



Collings Foundation, Inc.  
Windsor Locks, CT  
October 2, 2019  
ERA20MA001

**NATIONAL TRANSPORTATION SAFETY BOARD  
WASHINGTON, D.C.**

ATTACHMENT 1

AERODESIGN ENGINEERING DOCUMENT #1191-4

18 Pages

U.S. Department of Transportation Federal Aviation Administration <b>STATEMENT OF COMPLIANCE WITH THE FEDERAL AVIATION REGULATIONS</b>			Date JAN 24 1995
Aircraft or Aircraft Component Identification			
Make BOEING AIRCRAFT	Model No. B-17G	Type(Airplane, Radio, Helicopter, etc.) AIRPLANE	Name of Applicant COLLINGS FOUNDATION
LIST OF DATA			
Identification	Title		
AERODESIGN REPORT #1191-4, REV. IR, 1-24-95	"STRUCTURAL SUBSTANTIATION, SEATS, BOEING MODEL B-17G"		
<b>STRUCTURAL APPROVAL ONLY</b>			
Note: This aircraft is certified under a limited Type Certificate; It does meet any FAR's or CAR's. It is an ex-military aircraft. The appropriate sections of CAR 4b were used for substantiation.			
Purpose of Data SUPPORT OF FAA FORM 337 (MAJOR ALTERATION); DESIGN APPROVAL ONLY			
Applicable Requirements (List specific sections)  CAR 4b.200(a)(c), 4b.201(a)(b)(c), 4b.202(a)(b), 4b.260(a)(c), 4b.302, 4b.303  4b.306(a)(b)(c), 4b.358(a)(b)(c)			
CERTIFICATION - under authority vested by direction of the Administrator and in accordance with limitations of appointment under Part 183 of the Federal Aviation Regulations, data listed above and on attached sheets numbered <u>NONE</u> have been examined in accordance with established procedures and found to comply with applicable requirements of the Federal Aviation Regulations.			
I (We) Therefore <input type="checkbox"/> Recommend approval of these data			
I (We) Therefore <input checked="" type="checkbox"/> Approve these data			
Signature(s) of Designated Engineering Representatives		Designation Number(s)	Classifications
R.M. Howard, Jr. 			Structural

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Engineering Report No. 1191-4

"Structural Substantiation, Seats,  
Boeing Model B17G"

Prepared for: The Collings Foundation

Revision: IR

Prepared by:

Approved by:

Date: July 13, 1994

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report 1191-4 sheet 1  
prep. by R. Howard  
chkd. by [redacted]  
revision [redacted]

REVISION PAGE

Rev. Letter	Description	Date	Approval
--	initial release	1-24-95	[redacted]

#### REFERENCES

1. MIL-HDBK-5F, "Metallic Materials and Elements for Aerospace Vehicle Structures."
2. Bruhn, E. H., Analysis and Design of Flight Vehicle Structures, 1973 Edition.
3. Roark, Raymond, Formulas for Stress and Strain, Fourth Edition, McGraw-Hill Book Company, 1965.
4. Bell Helicopter Textron, "Structural Design Manual," Revision C.
5. Machinery's Handbook, 21st Edition, Industrial Press, Inc., 1981.
6. Summerill Aircraft Tubing Data, March 1941, Section III, "Design Charts, Design Data, and Formulas for Aircraft Tubing."
7. Civil Aviation Regulations, CAR 4b.

## 1.0 INTRODUCTION

The aircraft to be modified is a Boeing Model B-17G, certified with a Limited Type Certificate.

The modification pertains to the installation of seats in the aircraft for crew (in addition to the pilot and co-pilot) and/or passengers.

The seats consists of supports at the occupants bottom and back, for all seats.

## 1.1 SCOPE

This report includes the structural installation of the seats only. No other substantiations are included here. The installation of seat belts is not a part of this report, but is contained within AERODESIGN Report #1191-1, and has been approved previously.

The aircraft is a converted military aircraft, which was given a Limited Type Certificate, after World War II. The aircraft was not certified in accordance with any Civil Air Regulations, since it was a military aircraft. The appropriate certification regulations of CAR 4b will be used for this substantiation, as these regulations came into effect soon after the aircraft were given the Limited Type Certificate.

## 2.0 DESCRIPTION OF MODIFICATION

The modification consists of adding the following seats:

1. Four seats in the aft area of the waist gunners. The seats (side by side) are two per side of the aircraft. The occupants have support underneath and on the outboard side (at the back of the occupants). The support outboard consists of a 5/8" plywood seat back attached to the aircraft frames by aluminum angles and brackets. The support underneath consists of a cushion secured to the floor panel. All cushions consists of a minimum of 2" of stiff foam, covered with a durable fabric, secured with Velcro.
2. One seat, aft facing, against the bulkhead just forward of the belly turret. The occupant has support underneath and on the forward side, at the bulkhead (at the back of the occupant). The support at the forward side (the occupant's back) is a cushion secured to the bulkhead by Velcro. The support underneath consists of a cushion secured to the floor panel, with Velcro.
3. Two persons (across from each other), side facing, in the radio operator's room. These occupants have support underneath and on the outboard side (at the back of the occupants). The support outboard consists of a 5/8" plywood seat back attached to the aircraft frames by aluminum angles and brackets. The support underneath consists of a cushion secured to the floor panel with Velcro. All cushions consists of a minimum of 2" of stiff foam, covered with a durable fabric, secured in place with Velcro.
4. Two occupants located just aft of the flight crew. One is behind the pilot and one is behind the co-pilot. These are aft facing seats, with support underneath and on the forward side. The support at the forward side (the occupant's back) is a cushion secured to the structure by Velcro. The support underneath consists of a cushion secured to the floor panel, with Velcro.

It should be noted that one of these seats (behind the pilot or co-pilot) has been approved previously for use by a crew member by an FAA FSDO Office. Please see the aircraft records for more detailed information.

### 3.0 LOAD FACTORS

From CAR 4b.260, the emergency landing ultimate load factors are

sideward	1.5 g's
upward	2.0 g's
forward	9.0 g's
downward	4.5 g's.

For maneuvering and gust conditions, the values of 6.6 g's downward and 3.0 g's up can be used in accordance with AC43.13-2A for ultimate load factors.

From TSO-C39b, and NAS 809, which is the basis for the loads to be substantiated by TSO-C39b, "Aircraft Seats and Berths," the load factors for a transport category aircraft are

2.0 g's up
6.0 g's down
9.0 g's forward
3.0 g's side

The load factors to be used for analysis here are the highest for each direction, taken from the above values. These are given below.

sideward	3.0 g's
upward	3.0 g's
forward	9.0 g's
downward	6.6 g's.



#### 4.0 STRUCTURAL SUBSTANTIATION

The seating positions are specified below in accordance with the listing in Section 2.0 above.

##### 4.1 POSITION #1

###### 4.1.1 Forward Loads

The critical forward loads are on the belt attachments (see Report #1191-1).

The resulting downward component of the load is 765 lbs. (see Report #1191-1). The loads are reacted through the cushion into the floor. The floor can support this load, by inspection. No further analysis is required.

The outboard component of the load, 765 lbs. (see Report #1191-1), is reacted by the seat back. Each seat back has its own support structure attached to the airframe. The outboard load can be divided between the forward and aft sides. The most critical of the four aft seats will be substantiated. The other three are adequate by comparison.

All of the seat backs have the plywood attached to an extruded angle, 1.5" by 1.5" by .125" thick, made from 2024-T3 aluminum per QQ-A-200/3. These are attached by AN3 bolts or similar hardware of 125 ksi tensile strength. One bolt attaches each angle to the seat back (total of 4 for the back).

The angle is attached to a bracket made from .125" thick 2024-T3 aluminum sheet. The bracket is at least 1.5" high, for all cases. The length (the distance from the airframe attachment to the angle at the plywood back) ranges from 0" (for the angle attached directly to the frame) to 11".

For all cases, two bolts (#1032, AN3 or MS27039-1 screws) are used to attach the angle to the bracket, and the bracket to the airframe. The load is only in the outboard direction; there are no other components of load. All other loads are reacted by the belts and the floor.

The shear per bolt is  $(765/2) * .5 = 192$  lbs. and is not critical, as the bolts are rated for 2259 lbs. in shear (per reference 1).

The angles or brackets are not critical in bearing because of the .125" thickness. From Report #1191-1, the minimum frame thickness is .063". The aircraft frame bearing stress is (for two bolts at the connection)  $192 / (.063 * .188) = 16,211$  psi, and is not critical.

The only critical aspect of the installation is the bracket in compression. From reference 2, page C2.1, for columns, the allowable load is

$$F_{cr} = \pi^2 * E / (L/\rho)^2$$

For the bracket,  $I = bh^3/12 = 1.5 * 1.5 * (.125)^3/12 = .000244$  in<sup>4</sup>. The cross sectional area =  $.125 * 1.5 = .188$  in<sup>2</sup>.

Therefore,  $\rho = \text{SQRT}(I/A) = \text{SQRT}(.000244/.188) = .0361$  in.

The allowable load is

$$F_{cr} = \pi^2 * 10.5E6 / (11/.0361)^2$$
$$= 1134 \text{ lbs.}$$

$$M.S. = 1134/192 - 1 = +4.91 \quad \leftarrow \text{-----}$$

#### 4.1.2 Aft Loads

Aft loads are not required. The assumed load factor of 1.5 is less than the forward loads; the installation of the seat and belts are loaded the same as for the forward condition. These are not as critical as for the forward condition. No analysis is required.

#### 4.1.3 Down Loads

Down loads are reacted from the seat bottom into the floor. The load is distributed from the cushion into the floor. The floor is adequate the support this load. No further analysis is required.

#### 4.1.4 Up Loads

The up load per occupant is  $3.0 * 170 = 510$  lbs. This imposes an outboard load component per occupant of  $.707 * 510 = 361$  lbs. This is less than the upward load imposed by the forward load condition, and is not critical. No further analysis is required.

#### 4.1.5 Side Loads

The side load per occupant is  $3.0 * 170 = 510$  lbs. This imposes an outboard load of 361 lbs. against the seat back. This is less than the outboard load imposed by the forward load factor analyzed previously, and is not critical. No further analysis is required.

#### 4.2 POSITION #2

##### 4.2.1 Forward Loads

The forward loads are reacted by the seat back into the bulkhead. The occupant has a padded headrest and seat back attached to the bulkhead. The 2 inch thick padding (minimum) stiff foam pad is adequate to support the head and back for forward loads.

The bulkhead is adequate by inspection to react the forward loads; no further analysis is required.

##### 4.2.2 Aft Loads

The aft loads impose a downward load on the seat bottom. This load is small compared to the load from the downward load condition, and is not critical.

##### 4.2.3 Down Loads

Down loads are reacted from the seat bottom into the floor. The load is distributed from the cushion into the floor. The floor is adequate the support this load. No further analysis is required.

##### 4.2.4 Up Loads

The up load per occupant is 510 lbs. (see Report #1191-1). This imposes a forward load of 255 lbs., which is less than the forward load analyzed above. This is not critical. No analysis is required.

#### 4.2.5 Side Loads

The side load per occupant is 510 lbs. This imposes a forward load against the seat back and the bulkhead of  $.707 * 510 = 361$  lbs. due to the angle of the seat belts. This is less than the loads analyzed previously, and is not critical. No further analysis is required.

### 4.3 POSITION #3

#### 4.3.1 Forward Loads

These positions are identical on opposite sides of the aircraft. The occupants are seated on the seat bottom, which is attached to the floor.

The resulting downward component of the load is 765 lbs. (see Report #1191-1).

The outboard component of the load, 765 lbs. (see Report #1191-1), is reacted by the seat back. The seat back is similar to those used for the position #1 seats. The brackets are not used or shorter than those used for the aft seats. The loads are the same, and other installation details are the same.

By comparison to the data analyzed previously for position #1 seats, these seats are acceptable for forward loads.

#### 4.3.2 Aft Loads

Aft loads are not required. The assumed load factor of 1.5 is less than the forward loads; the installation of the seats and belts are loaded the same as for the forward condition. These are not as critical as for the forward condition. No analysis is required.

#### 4.3.3 Down Loads

Down loads are reacted from the seat bottom into the floor. The load is distributed from the cushion into the floor. The floor is adequate the support this load. No further analysis is required.

#### 4.3.4 Up Loads

The up load per occupant is 510 lbs. This imposes an upward load per side of 255 lbs. This is less than the upward load imposed by the forward load condition, and is not critical. No analysis is required.

#### 4.3.5 Side Loads

The side load per occupant is 510 lbs. This imposes an outboard load of 361 lbs. against the seat back. This is less than the outboard load imposed by the forward load factor analyzed previously, and is not critical. No further analysis is required.

#### 4.4 POSITION #4

##### 4.4.1 Forward Loads

These are aft facing seats. The forward load per occupant is 1530 lbs. (see Report #1191-1). This is reacted by the seat back into the existing support structure. The seat back distributes the load across the existing structural web.

The web across the tubing supports is made from .071" aluminum. This web acts as a diaphragm, supporting the occupant. This web is 36 inches from the floor, providing support for the seat back. This structural support was substantiated in Report #1191-1. No further analysis is required.

##### 4.4.2 Aft Loads

Aft loads are not required. This condition is not critical for the low loads on the belts no the imposed downward loads on the seat bottom. No analysis is required.

##### 4.4.3 Down Loads

Down loads are reacted from the seat bottom into the floor. The load is distributed from the cushion into the floor. The floor is adequate the support this load. No further analysis is required.

**4.4.4 Up Loads**

The up load is reacted by the belts. The imposed forward load due to the upward load is 255 lbs., which is less than the forward load analyzed above. This is not critical. No analysis is required.

**4.4.5 Side Loads**

The side load per occupant is 510 lbs. This imposes a forward load against the seat back and the bulkhead of 361 lbs. due to the angle of the seat belts. This is less than the loads analyzed previously, and is not critical. No further analysis is required.

**5.0 CONCLUSION**

The seats specified above, when installed in accordance with the data described above, are acceptable for use on the Boeing Model B-17G, for the one aircraft only.

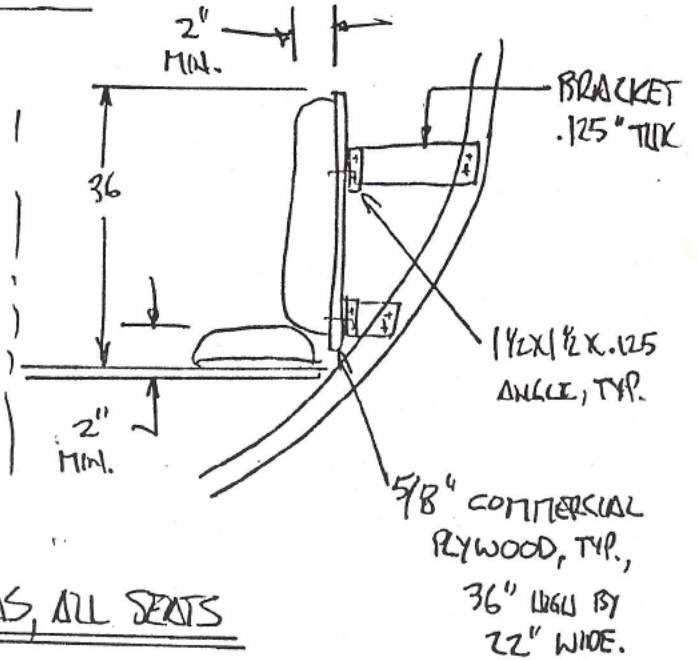
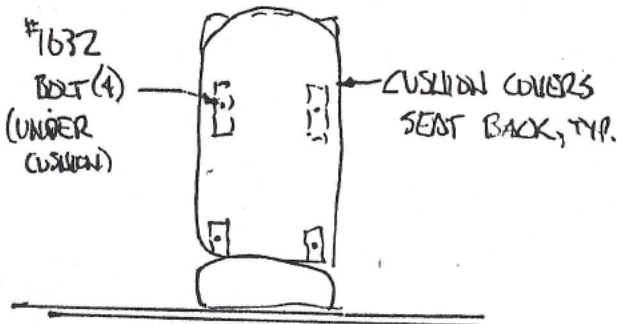
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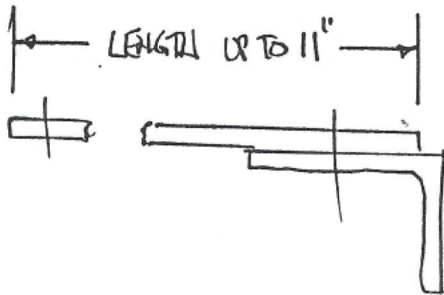
## Appendix A

### Sketches - Seat Details

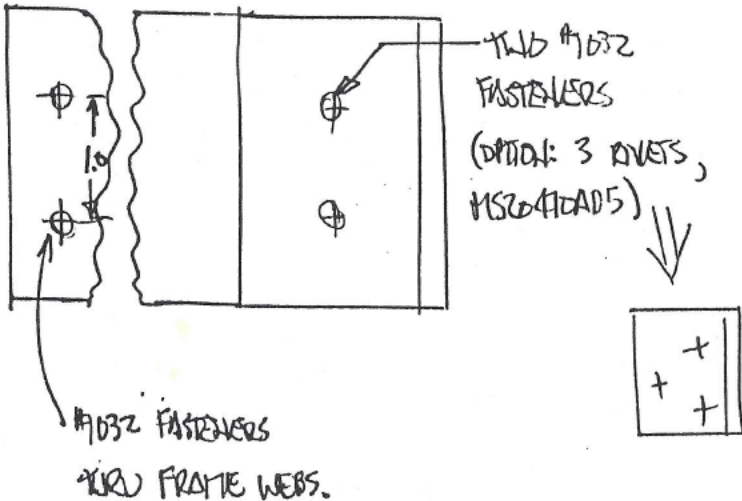
SEAT LOCATION #1



NOTE: CUSHIONS ATTACHED BY VELCRO.

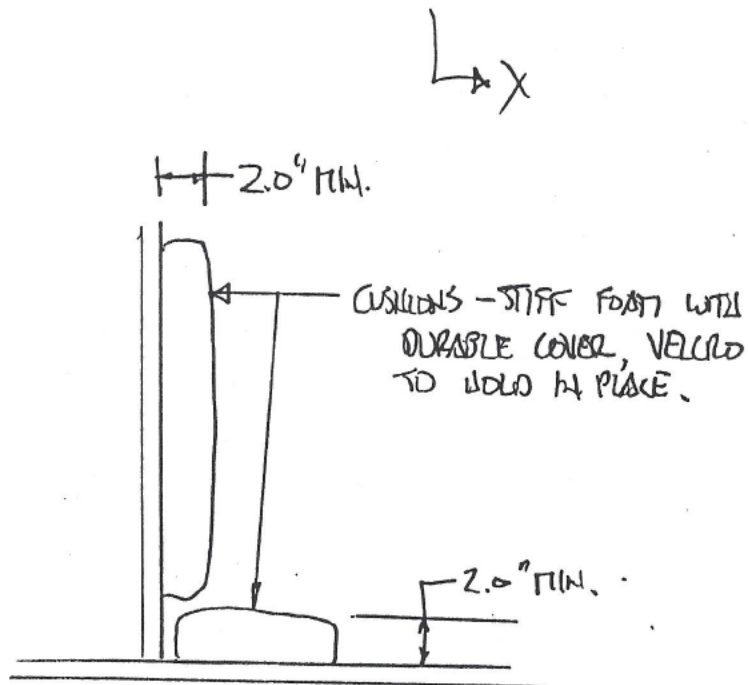
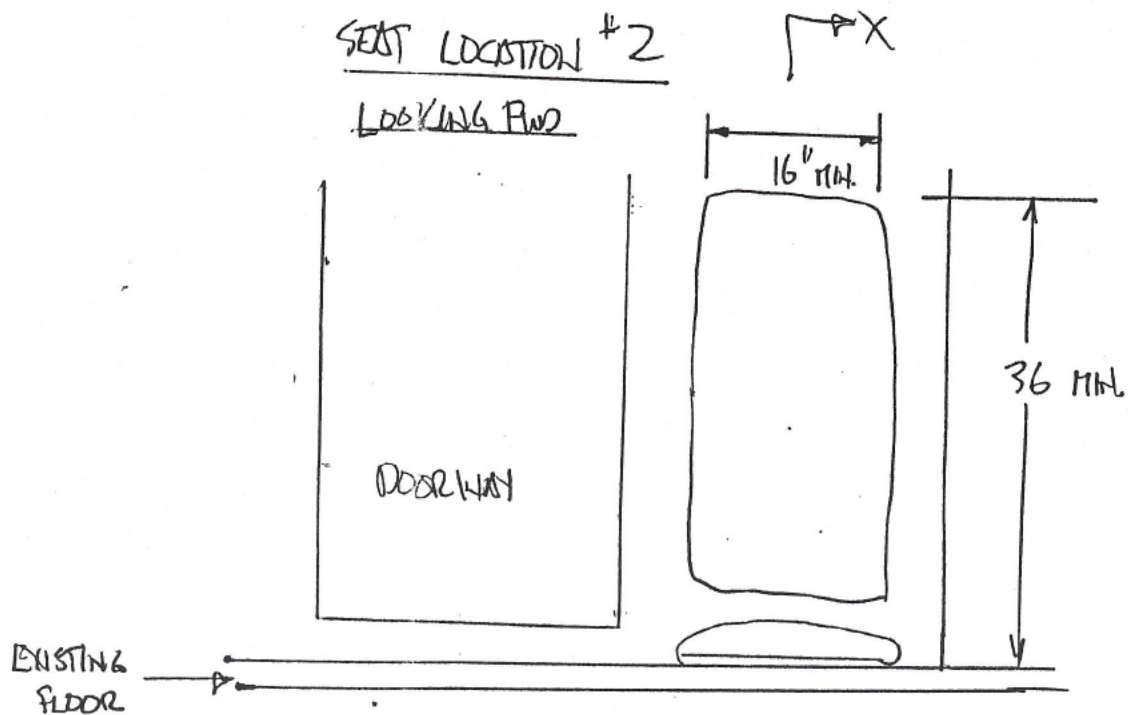


TYPICAL VIEWS, ALL SEATS

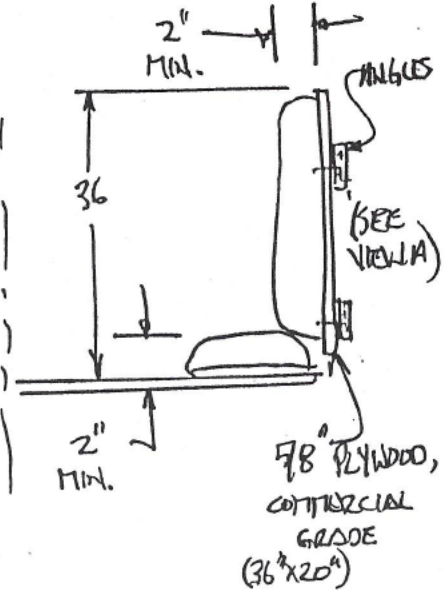
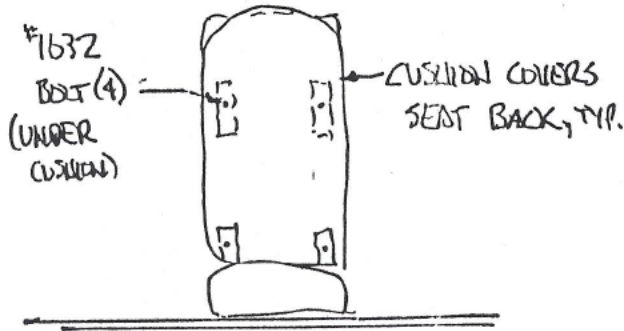


TYPICAL ANGLE/BRACKET INST.



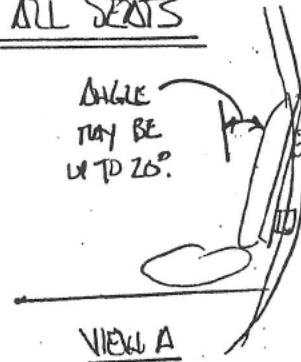
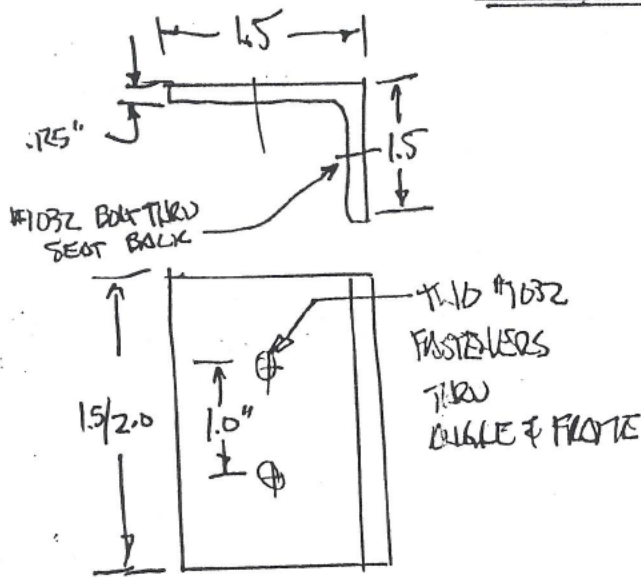


SEAT LOCATION #3



NOTE: CUSHIONS ATTACHED BY VELCRO.

TYPICAL VIEWS, ALL SEATS



TYPICAL ANGLE INSTL.

SEAT LOCATION #4

