The University of Texas at Arlington Department of Mechanical and Aerospace Engineering

MAE 3344.001: Introduction to Manufacturing Engineering

MAE 3344 Project

FSAE Pedal Box

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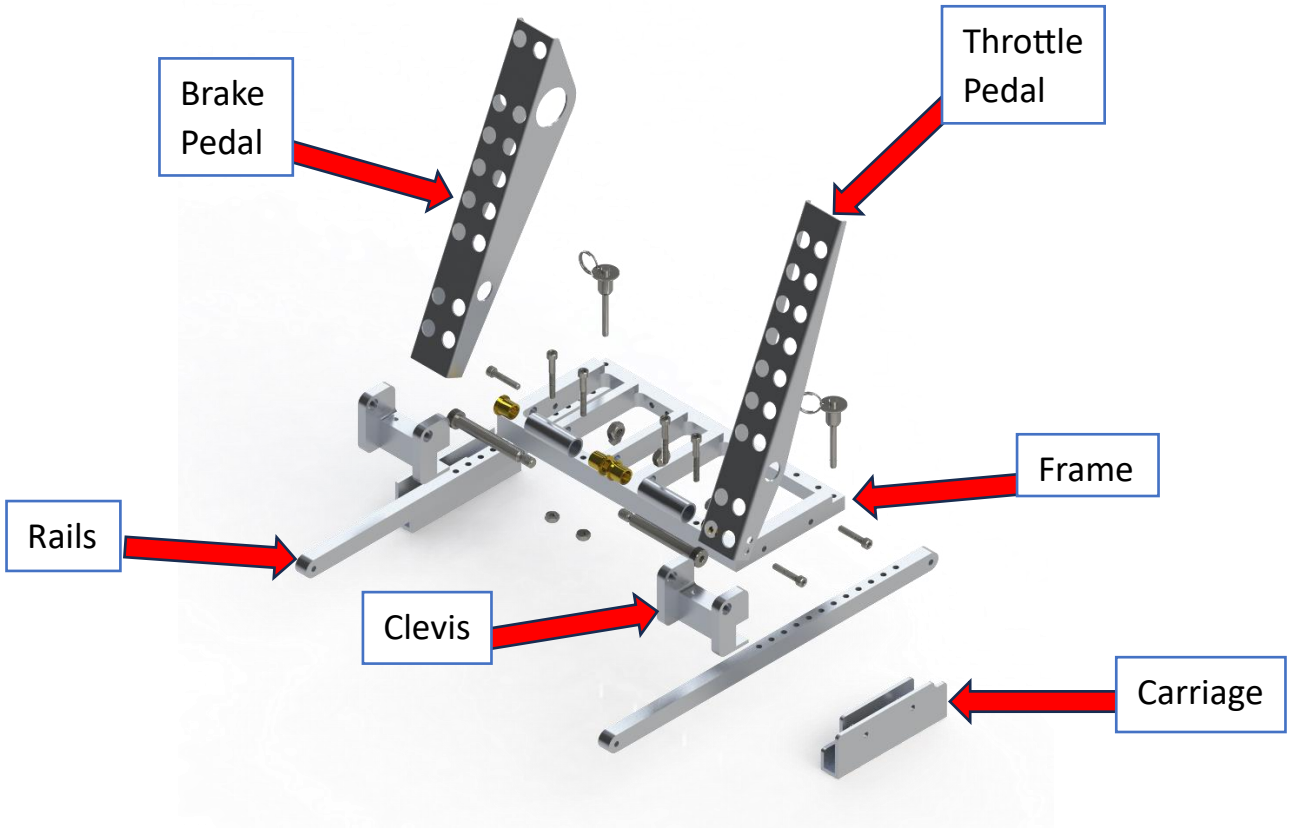
Pedal Box Assembly

The assembly being made is a modified version of a pedal box assembly used by a team in an FSAE Collegiate Competition where teams at different universities across the world build and race their won formula style cars. Each team designs and builds a car from scratch, from the chassis, suspension, aerodynamics, and many other systems. This also includes the braking system of the car and how the driver interacts with it, in other words, the pedal box with a throttle pedal and brake pedal. This assembly has had each part modified to be easily mass-produced cost effectively, so that the assembly may be sold to the teams within the FSAE community. It has been redesigned so that any team may install into their car since the total space occupied by the assembly requires less space than the minimum space required by competition rules. Since there are both electric and internal combustion engine cars, the accessories for throttle control and the braking components do not come with the assembly. In its place, there are mounting points in the form of #10 diameter holes for mounting throttle control accessories, safety sensors, and any other sensors or accessories a team would want. Cutting the design and manufacturing time of an entire assembly would be a commodity for many teams, and with hundreds of teams within both electric FSAE, IC FSAE, and even other SAE collegiate competitions, there are plenty of teams which would be potential customers for this product.

As for the production rate, there will be 200 assemblies produced a year, at $500.00 per assembly. While there are teams which are easily capable of manufacturing their own pedal box assemblies, there are more teams which would pay for a complete assembly rather than spend time and more money creating their own. The only downside to two pedals is the lack of a third clutch pedal, which would not be an issue as most modern teams use pedal shifters, hand actuated clutches, or are fully electric.



Assembly Manufacturing Traveler

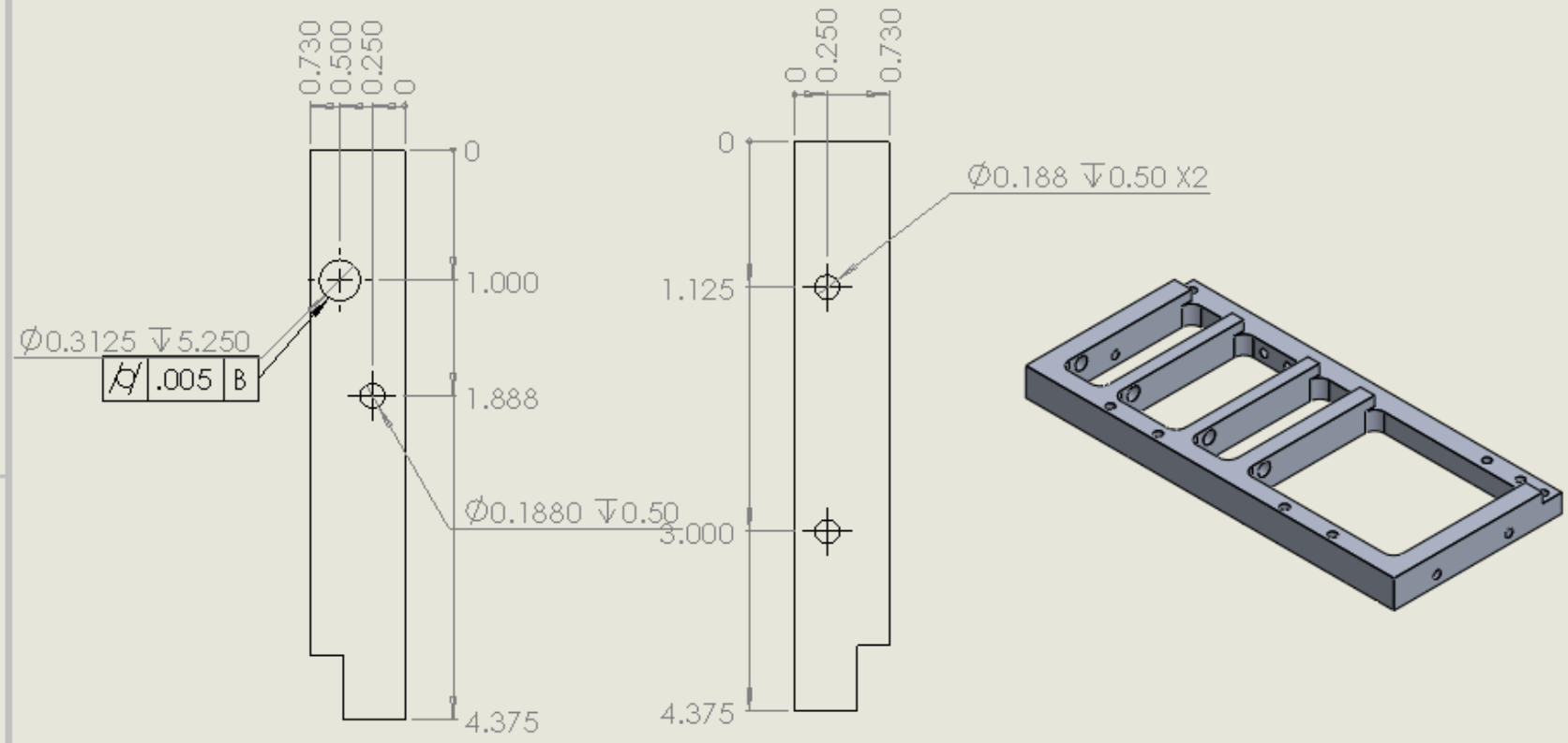
Sequence	Process	Description	Hardware	Time
1	Attach clevises to frame	Bolt in clevis to mounting holes on frame	4 x 10-32 Shoulder Bolts 4 x 10-32 Nylon Locknuts	3 min
2	Attach carriages to frame	Bolt in left and right carriages to frame	3 x 10-32 Shoulder Bolts 3 x 10-32 Nylon Locknuts	3 min
3	Attach rails to frame	Slide rails into carriages and line up holes with mounting holes on frame.	2 Push Button Quick Release Pins	1 min
4	Attach pedals to clevises	Bolt brake pedal to left clevis, throttle pedal on right clevis.	2 x 10-32 Shoulder Bolts 2 x 10-32 Nylon Locknuts	3 min

Pedal Box Frame

The pedal box frame is the base of the pedal box where all other parts will mount onto, since every other part will depend on the frame being dimensionally accurate it will have tighter geometrical tolerancing than other parts. It will be made using 6061-T6 Aluminum Alloy 0.75” sheet metal stock. Cutting the stock into 10”x5” blanks will result in stock which is ready for the first facing in a 3-axis CNC mill, and for the holes on the side drilled using fixtures on a manual mill to shorten production time. After the manual milling, the rest of the part will be finished through CNC since the remaining features are more complex and time consuming than the earlier operations. Once the part is finished and through machine operations it will be inspected to ensure it will be able to fit within an assembly without issue.

3-axis milling, both CNC and manual milling, are chosen for this part since it is completely a simple 2-D profile, and not so much of a complex geometry which would require more operations. As opposed to other methods such as water jetting, laser cutting, casting, or any other method which could be a part of its process or be the start of the part, they all would need post-operation machining. Allowing a simple billet machining process to be the best solution since the part will be finished after deburring and have the best structural properties which are important for driver safety.

Sequence	Process	Description	Cycle Time
1	Saw	Saw out billet from billet stock	5min
2	CNC	Face mill surfaces to get billet into dimensions	30min
3	Manual Mill	Drill out holes on side, using jigs and fixtures	15min
4	CNC	Mill out top profile	30 min
5	Deburr	Deburr part	15min
		Total Parts Per Hour: 1	



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
TWO PLACE DECIMAL ±0.02
THREE PLACE DECIMAL ±0.002

TITLE:

Pedal Box Frame

MATERIAL: 6061-T6 (SS)

FINISH: Machined

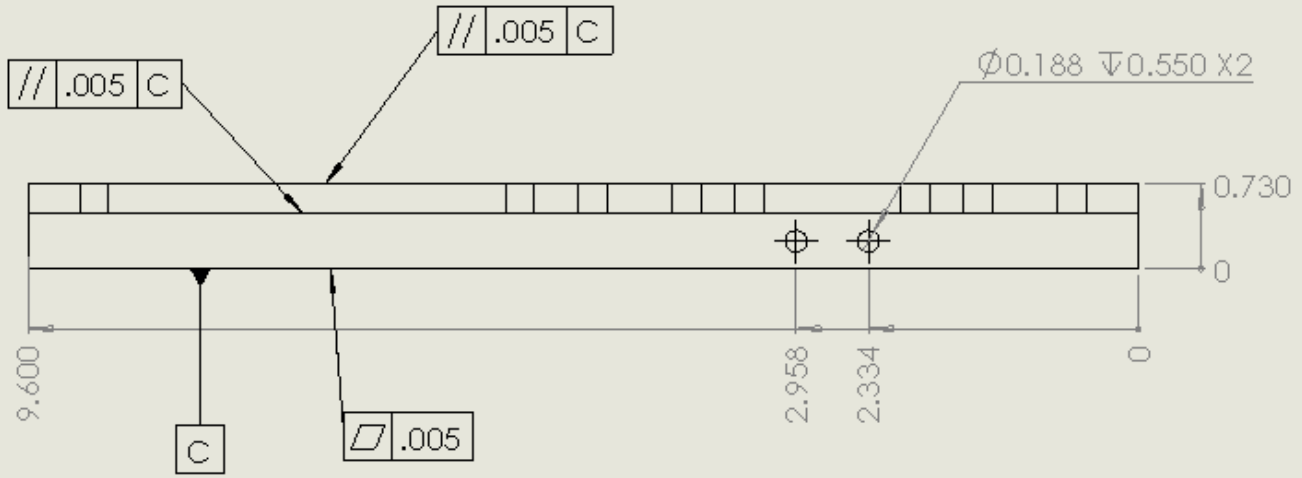
DO NOT SCALE DRAWING

SIZE: A

DWG. NO. 2

REV: 1

SCALE: 1:5 | WEIGHT: 0.96 | SHEET 2 OF 3



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
TWO PLACE DECIMAL ±0.02
THREE PLACE DECIMAL ±0.002

TITLE:

Pedal Box Frame

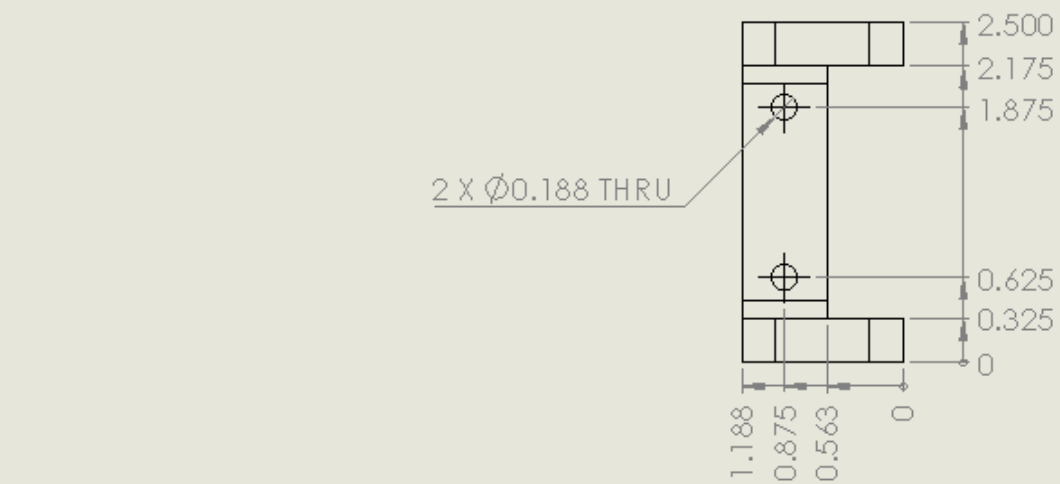
MATERIAL	SIZE	DWG. NO.	REV
6061-T6 (SS)	A	1	2
FINISH: Machined			
DO NOT SCALE DRAWING	SCALE: 2:3	WEIGHT: 0.96	SHEET 1 OF 3

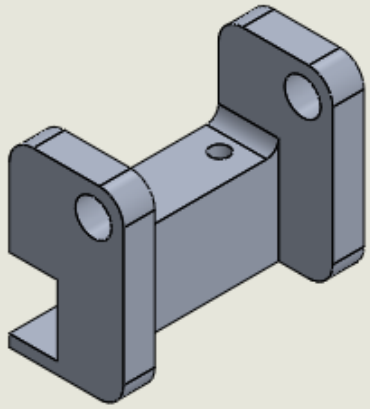
Clevis

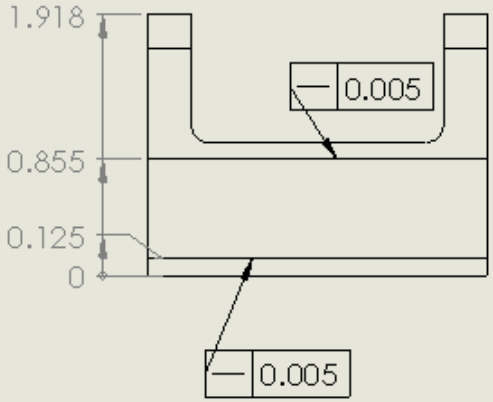
The pedal clevis can be machined by either a single 4 axis CNC, two 3-axis CNC operations with an extra drilling operation, or a manual mill with 3 operations. Whether a shop would choose to do this as a chain of simpler operations or a single operation with a 4-axis mill would likely depend on the setup of that specific shop For this case, the initial cutting operation will be done on a 3 axis CNC with the mounting slot and pedal bolt holes done on a manual mill and drill respectively since they are simple features.

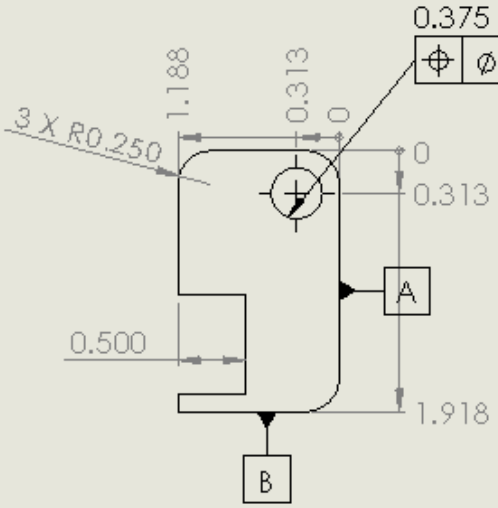
This part could potentially be made by both casting or some form of SLS printing, however, casting would require finishing operations anyway on features such as the drilled holes or the cutout where the clevis meets the rail, and 3d printing would not be cost effective for this quantity of parts.

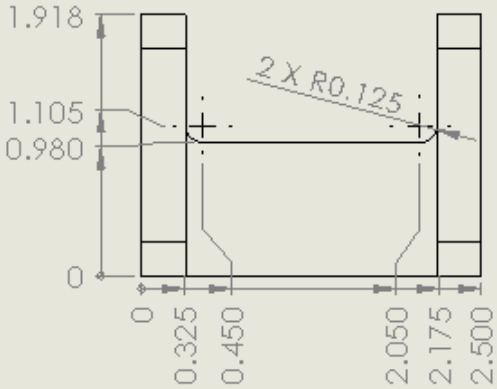
Sequence	Process	Description	Cycle Time
1	Saw	Cut 2x1.25 rectangular bar stock to length	2 min
2	CNC 3-axis	Cut pedal clevis and drill rail mounting holes	5 min
3	Manual Mill	Cut slot for mounting to pedal box	3 min
4	Drill press with fixture	Drill Pedal bolt holes	2 min
		Total Parts Per Hour: 5	











UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TWO PLACE DECIMAL ±0.010
THREE PLACE DECIMAL ±0.005

MATERIAL
6061-T6 (SS)

FINISH
Machined

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:
Pedal Clevis

SIZE	DWG. NO.	REV
A	2	

SCALE: 1:1.25 | WEIGHT: 0.16 | SHEET 1 OF 1

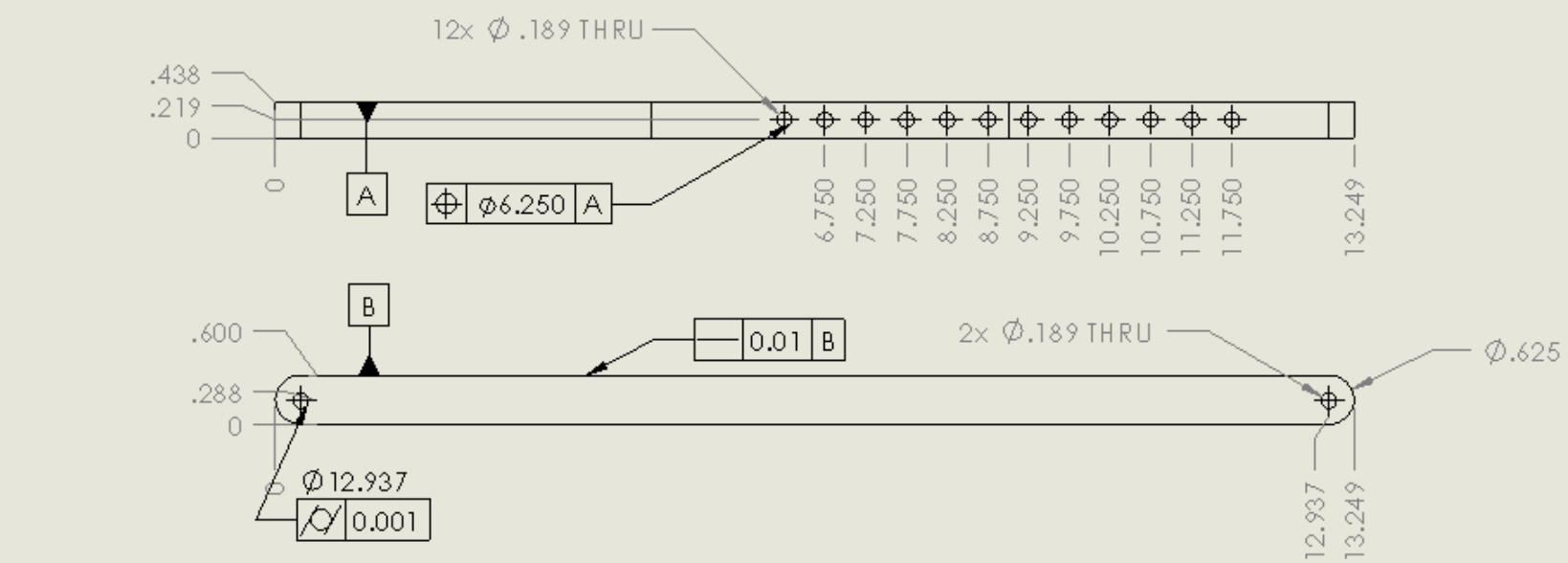
Pedal Box Mounting Rails

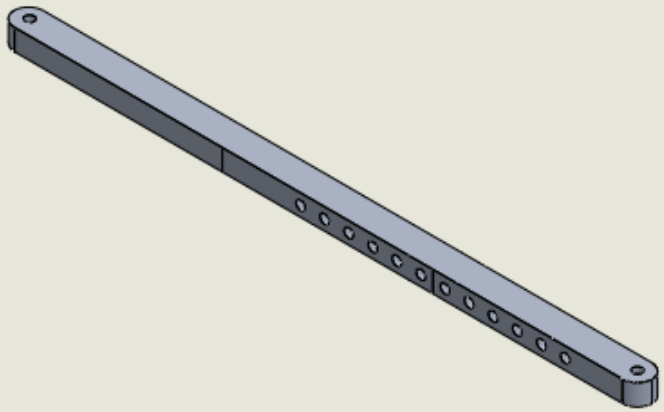
The mounting rails are the part that connect the pedal box to the chassis or a car and allow for forwards and backwards adjustment. The chosen method for the rails is CNC machining, since it allows for precise and accurate control and high repeatability. Precise controls are needed because there are multiple holes on the mounting rails that mount to other pieces, and it needs to have constant precision across the 400 pieces that are going to be manufactured. In addition, CNC machining reduces the need for outside intervention thus reducing the overall cost of creating the piece. The stock material will be 6061-T6 sheet stock with a thickness of 0.75”, the same stock from which the pedal box frame will be cut to reduce the amount of total material being bought. In the manufacturing process, the first step involves sawing a 13.25x0.44 rectangular bar stock to the required length. Subsequently, CNC machining is employed to face mill surfaces, bringing the billet into precise dimensions. Moving on, CNC operations are used to drill through holes on the side, employing jigs and fixtures for accuracy. Further CNC machining is applied to round out fillets, enhancing the part's overall geometry. Finally, the completed piece undergoes deburring to ensure a smooth and polished final product.

Die casting lacks the precision needed for pedal mounting rails, punching, may lead to hole deformations and comprise the dimensional accuracy, 3D printing, and water jetting could work, but both would need machining afterwards. Since most other methods would require machining afterwards, it is more cost and time efficient to produce the part through CNC machining.

Sequence	Process	Description	Cycle Time
1	Saw	Cut 13.25x0.44 rectangular bar stock to length	3min
2	CNC	Face mill surfaces to get billet into dimensions	15 min
3	CNC	Drill out through holes on side, using jigs and fixtures	10 min
4	CNC	Round out fillets	10 min
5	CNC	Deburr part	10 min
		Total Parts Per Hour: 1	

Drawn	Checked	Approved
MS	OA	CGIII





THIRD ANGLE PROJECTION

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DIMENSIONS ARE IN INCHES
DIMENSIONS ENCLOSED BY [ ] ARE IN MM

.XX	.XXX	.XXXX	∠
±0.02	±0.005	±0.0005	±1°

REMOVE ALL BURRS AND SHARP EDGES
R 0.01 OR CHAMFER MAX

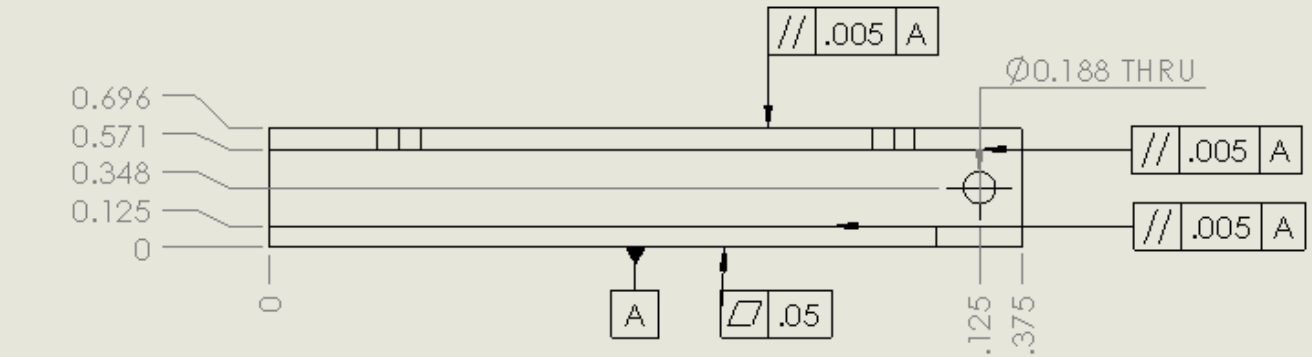
MATERIAL: 6061 Aluminum
HEAT TREAT: T6
FINISH: XXX
QUANTITY: 2
PART NAME: Pedal Mounting Rail
ASSEMBLY:
DRAWN: 12/8/2023
SCALE: 1:4
WEIGHT: 0.33 LBS
SHEET 1 OF 1

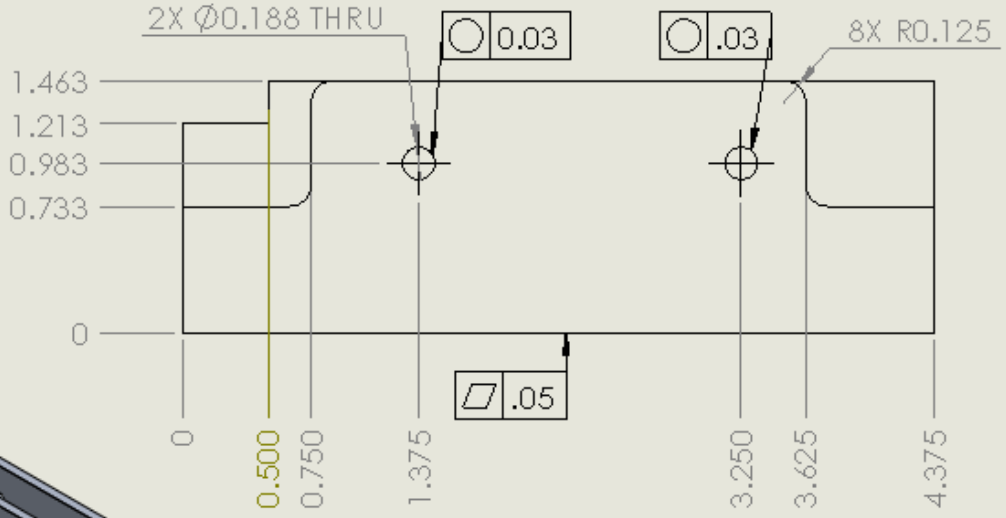
Carriages

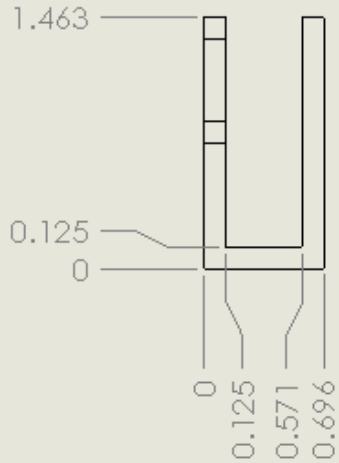
The Carriage is used to mount the pedal box to the railing system so the position can be adjustable for different drivers. The slot on the carriage allows for the pedal box to move smoothly along the rails. This slot needs to be high precision for the part to accomplish this goal. CNC manufacturing allows for good control and create parts with high tolerance features. Since the slot in the carriage has a higher tolerance than the rest of the part CNC manufacturing will be the best option for this part. The material used for this part is 6061-T6 aluminum alloy, for its strength, and machineability. The billet dimensions will be face milled manually before the part is loaded into the CNC. The holes on the carriage's side will be drilled after the profile is made in the CNC.

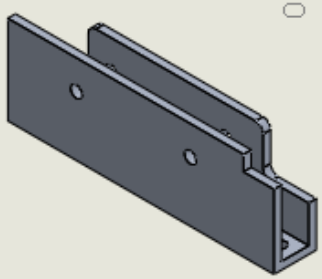
Some other options for manufacturing this part are using a waterjet to cut out a profile out of 6061 sheet metal. Then bending the sheet metal to get the proper shape. An issue with this process is that the minimum bend radius for the part is smaller than the material's. The high tolerance of the slot will also not be achieved with this process. Although a benefit of this process compared to the CNC machining is that using bent sheet metal will have a lot less material waste. Since the parts per year are around 400, creating a die for the carriage will be unnecessary and expensive.

Sequence	Process	Description	Cycle Time
1	Saw	Saw out billet from rectangular bar stock	1 min
2	CNC	Face mill surfaces to get billet into dimensions	5 min
3	CNC	Mill out profile and slot	15 min
4	Manual Mill	Drill side holes	3 min
		Total Parts Per Hour: 4	









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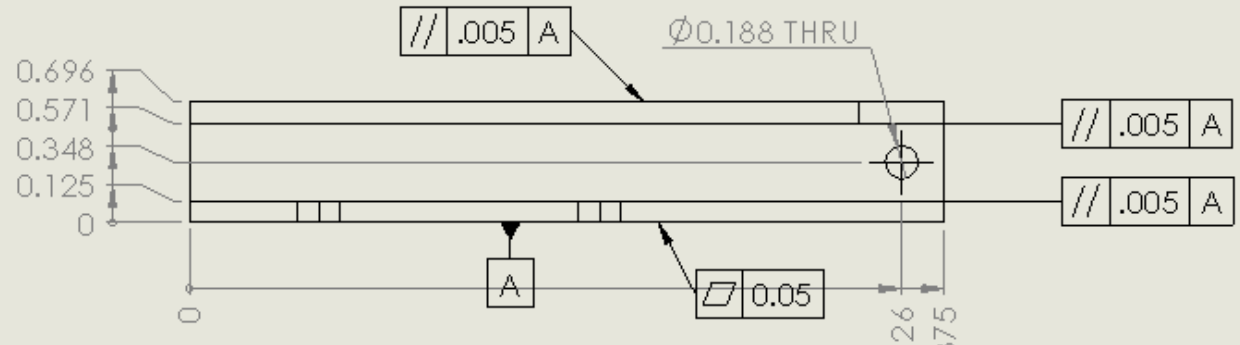
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TWO PLACE DECIMAL ±0.01 THREE PLACE DECIMAL ±0.005	DRAWN		
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL: 6061-T6(SS)	COMMENTS:		
FINISH: Machined Finsih			
NEXT ASSY / USED ON			
APPLICATION	DO NOT SCALE DRAWING		

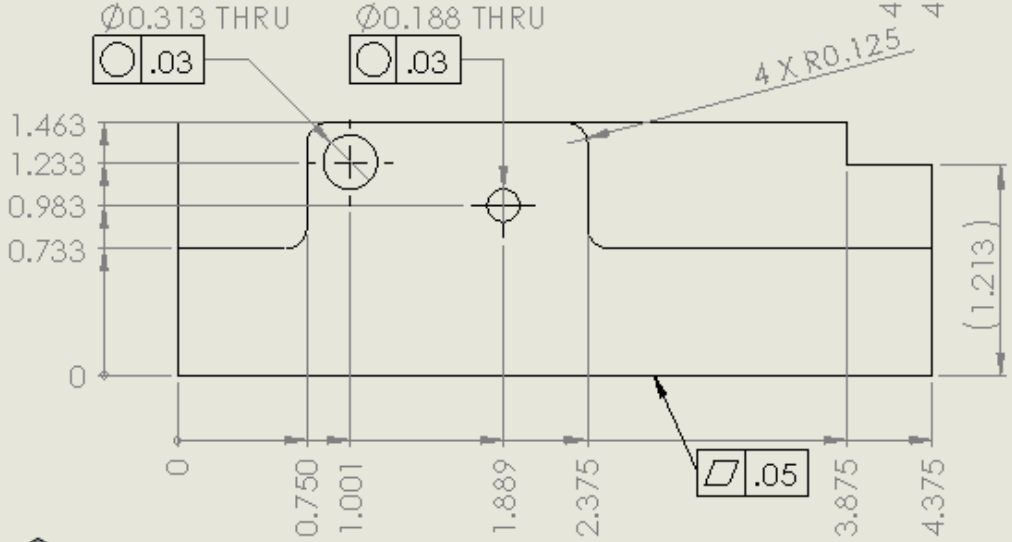
TITLE:

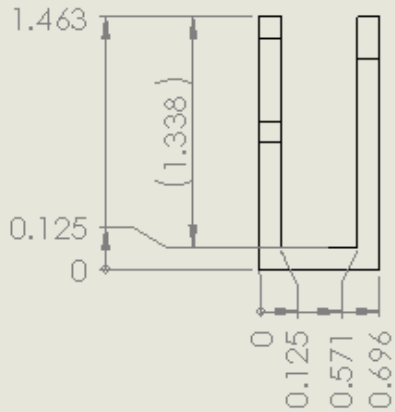
Pedal Box Carriage

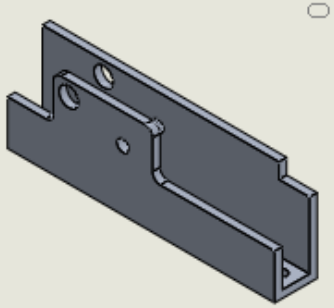
SIZE	DWG. NO.	REV
A	3	

SCALE: 1:1 | WEIGHT: 0.16 | SHEET 1 OF 1









	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TWO PLACE DECIMAL ±0.010
THREE PLACE DECIMAL ±0.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL: 6061-T6 Aluminum
FINISH: Machined
DO NOT SCALE DRAWING

TITLE:
Pedal Box Carriage Left

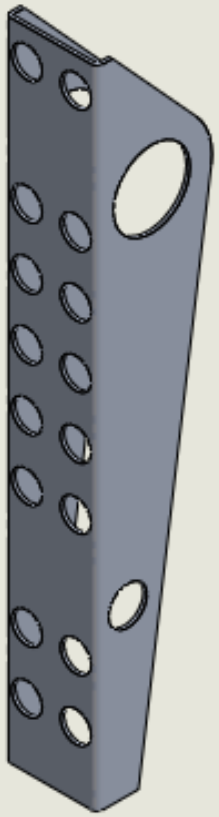
SIZE: A | DWG. NO. | REV
SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

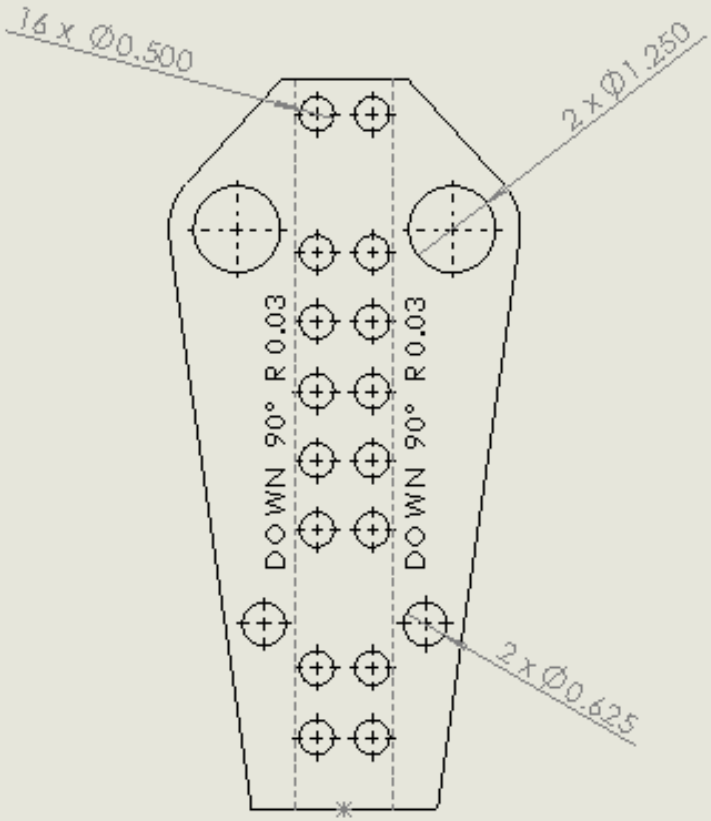
Pedals

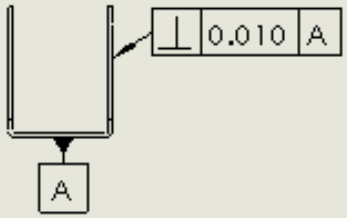
The pedals are a simple part to manufacture, done by a waterjet and sheet metal bender. Both the throttle and brake pedal will be manufactured by the same process, but the geometry of each will be slightly different. For this case, we will use 1/16” 5052-H32 aluminum that is easily bendable and can have tighter bends than other alloys. A program for the waterjet can be made to cut the geometry of the pedals. Before bending, the pedal can be deburred to get rid of all sharp edges. Then it can be taken to a sheet metal bending brake and bent using a solid block on the inside to ensure a proper bend angle.

Water jetting the geometry of the pedals is more effective than stamping and more cost effective than laser cutting. Having a quantity of 200 of each pedal does not justify creating a die or the cost of laser machining. Using a sheet metal bender is also a cost effective and uncomplicated way to bend all the pedals for the low quantity being manufactured.

Sequence	Process	Description	Cycle Time
1	Waterjet	Cut out pedal geometry	5min
2	Deburr	Remove all sharp edges	2 min
3	Bend	Bend pedals into shape	3 min
		Total Parts Per Hour: 6	







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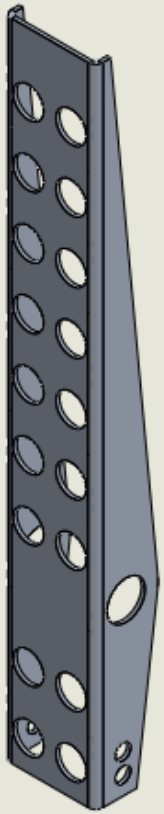
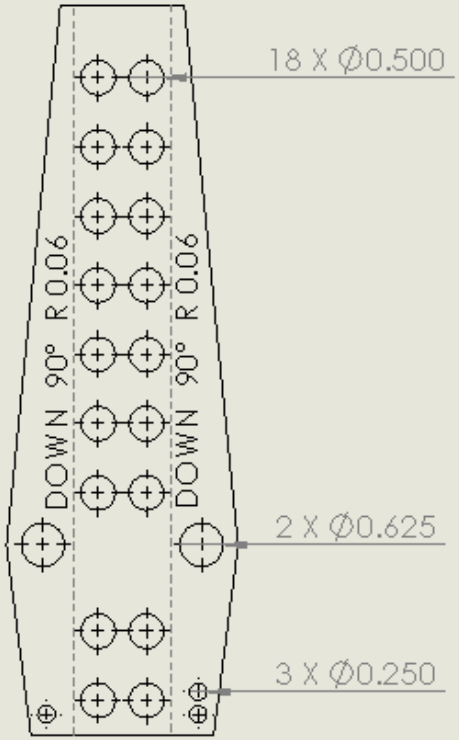
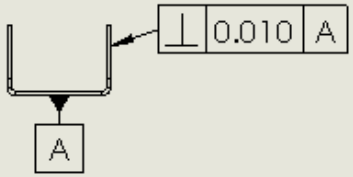
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL 6061-T6 (SS)	COMMENTS:		
NEXT ASSY	USED ON		
APPLICATION	DO NOT SCALE DRAWING		

TITLE:

SIZE	DWG. NO.	REV
A	Brake Pedal	
SCALE: 1:5	WEIGHT: 0.21	SHEET 1 OF 1







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	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL 6061-T6 (SS)	COMMENTS:		
FINISH			
NEXT ASSY / USED ON			
APPLICATION / DO NOT SCALE DRAWING			

TITLE:

SIZE	DWG. NO.	REV
A	Throttle Pedal	

SCALE: 1:5 | WEIGHT: 0.15 | SHEET 1 OF 1