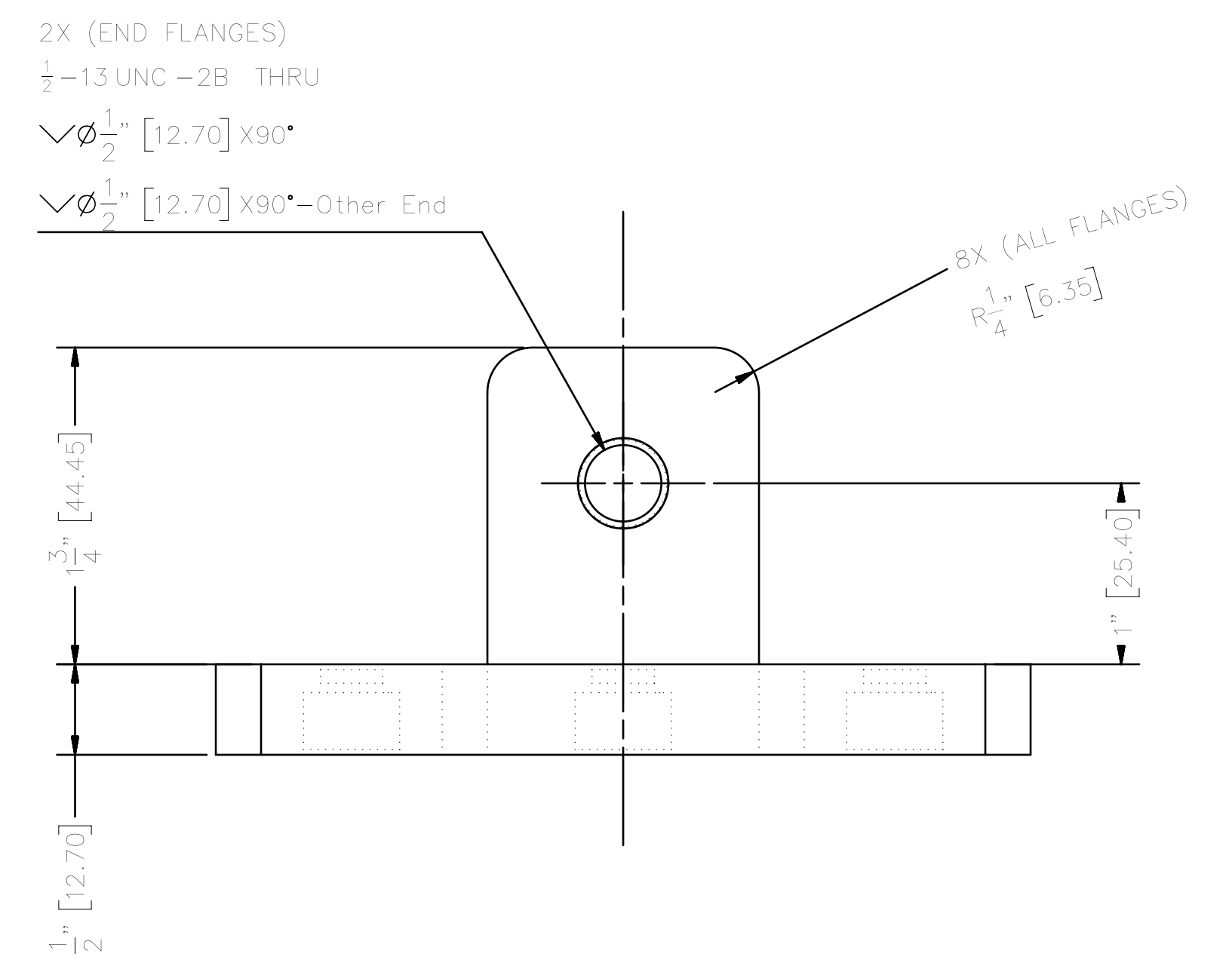
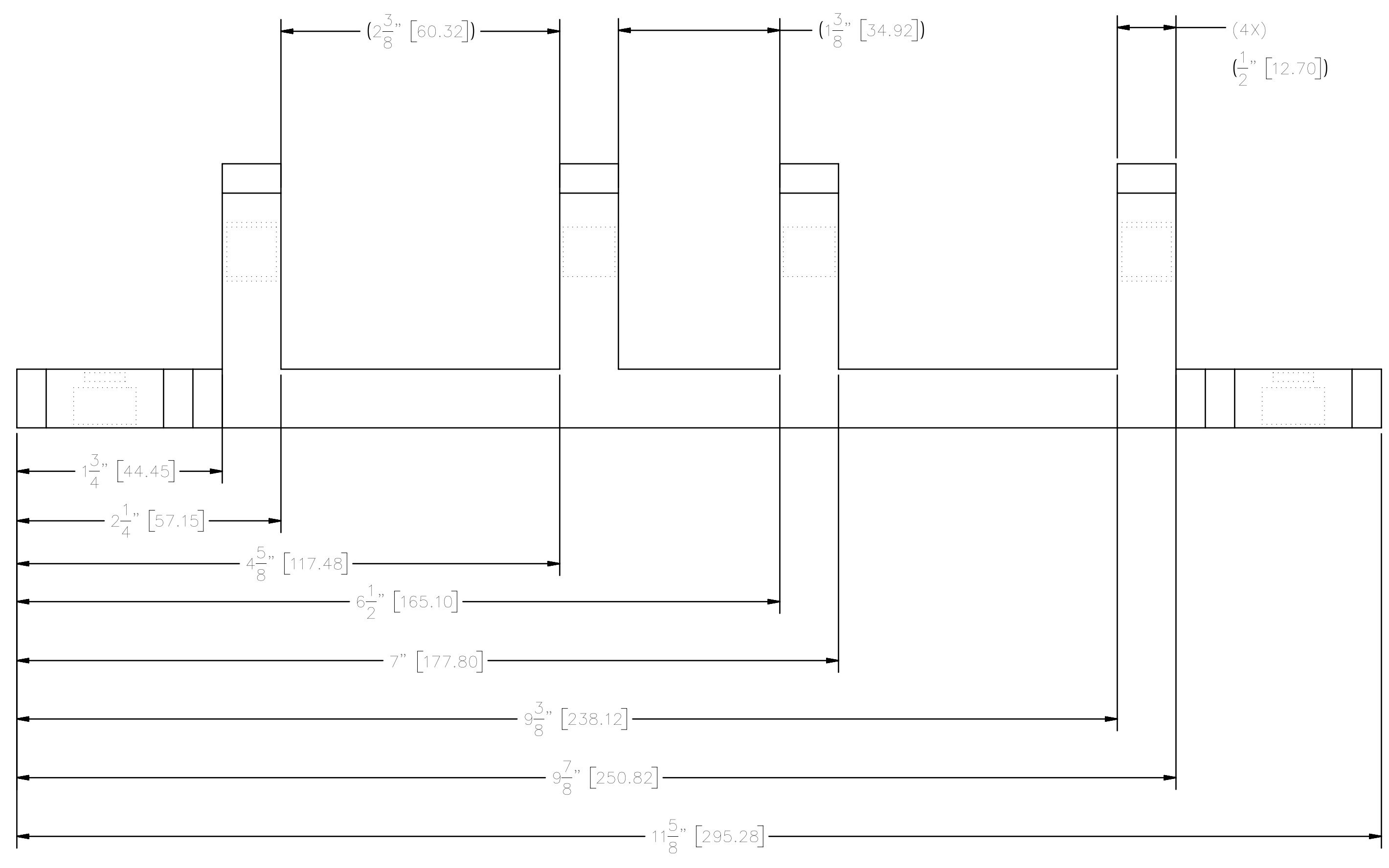
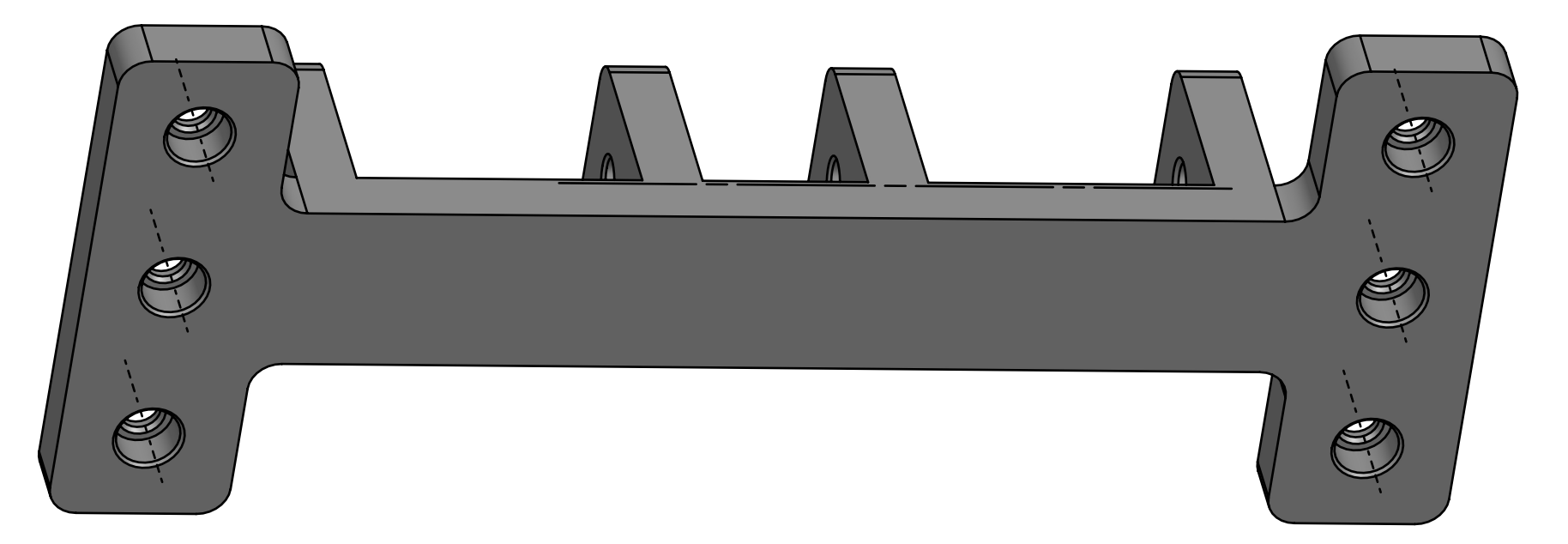
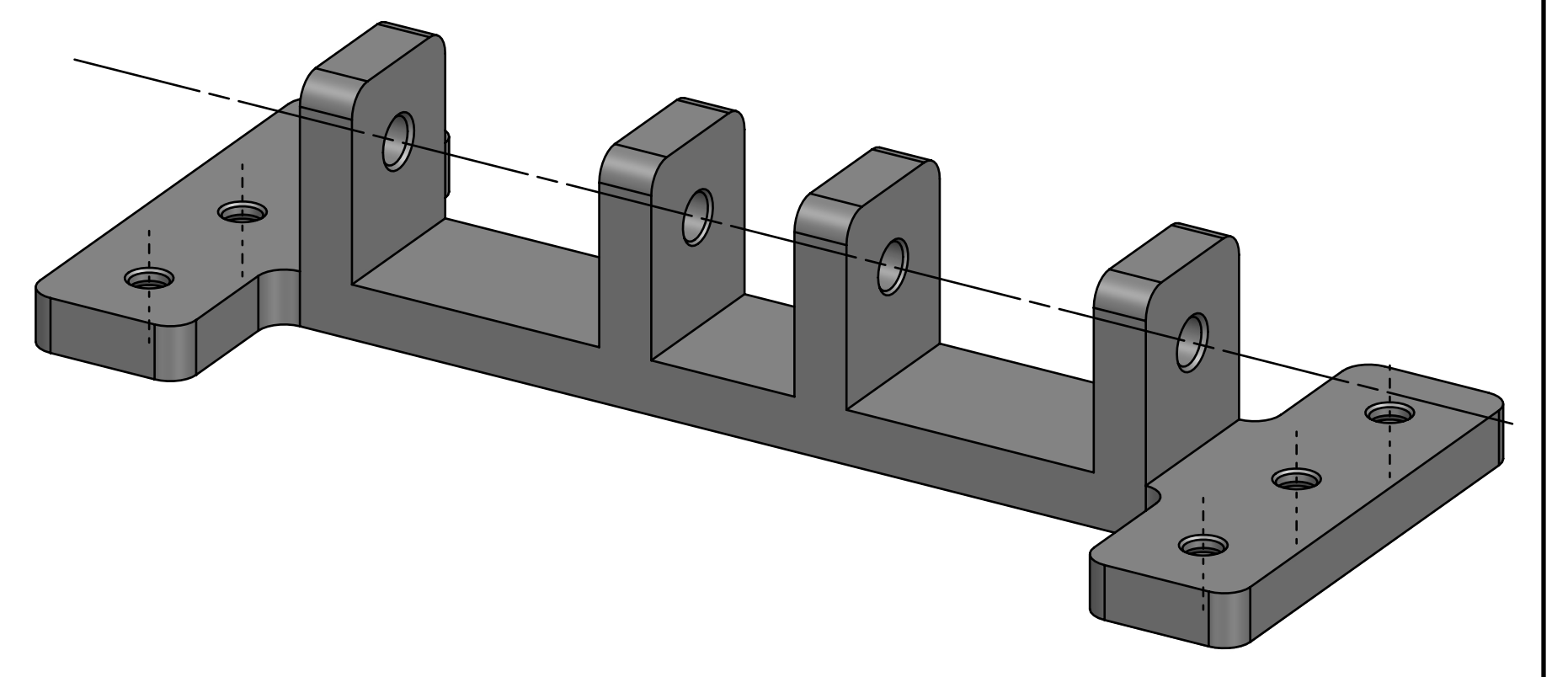
QTY: 1

Materials: Aluminum (6061, 6005),
 Steel

Units:
 US inches
 [mm]

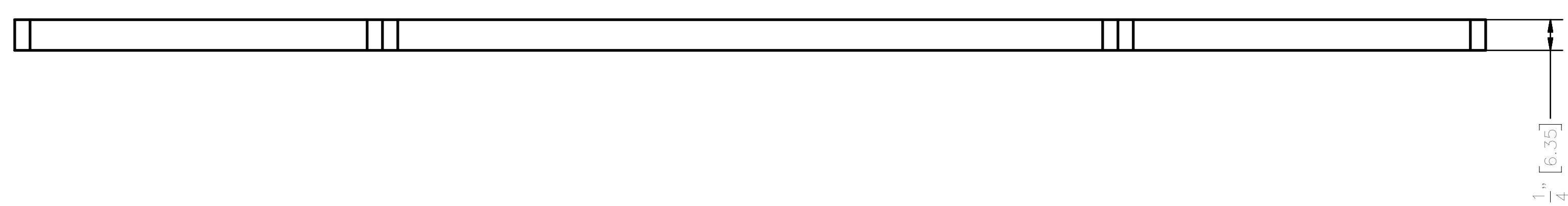
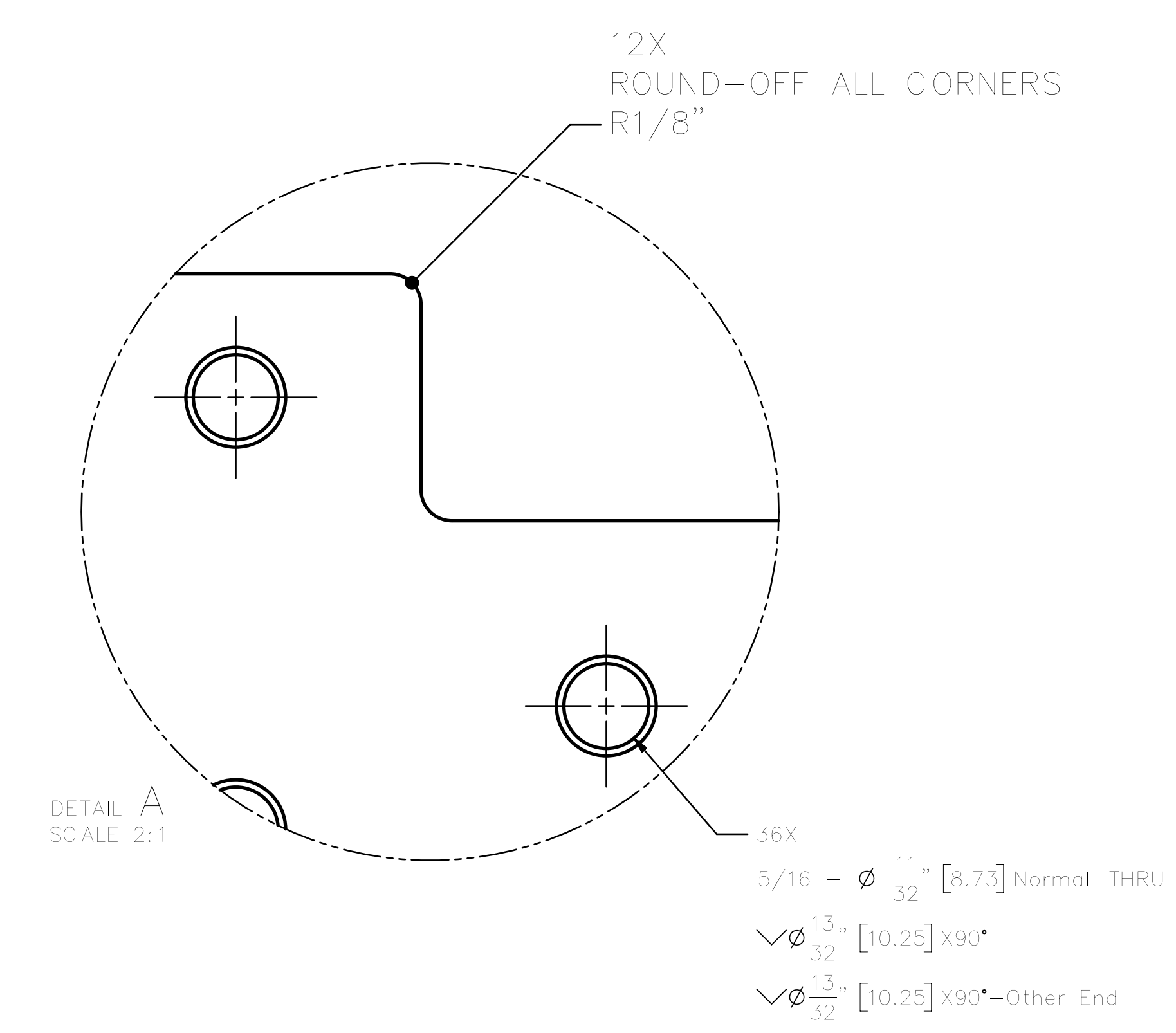
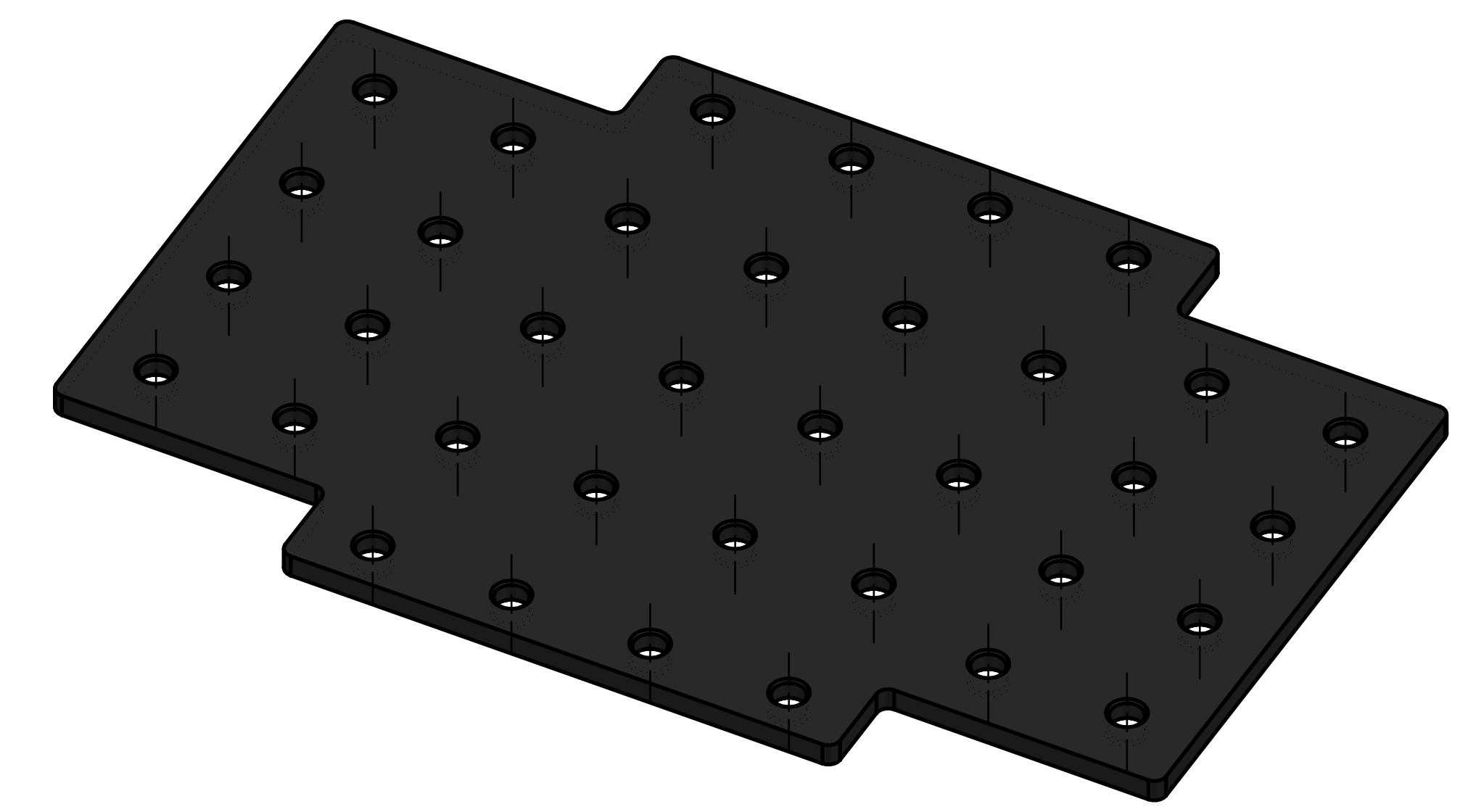
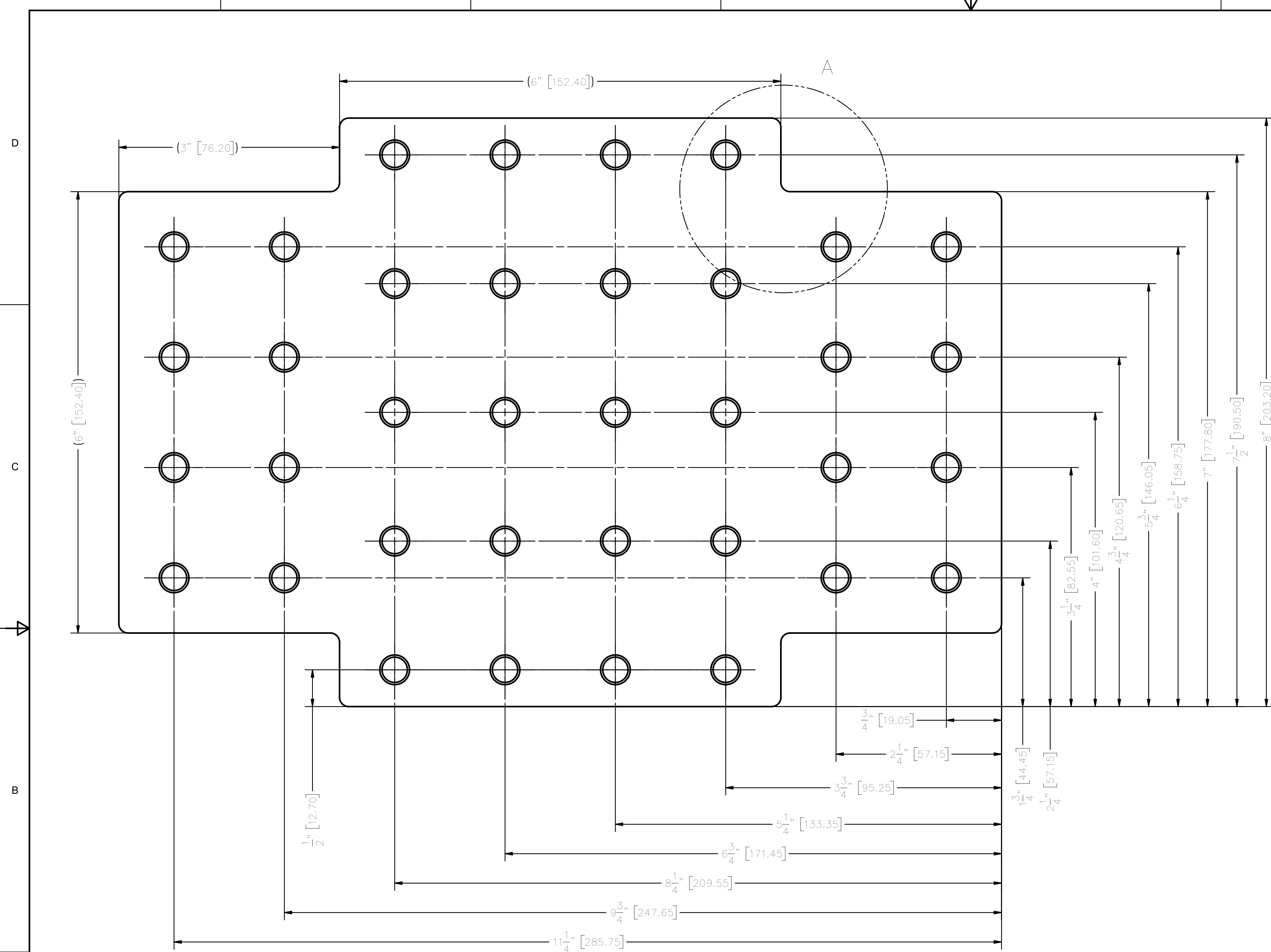


- 6X
- $5/16 - \phi \frac{11}{32}$ [8.73] Normal THRU
- $\sphericalangle \phi \frac{17}{32}$ [13.49] $\nabla \frac{11}{32}$ [8.71]
- $\sphericalangle \phi \frac{19}{32}$ [15.02] X90°
- $\sphericalangle \phi \frac{13}{32}$ [10.25] X60°
- $\sphericalangle \phi \frac{13}{32}$ [10.25] X90°-Other End



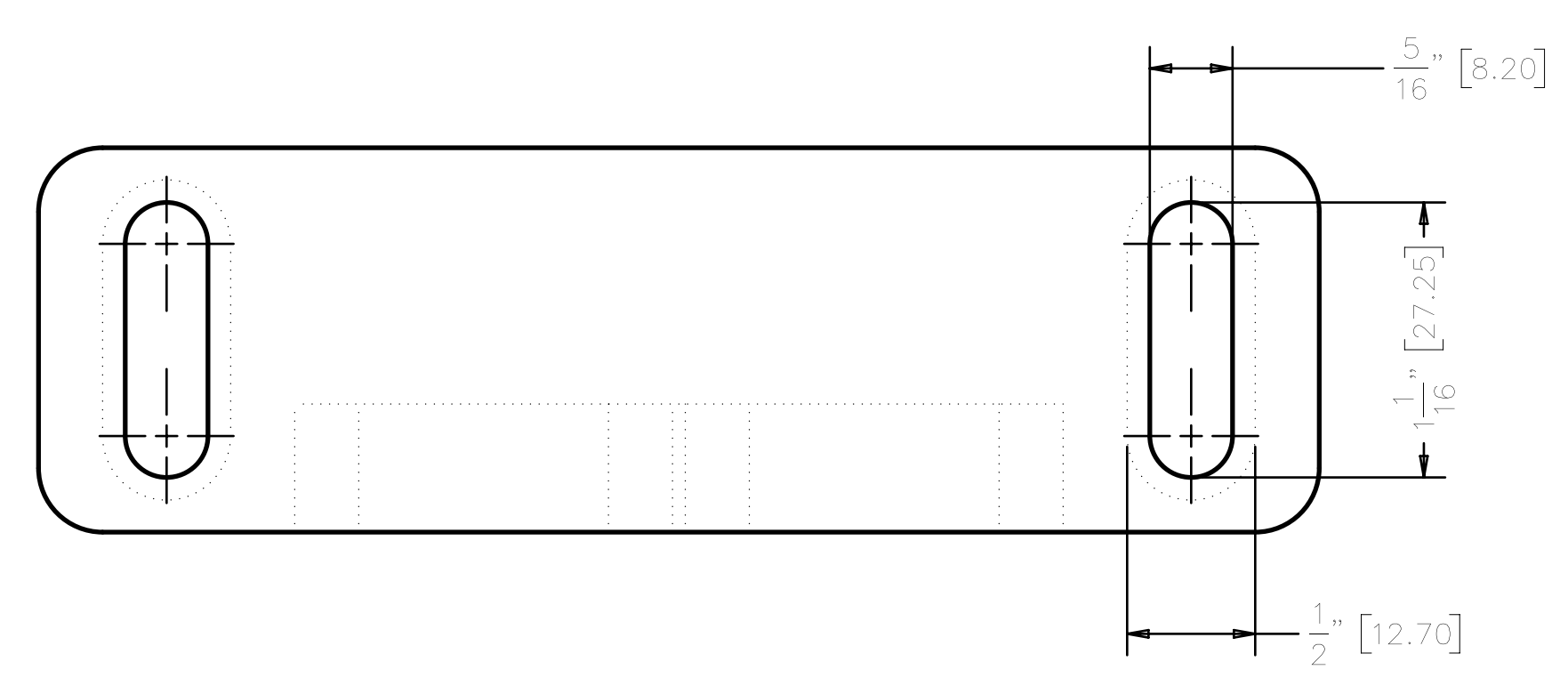
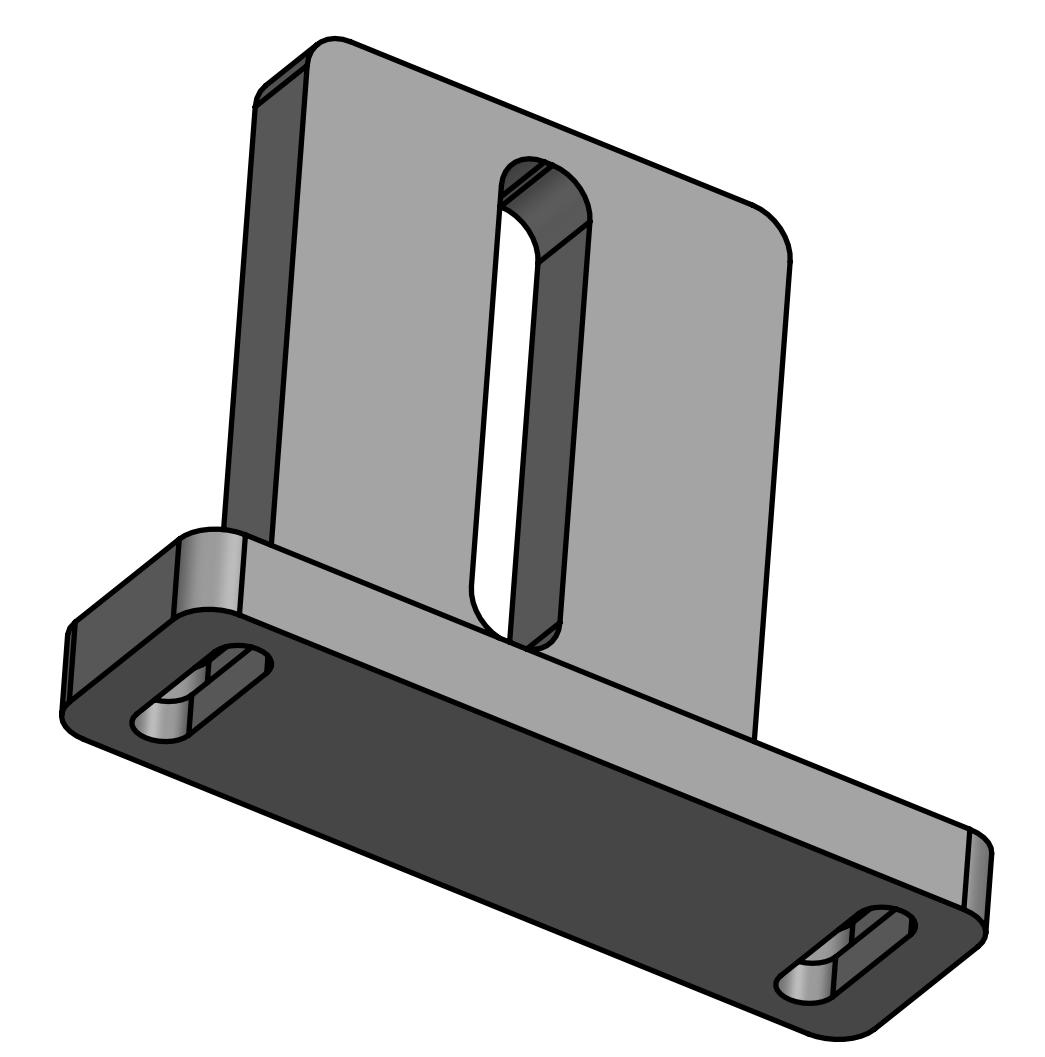
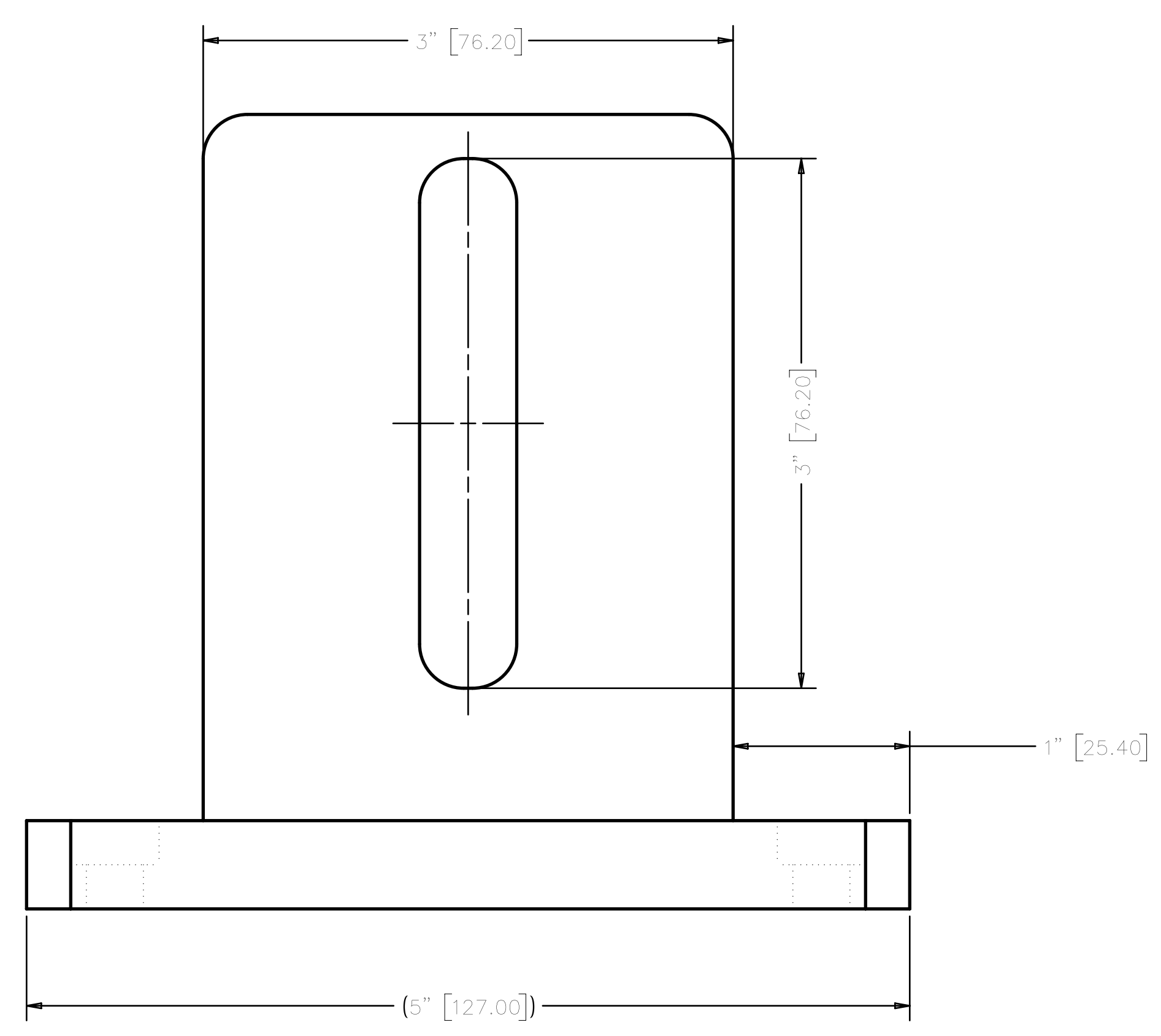
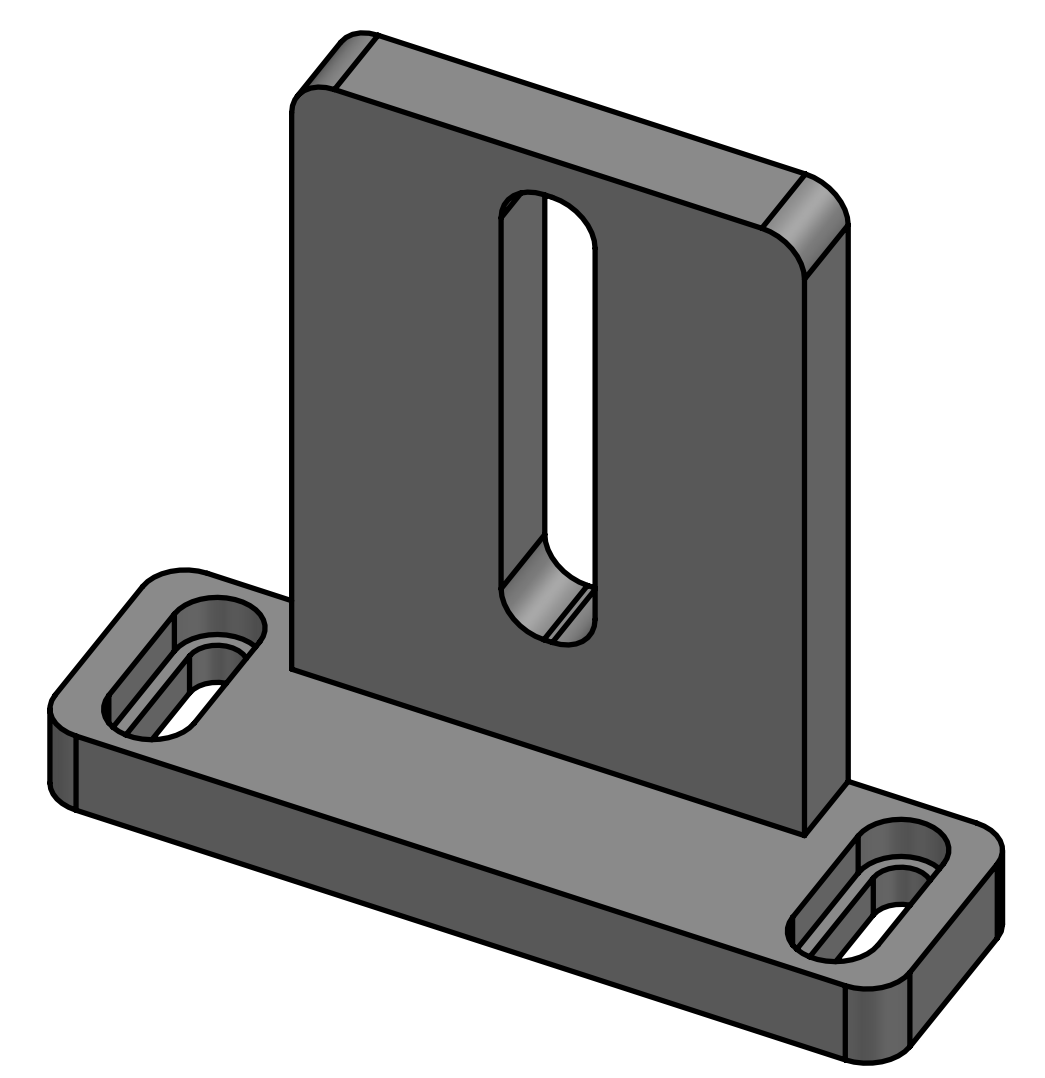
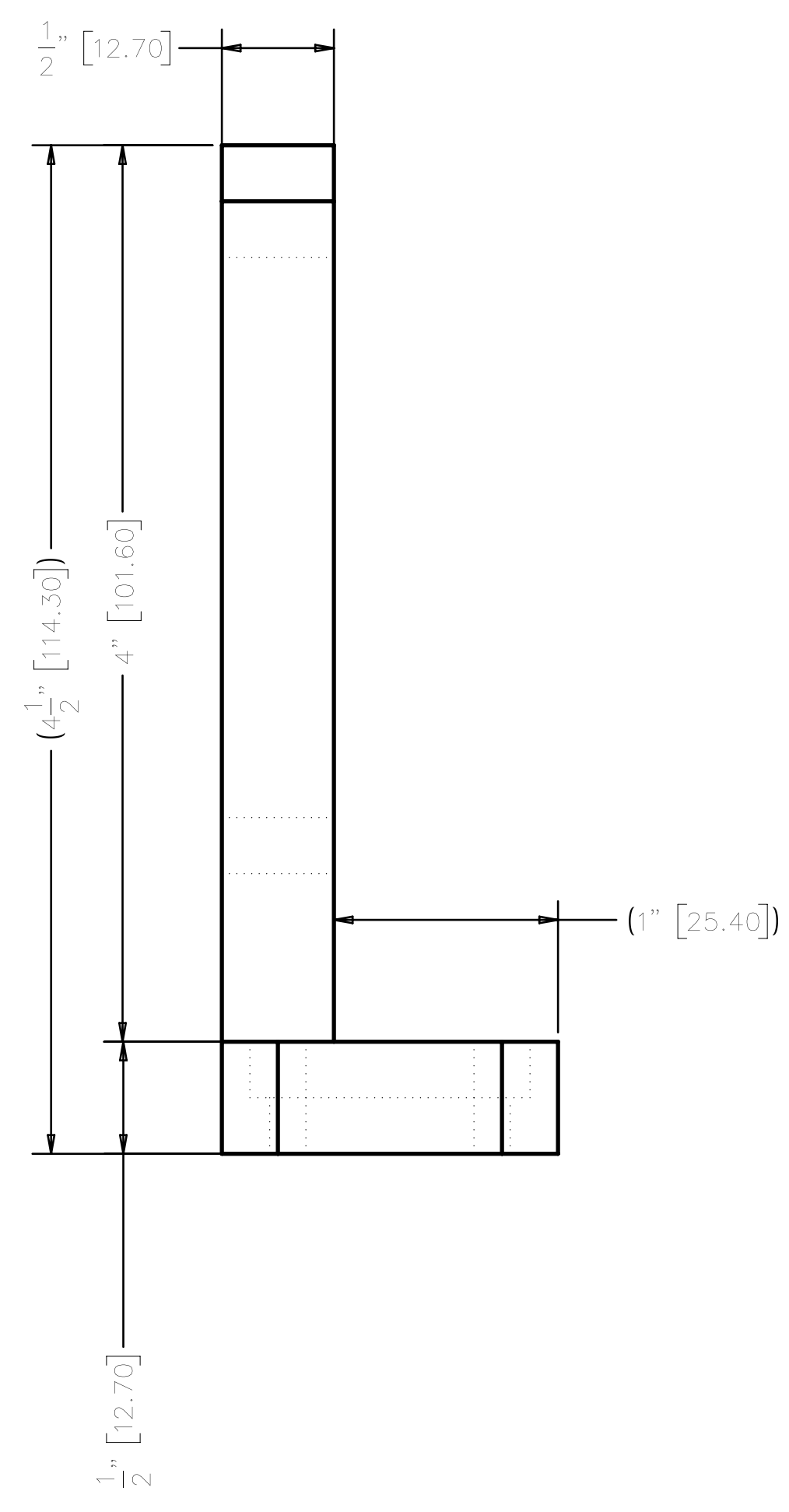
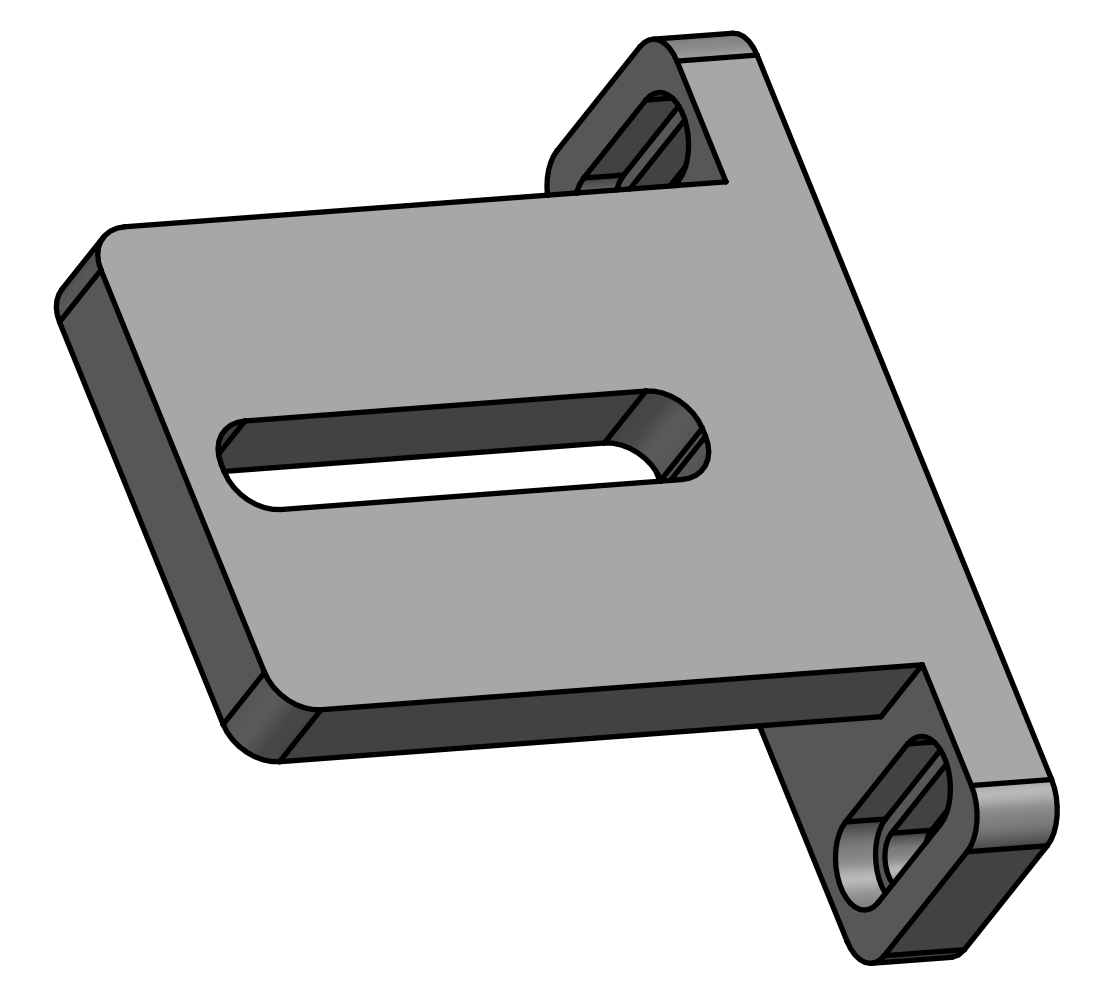
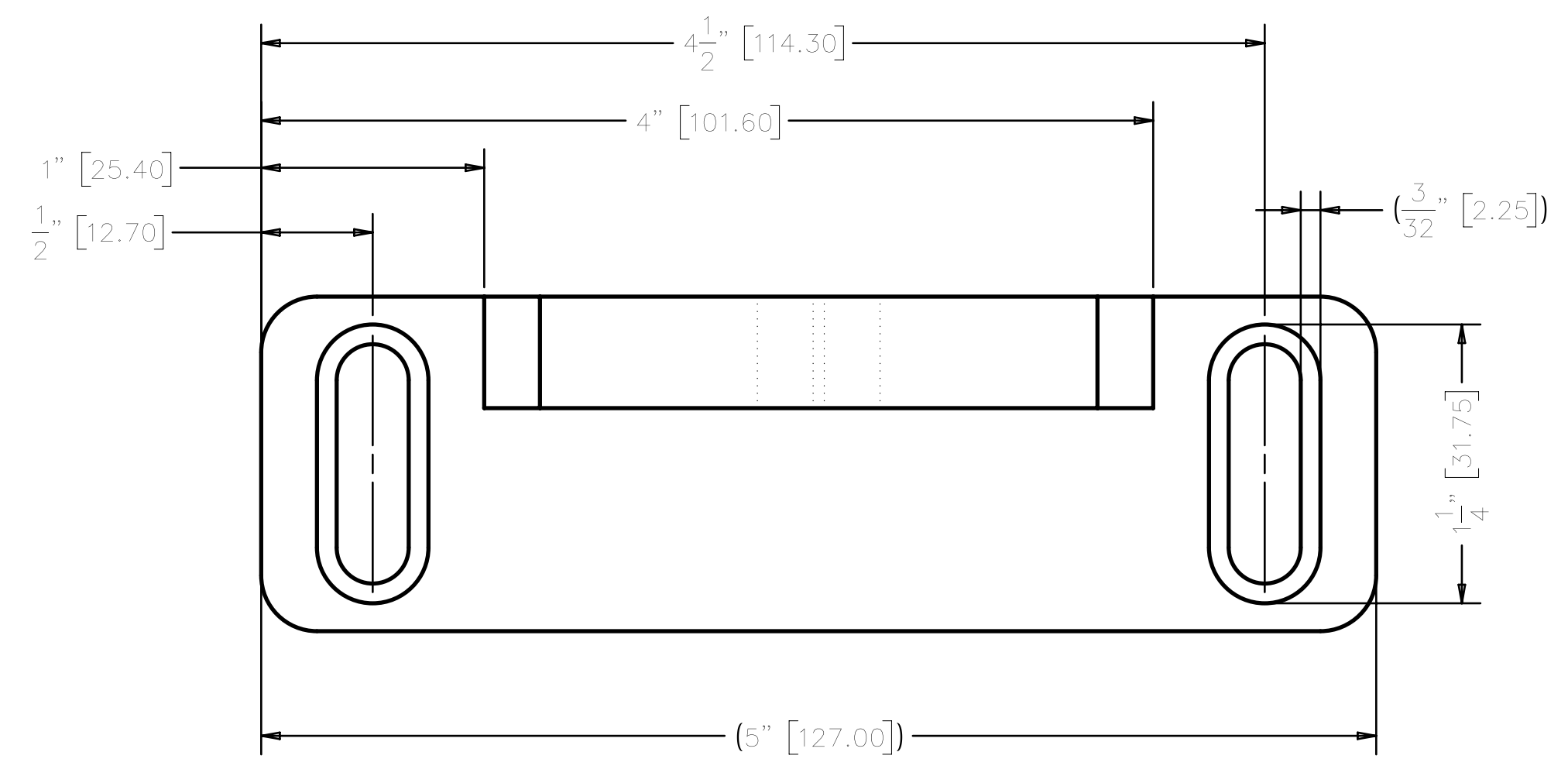
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 NOT VALID FOR EXECUTION

	Spool Joining Bracket – Kicker PFL Installation	
	IOTA Proton Injector	
Drawn by: Daniel R. MacLean Date: 21-MARCH-2024	FAST Facility / IOTA	
	QTY: 2	Materials: Aluminum (6061-T6)
		Units: US inches [mm]



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	Main Support Joining Bracket – Kicker PFL Installation	
	IOTA Proton Injector	
Drawn by: Daniel R. MacLean		
Date: 12-MARCH-2024		
	FAST Facility / IOTA	
	QTY: 1	Materials: Aluminum (6061-T6)
		Units: US inches [mm]



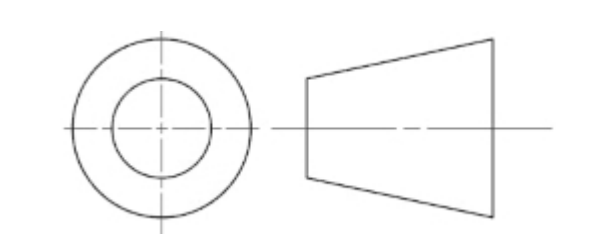
Central Joining Bracket Kicker PFL Installation

Drawn by: Daniel R. MacLean

IOTA Proton Injector

Date: 12-MARCH-2024

FAST Facility / IOTA

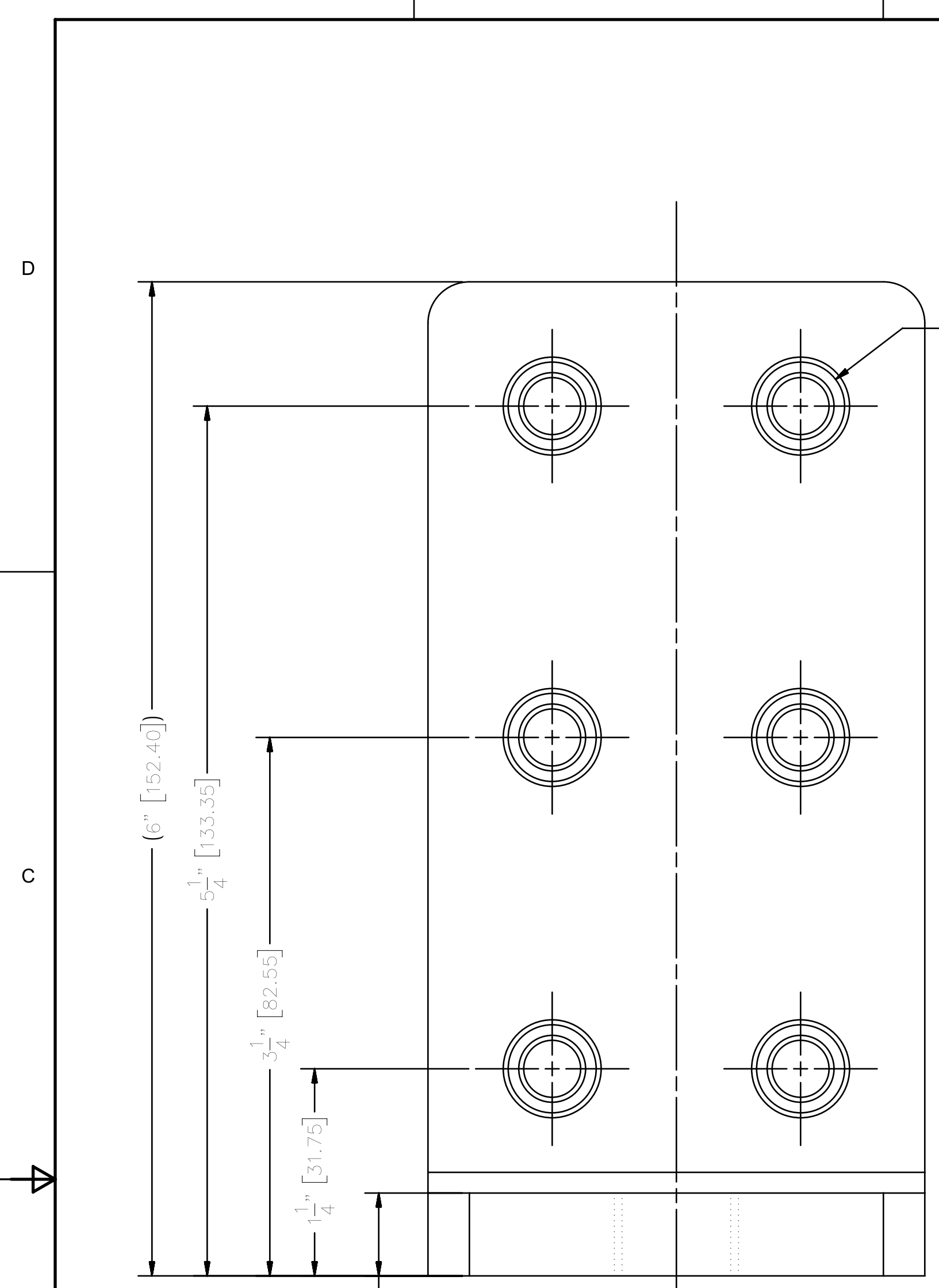


QTY: 4

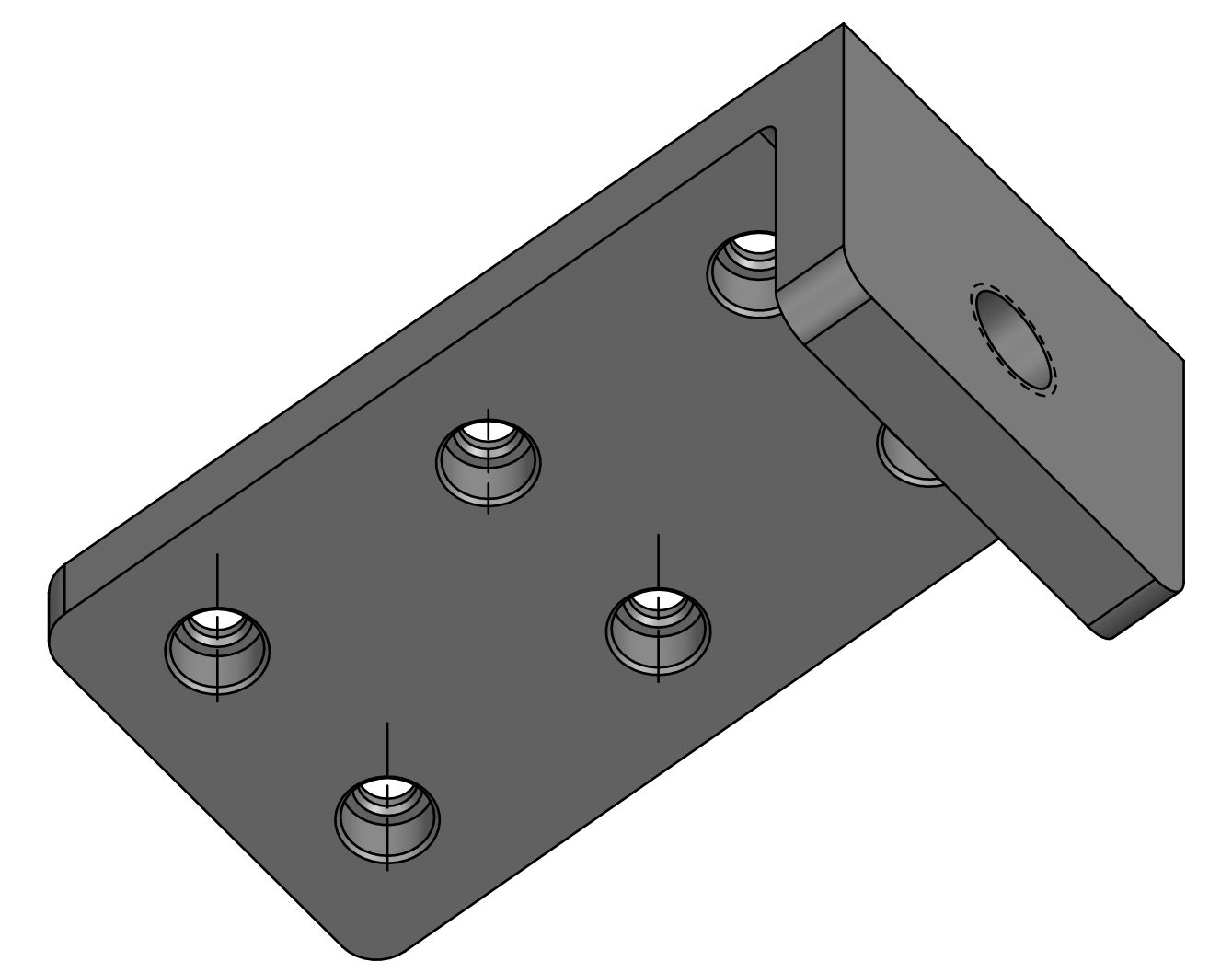
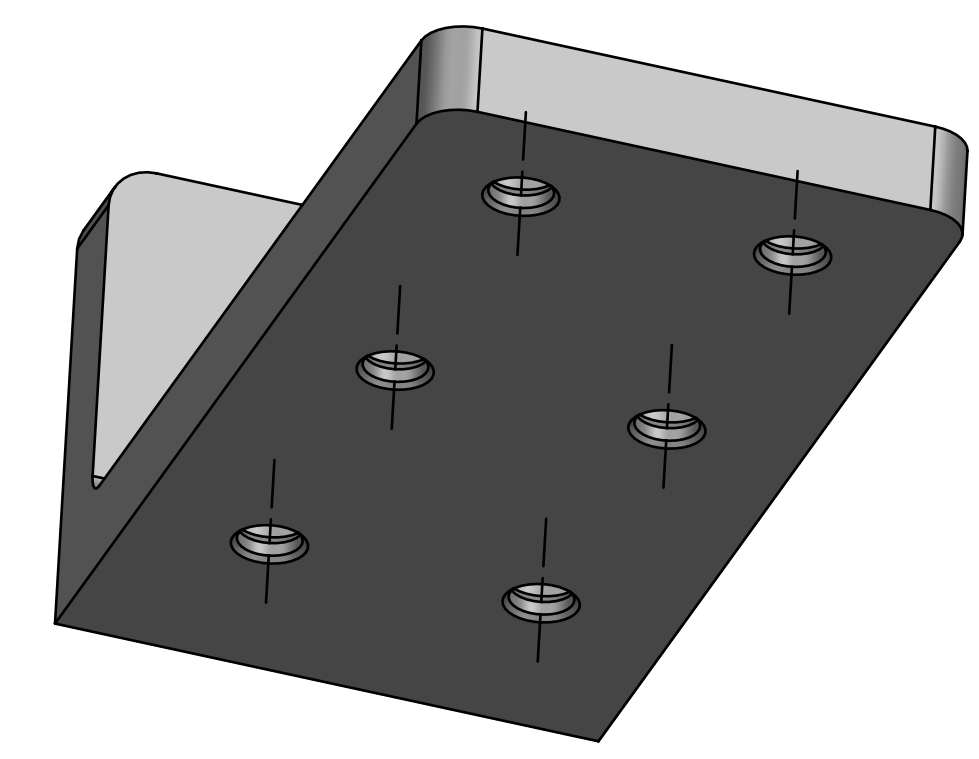
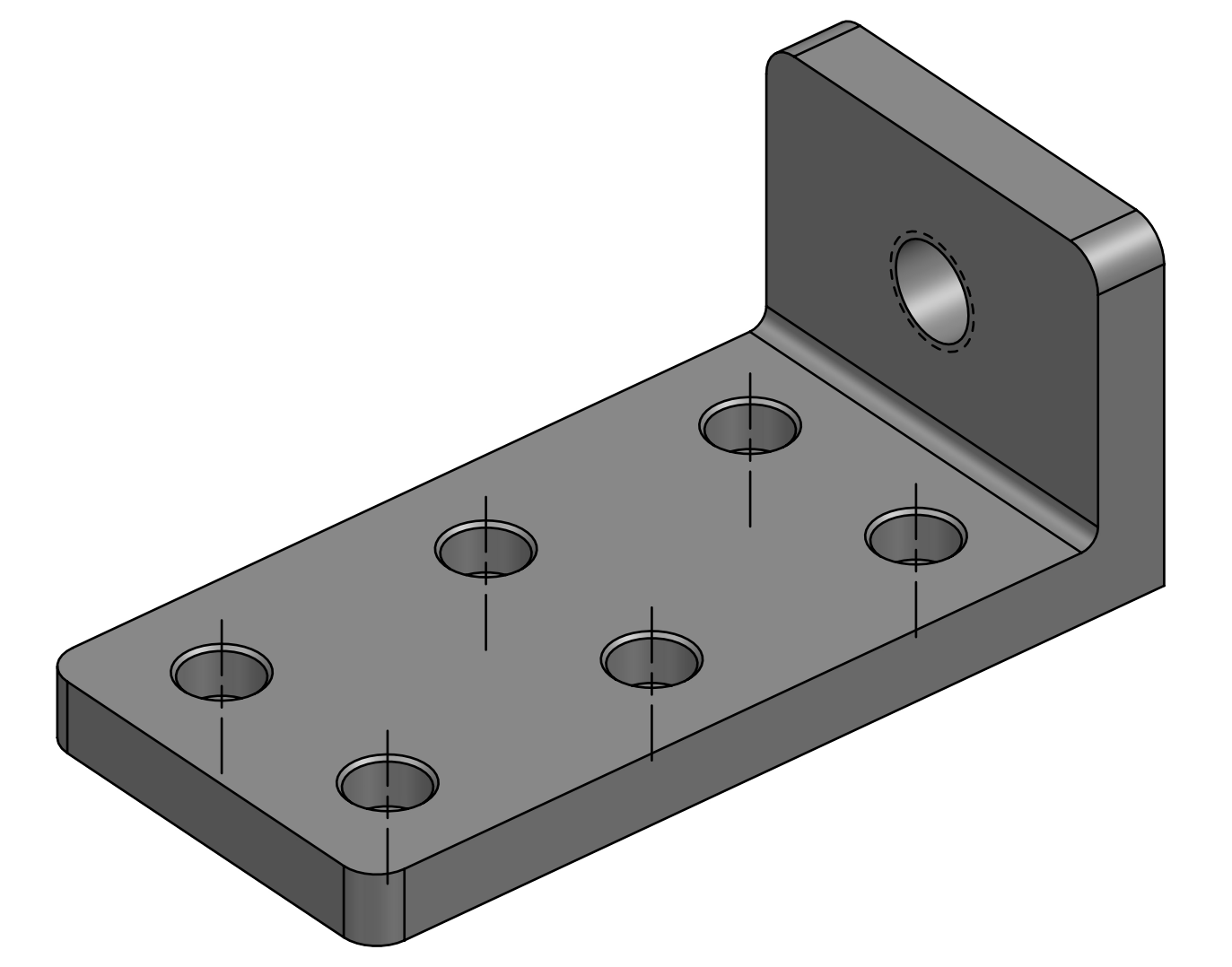
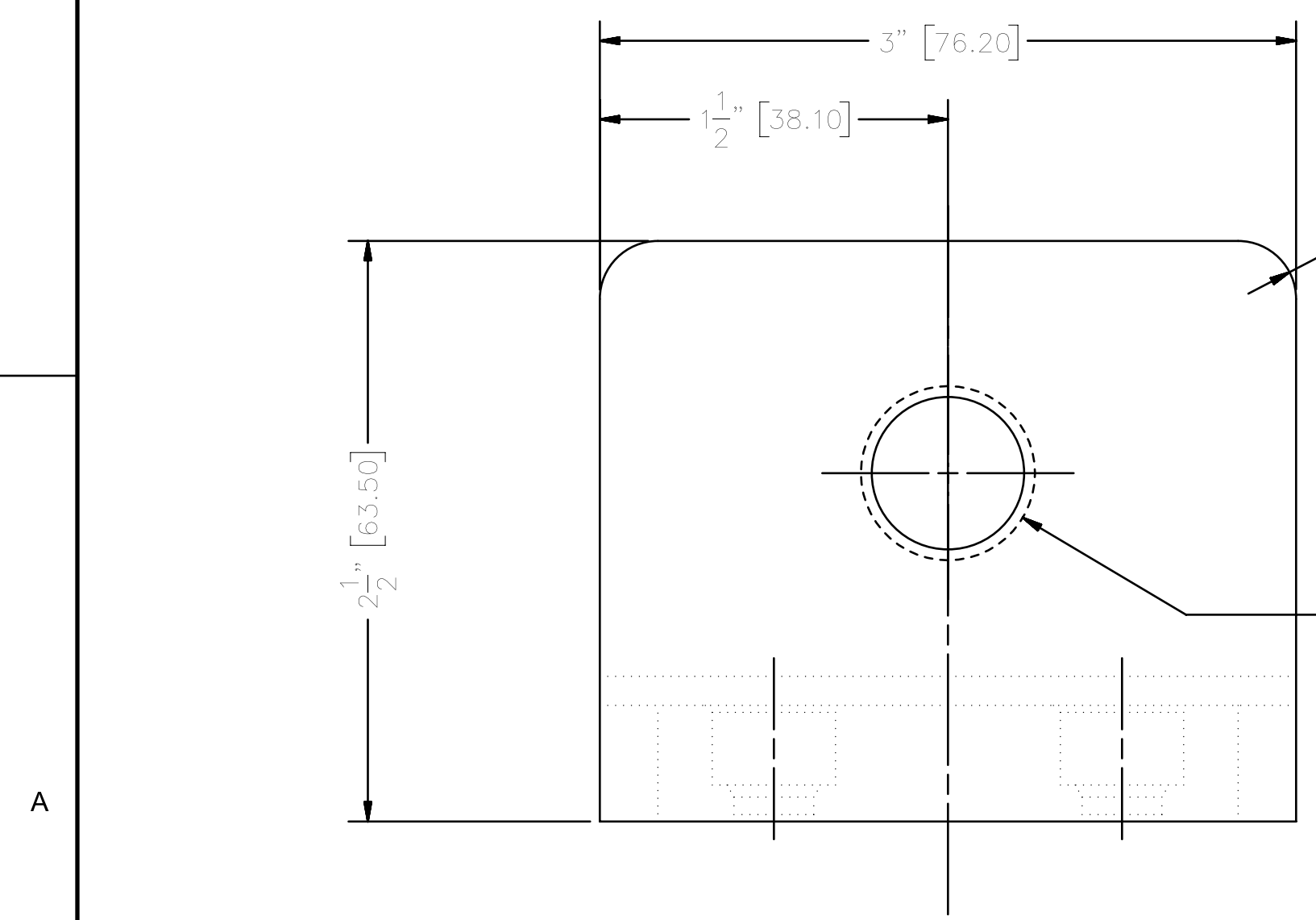
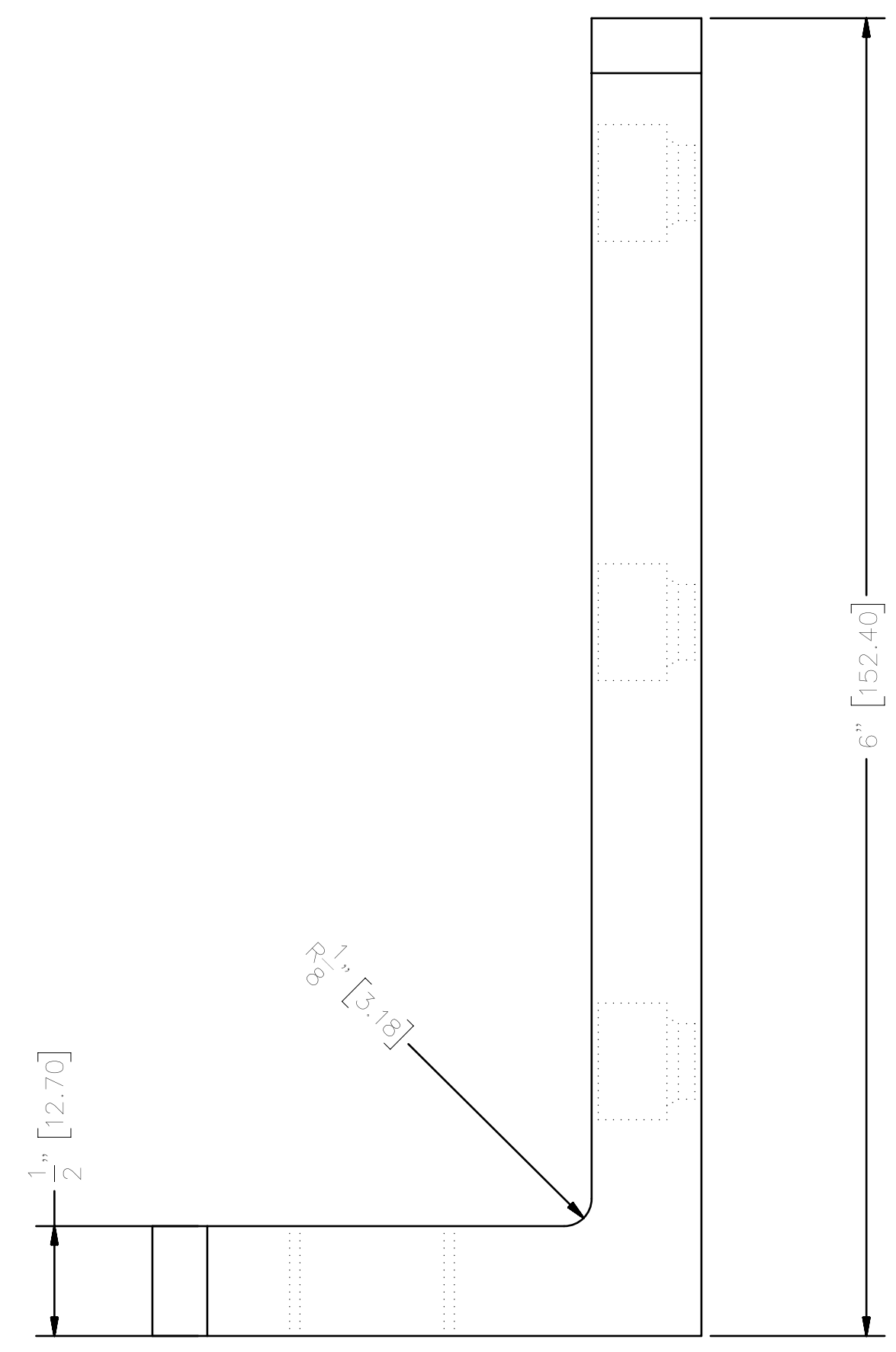
Materials: Aluminum (6061-T6)

Units:
US inches
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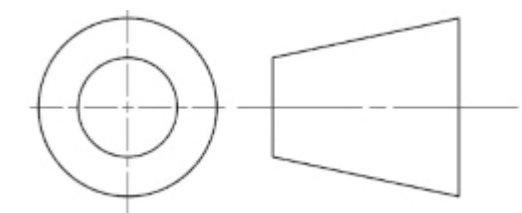


- 6X
- 5/16 - \varnothing 11/32 [8.73] Normal THRU
- \perp \varnothing 17/32 [13.49] ∇ 11/32 [8.71]
- \sphericalangle \varnothing 19/32 [15.02] X90°
- \sphericalangle \varnothing 13/32 [10.25] X60°
- \sphericalangle \varnothing 13/32 [10.25] X90°-Other End



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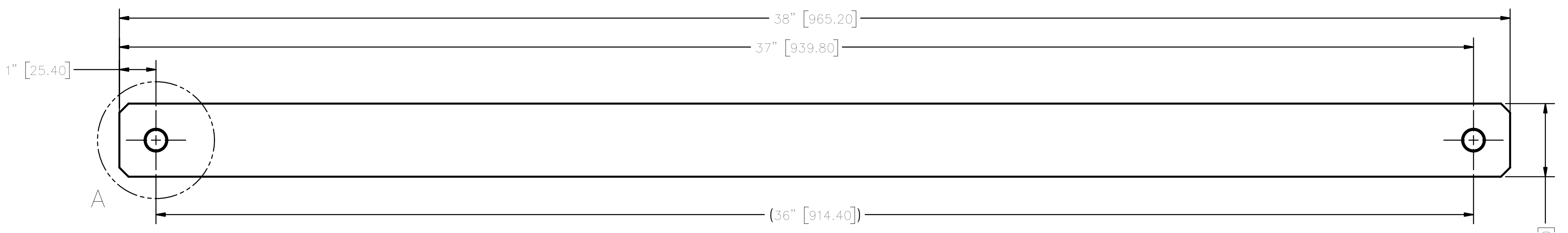
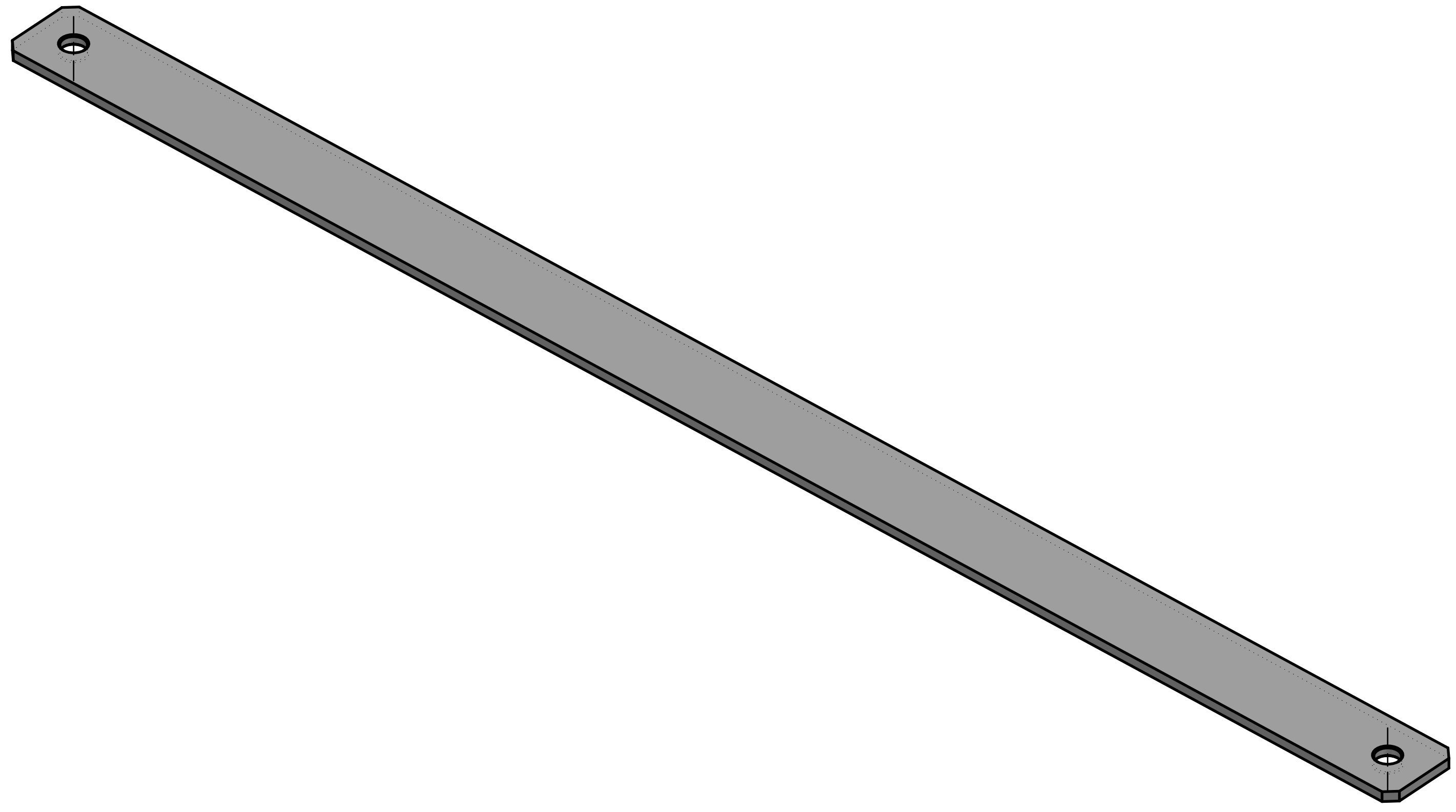
		Eyebolt Fixture Plate – Kicker PFL Installation	
		IOTA Proton Injector	
Drawn by: Daniel R. MacLean Date: 21-MARCH-2024		FAST Facility / IOTA	
QTY: 2	Materials: Aluminum (6061-T6)	Units: US inches [mm]	




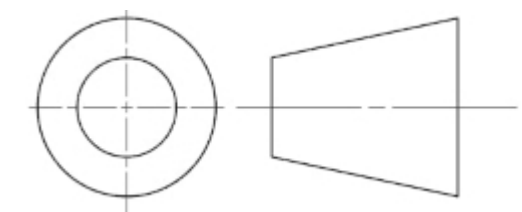
2X
 1/2 - $\varnothing \frac{9}{16}$ [14.29] Normal THRU
 $\sphericalangle \varnothing \frac{5}{8}$ [15.81] X90°
 $\sphericalangle \varnothing \frac{5}{8}$ [15.81] X90°-Other End

1/4" CHAMFER 45°
 (4X; ALL CORNERS)

DETAIL A
 SCALE 2:1



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	Tie-Down Bracket – Kicker PFL Installation		
	IOTA Proton Injector		
Drawn by: Daniel R. MacLean			
Date: 12-MARCH-2024			
	FAST Facility / IOTA		
	QTY: 4	Materials: Aluminum (6061-T6)	Units: US inches [mm]

8

7

6

5

4

3

2

1

D

C

B

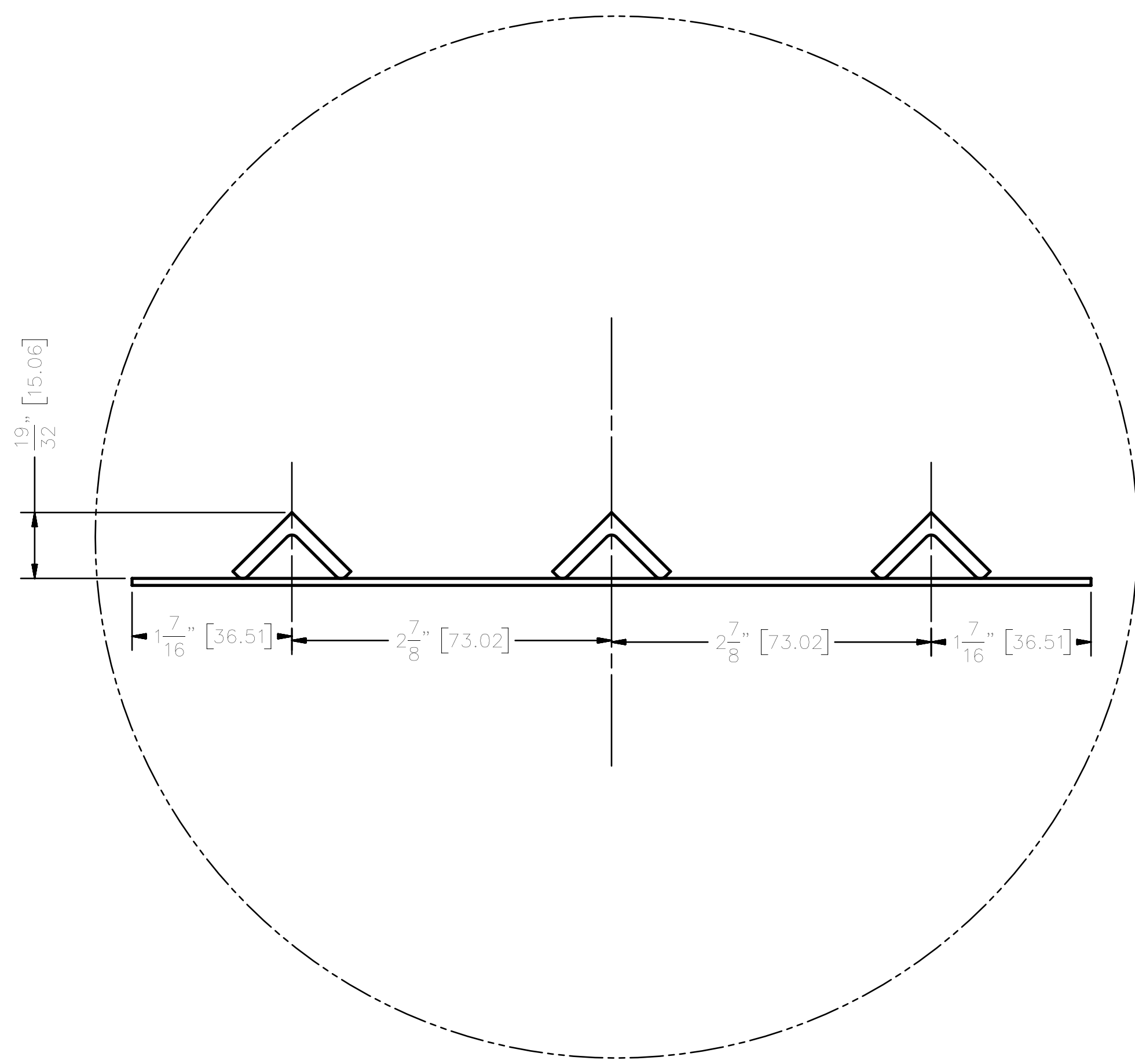
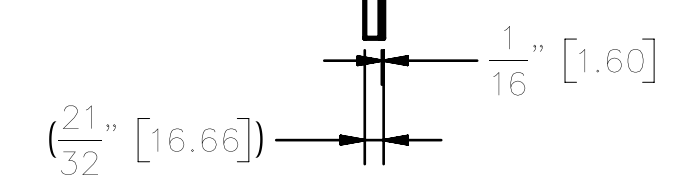
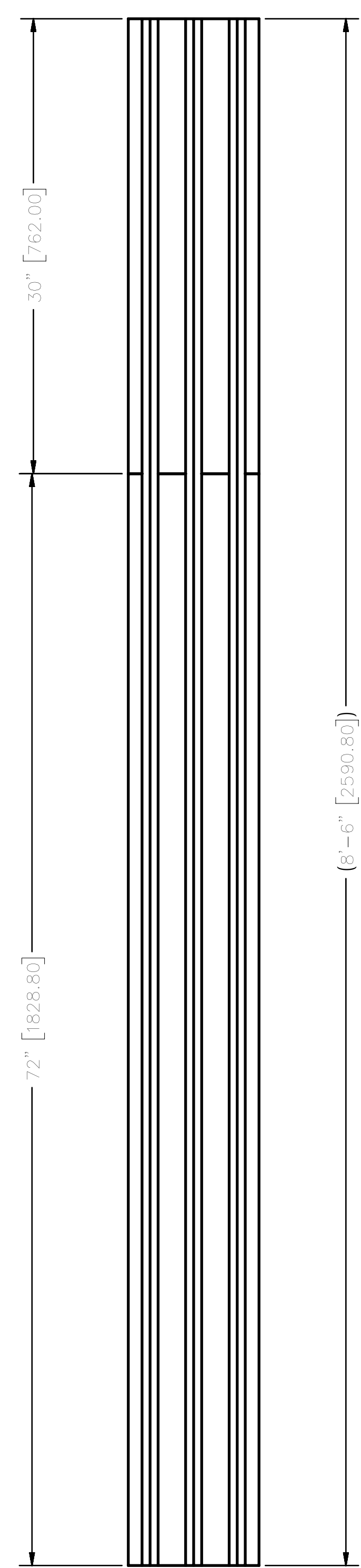
A

D

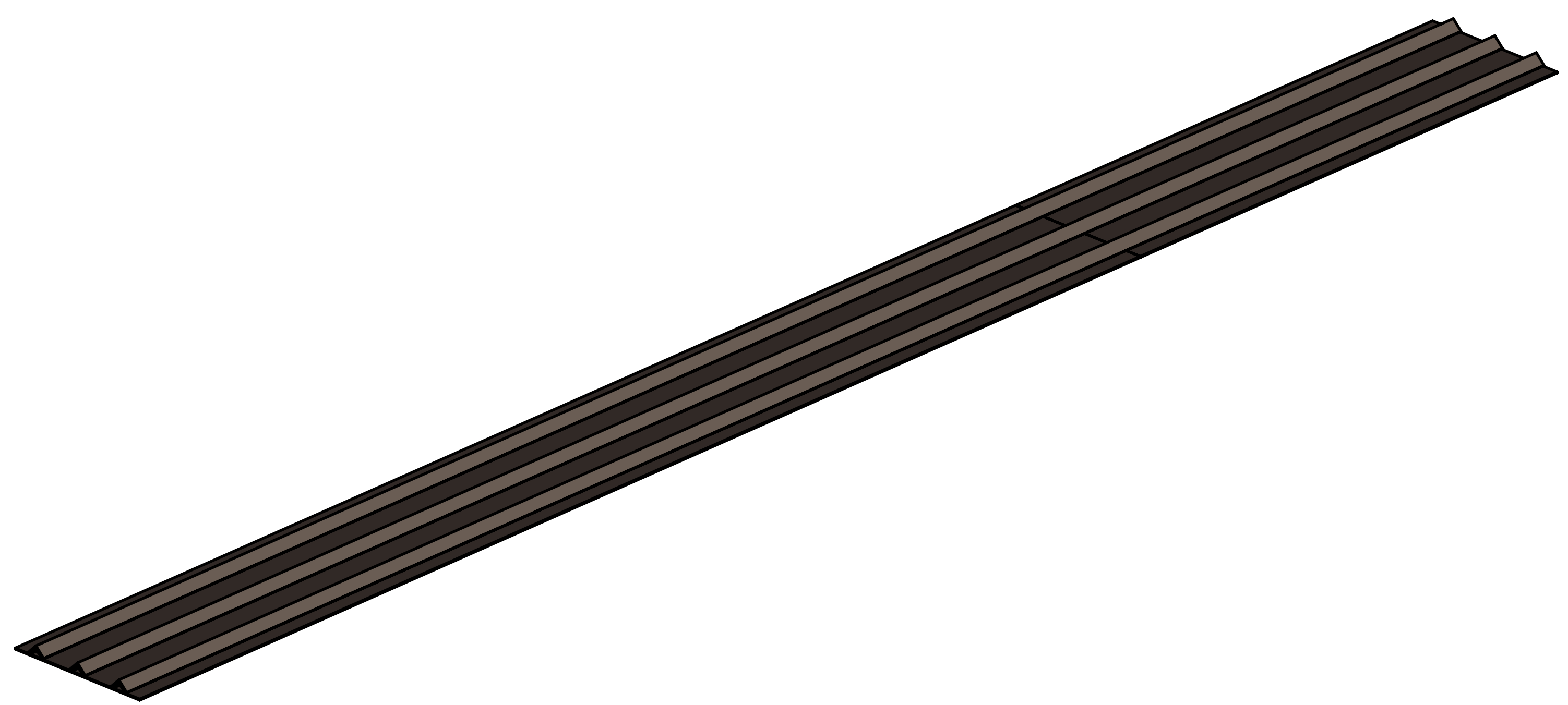
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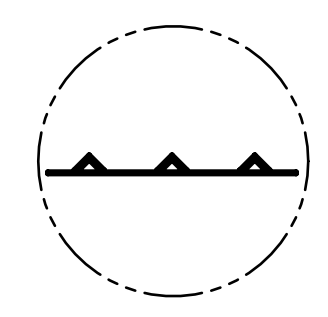
A



DETAIL A
SCALE 1:1



--- UNCONTROLLED ---
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A

	Wheel Guide / Track Sub-Assembly – IOTA Kicker PFLs	
	IOTA Proton Injector	
Drawn by: Daniel R. MacLean Date: 22-MARCH-2024	FAST Facility / IOTA	
	QTY: 1	Materials: Steel (ASTM A36, 4130-Chromoly)
		Units: US inches [mm]

8

7

6

5

4

3

2

1

