National Center for Atmospheric Research

Airborne Vertical Atmospheric Profiling System (AVAPS) Installation

Structural Analysis SA-AVAPS-100

NSF Gulfstream V Aircraft, SN 677

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1.0 Introduction

1.1 Discussion

NCAR has developed main cabin equipment (MCE) racks and a baggage compartment equipment (BCE) rack to support atmospheric research equipment installations on the National Science Foundation (NSF) GV aircraft, SN677, IAW STC number ST00585DE. Equipment mounting provisions and research power wiring were previously installed by Lockheed Martin Aircraft Company IAW STC ST03056AT. Research equipment will not interface with existing aircraft systems, nor will the equipment provide information to the flight crew to assist them with operation of the aircraft. Therefore, AC 25-10 (Guidance for the Installation of Miscellaneous, Non-required Electrical Equipment) will be utilized show compliance with the applicable regulations of 14 CFR Part 25.

This report will substantiate the structural strength of the AVAPS equipment installation which is comprised of the following subassemblies:

1. MCE rack AVAPS equipment installation at GVFS 594, LBL 21;
2. BCE rack launcher assembly installation at GVFS 738, RBL 22;
3. Plug replacement on fuselage pre-existing mounting location for expendable ejection;
4. UHF antenna install on pre-existing fuselage mounting location; and
5. Associated interconnecting power and signal wiring.

1.2 Applicable Drawings

The MCE rack AVAPS equipment installation is described on NCAR drawing number 67705AVAPS-1, AVAPS MCE Rack Equipment Installation. The Storage Box is detailed on NCAR drawing number 67705AVAPS-2, Storage Box Assembly, AVAPS Rack.

The BCE rack launcher installation is shown on NCAR drawing number 677-05-25-500, Dropsonde Dispenser Instl., Baggage Compartment.

The UHF telemetry antenna structural installation is described on NCAR drawing 67705AVAPS1217, AVAPS UHF Antenna Installation.

Drawings are included in Appendix A.

1.3 Minimum Margins of Safety

Item	Load Condition	Stress Condition	MS Min
MCE Rack	Allowable Weight		+1.14
MCE Rack	Allowable Moment		+0.90
Computer Chassis Bracket	9g Forward	Bending	+1.46
Bracket M4 x 0.7 Screw	9g Forward	Shear	High
Bracket AN3 Bolt	9g Forward	Tension	High
Chassis Strap	6g Down	Bending	High
Strap M4 x 0.7 Screw	6g Down	Shear	High
Strap AN525-10 Screw	6g Down	Shear	High
Telemetry/Fan Tray Support Angle	6g Down	Bending	+2.81
Angle AN525-10 Screw	6g Down	Tension + Shear	+1.25
Storage Box AN3 Panel Bolt	9g Forward	Tension	High
BCE Rack	Allowable Weight		+1.08
BCE Rack	Allowable Moment		+0.96
-41 Tube Assembly	7g Down	Column Buckling	High
-11, -21 Support Assembly	9g forward	Axial + Bending	High
ME6 Rod End	7g Down	Radial	High
-15 Tab	100 lb	Bending	+6.48
Tab HL18-5 Pin	100 lb	Tension + Shear	High
-25 Bracket	7g Down	Bending	+4.66
-41 Rail	9g Forward	Axial + Bending	+2.36
BCE Rack Frame	3g Sideward	Axial + Bending	+3.16
-63 Fitting	Ultimate Pressure	Bending	+2.29
-65 Tube	Ultimate Pressure	Compression	High
UHF Antenna Fastener	Handling	Tension + Shear	High

2.0 AVAPS Installation Analysis

2.1 Description

The AVAPS MCE rack installation consists of the following components:

Location	Component	Manufacturer	Model/Part Number
Front			
	Eject Control Panel	NCAR	67705AVAPS-03
	Monitor	Interlogic Industries	RDF19AX-SHB
	Computer	PCS	2USCP43
	Keyboard	Cyber Research	OIX 1910B-P
	Telemtry Chassis	NCAR	98000000
	Fan Tray	Schroff	20713217A1001
	Storage Box	NCAR	67705AVAPS-02
Rear			
	Power Strip	NCAR	677-05-24-104
	PS Mount	NCAR	EQPM-05-24-500
	Power Supply	Vicor	VP-F1311991

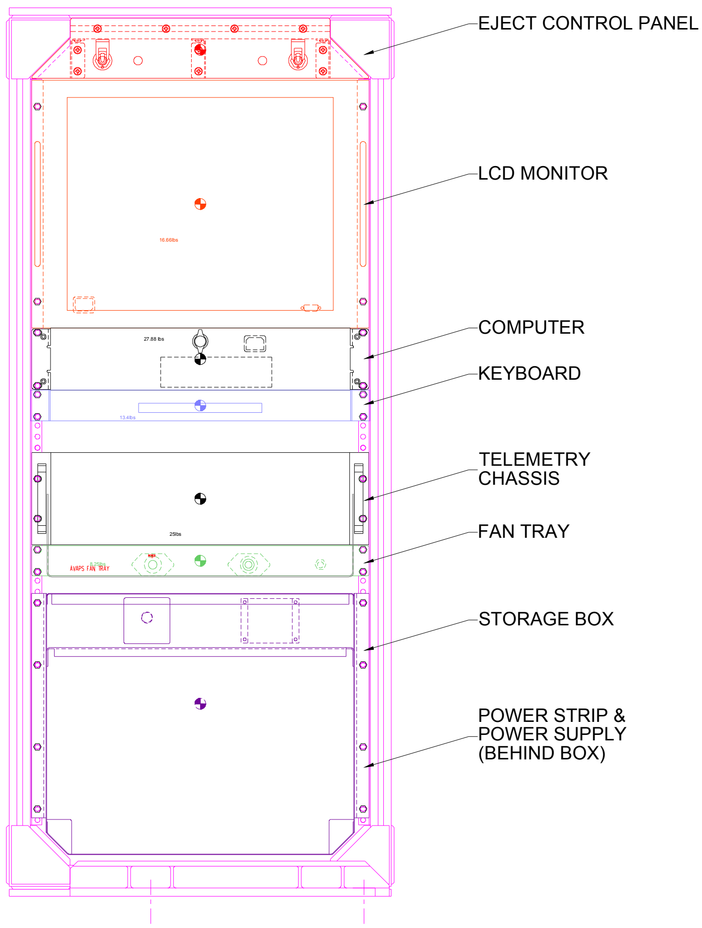
Vendor data is included in Appendix B. The rack mounted equipment is secured to the MCE rack mounting rails with AN3 bolts, NAS1149 washers, and nut clips. The Monitor is attached with a 12 gage (0.105 inch) steel face panel. In addition to face mounting, the Computer and Telemetry Chassis/Fan Tray are supported by support straps and support angles respectively which are secured to both the front and rear MCE rack mounting channels. The Keyboard is attached to sliding rails. The Keyboard rails attach only to the front face of the MCE rack. The Keyboard installation is stiffened with plates to reduce the moment on the forward face of the MCE rack mounting channel. The Computer, Telemetry Chassis, and Storage Box are secured to the MCE rack mounting rail with 0.125 inch aluminum alloy angle mounting brackets.

The launcher assembly is attached to the BCE rack with a framework structure consisting of square and round tubing attached to channel sections bolted to the BCE rack MX mounting rails. The launcher is manufactured by Aeromet IAW drawing list 01900-003MD. The plug fitting in the fuselage is replaced by a fitting to permit launching of the expendables form the aircraft. A thermoplastic tube provides a continuous path from the launcher to the fitting for the expendables.

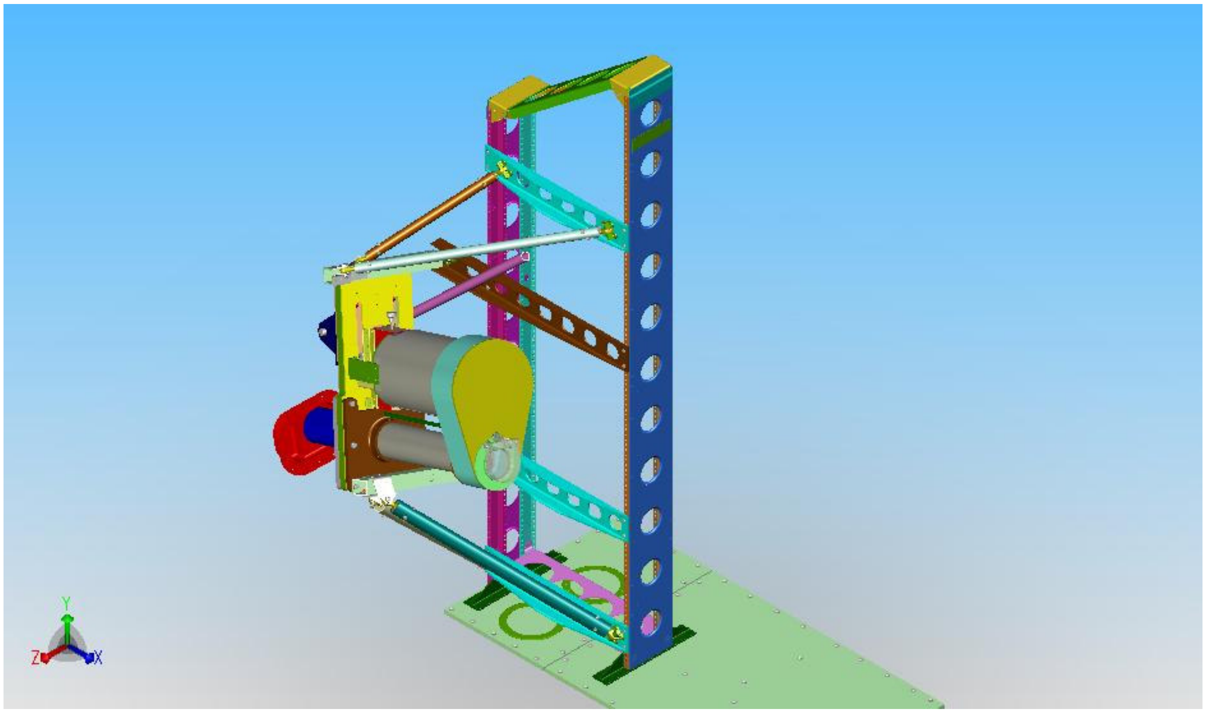
The UHF antenna is mounted to an existing centerline mounting provision on the bottom of the aircraft fuselage at GVFS 271. The antenna is manufacture by Sensor Systems, Inc. (Part Number S65-1217).

2.2 Geometry

The MCE rack AVAPS equipment installations are shown below:



The BCE rack launcher assembly installation is shown below:



2.3 Weights

The MCE rack mounted equipment component weights are:

Location	Component	Wt, lb	CG Ht, in	Mom, in-lb
Front				
	Eject Control Panel	1	47.8	47.8
	Monitor	17	39.1	664.7
	Computer	28	30.3	848.4
	Support Strap	2	30.3	60.6
	Keyboard	14	27.7	387.8
	Telemetry Chassis	25	22.4	560.0
	Fan Tray	8	18.9	151.2
	Support Angle	2	18.6	37.2
	Storage Box	40	10.9	436.0
	Wiring (est.)	15	25.1	376.5
Rear				
	Power Strip	8	10.2	81.6
	PS Mount	1	7.6	7.6
	Power Supply	2	7.6	15.2
	Total	163	22.5	3675

The launcher assembly weighs 56 pounds. Launcher attachment structure to secure the launcher to the BCE rack weighs 16 pounds. The center of gravity of the assembly is located 29.7 inches above WL 71.1 (top of floor).

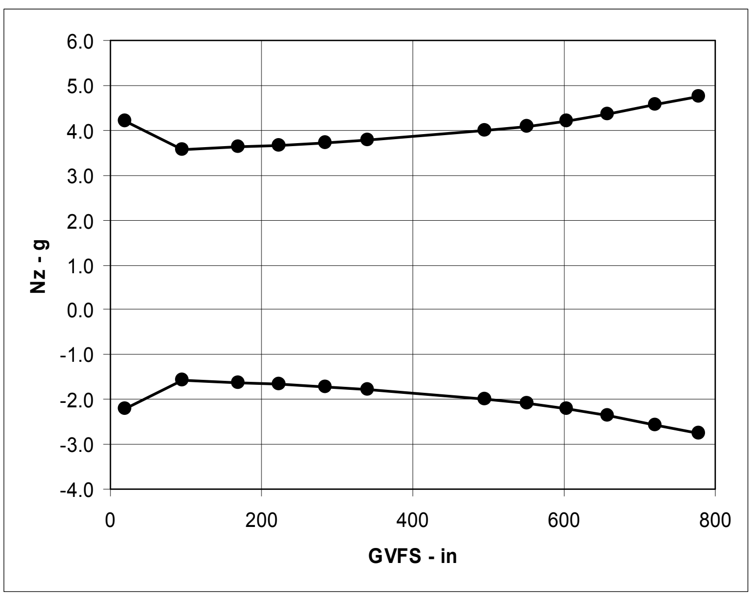
2.4 Loads

All items of mass that could cause injury to an occupant if it broke loose, or become a hazard by shifting, must be restrained for the emergency landing conditions. The emergency landing inertia load factors per 14 CFR Part 25.561(b) are:

Direction	Emergency Landing Load Factor
Upward	3.0g
Forward	9.0g
Sideward	±3.0g (Airframe) ±4.0g (Seats & Seat Attachments)
Downward	6.0g
Rearward	1.5g

The emergency landing condition loads act separately and are ultimate loads. These loads act independent of the flight loads and pressurization loads.

Inertia loads also result from taxi, flight (gust conditions, dynamic maneuvers), and normal landing. The limit vertical load factor versus fuselage station for the design of equipment support structure (Gulfstream Aerospace Corporation (GAC) data) is:



These load factors must be multiplied by 1.5 for ultimate conditions. Also, positive g loading will produce a load directed downward, while negative g loading will produce a load directed upward. Thus, for this installation (equipment mounted in the MCE racks between GVFS 259 and GVFS 594), ultimate vertical inertial load factors of +6.0g and -3.0g are applicable. These load factors are equivalent to the upward and downward emergency landing load factors.

For equipment mounted in the baggage compartment (GVFS 684 to GVFS 758), +7.0g and -4.0g ultimate vertical load factors are applicable.

The worst case lateral load factor is +/- 2.0g limit and acts concurrently with a 1.0g down limit load factor. GAC considers this condition to be conservative for all areas of the aircraft. This lateral load factor, when multiplied by a safety factor of 1.5 for ultimate, is also equivalent to the sideward emergency landing load factor.

For lightweight equipment installations, unless other criteria are more severe, the immediate equipment support structure (bracket, gusset, rail, etc.) should be designed for a 50 pound ultimate load acting at the equipment center of gravity in any direction. This provides adequate stiffness and prevents harmful vibration coupling (resonance) of the equipment installation and aircraft structure.

Handling loads should be considered for equipment that protrudes outward from a mounting surface and is accessible. Such installations must take into account the fact that it will either intentionally or unintentionally be used as a pulling or pushing surface. Such surface should be designed for a 100 pound ultimate load in any direction.

2.5 Stress Analysis

MCE RACK AVAPS Equipment Installation

The MCE rack allowable equipment weight and moment were determined in the Quick Change Cabin Configuration Structural Analysis, Report Number SA-100-05, dated 25 May 2005, and are 350 pounds and 7000 inch-pounds respectively. The AVAPS MCE rack installation weight and moment as shown previously in Section 2.3 are 163 pounds and 3682 inch-pounds respectively (Note: expendables weight of 24 pounds is included in the Storage Box weight). The margins for the MCE rack with the AVAPS equipment are:

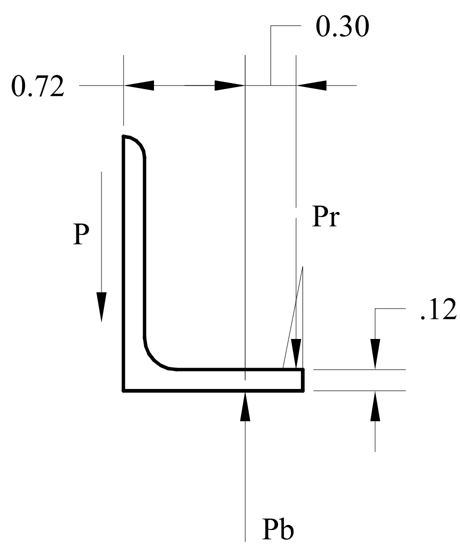
$$MS = (350 / 163) - 1 \quad \Rightarrow \quad MS = +1.14$$
$$MS = (7000 / 3674) - 1 \quad \Rightarrow \quad MS = +0.90$$

By inspection the critical installations are the computer, keyboard, telemetry chassis and fan tray, and storage box. The Keyboard installation is identical to a previously approved keyboard installation (NCAR Drawing List DL-600-05, dated 25 August 2005, and Structural Analysis Report SA-600-05, dated 22 August 2005) and requires no further analysis.

Computer

The Computer is 2U (3.47 inches) rack mountable unit 18 inches deep and weighing 28 pounds. The computer is secured to the MCE rack at each forward mounting channel by a mounting bracket and supported longitudinally by a strap along each side. The mounting bracket is a 1 x 1 x 1/8 inch 2024-T3 extruded aluminum angle section with one leg secured to the side of the Computer chassis with four M4 x 0.7 carbon steel screws and the other leg attached to the MCE rack mounting channel flange with two AN3 bolts. The support strap is 2.5 inches high by 1/8 inch thick aluminum sheet attached at each end to the MCE mounting rails to eliminate the moment due to equipment overhang from the mounting channel flange. The strap is fastened to the chassis with three M4 x 0.7 screws and to the rack at each end with two AN525-10 screws.

For the 9g forward emergency landing condition, conservatively assume the entire load is transferred through the brackets to the mounting channels. The free body diagram of the bracket is:



The load per bracket is:

$$P = 9 \times 28 / 2 = 126 \text{ pounds} \qquad \text{(ultimate)}$$

Assuming half of this load is reacted by each AN3 bolt over 0.95 inches of flange width, the maximum bending stress in the bracket due to the eccentric load is:

$$fb = 6 (P / 2)\, d / (b\, t^2)$$
$$= 6 (126 / 2) (0.72 – 0.22) / (0.95 (.12)^2)$$
$$= 13.8 \text{ ksi} \qquad \text{(ultimate)}$$

The compressive yield strength of 2024-T3 aluminum alloy extrusion per DOT/FAA-AR-MMPDS-01 is 34 ksi. The margin of safety for the bracket in bending is:

MS = (34 / 13.8) – 1 ⇨ MS = +1.46

The shear per chassis fastener is:

Ps = P / 4 = 126 / 4 = 32 pounds (ultimate)

The shear strength for a M4 x 0.7 ISO class 4.8 steel fastener (root diameter = 3.14 mm) is:

Psu = Amin x 0.6 x Ftu
= 0.012 x 0.6 x 60,900 psi = 438 pounds (ultimate)

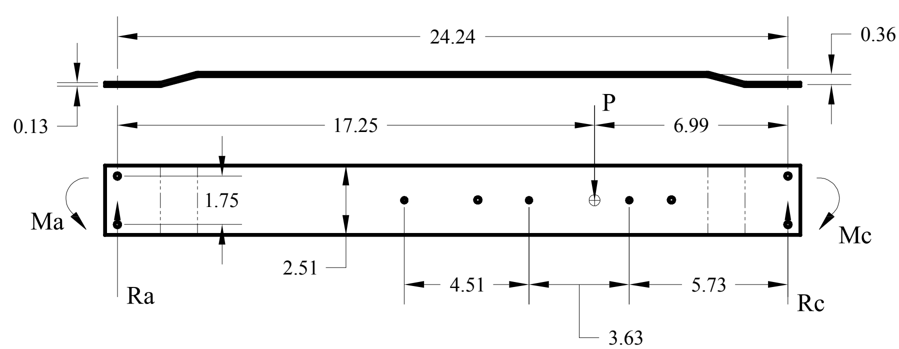
By inspection a high margin of safety will exist for the M4 x 0.7 screw.

The shear per mounting channel flange fastener is (see free body diagram above):

Pb = (P / n) (a + b) / b
= (126 / 2) (0.72 + 0.30) / 0.30 = 214 pounds (ultimate)

The ultimate tension strength for an AN3 bolt per DOT/FAA-AR-MMPDS-01 is 2255 pounds. By inspection a high margin of safety will exist for the AN3 bolt.

For a 6.0g downward ultimate load factor, conservatively assume the computer is entirely supported by the straps (no support from the brackets). The strap is assumed fixed at both ends due to the fastener arrangement. The free body diagram of the strap is:



The load per strap is:

$P = 6\ (28) / 2 = 84$ pounds (ultimate)

The reactions can be determined from standard beam tables and are:

$$Ra = (P\ b^2 / L^3)\ (3a + b)$$
$$= (84\ (6.99^2) / 24.24^3)\ (3(17.25) + 6.99) = 17 \text{ pounds}$$
$$Rc = (P\ a^2 / L^3)\ (3b + a)$$
$$= (84\ (17.25^2) / 24.24^3)\ (3(6.99) + 17.25) = 67 \text{ pounds}$$
$$Ma = P\ a\ b^2 / L^2 = 84\ (17.25)\ (6.99)^2 / (24.24)^2 = 129 \text{ inch-pounds}$$
$$Mc = P\ a^2\ b / L^2 = 84\ (17.25)^2\ (6.99) / (24.24)^2 = 297 \text{ inch-pounds}$$

The eccentric loading due to the joggle will produce a torque on the strap reacted by a moment at each end of the strap of:

$$Ta = T\ (\ 1 - (a / L) = (84 \times 0.36)\ (\ 1 - (17.25 / 24.24)) = 9 \text{ inch-pounds}$$
$$Tc = T\ (a / L) = (84 \times 0.36)\ (17.25 / 24.24) = 22 \text{ inch-pounds}$$

Clearly, end ‘c’ is critically loaded (maximum moment and torque). The bending stress is:

$$fb = 6\ M / (b\ t^2)$$
$$= 6\ (297) / (0.12\ (2.5)^2) = 2.4 \text{ ksi} \qquad \text{(ultimate)}$$

The shear due to the torque is:

$$fs = 3\ T / (b\ t^2)$$
$$= 3\ (22) / (0.12\ (2.5)^2) = 88 \text{ psi} \qquad \text{(ultimate)}$$

The compressive yield and shear ultimate for 6061-T6 aluminum alloy sheet per DOT/FAA-AR-MMPDS-01 is 37 ksi and 28 ksi respectively. By inspection a high margin of safety will exist for the strap.

The chassis load is transferred to each strap by three M4 x 0.7 fasteners. The centroid of the fastener group is:

$r = \sum r / n = (-4.51 + 3.63) / 3 = -0.29$ inches (i.e. 0.29 inches to the left of the center fastener)

The equivalent force system due to P through the fastener centroid is:

$$F = P = 84 \text{ pounds}$$
$$M = P \times D = 84 \times (5.73 + 3.63 + 0.29 - 6.99) = 223 \text{ inch-pounds}$$

The maximum shear for the M4 x 0.7 strap fastener is:

$$Ps = [(F / n)^2 + (M\ r / \sum r^2)^2]^{1/2}$$
$$= [(84 / 3)^2 + (223\ (4.22) / 33.26)^2]^{1/2}$$
$$= 28 \text{ pounds} \qquad \text{(ultimate)}$$

By inspection a high margin of safety will exist for the M4 x 0.7 screw.

The shear per screw at the MCE rack mounting channel is:

$$fs = [(Rc / n)^2 + (Mc / h)^2]^{1/2}$$
$$= [(67 / 2)^2 + (297 / 1.75)^2]^{1/2}$$
$$= 173 \text{ pounds} \qquad \text{(ultimate)}$$

The ultimate shear strength for an AN525-10 screw per DOT/FAA-AR-MMPDS-01 is 2125 pounds. By inspection a high margin of safety will exist for the AN525-10 screw.

Telemetry Chassis / Fan Tray

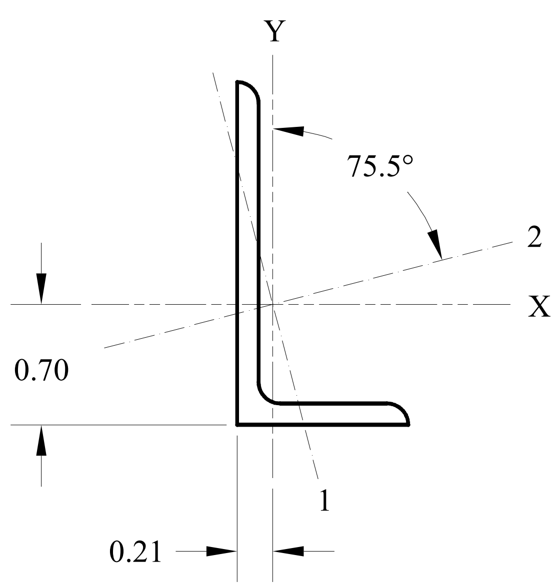
The Telemetry chassis is a 3U unit that rests on top of the 1U Fan Tray. Due to the overhang distance from the face of the mounting channel, the units rest on 2 x 1 x 1/8 6061-T6 extruded aluminum alloy support angles which are attached to the front and aft mounting channels (length = 24.24 inches between attachment locations) with two AN525-10 screws at each end. The screws are spaced 1.25 inches apart vertically on the 2 inch leg of the angle. Each support angle can be considered a beam fixed at both ends. To substantiate the support angle design, assume an equipment load of 110 pounds. For the 6g downward load factor, conservatively assume the load transferred to each rail (omitting the panel mount contribution for rack mountable equipment) is:

$P = 6\ (110) / 2 = 330$ pounds (ultimate)

The reactions at each end, assuming uniform loading along the length (w = 330 / 24.24), can be determined from standard beam tables and are:

$Ra = (w\ L) / 2 = 330 / 2 = 165$ pounds (ultimate)
$Rc = (w\ L) / 2 = 330 / 2 = 165$ pounds (ultimate)
$Ma = (w\ L^2) / 8 = 330\ (24.24) / 8 = 1000$ inch-pounds (ultimate)
$Mc = (w\ L^2) / 8 = 330\ (24.24) / 8 = 1000$ inch-pounds (ultimate)

The support angle cross section is shown below:



The section properties are:

A = 0.356 inches
$I_x = 0.1448$ in^4
$I_y = 0.0244$ in^4
$I_{xy} = -0.0335$ in^4
$\phi = 75.5^{o}$
$I_1 = 0.0157$ in^4
$I_2 = 0.1535$ in^4

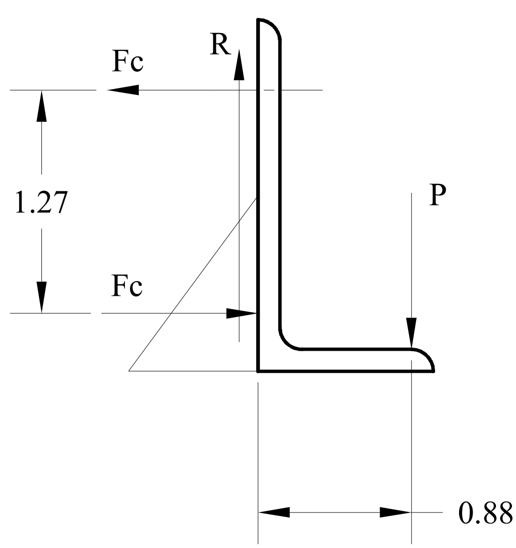
The attachment to the MCE rack will prevent rotation of the section at the ends. Thus, the maximum bending stress in the section is:

$$fb = M\ c / I = 1000\ (2.0 - 0.7) / 0.1448 = 9.7 \text{ ksi} \qquad \text{(ultimate)}$$

The ultimate tensile strength for 6061-T6 aluminum alloy extrusion per DOT/FAA-AR-MMPDS-01 is 37 ksi. The margin of safety for the support angle in bending is:

$$MS = (37 / 9.7) - 1 \quad \Rightarrow \quad MS = +2.81$$

The end attachment geometry is shown below:



The eccentric loading will produce a force couple of:

$$Fc = (P / 2)\ d / h = 165\ (0.88) / 1.27 = 114 \text{ pounds} \qquad \text{(ultimate)}$$

This force will produce tension in the upper attachment fastener. The total shear on the fastener is:

$$fs = [(R / n)^2 + (M / h)^2]^{1/2}$$
$$= [(165 / 2)^2 + (1000 / 1.25)^2]^{1/2}$$
$$= 804 \text{ pounds} \qquad \text{(ultimate)}$$

The ultimate tension and shear strength for an AN525-10 screw per DOT/FAA-AR-MMPDS-01 is 2255 pounds and 2125 pounds respectively. The stress ratios, including fitting factor, for the screw are:

$$Rt = (1.15 \times 114) / 2255 = 0.06$$
$$Rs = (1.15 \times 804) / 2125 = 0.44$$

The margin of safety for the AN525-10 screw is:

$$MS = (1 / (Rt^2 + Rs^2)^{1/2}) - 1$$
$$= (1 / (0.06^2 + 0.44^2)^{1/2}) - 1 \quad \Rightarrow \quad MS = +1.25$$

Thus the support angles are capable of supporting equipment weighing 110 pounds with a uniformly distributed load per angle along the entire length of:

$$w = Wt / (2 \times L) = 110 / (2 \times 24.24) = 2.27 \text{ pounds per inch}$$

The telemetry chassis / fan tray weight is 33 pounds distributed along 10.56 inches of each angle. The distributed loading per support angle is:

$$w = (33 / 2) / 10.56 = 1.56 \text{ pounds per inch}$$

The telemetry chassis / fan tray lower weight and lower distributed loading will result in higher margins for the support angles; no further analysis is required.

Storage Box

The Storage Box is a 19 inch rack mountable, custom fabricated, box, 15.2 inches in height and 17 inches deep. Mounting angles 12.7 inches in length are permanently attached to the storage box with thirteen (13) MS20470AD4 rivets. The other leg of the mounting angle attaches to the MCE rack mounting channel with four (4) AN3 bolts. The box is cantilevered off the rack mounting channels with a center of gravity located 8.1 inches aft of the mounting face. The storage box weighs 10 pounds empty and 40 pounds when fully loaded with expendables. For the 9g forward load condition, the tension per AN3 fastener is:

$$P = F / n = (9 \times 40) / 8 = 45 \text{ pounds} \qquad \text{(ultimate)}$$

For the 6g downward load condition, assume the entire box heels about the uppermost fastener. The maximum tension load resisting the overturn moment is:

$$P = M\,r / \sum r^2 = (6 \times 40)\,(11.62) / (2 \times (11.62^2 + 8.12^2 + 3.5^2))$$
$$= 7 \text{ pounds} \qquad \text{(ultimate)}$$

The shear per fastener is:

$$V = F / n = (6 \times 40) / 8 = 30 \text{ pounds} \qquad \text{(ultimate)}$$

The ultimate tension and shear strength for an AN3 bolt per DOT/FAA-AR-MMPDS-01 is 2255 pounds and 2125 pounds respectively. By inspection, high margins will exist for the AN3 attachment bolts.

BCE Rack Launcher Installation

The BCE rack allowable equipment weight and moment were determined in the Quick Change Cabin Configuration Structural Analysis, Report Number SA-100-05, dated 25 May 2005, and are 150 pounds and 4200 inch-pounds respectively. The margins for the BCE rack with the AVAPS launcher are:

$$MS = (150 / 72) - 1 \quad \Rightarrow \quad MS = +1.08$$
$$MS = (4200 / (72 \times 29.7)) - 1 \quad \Rightarrow \quad MS = +0.96$$

However, since the equipment is suspended from the forward face of the rack by the support and tube assemblies, additional analysis of the BCE rack is required. Two finite element models were developed; one to analyze the support and tube assembly framework (AVAPS launcher installation) and the other to analyze the BCE rack with rails (AVAPS BCE installation). The AVAPS launcher installation model consisted of 368 nodes and 347 elements. The launcher assembly was modeled as a mass element. The launcher weight was distributed by rigid connections to the valve plate. The support (1.5 inch square by 1/8 inch thick wall 6061-T6 extruded tube) and tube (∅1.5 inch and ∅1.0 inch by 1/8 inch thick wall 6061-T6 extruded tube) assemblies were modeled as beam elements with the appropriate material and cross sectional properties. The round tubes were free to rotate at both ends in order to simulate the rod end bearings. All attachments at the BCE rack interface were pinned (i.e. translational restraint but rotational freedom). Three load conditions were considered: 9g forward, 7g downward, and 3g sideward. The following table shows the comparison between the FEM weights and the actual hardware weights:

Item	FEM Weight	Actual Weight
Launcher Assembly	58 pounds	56 pounds
Support Structure	13 pounds	16 pounds
Total	71 pounds	72 pounds

The following deflections were obtained from the FEA for the three load conditions analyzed:

	9g Forward	7g Downward	3g Sideward
Deflection, inches	0.008	0.007	0.005

These deflections are not significant.

The following table shows the geometric properties for the tube assemblies:

Tube Assembly	L, inches	A, inches^2	I, inches^4
677-05-25-500-31	26.8	0.54	0.1287
677-05-25-500-41	21.6	0.54	0.1287
677-05-25-500-51	28.4	0.3436	0.0228
677-05-25-500-61	17.4	0.3436	0.0228

The following table shows the FEA axial load results for the pin-ended tube assemblies for each of the load conditions:

Tube Assembly	9g Forward	7g Downward	3g Sideward
677-05-25-500-31	6 pounds	-56 pounds	-189 pounds
677-05-25-500-41	-119 pounds	-527 pounds	86 pounds
677-05-25-500-51	33 pounds	-91 pounds	-70 pounds
677-05-25-500-61	117 pounds	85 pounds	-26 pounds

The critical column load is given by $P_c = c\, \pi^2\, E_t\, I / L^2$, where c = 1 for a concentrated axial load and both ends pinned and $E_t = E_c$ in the elastic range. The critical column load for the tube assemblies is shown in the following table:

Tube Assembly	Pc, pounds
677-05-25-500-31	17,862
677-05-25-500-41	27,497
677-05-25-500-51	2,817
677-05-25-500-61	7,506

By inspection, large margins exist for all the tube assemblies for column buckling.

The -11 and -21 support assemblies are fabricated from 1.5 inch square tubing and are attached to the launcher valve plate. One end of each tube assembly ties into the support assemblies. The following table shows the maximum and minimum combined stress for the support assemblies:

Stress Condition	9g Forward	7g Downward	3g Sideward
Max Combined	3425 psi	2329 psi	709 psi
Min Combined	-3013 psi	-1691 psi	-649 psi

The yield compressive stress for 6061-T6 extruded tube per DOT/FAA-AR-MMPDS-01 is 34,000 psi. By inspection, large margins exist for the support assemblies.

The tube assembly axial loads are transferred through ∅3/8 inch, aircraft series, MS, self lubricating, spherical rod ends (Heim Part No. ME6 and MEL6) at each end of the tube. Each rod end is secured to the tube with two NAS6203 bolts. These bolts are in double shear and the allowable single shear load per bolt is 2690 pounds. By inspection large margins exist for the NAS6203 bolts.

The maximum static radial load for this rod end is 8,550 pounds. By inspection, large margins exist for the rod end.

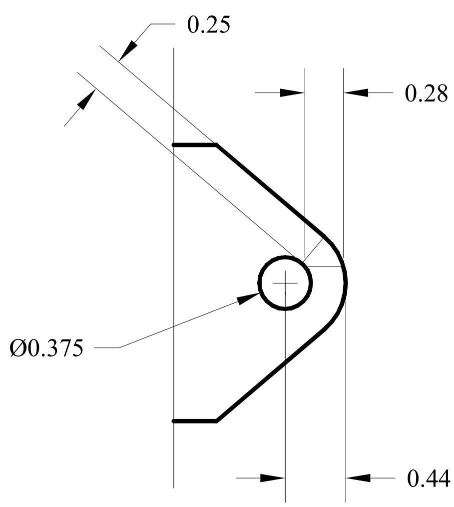
The rod ends on the launcher side are attached to an assortment of tabs and brackets fabricated from 0.10 inch thick 4130 steel sheet. The tabs act as lugs and are installed in pairs. They sandwich the rod end and place the pin in double shear. The bracket (677-05-25-500-25) provides rod end attachment which places the pin in single shear for the -41 tube assembly.

The maximum bearing will occur at the -25 bracket and is:

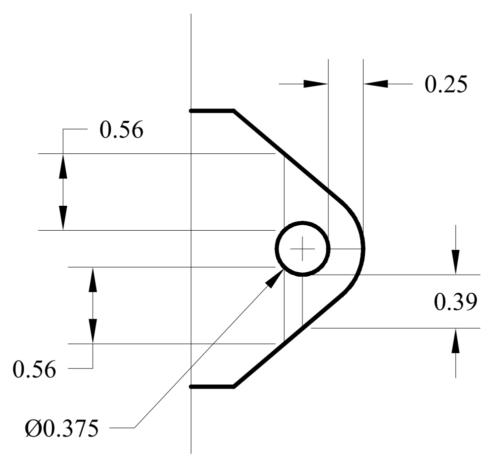
$$f_{br} = P / A = 527 / (.375 \times 0.10) = 14.1 \text{ ksi} \qquad \text{(ultimate)}$$

The ultimate bearing for 4130 alloy steel sheet (Ftu = 95 ksi) per DOT/FAA-AR-MMPDS-01 is 200 ksi. By inspection, high margins will exist for the bracket in bearing.

The lug geometry for the -05, -07, -13, and -15 tabs for attachment of the upper tube assemblies (-51 and -61) are identical. Only the bend angle of each tab differs to provide correct geometric alignment of the tube assemblies. The tab lug geometry applicable to axial and transverse loading is:



Axial



Transverse

The ratios required to determine the efficiency factors (K) are:

$$w / D = 2 (0.25) / .375 = 1.33$$
$$e / D = 0.44 / 0.375 = 1.17$$
$$A_{av} = 6 (0.10) / [(3 / 0.56) + (1 / 0.39) + (1 / 0.25) + (1 / 0.56)] = 0.044$$
$$A_{av} / (D\,t) = 0.044 / (0.375 \times 0.10) = 1.17$$

Tension across the net section for axial loading is:

$$P_u = K_t F_{tu} A_t = 1.0 (95,000) (2 x 0.25) (0.10) = 4750 \text{ pounds}$$

Shear-out bearing strength for axial loading is:

$$P_{bru} = K_{bru} F_{tu} A_{br} = 1.05 (95,000) (2 x 0.28) (0.10) = 5586 \text{ pounds}$$

Thus the lug will be critical for tension failure when loaded axially. The strength of the lug when loaded transversely is:

$$P_{tu} = K_{tu} F_{tu} A_{br} = 1.45 (95,000) (0.375 x 0.10) = 5165 \text{ pounds}$$

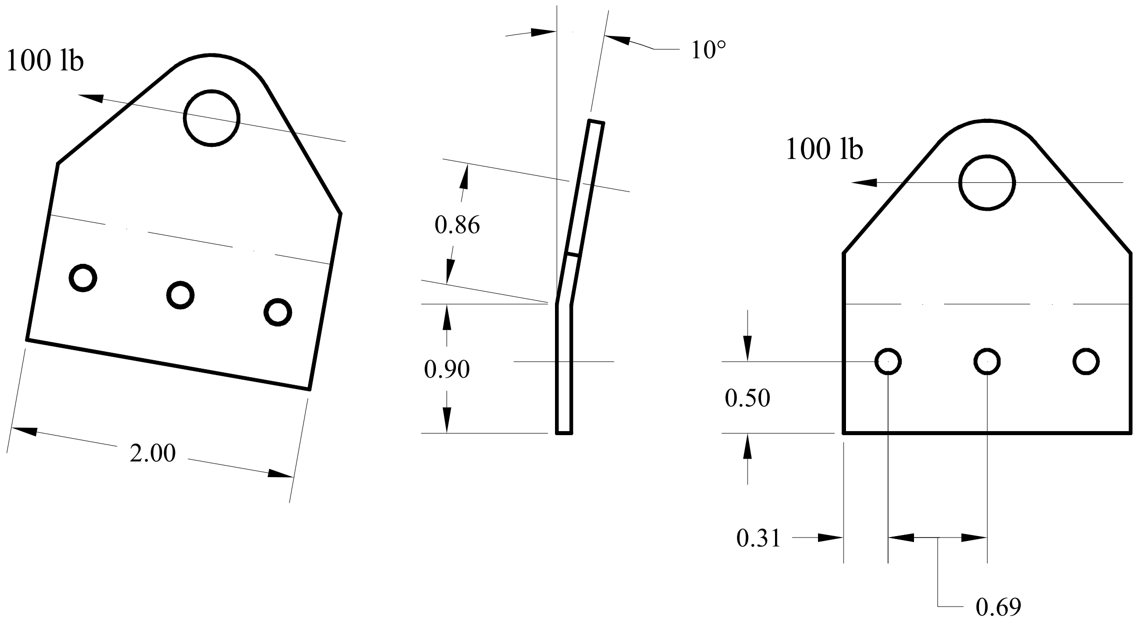
For obliquely loaded lugs, the applied load can be resolved into axial and transverse components and the load ratios R_a (= P_a / P_u) and R_{tr} (= P_{tr} / P_{tu}) determined. The margin of safety is determined from:

$$MS = [1 / (R_a^{1.6} + R_{tr}^{1.6})^{0.625}] - 1$$

Clearly the loads from the table above will result in high margins of safety for the lug sections of the upper tube assembly tabs.

Each tab for upper tube assembly attachment is secured to the support assembly with three (3) HL18-5 Hi-Lok pins. The maximum axial load for an upper tube assembly is 117 pounds. This load will be equally divided between two tabs. Therefore to substantiate the upper tabs assume a 100 pound load acting in any direction for each tab. The -13 and -15 tabs will be critical since they represent the minimum and maximum bend for the tabs. Additionally the -13 tab will be critical for a transverse load (max torque on Hi-Lok fastener pattern) and the -15 tab will require substantiation for both an axial load (tension clip) and transverse load (shear clip).

The -13 tab free body diagram for the transverse substantiation load is:



By inspection the maximum shear will occur at the end Hi-Lok fastener and is:

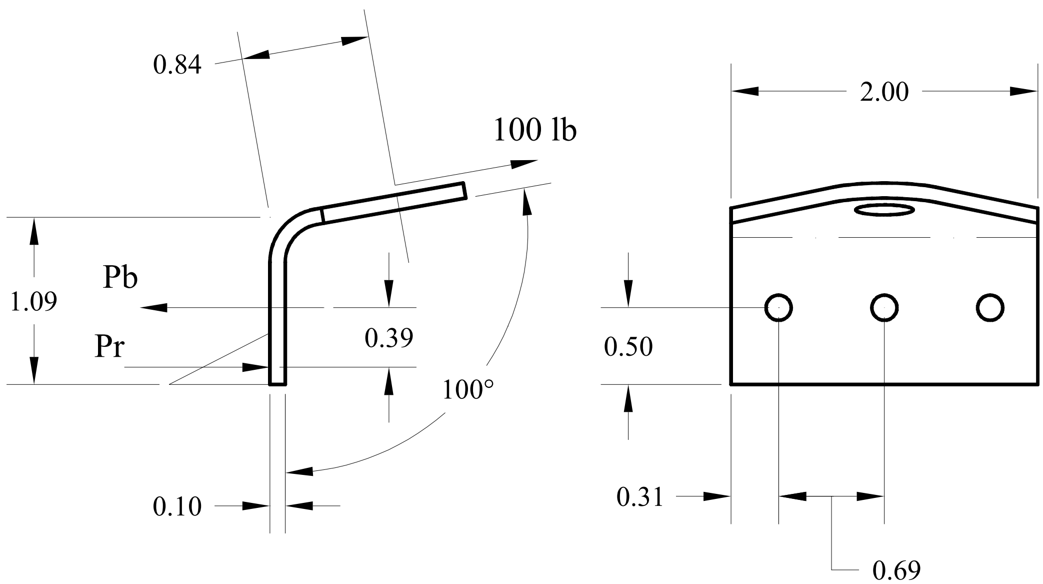
$$fs = ((F / n)^2 + (M / h)^2)^{1/2}$$
$$= ((100 / 3)^2 + (100\ (0.4 + 0.86\ (\cos 10)) / (2 \times 0.69))^2)^{1/2}$$
$$= 96 \text{ pounds} \qquad \text{(ultimate)}$$

The tension load on the end fastener from the eccentric load is:

$$ft = M / h = 100\ (0.86 \sin 10) / (0.67 + 0.69) = 11 \text{ pounds} \qquad \text{(ultimate)}$$

The ultimate shear and tension for a HL18-5 pin with a HL70-5 collar per DOT/FAA-AR-MMPDS-01 is 2005 pounds and 1955 pounds respectively. By inspection, high margins will exist for the fastener.

The -15 tab free body diagram for the axial substantiation load (tension clip) is:



The bending stress in the tab is:

$$fb = 6\ M / (b\ t^2) = 6\ (100 \cos 10)\ (0.59 - 0.16) / (2\ (0.10)^2)$$
$$= 12.7 \text{ ksi} \qquad \text{(ultimate)}$$

The ultimate tension stress for 4130 steel sheet per DOT/FAA-AR-MMPDS-01 is 95 ksi. The margin of safety for the -15 tab in bending is:

$$MS = (95 / 12.7) - 1 \quad \Rightarrow \quad MS = +6.48$$

The tension load per HL18-5 pin is:

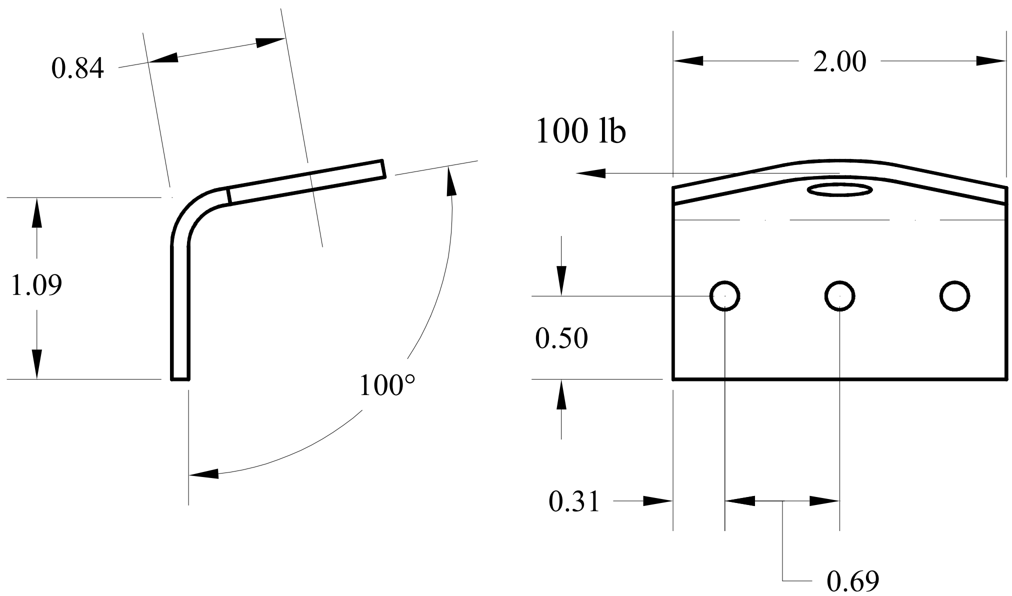
$$Pb = (100 \cos 10)\ (0.39 + 0.59) / (3 \times 0.59) = 55 \text{ pounds} \qquad \text{(ultimate)}$$

The shear per HL18-5 pin is:

$$fs = (100 \sin 10) / 3 = 6 \text{ pounds} \qquad \text{(ultimate)}$$

By inspection high margins will exist for the fastener.

The -15 tab free body diagram for the transverse substantiation load (shear clip) is:



By inspection the maximum shear will occur at the end Hi-Lok fastener and is:

$$fs = ((F / n)^2 + (M / h)^2)^{1/2}$$
$$= ((100 / 3)^2 + (100\ (0.59 + 0.84\ (\sin 10)) / (2 \times 0.69))^2)^{1/2}$$
$$= 63 \text{ pounds} \qquad \text{(ultimate)}$$

The tension load on the end fastener from the eccentric load is:

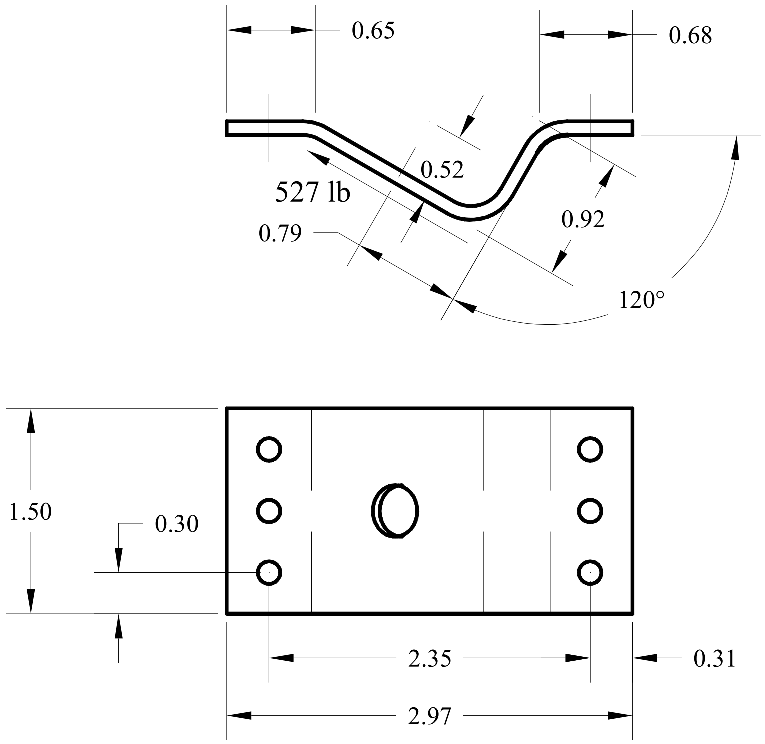
$$ft = M / h = 100\ (0.84 \cos 10) / (0.67 + 0.69) = 61 \text{ pounds} \qquad \text{(ultimate)}$$

By inspection high margins will exist for the fastener.

High margins exist for the critical tabs subjected to substantiation loads in excess of the anticipated loads in service. Therefore, the -5, -7, -13, and -15 tabs are structurally acceptable.

Of the lower tabs and bracket attachments, the -25 bracket will be critical as it transfers the entire load to the -41 tube assembly. The six (6) HL18-5 pins that secure the bracket to the support assembly also transfer half the -31 tube assembly axial load through the -9 tab.

The -25 bracket geometry and applied load for the critical 7g downward condition is shown in the following diagram:



The shear load per HL18-5 pin from the -41 tube assembly is:

fs = P cos 30 / n = (527 cos 30) / 6 = 76 pounds (ultimate)

The tension load per HL18-5 pin from the -41 tube assembly is:

ft = M / (n h) = (527 x 0.52) / (3 x 2.35) = 39 pounds (ultimate)

Bending in the -25 bracket at the critical section is:

$fb = 6\ M / (b\ t^2) = 6\ (39 \times 3 \times (0.68 - 0.31) / (1.5\ (0.10)^2)$
$= 17.3$ ksi (ultimate)

The margin of safety for the -25 bracket in bending is:

MS = (95 / 17.3) – 1 ⇨ MS = +4.66

The additional load on the HL18-5 pin from the -9 tab for this load condition will be less than the pin loading from the -25 bracket. By inspection, conservatively doubling the shear and tension loads determined above still results in a high margin of safety for the pin.

The maximum combined stress (axial + bending) for the support assemblies is

The launcher and attachment framework inertia loads are transferred into the BCE rack through mounting rails attached to the front face of the rack. The support and tube assemblies are held to the rails with pin-ended connections at the ends of the support and tube assemblies. The reactions at the saddle assemblies and pins from the launcher FEA are:

Assembly	Reaction	9g Forward	7g Downward	3g Sideward
-61 Tube	Rx, lbs	73	51	-15
	Ry, lbs	-62	-45	15
	Rz, lbs	71	53	-15
-51 Tube	Rx, lbs	17	-35	-27
	Ry, lbs	-27	76	60
	Rz, lbs	13	-32	-28
-11 support	Rx, lbs	205	-16	44
	Ry, lbs	131	22	19
	Rz, lbs	-71	97	5
-21 support	Rx, lbs	414	386	40
	Ry, lbs	-44	-113	5
	Rz, lbs	-97	-47	-8
-41 Tube	Rx, lbs	-75	-355	58
	Ry, lbs	6	27	-3
	Rz, lbs	88	392	63
-31 Tube	Rx, lbs	10	-30	-101
	Ry, lbs	-4	34	118
	Rz, lbs	-3	38	110

These reaction output from the AVAPS launcher installation were applied to the AVAPS BCE installation FEM as load inputs. The AVAPS BCE installation consists of 206 nodes and 208 elements. The BCE rack vertical frames and the launcher rails were modeled as beam elements with the appropriate material and cross section properties. The BEC rack vertical frames were restrained at the top against translation in the horizontal plane and restrained at the bottom to prevent translation and rotation about the major axis and torsion axis.

The following deflections were obtained from the FEA for the three load conditions analyzed:

	9g Forward	7g Downward	3g Sideward
Deflection, inches	0.039	0.012	0.018

These deflections are not significant.

The following table shows the reaction forces and moments for the three load conditions considered;

Location	Restraint Reaction	9g Forward	7g Downward	3g Sideward
Upr Outbd	Rx, lbs	267	65	16
	Ry, lbs	6	21	111
Upr Inbd	Rx, lbs	39	-12	-19
	Ry, lbs	-1	1	8
Lwr Outbd	Rx, lbs	460	-36	110
	Ry, lbs	-6	-25	80
	Rz, lbs	-1	623	-91
	My, in-lbs	6459	2319	925
	Mz, in-lbs	-550	187	-186
Lwr Inbd	Rx, lbs	94	-16	-108
	Ry, lbs	0	5	86
	Rz, lbs	2	46	92
	My, in-lbs	1095	38	-560
	Mz, in-lbs	-195	-144	91

The following table shows the maximum and minimum combined stress for the rack and rails:

Stress Condition	9g Forward	7g Downward	3g Sideward
Max Combined	10758 psi	7648 psi	13178 psi
Min Combined	-10109 psi	-7629 psi	-7366 psi

All of these maxima or minima values are for the rack frames with the exception of the minimum combined stress for the 9g forward condition which occurs in the -47 rail. The rail is a 3.0 x 1.38 inch, 0.19 inch thick, 6061-T6 aluminum extruded channel section. The yield compressive stress for 6061-T6 extrusion per DOT/FAA-AR-MMPDS-01 is 34,000 psi. The margin of safety for the -41 rail is:

$$MS = (34 / 10.1) - 1 \quad \Rightarrow \quad MS = +2.36$$

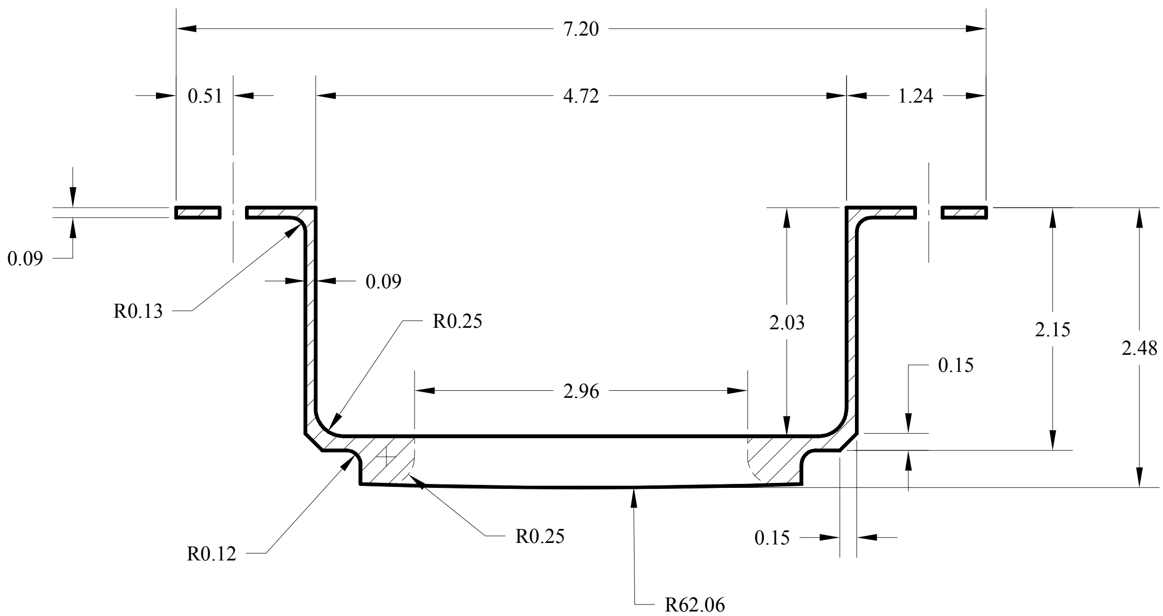
The rack frame is fabricated from formed steel sheet with ultimate tension strength per DOT/FAA-AR-MMPDS-01 of 55 ksi. The minimum margin of safety for the BCE rack frame

$$MS = (55 / 13.2) - 1 \quad \Rightarrow \quad MS = +3.16$$

The floor attachment fitting was substantiated for 9g forward load condition producing a 504 pound shear load and 7935 inch-pound moment as part of STC00585DE. That structural substantiation assumed 50% fixity at the floor. The Rx and My reactions for the 9g load condition for the AVAPS installation at the lower outboard floor attachment (460 pounds and 6459 inch-pounds respectively) are less than the STC substantiated force and moment and assume complete fixity. Thus positive margin will exist for the attachments and no further analysis is required.

The 677-05-25-500-63 fitting (9.2 inches long by 7.2 inches wide by 2.48 inches deep) replaces the existing fuselage plug to permit ejection of expendables from the aircraft. The existing plug is part of the baggage compartment fuselage mounting provision installed by LMAC as part of STC ST03056AT. The fitting is also a flanged plug with a ∅2.96 inch through hole and will pick up the existing attachment pattern. The fitting is machined from 7050-T7451 aluminum alloy plate. The -65 tube is attached to the launcher assembly and rests in a machined pocket on the flange. Thus load transfer from the launcher to the fitting will be negligible. Two O-rings maintain pressure seal. The base thickness of the fitting varies to maintain the aircraft OML and provide sufficient depth for the tube. The base is 6.72 by 4.72 inch rectangular shape with 1.86 inch corner radii. The perimeter walls of the fitting are 0.09 inches thick and approximately 2 inches deep. The attachment flange is 1.24 inches wide around the perimeter and 0.09 inches thick. Fourteen (14) fasteners secure the fitting to the aircraft.

The following figure shows the cross section through the width at the minimum base thickness section:



For analysis, assume the base can be approximated by a uniformly loaded square plate with a central circular hole. Conservatively assume the base to be 0.12 inches thick uniformly and 5.72 inches square (average of rectangular sides) with a ∅2.96 inch through hole. The ultimate uniform pressure load is:

$$q = p_{rv}\ (SF_1)\ (SF_2) = 10.48\ (1.67)\ (1.5) = 26.25 \text{ psi} \qquad \text{(ultimate)}$$

The plate ratio is:

$$R / b = 1.48 / 2.86 = 0.52 \qquad \text{(conservatively use 1/2)}$$

The plate stiffness coefficient is;

$$D = E\, t^3 / (12\ (1 - \mu^2))$$
$$= (10{,}300{,}000)\ (0.12)^3 / (12\ (1 - 0.33^2)) = 1664$$

The maximum deflection of a simply supported square plate with a circular hole subjected to a uniform load per the Astronautic Structures Manual, Volume 2, TM-X-73306, NASA MSFC, August 1975, is:

$$W_{max} = k\ q\ b^4 / D$$
$$= 0.053\ (26.25)\ (2.86^4) / 1664 = 0.06 \text{ inches} \qquad \text{(ultimate)}$$

This deflection is not excessive. The maximum moment would occur at the edge of the hole for a simply supported plate. The maximum moment per the Astronautic Structures Manual, Volume 2, TM-X-73306, NASA MSFC, August 1975, is:

$$M_\theta = \beta\ q\ b^2 = 0.207\ (26.25)\ (2.86^2) = 44.5 \text{ inch-pounds / inch}$$

This moment produces a bending stress in the plate of:

$$\sigma_b = 6\ M_\theta / t^2 = 6\ (44.5) / (.12)^2 = 18.5 \text{ ksi} \qquad \text{(ultimate)}$$

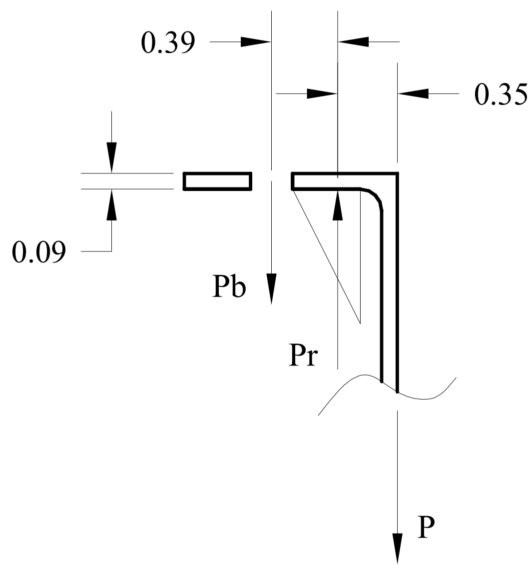
The yield compressive stress for 7050-T7451 aluminum alloy plate per DOT/FAA-AR-MMPDS-01 is 61 ksi. The margin of safety for the fitting is:

$$MS = (61 / 18.5) - 1 \quad \Rightarrow \quad MS = +2.29$$

The maximum reaction for a rectangular plate with simply supported edges and uniform load over the entire plate occurs at the center of the long sides. The maximum reaction per Roark's Formulas for Stress and Strain, 7th edition, (a / b = 6.72 / 4.72 = 1.43), is:

$$R_{max} = \gamma\ q\ b = 0.48\ (26.25)\ (4.72) = 59.5 \text{ pounds per inch} \qquad \text{(ultimate)}$$

The fastener pitch along the mounting flange is 1.75 inches. The free body diagram of the flange section is:



The bolt tension load is:

$$Pb = P\,(0.35 / 0.39) = 59.5\,(1.75)\,(0.35 / 0.39) = 93 \text{ pounds}$$

By inspection, a high margin of safety will exist for a 125 ksi #10 MS fastener (Ftu = 2255 pounds).

The flange bending stress is:

$$fb = 6\,M / t^2 = 6\,(59.5)\,(0.35) / (.12)^2 = 8.7 \text{ ksi} \qquad \text{(ultimate)}$$

The maximum flange stress is lower than the maximum base stress, thus a higher margin of safety will exist.

The -65 tube is clamped to the launcher at one end and is guided by the fitting at the opposite end. The tube is 11.3 inches long with a 3.5 inch outside diameter and a 2.91 ± 0.01 inch inside diameter. The tube is fabricated from cast Nylon 6 (PA 6), per federal specification L-P-410A. The tube is subjected to pressure loading only and does not support structural loads. The critical loading condition will be ultimate external pressure acting on the outside of the tube. The ultimate pressure load is:

$$q = P_{rv}\ SF_1\ SF_2 = 10.48\ (1.67)\ (1.5) = 26.25 \text{ psi} \qquad \text{(ultimate)}$$

The tube radius to thickness ratio is:

$$R_{avg} / t = (3.2 / 2) / 0.29 = 5.5$$

Thus the tube is a thick shell of revolution. Due to the end support geometry assume longitudinal pressure is externally balanced. The maximum circumferential (hoop) stress will occur on the inside surface and is:

$$\sigma_{2max} = - 2\ q\ r_o^2 / (r_0^2 - r_i^2)$$
$$= - 2\ (26.25)\ (1.75)^2 / ((1.75)^2 - (1.45)^2) = - 167 \text{ psi}$$

The maximum radial stress will occur on the outside surface and is:

$$\sigma_{3max} = - q = - 26.25 \text{ psi}$$

The ultimate tensile strength for monomer cast (nylon 6) per Federal Specification L-P-410a is 11ksi. The compressive yield strength for thermoplastics is greater than the ultimate tensile strength. Conservatively use Ftu for tension and compression. For non-metallic castings receiving 100% visual inspection, a casting factor of 3 is appropriate. By inspection the tube shows a high margin of safety.

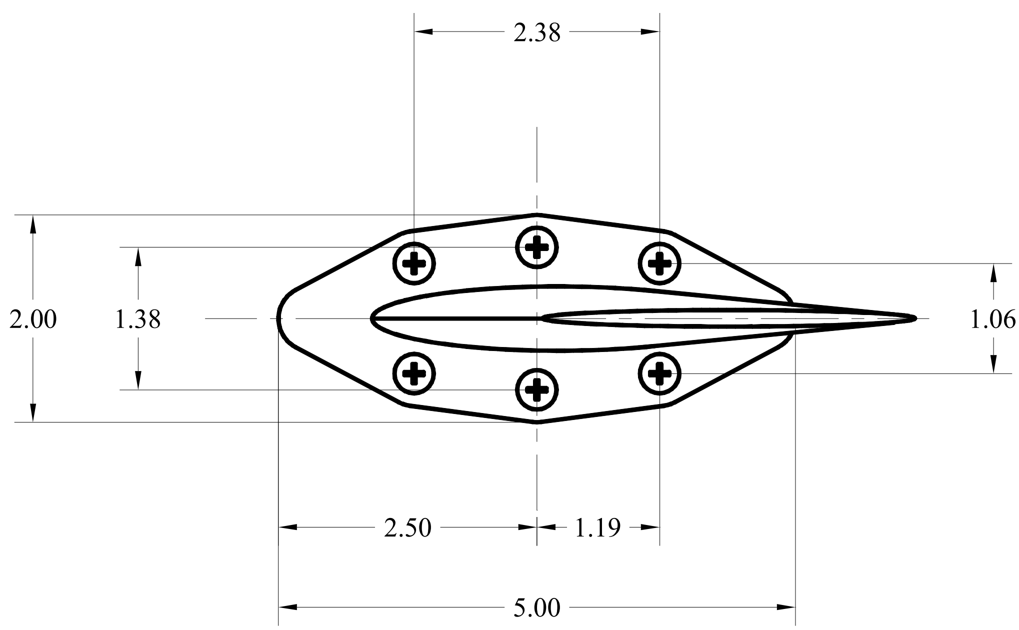
The UHF antenna is installed to a pre-existing mounting provision located at GVFS 271 on the bottom centerline of the fuselage. The antenna is a Sensor System Inc. blade style antenna which weighs less than one (1) pound and extends 5.31 inches from the fuselage. The antenna is swept back at 20 degrees. The antenna is secured to an adapter plate with six (6) #10 MS24694 screws and MS21209-10 locking helical inserts. The adapter plate is secured to the existing mounting provision with six (6) #10 MS24694 screws and NAS1473A3 sealed nut plates. The vendor estimated drag at Mach 0.85 and 35,000 feet altitude is five (5) pounds.

Any pair of center fuselage mounting provision is capable of supporting a 50 pound load with a center of gravity located 12.85 inches from the fuselage skin and a frontal area of 144 square inches per LMAC ICD 02006SN530245, Rev. B, Center Fuselage Mounts. The spacing between center mounting provision pairs varies from 36 to 39 inches. Conservatively assuming a 1g longitudinal load factor, the shear and tension reactions per center mounting provision are:

Fs = Wt / n = 50 / 2 = 25 pounds (ultimate)
Ft = Wt x h / d = 50 (12.85) / 39 = 16 pounds (ultimate)

By inspection, adequate margin exists for the center fuselage mounts. No further analysis of the existing mounting provision is required.

The antenna fastener pattern is shown in the diagram below:



Clearly, a 100 pound ultimate handling load applied sideward at the tip of the antenna will be critical. This load will produce a shear force (V), torque (T), and bending moment (M) at the base mounting flange fastener centroid of:

$V = 100$ pounds
$T = 100\ (5.31)\ (\sin 20) = 182$ inch-pounds
$M = 100\ (5.31) = 531$ inch-pounds

The moment will produce tension in the fasteners located on one side of the flange and compressive bearing of the flange against the adapter plate on the opposite side.

Conservatively assume the antenna flange will heel about the two collinear fasteners on the compression side. The maximum tension reaction will occur at the center fastener on the tension side and is:

$$P_m = (M\ r) / \sum(r_n^2)$$
$$= 531\ (1.22) / (1.22^2 + 2\ (1.06)^2) = 173 \text{ pounds} \qquad \text{(ultimate)}$$

The direct shear per fastener is:

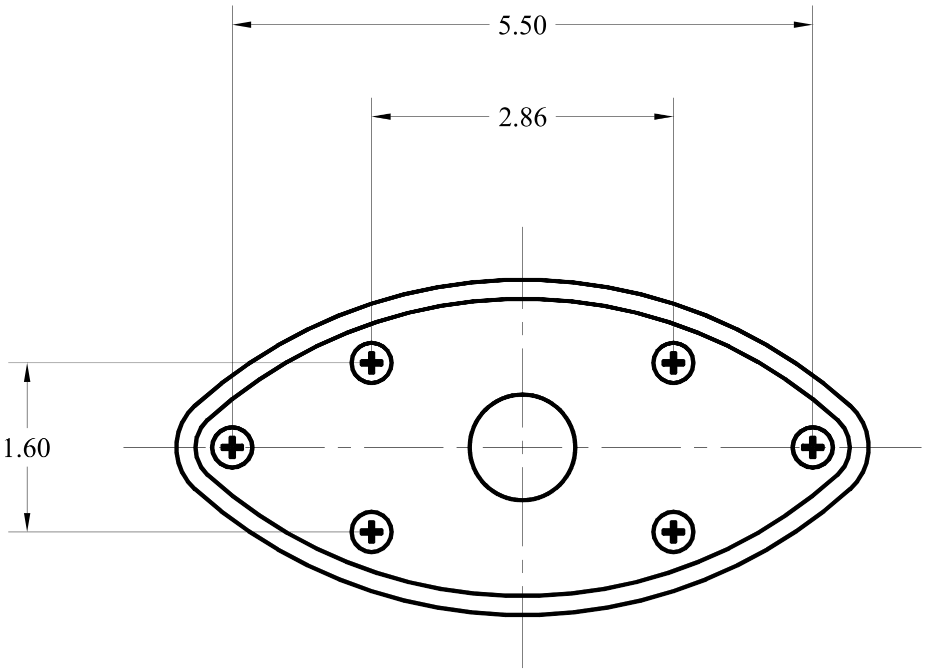
$$P_v = V / 6 = 100 / 6 = 17 \text{ pounds} \qquad \text{(ultimate)}$$

The shear due to the torque will be a maximum at the four fasteners greatest distance from the centroid and is:

$$P_t = (T\ r) / \sum(r_n^2)$$
$$= 182\ (1.30) / (2 \times (0.69)^2 + 4 \times (1.30)^2)$$
$$= 31 \text{ pounds} \qquad \text{(ultimate)}$$

The ultimate tension and shear strength for a #10 MS24694 screw per DOT/FAA-AR-MMPDS-01 is 2255 pounds and 2125 pounds respectively. By inspection, the margin of safety for the fastener will be high.

The adapter plate fastener pattern is shown in the diagram below:



The 100 pound ultimate sideward handling load will produce a shear force (V), torque (T), and bending moment (M) at the adapter plate fastener centroid of:

V = 100 pounds
T = 100 (2.42) = 242 inch-pounds
M = 100 (5.55) = 555 inch-pounds

The moment will produce tension in the fasteners located on one side of the adapter plate and compressive bearing of the adapter plate against the mounting provision on the opposite side.

Conservatively assume the adapter plate will heel about the two collinear fasteners on the compression side. The maximum tension reaction will occur at the center fastener on the tension side and is:

$$P_m = (M\ r) / \sum(r_n^2)$$
$$= 555\ (1.60) / (2\ (1.60)^2 + 2\ (0.80)^2) = 139 \text{ pounds} \quad \text{(ultimate)}$$

The direct shear per fastener is:

$$P_v = V / 6 = 100 / 6 = 17 \text{ pounds} \qquad \text{(ultimate)}$$

The shear due to the torque will be a maximum at the two fasteners greatest distance from the centroid and is:

$$P_t = (T\ r) / \sum(r_n^2)$$
$$= 242\ (2.25) / (2 \times (2.25)^2 + 4 \times (1.64)^2)$$
$$= 26 \text{ pounds} \qquad \text{(ultimate)}$$

The loads on the adapter plate fasteners are less than the loads on the antenna fasteners. Since the fastener type is identical, a larger margin of safety will exist for the adapter attachment fasteners and no further analysis is required.

3.0 Summary

All margins of safety for the AVAPS installations (MCE rack instrumentation, BCE rack launcher, fuselage plug, UHF antenna) are positive. When utilizing existing mounting provisions, all installations meet the LMAC defined geometric and weight envelope criteria. The installations are acceptable based on static structural strength substantiation.

A.0 Appendix A

Drawings

B.0 Appendix B

FEM / FEA Results

C.0 Appendix C

Reference Data

National Center for Atmospheric Research

Airborne Vertical Atmospheric Profiling System (AVAPS) Installation

Drawing List DL-AVAPS-100

NSF Gulfstream V Aircraft, SN 677

Revisions

Revision	Date	Description	Pages	Approved
IR	20 Oct 05	Initial Release	1,2	MTL

Approved:

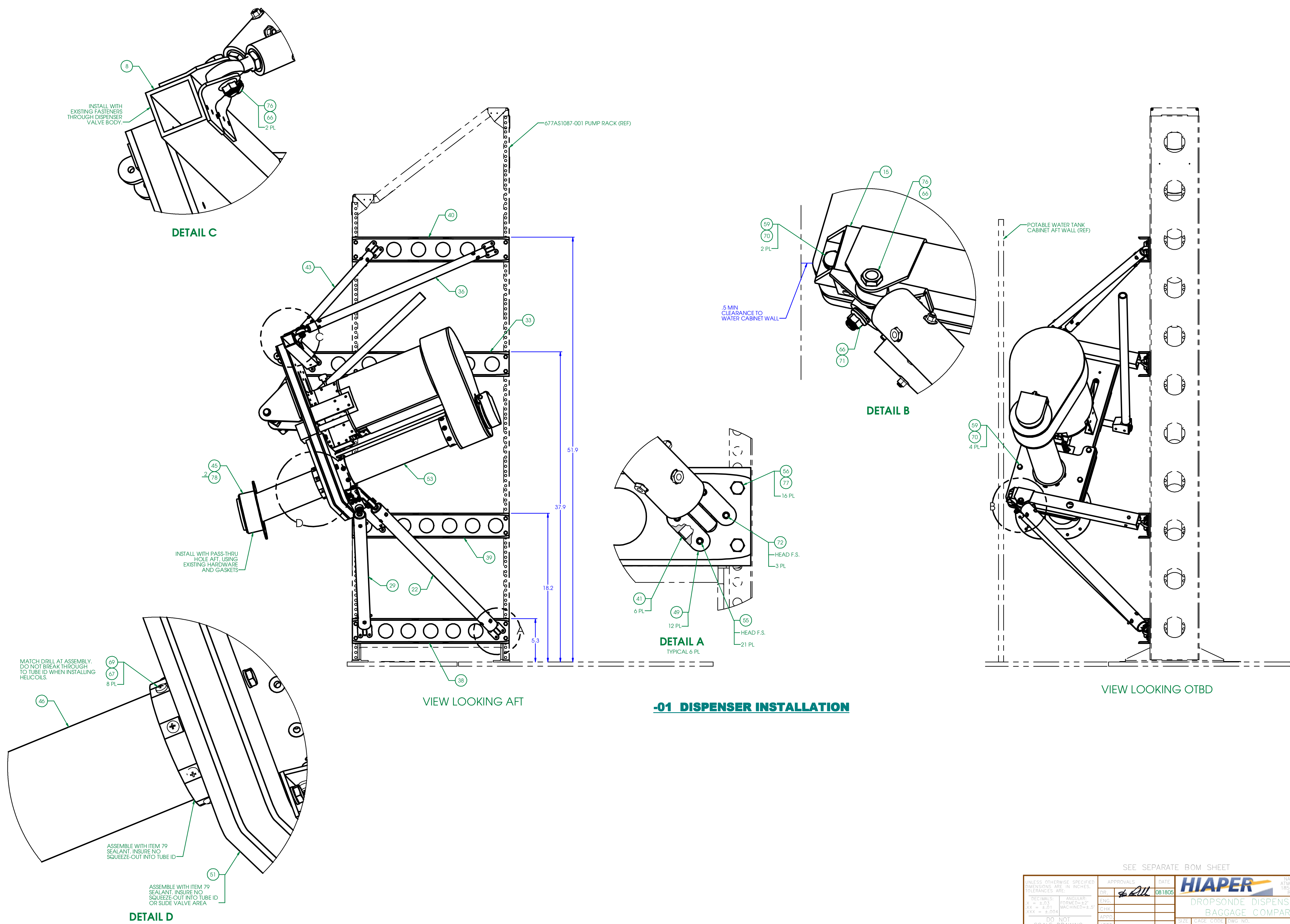
Date: October 20, 2005

Drawing List

Drawing Number	Title	Rev	Date
Mechanical			
677-05-25-500	Dropsonde Dispenser Installation, Baggage Compartment	NC	18 Aug 05
67705AVAPS-1	AVAPS MCE Rack Equipment Installation	NC	12 Sep 05
67705AVAPS-2	Storage Box Assembly AVAPS Rack	NC	06 Sep 05
67705AVAPS1217	AVAPS UHF Antenna Installation - GV	IR	12 Oct 05
Electrical			
677-05-EE-503	AVAPS Rack Cable Run	A	14 Oct 05
677AVAPS-100-01	Power Distribution Block Diagram	A	02 Sep 05
AVAPS-2-01	HIAPER Dropsonde Instrumentation Block Wiring Diagram	A	26 Oct 05
AVAPS-2-02	HIAPER Dropsonde Instrumentation Assembly Wiring Diagram	A	2 Sep 05
677AVAPS-3-01	AC Power Cable, Cooling Fan	A	19 Oct 05
677AVAPS-3-02	AC Power Cable, Cooling Fan to Telemetry Chassis	A	7 Sep 05
677AVAPS-3-03	AC Power Cable, 28 VDC Power Supply	A	7 Sep 05
677AVAPS-3-04	DC Power Cable, 28 VDC Power Supply to Launch Control Panel	A	7 Sep 05
677AVAPS-3-05	Launcher Control Cable, Launch Control Panel to 28 VDC Pwr Supply	A	7 Sep 05
677AVAPS-3-06	RF Coax Cable, UHF Antenna	A	19 Oct 05
677AVAPS-3-07	Control Cable to Dropwindsonde Launcher Assembly	A	25 Oct 05
677AVAPS-3-08	AC Power Cables, Computer	A	19 Oct 05
677AVAPS-3-09	GPS RF Cable, Sonde Storage Box to Telemetry Chassis	A	19 Oct 05
677AVAPS-3-10	GPS RF Cable, Sonde Storage Box	A	19 Oct 05
677AVAPS-3-11	AC Power Cables, Monitor	A	19 Oct 05
677AVAPS-3-12	Computer Video Monitor Cable	A	19 Oct 05
677AVAPS-3-13	Mouse/Keyboard Cable	A	19 Oct 05
677AVAPS-3-14	Digi Octopus Serial Cable	A	19 Oct 05
677AVAPS-3-15	RF Coax, Launcher GPS Reradiating Antenna	A	19 Oct 05

Approved:

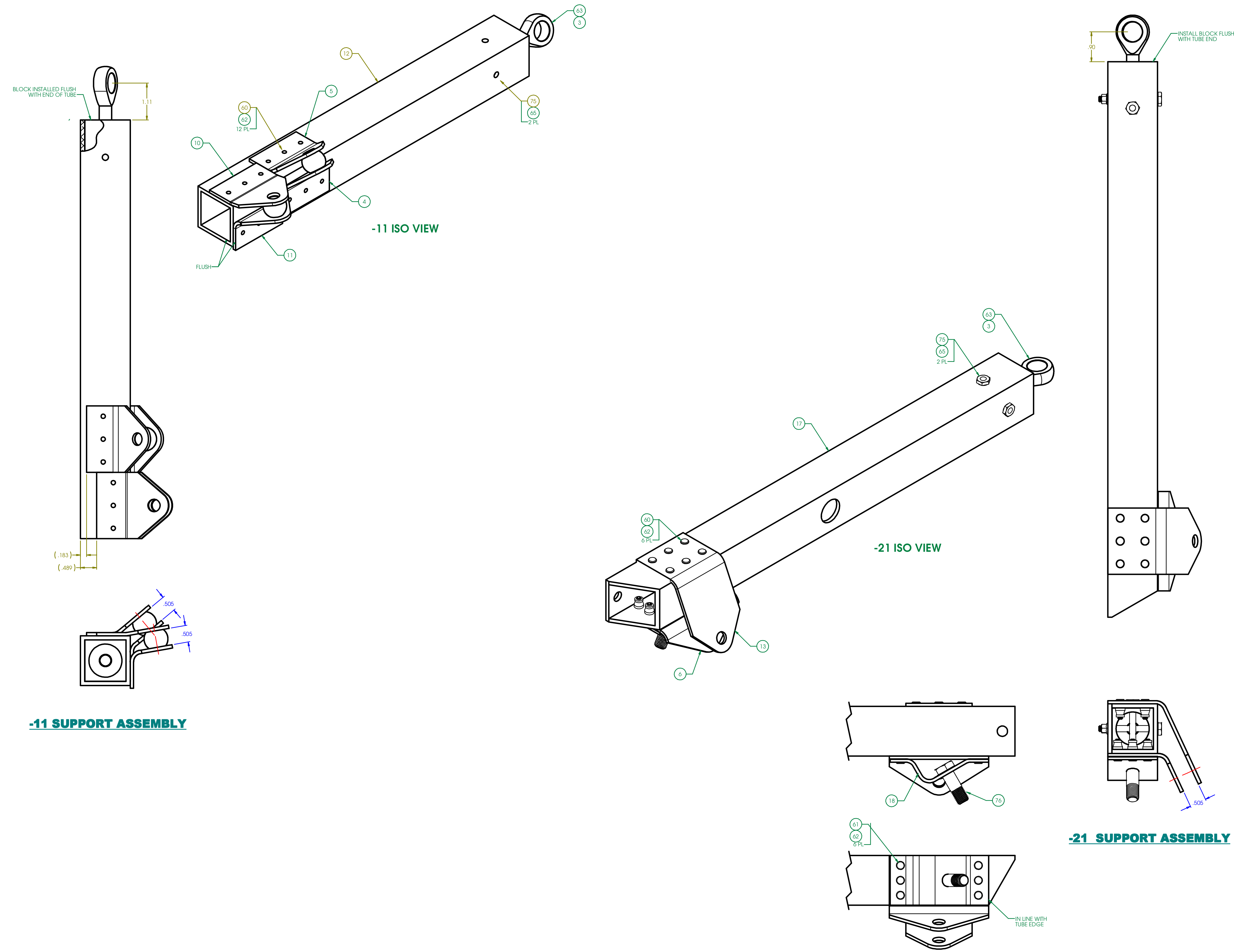
Date: October 20, 2005



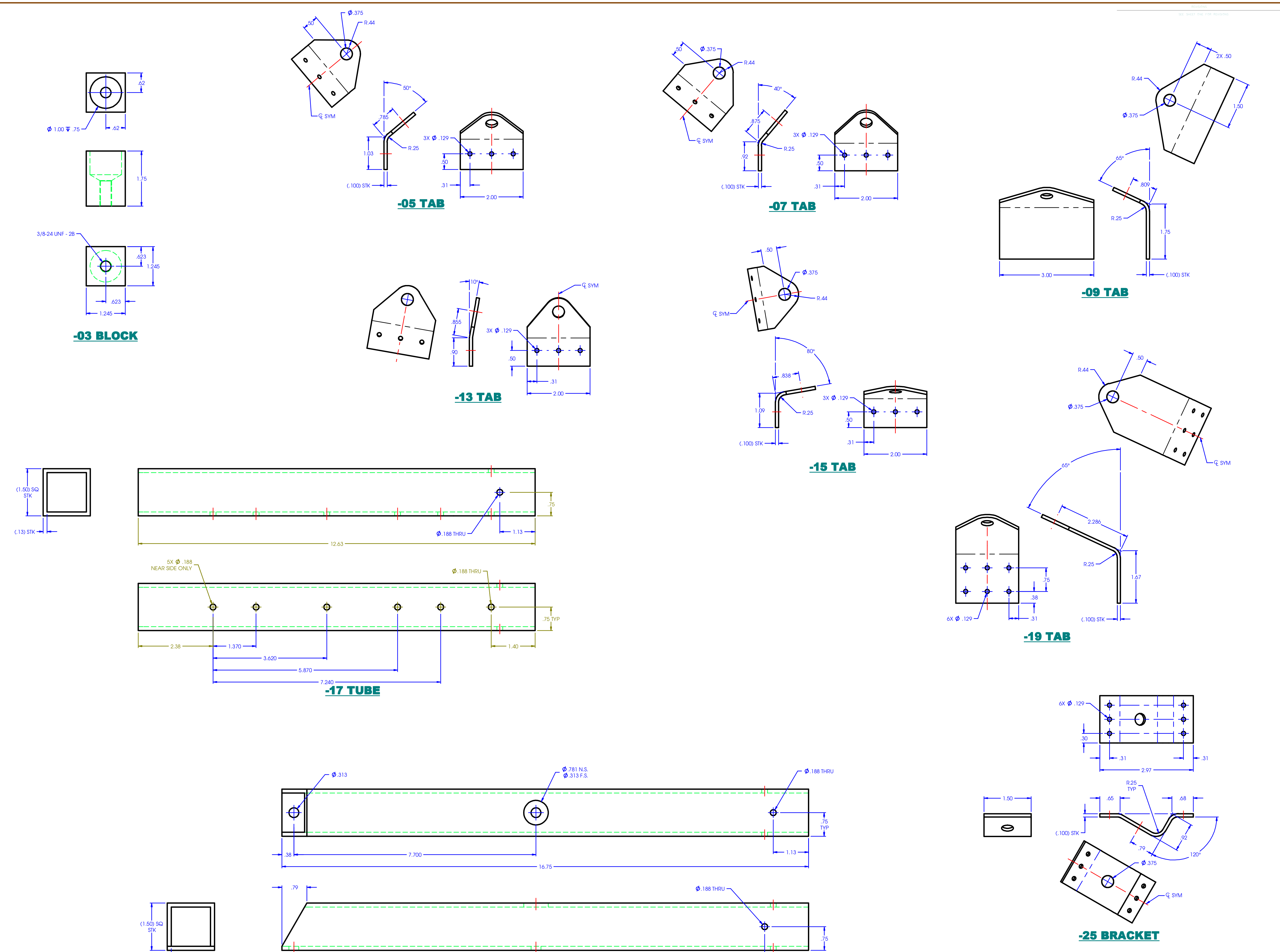
-01 DISPENSER INSTALLATION

SEE SEPARATE BOM SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS: .X = ±.03 .XX = ±.01 .XXX = ±.004 ANGULAR: FORMED=±2° MACHINED=±.5°	APPROVALS	DATE	HIAPER — NATIONAL CENTER FOR ATMOSPHERIC RESEARCH 1850 TABLE MESA DRIVE BOULDER, CO 80305
	DR.	081805	DROPSONDE DISPENSER INSTL BAGGAGE COMPARTMENT
	ENG.		SIZE E / CAGE CODE 0SEF6 / DWG NO. 677-05-25-500 / REV. NC
	CHK.		SCALE 1:1
DO NOT SCALE DRAWING	APPD.		DESIGN & FABRICATION SERVICES, ATMOSPHERIC TECHNOLOGY DIV.
NEXT ASSEMBLY	EFFECTIVITY GV S/N 677		SHEET 1 of 6



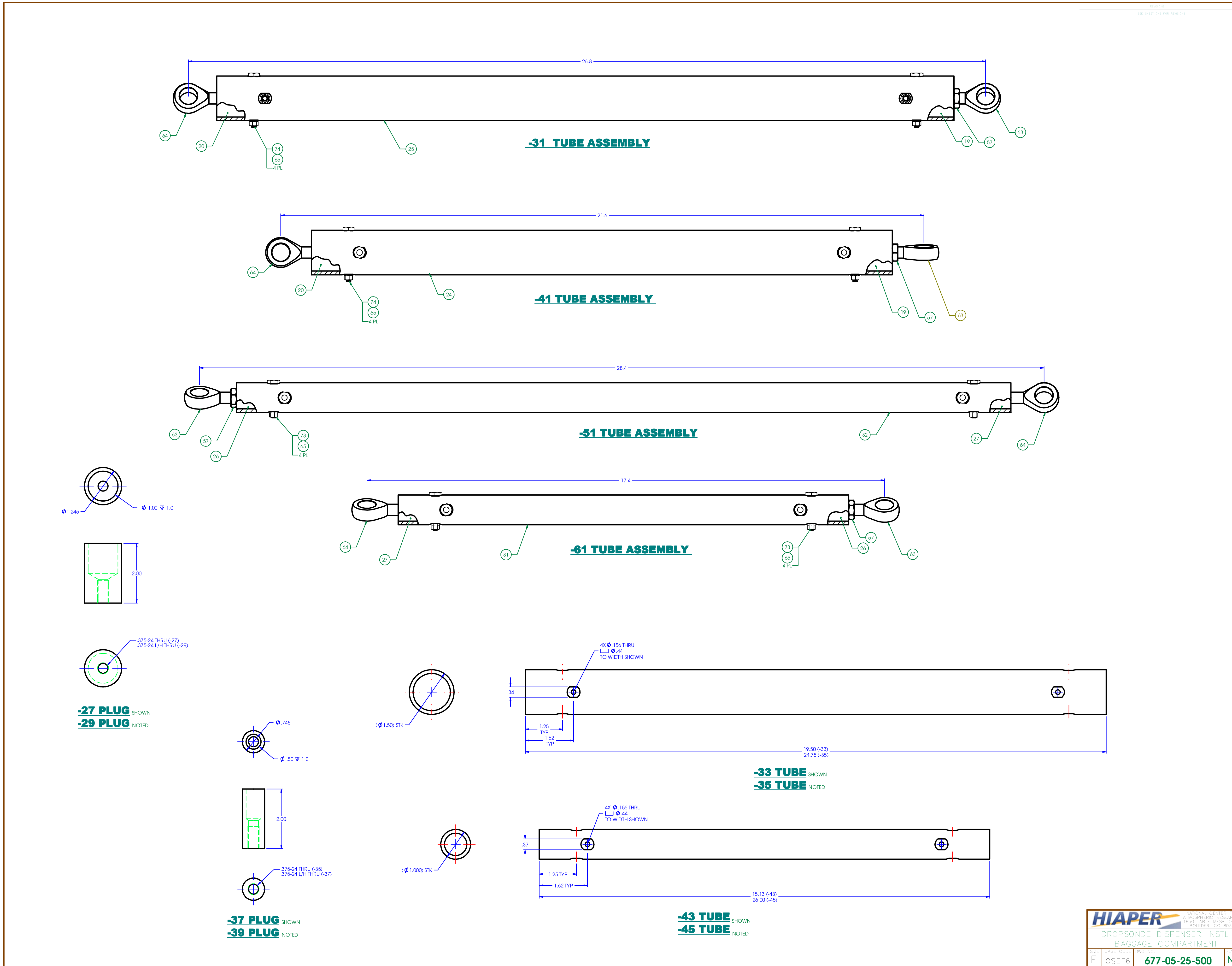
HIAPER	NATIONAL CENTER FOR ATMOSPHERIC RESEARCH 1850 TABLE MESA DRIVE BOULDER, CO 80305		
DROPSONDE DISPENSER INSTL BAGGAGE COMPARTMENT			
SIZE E	CAGE CODE 0SEF6	DWG NO. 677-05-25-500	REV. NC
SCALE 1:1	DESIGN & FABRICATION SERVICES, ATMOSPHERIC TECHNOLOGY DIV.	SHEET 2 of 6	

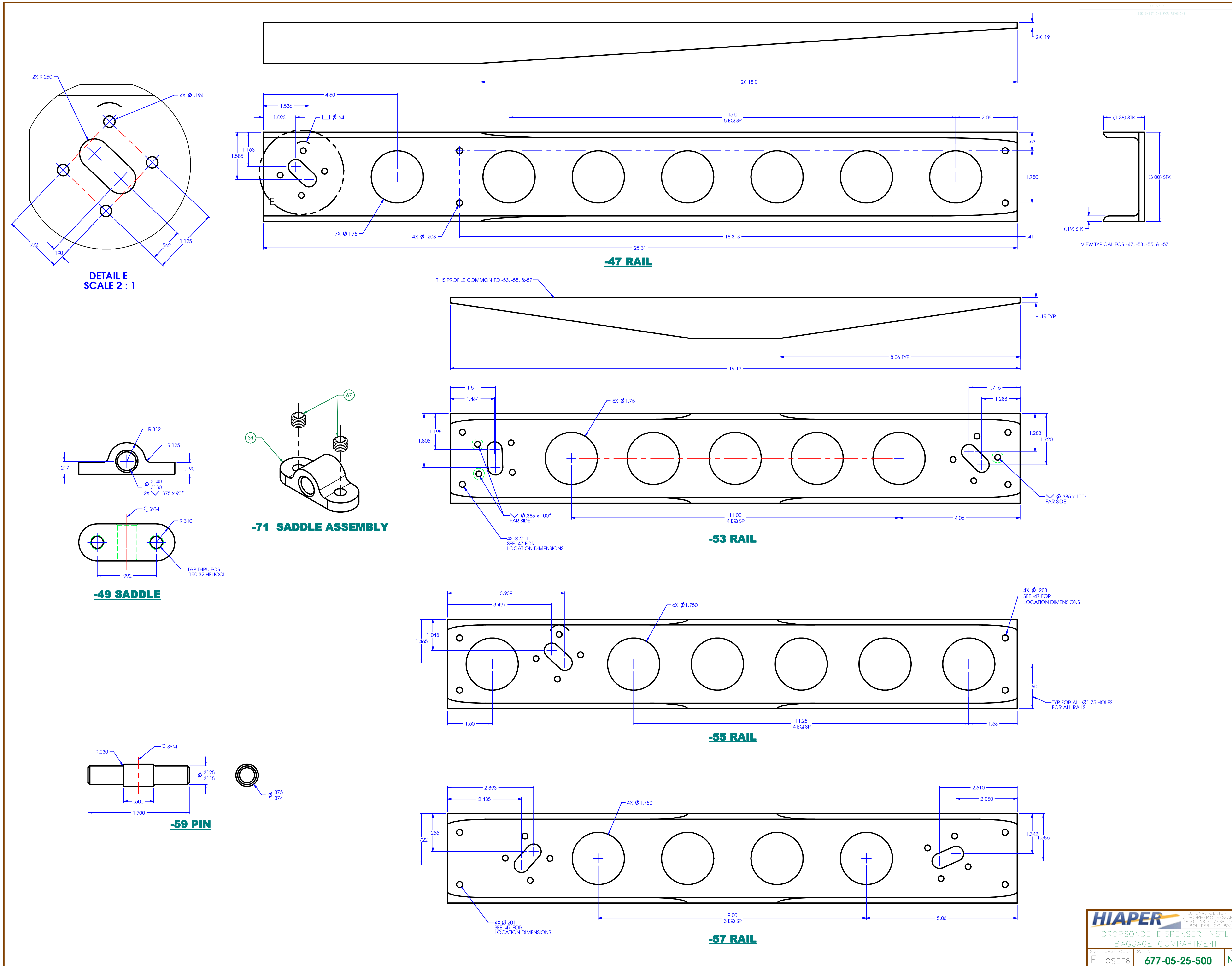


HIAPER
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
1850 TABLE MESA DRIVE
BOULDER, CO 80305

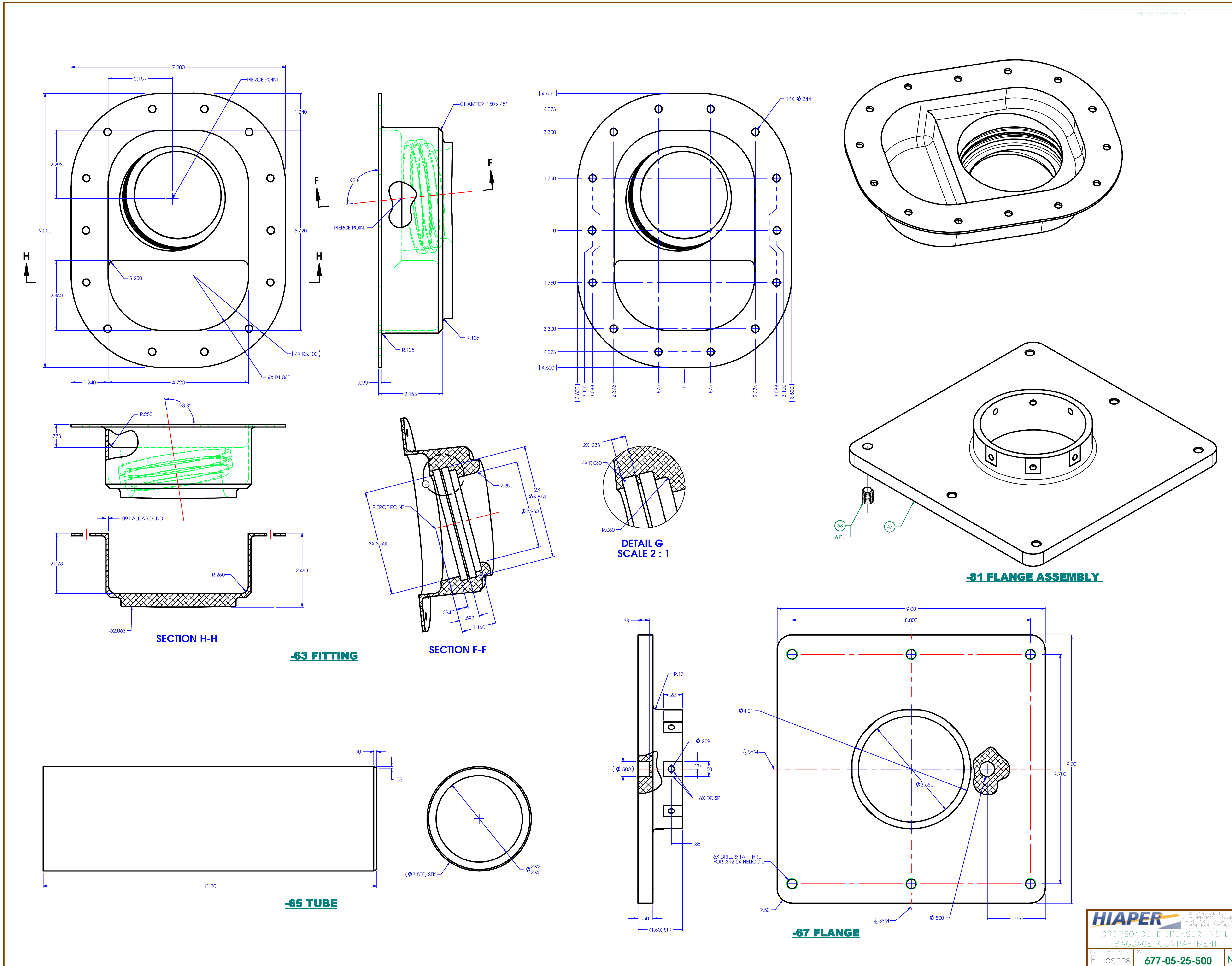
DROPSONDE DISPENSER INSTL
BAGGAGE COMPARTMENT

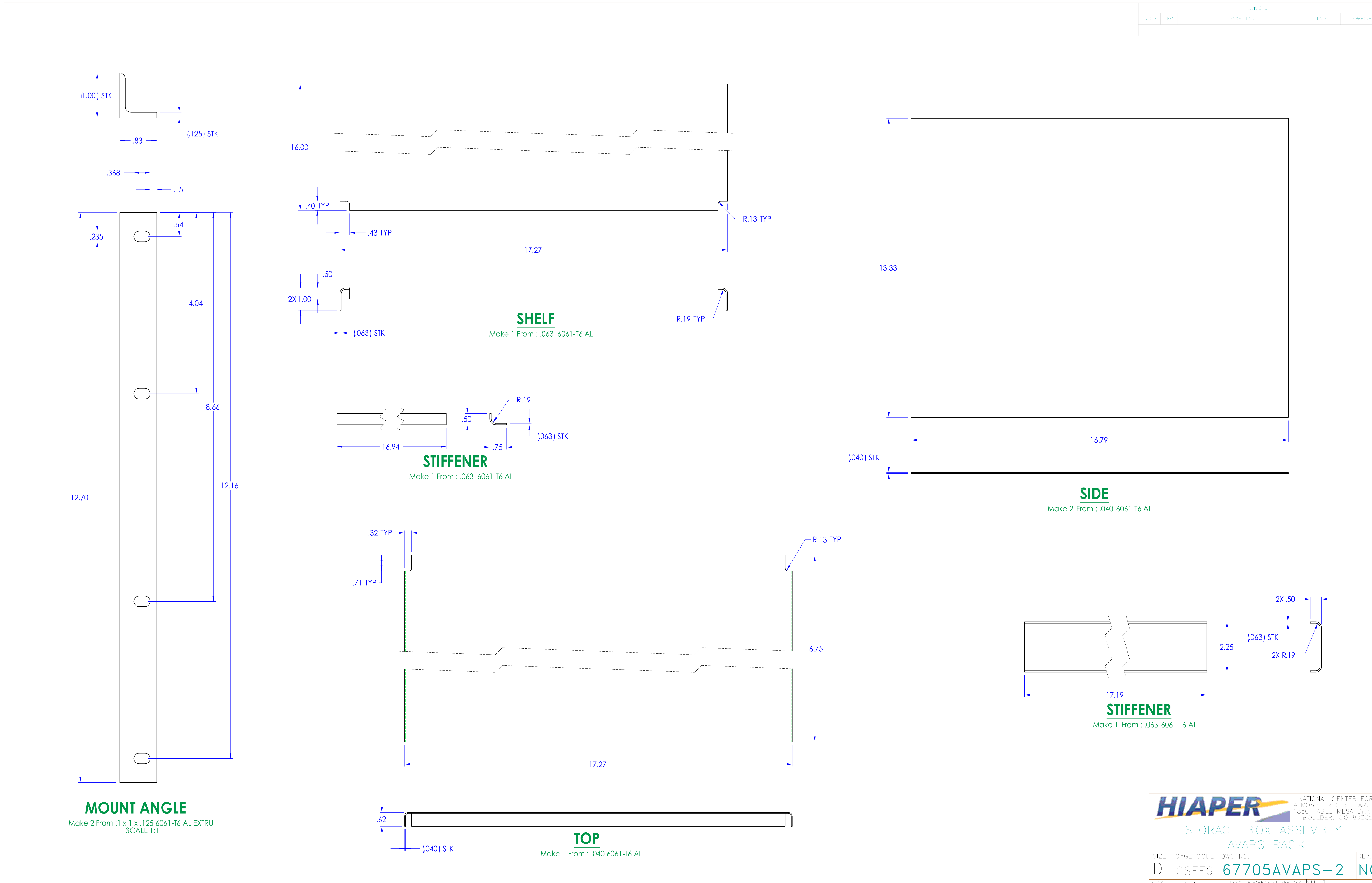
SIZE	CAGE CODE	DWG NO.	REV.
E	0SEF6	677-05-25-500	NC
SCALE 1:1	DESIGN & FABRICATION SERVICES, ATMOSPHERIC TECHNOLOGY DIV.	SHEET 3 of 6	


-31 TUBE ASSEMBLY
26.8
-41 TUBE ASSEMBLY
21.6
-51 TUBE ASSEMBLY
28.4
-61 TUBE ASSEMBLY
17.4
4 PL
-27 PLUG SHOWN
-29 PLUG NOTED
ϕ 1.245
ϕ 1.00 ↧ 1.0
2.00
.375-24 THRU (-27)
.375-24 L/H THRU (-29)
-37 PLUG SHOWN
-39 PLUG NOTED
ϕ .745
ϕ .50 ↧ 1.0
.375-24 THRU (-35)
.375-24 L/H THRU (-37)
(ϕ 1.50) STK
(ϕ 1.000) STK
-33 TUBE SHOWN
-35 TUBE NOTED
4X ϕ .156 THRU
ϕ .44
TO WIDTH SHOWN
19.50 (-33)
24.75 (-35)
1.25 TYP
1.62 TYP
.34
-43 TUBE SHOWN
-45 TUBE NOTED
15.13 (-43)
26.00 (-45)
.37
HIAPER
DROPSONDE DISPENSER INSTL
BAGGAGE COMPARTMENT
E
0SEF6
677-05-25-500
NC
1:1
4 of 6



-47 RAIL
-53 RAIL
-55 RAIL
-57 RAIL
-71 SADDLE ASSEMBLY
-49 SADDLE
-59 PIN
DETAIL E
SCALE 2 : 1
THIS PROFILE COMMON TO -53, -55, & -57
VIEW TYPICAL FOR -47, -53, -55, & -57
TYP FOR ALL Ø1.75 HOLES FOR ALL RAILS
4X Ø .203 SEE -47 FOR LOCATION DIMENSIONS
4X Ø.201 SEE -47 FOR LOCATION DIMENSIONS
Ø .385 x 100° FAR SIDE
TAP THRU FOR .190-32 HELICOIL
HIAPER
DROPSONDE DISPENSER INSTL
BAGGAGE COMPARTMENT
E 0SEF6 677-05-25-500 NC


SECTION H-H
-63 FITTING
SECTION F-F
DETAIL G
SCALE 2 : 1
-81 FLANGE ASSEMBLY
-65 TUBE
-67 FLANGE
6X DRILL & TAP THRU
FOR .312-24 HELICOIL
PIERCE POINT
CHAMFER .150 x 45°
.091 ALL AROUND
HIAPER
DROPSONDE DISPENSER INSTL
BAGGAGE COMPARTMENT
E
0SEF6
677-05-25-500
NC
1:1
6 of 6



MOUNT ANGLE
Make 2 From :1 x 1 x .125 6061-T6 AL EXTRU
SCALE 1:1
(1.00) STK
(.125) STK
.83
.368
.15
.235
.54
4.04
8.66
12.16
12.70
SHELF
Make 1 From : .063 6061-T6 AL
16.00
.40 TYP
.43 TYP
R.13 TYP
17.27
.50
2X 1.00
(.063) STK
R.19 TYP
STIFFENER
Make 1 From : .063 6061-T6 AL
16.94
.50
.75
R.19
(.063) STK
TOP
Make 1 From : .040 6061-T6 AL
.32 TYP
.71 TYP
R.13 TYP
16.75
17.27
.62
(.040) STK
SIDE
Make 2 From : .040 6061-T6 AL
13.33
16.79
(.040) STK
STIFFENER
Make 1 From : .063 6061-T6 AL
2.25
17.19
2X .50
(.063) STK
2X R.19
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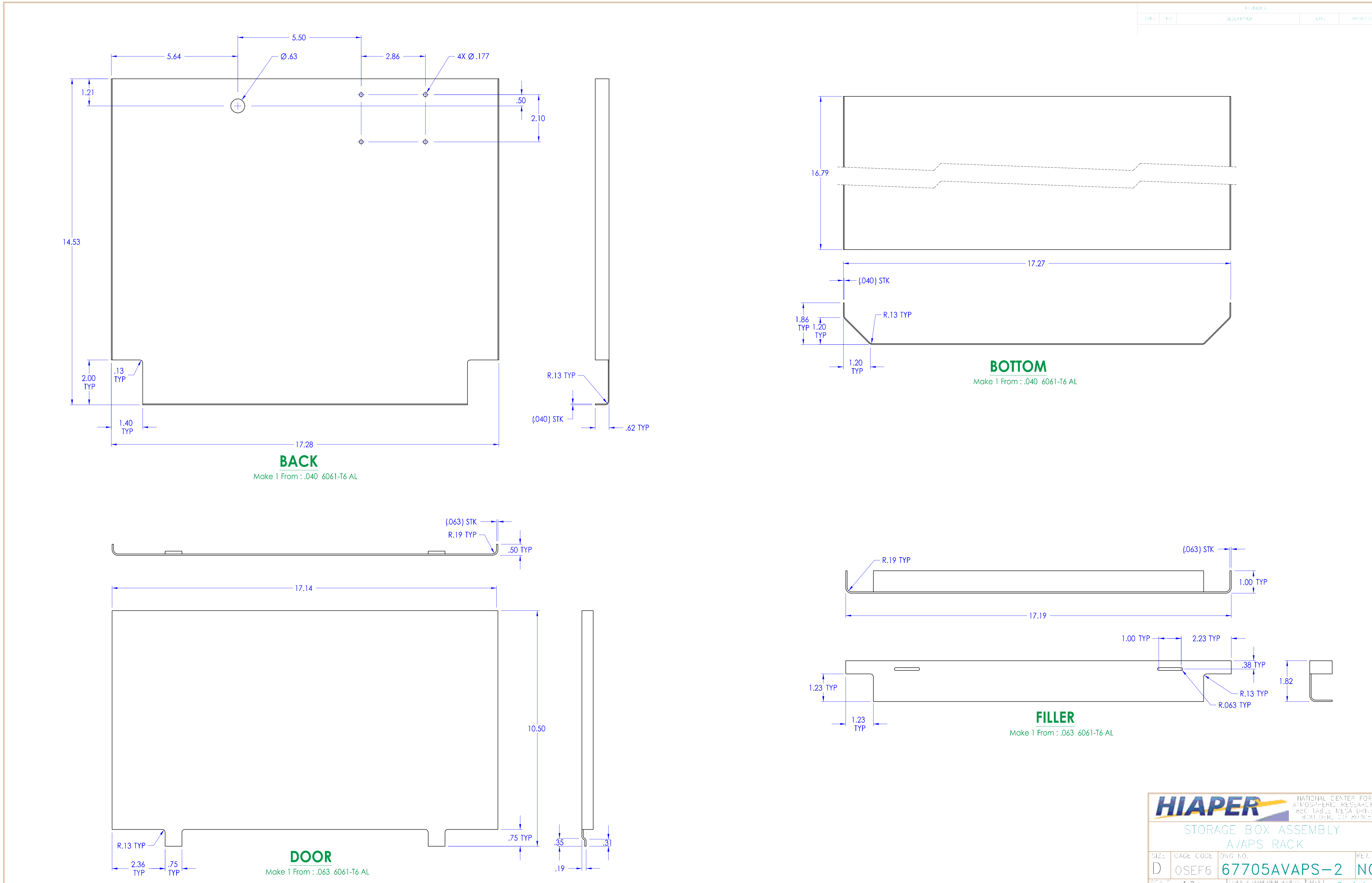
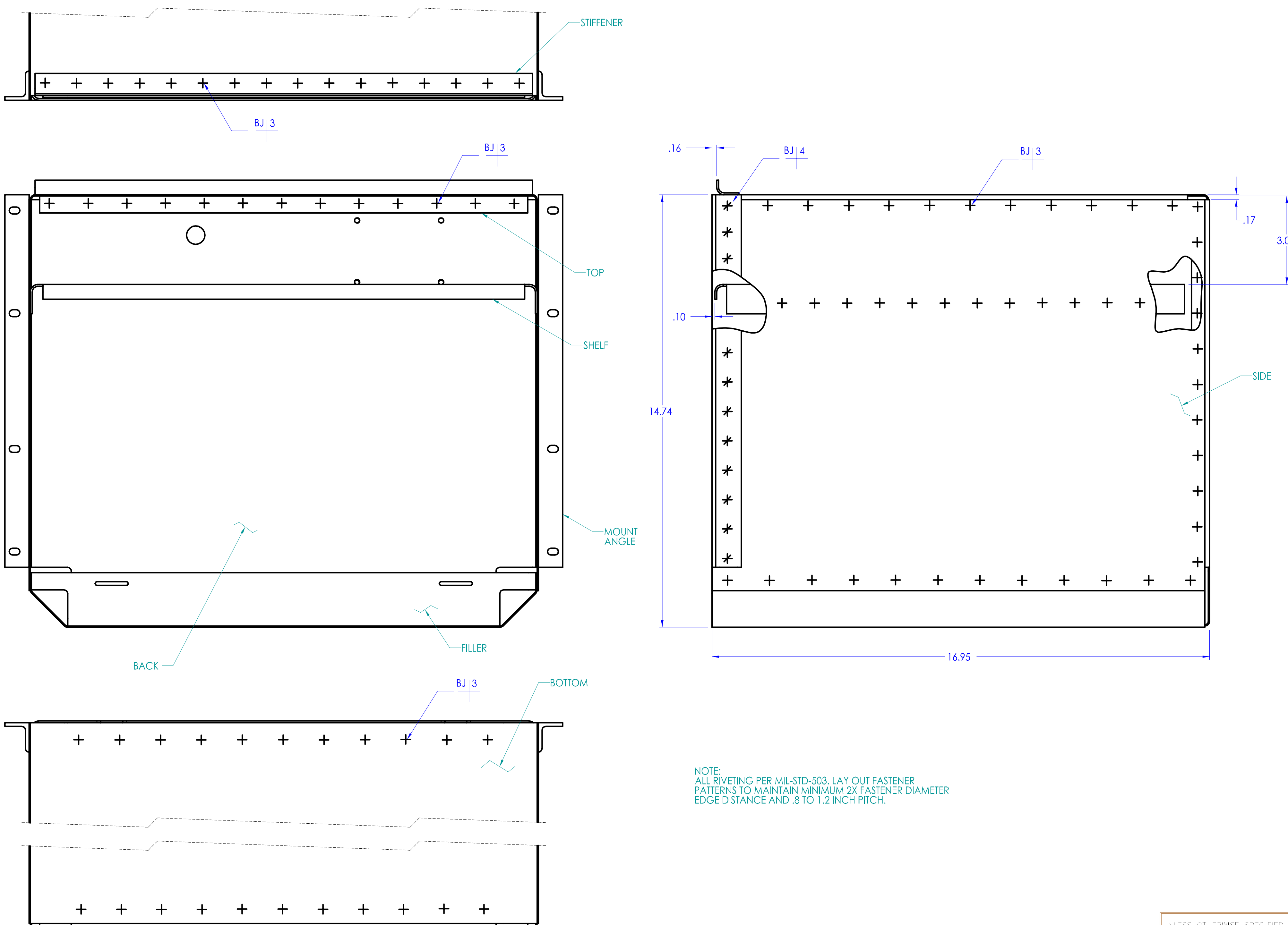
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
STORAGE BOX ASSEMBLY
A/APS RACK
SIZE D
CAGE CODE 0SEF6
DWG NO. 67705AVAPS-2
REV NC
SCALE 1:2
SHEET 3 of 4



BACK
Make 1 From: .040 6061-T6 AL
5.64
5.50
Ø.63
2.86
4X Ø.177
1.21
.50
2.10
14.53
2.00 TYP
.13 TYP
1.40 TYP
17.28
R.13 TYP
(.040) STK
.62 TYP
BOTTOM
Make 1 From: .040 6061-T6 AL
16.79
17.27
(.040) STK
1.86 TYP
1.20 TYP
R.13 TYP
1.20 TYP
DOOR
Make 1 From: .063 6061-T6 AL
(.063) STK
R.19 TYP
.50 TYP
17.14
10.50
R.13 TYP
2.36 TYP
.75 TYP
.75 TYP
.35
.31
.19
FILLER
Make 1 From: .063 6061-T6 AL
R.19 TYP
(.063) STK
1.00 TYP
17.19
1.00 TYP
2.23 TYP
.38 TYP
1.23 TYP
1.23 TYP
R.13 TYP
R.063 TYP
1.82
HIAPER
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
STORAGE BOX ASSEMBLY
A/APS RACK
SIZE D
CAGE CODE 0SEF6
DWG NO. 67705AVAPS-2
REV NC
SCALE 1:2
SHEET 2 of 4



NOTE:
ALL RIVETING PER MIL-STD-503. LAY OUT FASTENER PATTERNS TO MAINTAIN MINIMUM 2X FASTENER DIAMETER EDGE DISTANCE AND .8 TO 1.2 INCH PITCH.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
DO NOT SCALE DRAWING
NEXT ASSEMBLY

APPROVALS | DATE
DR. | 090605

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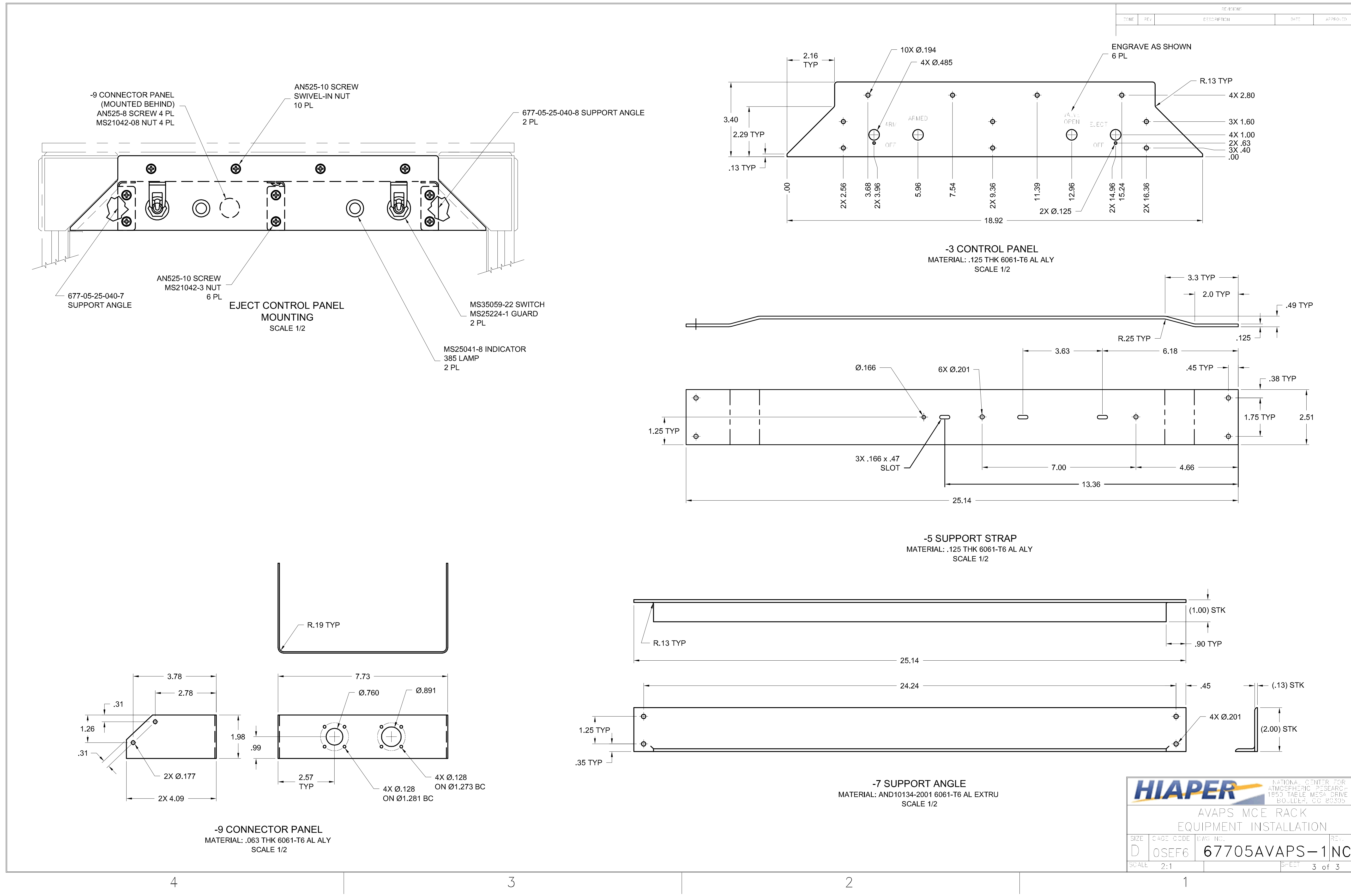
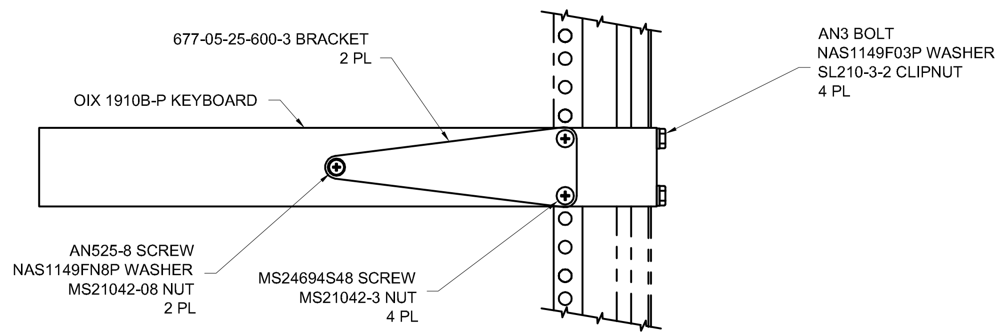
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
STORAGE BOX ASSEMBLY
AVAPS RACK

SIZE	CAGE CODE	DWG NO.	REV
D	0SEF6	67705AVAPS-2	NC

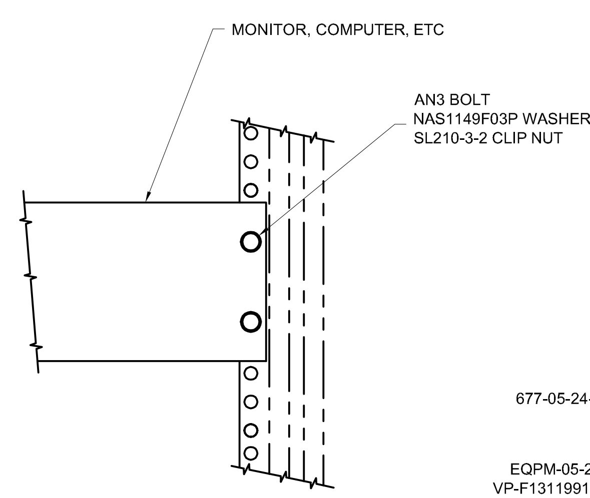
SCALE 1:2 SHEET 1 of 4



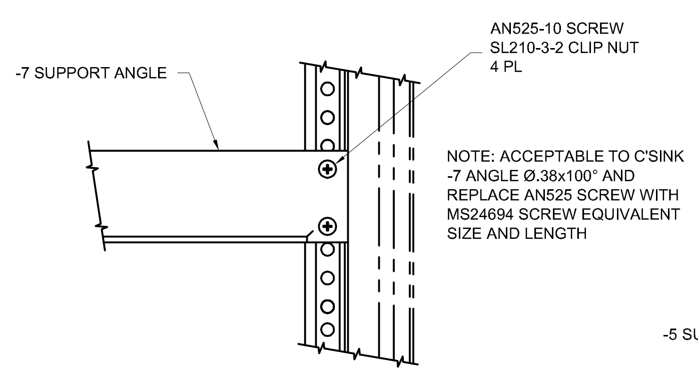
-9 CONNECTOR PANEL (MOUNTED BEHIND) AN525-8 SCREW 4 PL MS21042-08 NUT 4 PL
AN525-10 SCREW SWIVEL-IN NUT 10 PL
677-05-25-040-8 SUPPORT ANGLE 2 PL
AN525-10 SCREW MS21042-3 NUT 6 PL
677-05-25-040-7 SUPPORT ANGLE
EJECT CONTROL PANEL MOUNTING
SCALE 1/2
MS35059-22 SWITCH MS25224-1 GUARD 2 PL
MS25041-8 INDICATOR 385 LAMP 2 PL
10X Ø.194
4X Ø.485
ENGRAVE AS SHOWN 6 PL
R.13 TYP
2.16 TYP
3.40
2.29 TYP
.13 TYP
4X 2.80
3X 1.60
4X 1.00
2X .63
3X .40
.00
ARM
OFF
ARMED
VALVE OPEN
EJECT
OFF
.00
2X 2.56
3.68
2X 3.96
5.96
7.54
2X 9.36
11.39
12.96
2X Ø.125
2X 14.96
15.24
2X 16.36
18.92
-3 CONTROL PANEL
MATERIAL: .125 THK 6061-T6 AL ALY
SCALE 1/2
3.3 TYP
2.0 TYP
.49 TYP
R.25 TYP
.125
3.63
6.18
Ø.166
6X Ø.201
.45 TYP
.38 TYP
1.75 TYP
2.51
1.25 TYP
3X .166 x .47 SLOT
7.00
4.66
13.36
25.14
-5 SUPPORT STRAP
MATERIAL: .125 THK 6061-T6 AL ALY
SCALE 1/2
R.19 TYP
(1.00) STK
R.13 TYP
.90 TYP
25.14
24.24
.45
(.13) STK
4X Ø.201
(2.00) STK
1.25 TYP
.35 TYP
-7 SUPPORT ANGLE
MATERIAL: AND10134-2001 6061-T6 AL EXTRU
SCALE 1/2
3.78
2.78
.31
1.26
.31
1.98
2X Ø.177
2X 4.09
7.73
Ø.760
Ø.891
.99
2.57 TYP
4X Ø.128 ON Ø1.281 BC
4X Ø.128 ON Ø1.273 BC
-9 CONNECTOR PANEL
MATERIAL: .063 THK 6061-T6 AL ALY
SCALE 1/2
HIAPER
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH 1850 TABLE MESA DRIVE BOULDER, CO 80305
AVAPS MCE RACK
EQUIPMENT INSTALLATION
SIZE D
CAGE CODE 0SEF6
DWG NO. 67705AVAPS-1
REV NC
SCALE 2:1
SHEET 3 of 3



KEYBOARD INSTALLATION
SCALE 1/2

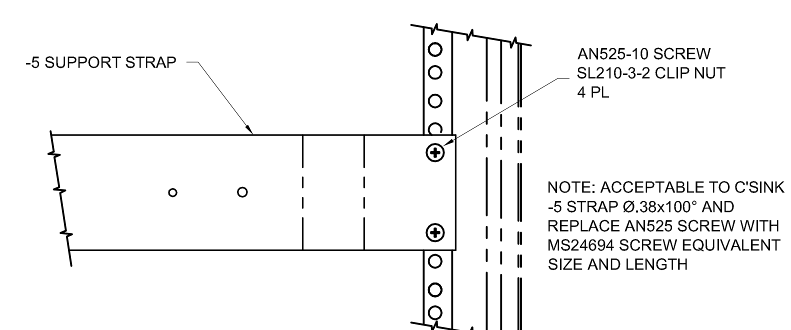


FACE PANEL MOUNTING, TYP
SCALE 1/2



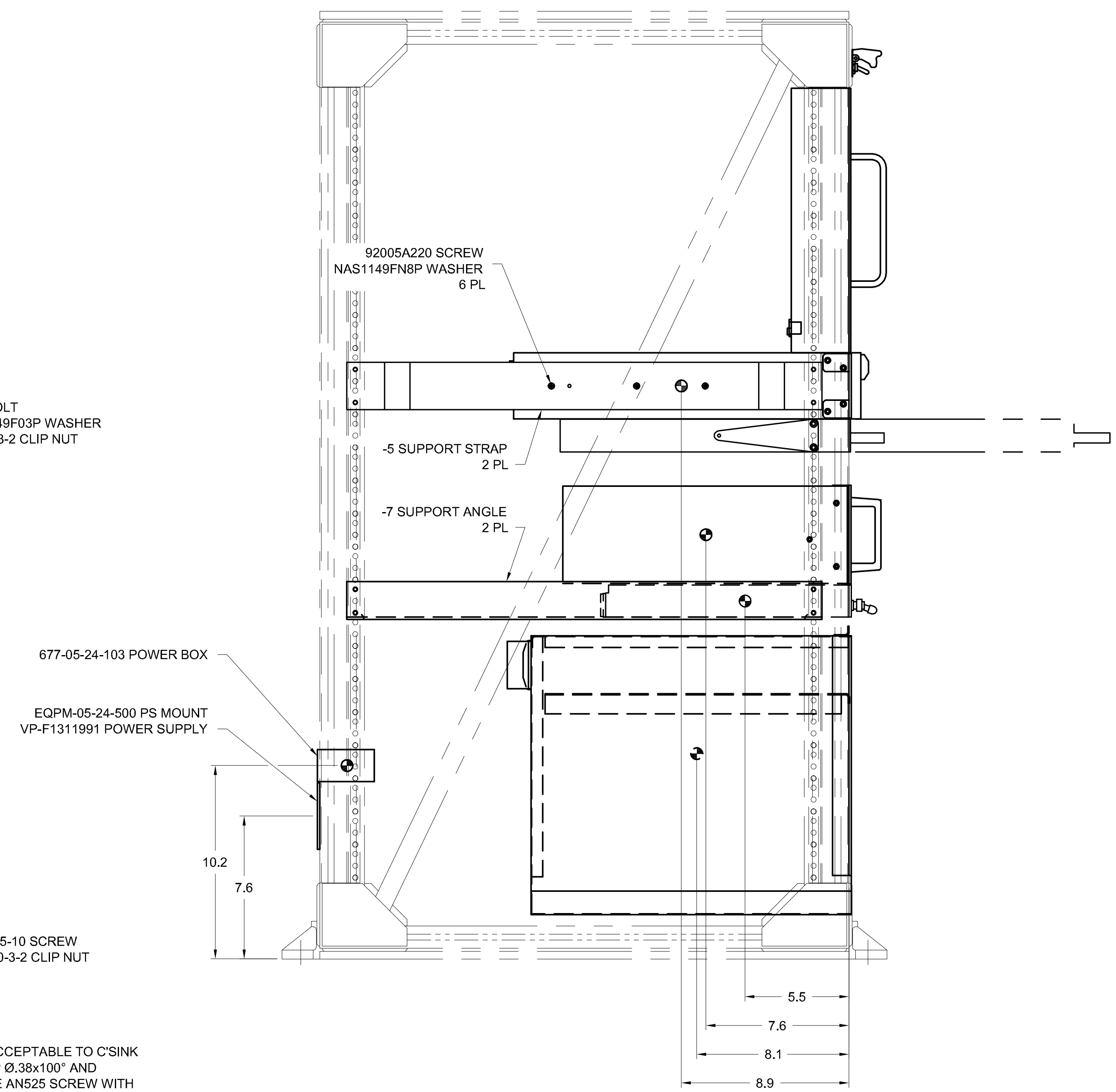
NOTE: ACCEPTABLE TO C'SINK -7 ANGLE Ø.38x100° AND REPLACE AN525 SCREW WITH MS24694 SCREW EQUIVALENT SIZE AND LENGTH

SUPPORT ANGLE MOUNTING, TYP
VIEW LOOKING OTBD FROM INSIDE RACK
SCALE 1/2



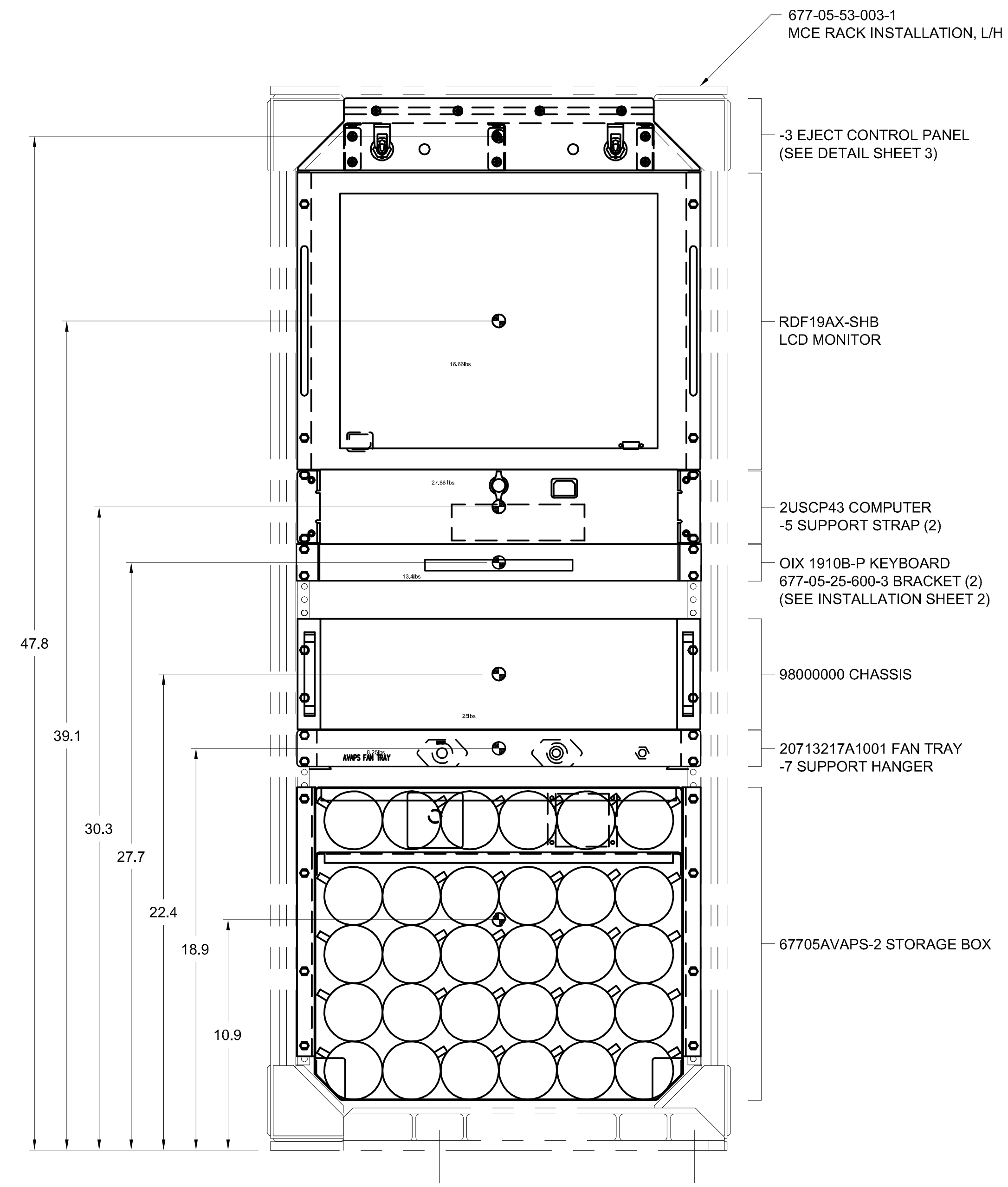
NOTE: ACCEPTABLE TO C'SINK -5 STRAP Ø.38x100° AND REPLACE AN525 SCREW WITH MS24694 SCREW EQUIVALENT SIZE AND LENGTH

SUPPORT STRAP MOUNTING, TYP
VIEW LOOKING OTBD FROM INSIDE RACK
SCALE 1/2



-1 AVAPS RACK EQUIP INSTALLATION
VIEW LOOKING OUTBOARD
SCALE 1/4

HIAPER		NATIONAL CENTER FOR ATMOSPHERIC RESEARCH 1850 TABLE MESA DRIVE BOULDER, CO 80305	
AVAPS MCE RACK EQUIPMENT INSTALLATION			
SIZE D	CAGE CODE 0SEF6	DWG NO. 67705AVAPS-1	REV. NC
SCALE 2:1		SHEET 2 of 3	



-1 AVAPS RACK EQUIP INSTALLATION

VIEW LOOKING AFT

ITEM	REQD	PART NO.	DESCRIPTION	MANUFACTURER OR MATERIAL	SPECIFICATION	WT.
35	10		SWIVEL-IN NUT	NCAR		
34	AR	SL210-3-2	NUT, CLIP, .190-32	SHUR-LOK		
33	AR	NAS1149F03P	WASHER, #10	STEEL, CAD PLT		
32	AR	NAS1149FN8P	WASHER, #8	STEEL, CAD PLT		
31	2	MS35059-22	SWITCH			
30	2	MS25224-1	GUARD			
29	2	MS25041-8	INDICATOR			
28	AR	MS21042-3	NUT, HEX, .190-32	STEEL, CAD PLT		
27	AR	MS21042-08	NUT, HEX, .164-32	STEEL, CAD PLT		
26	AR	MS24694S48	SCREW, 100° FL HD	STEEL, CAD PLT		
25	AR	MS24694S5	SCREW, 100° FL HD	STEEL, CAD PLT		
24	AR	AN525-10	SCREW, WASH HD	STEEL, CAD PLT		
23	AR	AN525-8	SCREW, WASH HD	STEEL, CAD PLT		
22	AR	AN3	BOLT, .190-32	STEEL, CAD PLT		
21	2	385	LAMP	CHICAGO MINIATURE		
20	6	92005A220	SCREW, M4 x 10mm	McMASTER-CARR	DIN7985	
19	1	-9	CONNECTOR PANEL	.063 6061-T6 AL	QQA-250/11	0.1
18	2	-7	SUPPORT ANGLE	6061-T6 AL EXTRUSION	QQA-200/8	1.8
17	2	-5	SUPPORT STRAP	.125 6061-T6 AL	QQA-250/11	1.6
16	1	-3	EJECT CONTROL PNL	.125 6061-T6 AL	QQA-250/11	0.9
15	2	677-05-25-040-8	SUPPORT ANGLE			0.1
14	1	677-05-25-040-7	SUPPORT ANGLE			0.1
13	2	677-05-25-600-3	SUPPORT BRACKET			0.3
12	1	677-05-24-103	POWER BOX 60Hz	NCAR		8.0
11	1	VP-F1311991	28V POWER SUPPLY	VICOR		2.0
10	1	EQPM-05-24-500	PS MOUNT	NCAR		0.8
9	1	RDF19AX-SHB	LCD MONITOR	INTERLOGIC IND.		16.7
8	1	2USCP43	COMPUTER	PCS		27.9
7	1	OIX 1910B-P	KEYBOARD	CYBER RESEARCH		13.1
6	1	98000000	TELEMETRY CHASSIS	NCAR		25.0
5	1	20713217A1001	FAN TRAY	SCHROFF		8.3
4	1	67705AVAPS-2	STORAGE BOX	NCAR		39.7
3	1	677-05-53-003-01	INSTL,STD EQUIP RACK	NCAR		59.8
2						
1		-1	AVAPS EQUIP INSTL			206

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE:
DECIMALS: .X = ±.03, .XX = ±.01, .XXX = ±.004
ANGULAR: FORMED=±2°, MACHINED=±.5°
DO NOT SCALE DRAWING
NEXT ASSEMBLY
APPROVALS: DR. [signature] DATE 091205; ENG.; CHK.; APPD.; APPD.
EFFECTIVITY

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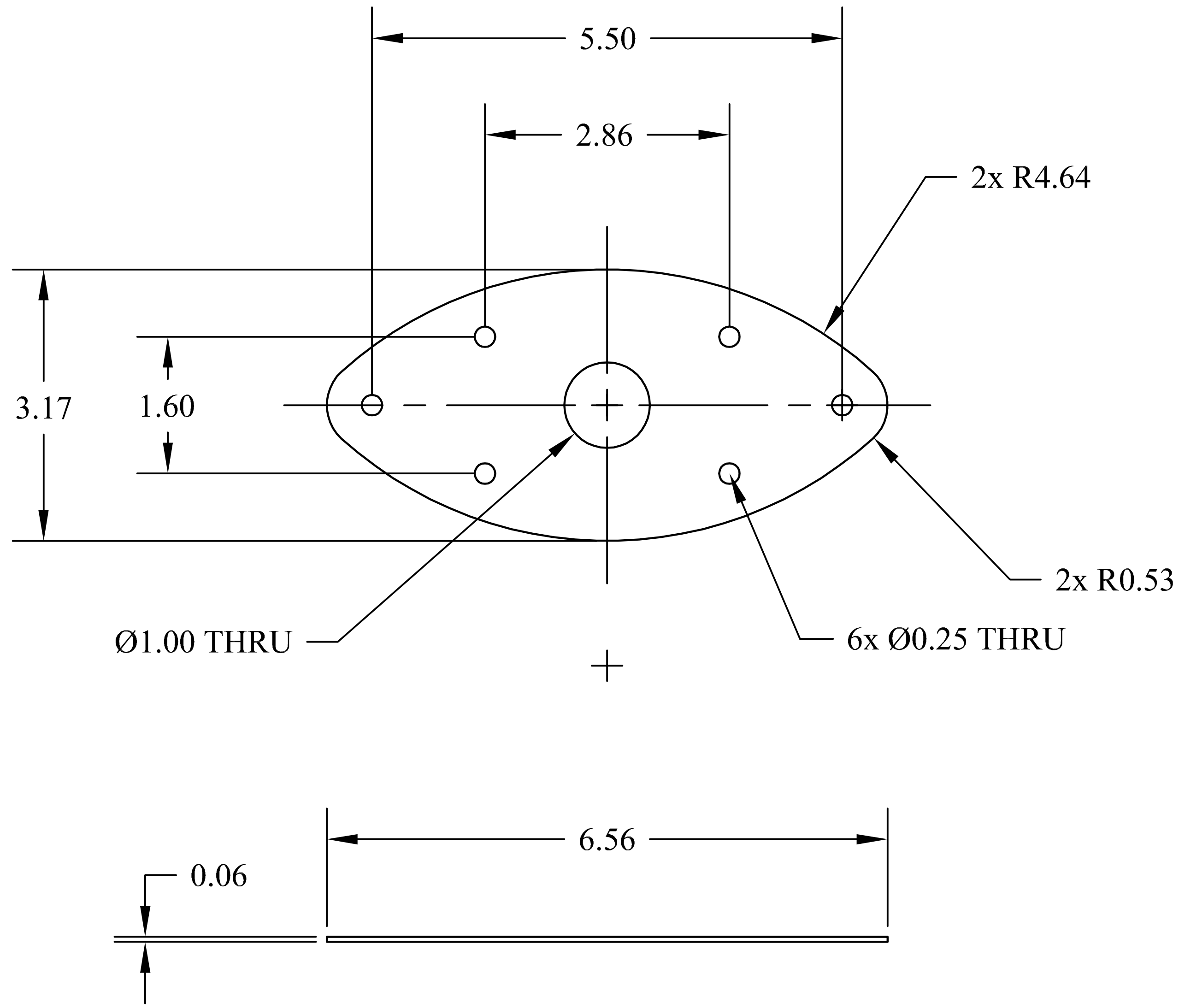
1850 TABLE MESA DRIVE
BOULDER, CO 80305

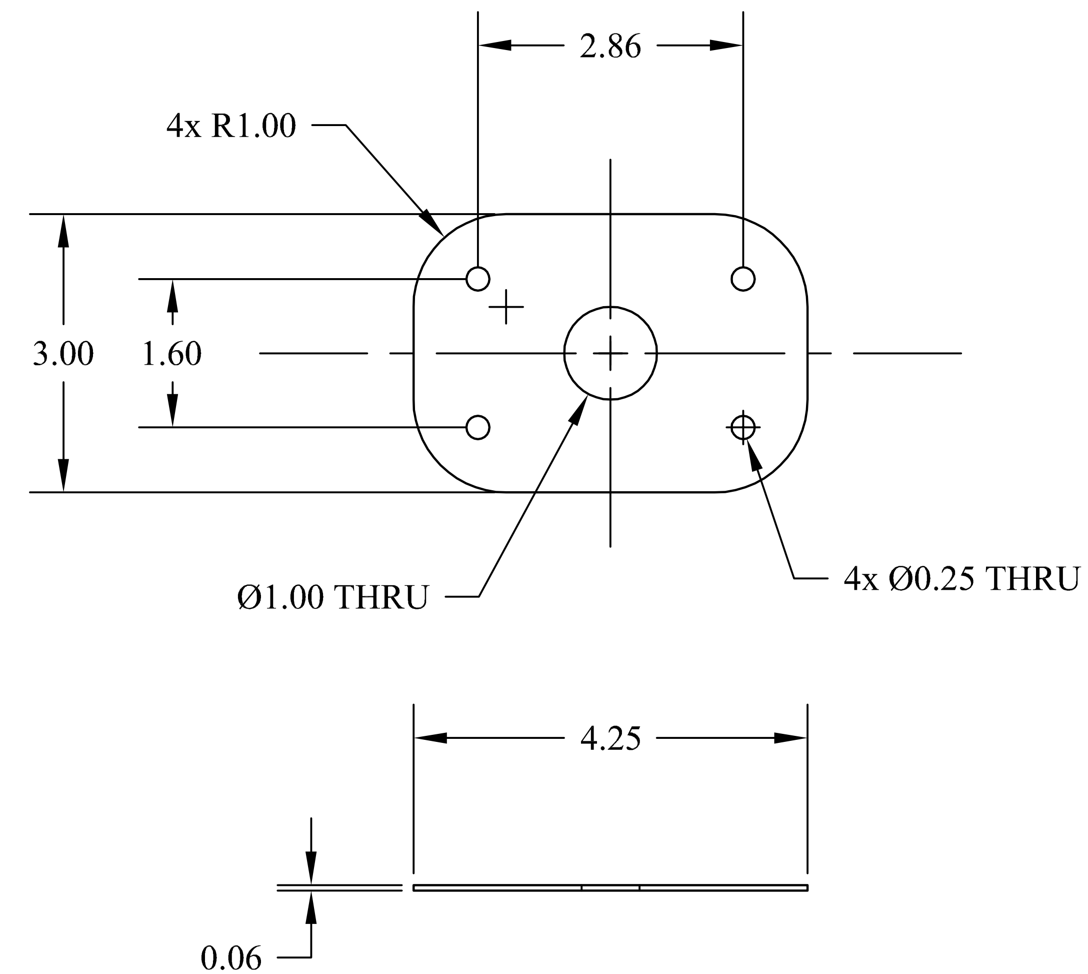
AVAPS MCE RACK EQUIPMENT INSTALLATION

SIZE D | CAGE CODE 0SEF6 | DWG NO. 67705AVAPS-1 | REV. NC
SCALE 1:4 | DESIGN & FABRICATION SERVICES, ATMOSPHERIC TECHNOLOGY DIV. | SHEET 1 of 3

REVISIONS: ZONE | REV | DESCRIPTION | DATE | APPROVED

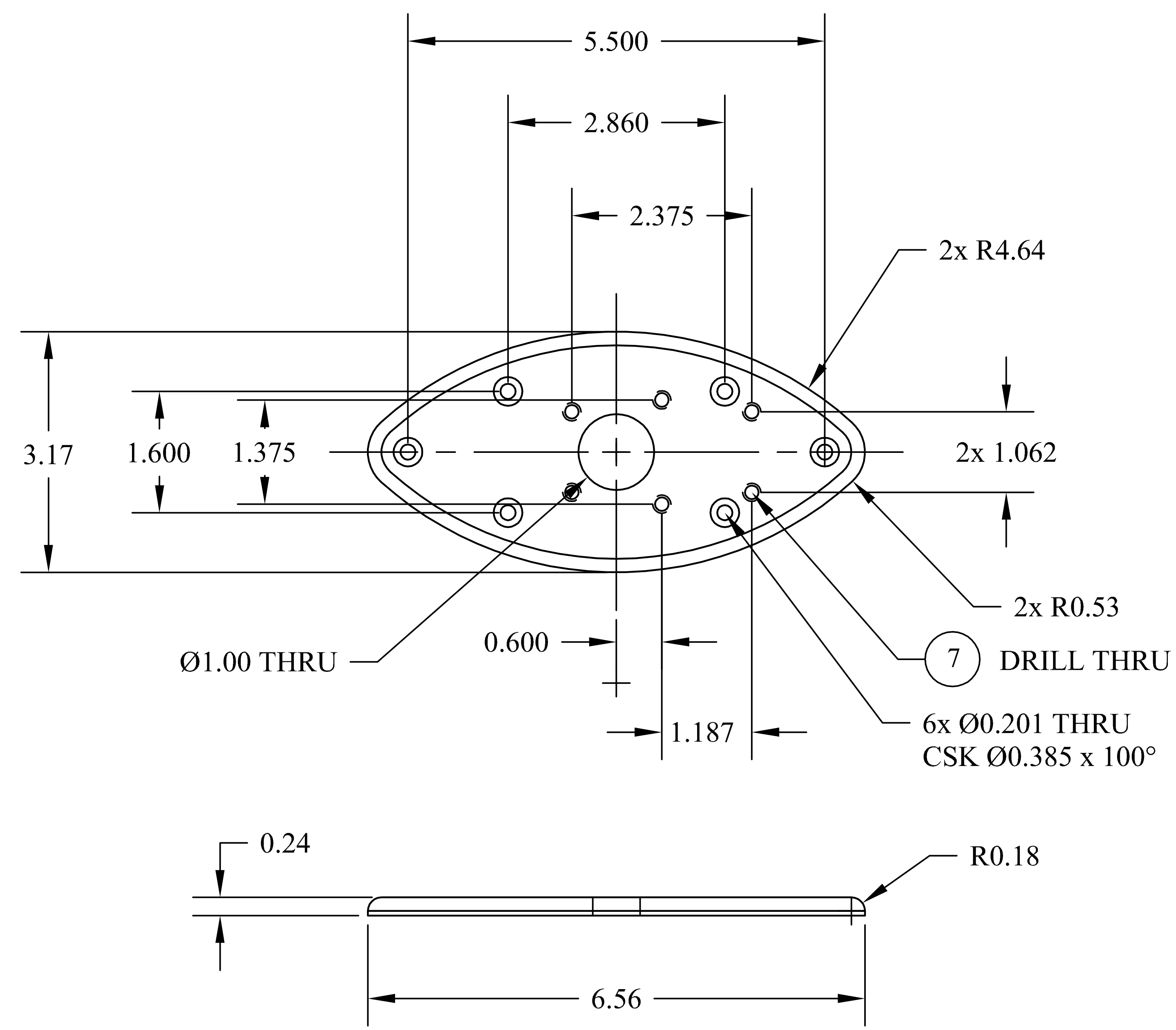


-7, GASKET

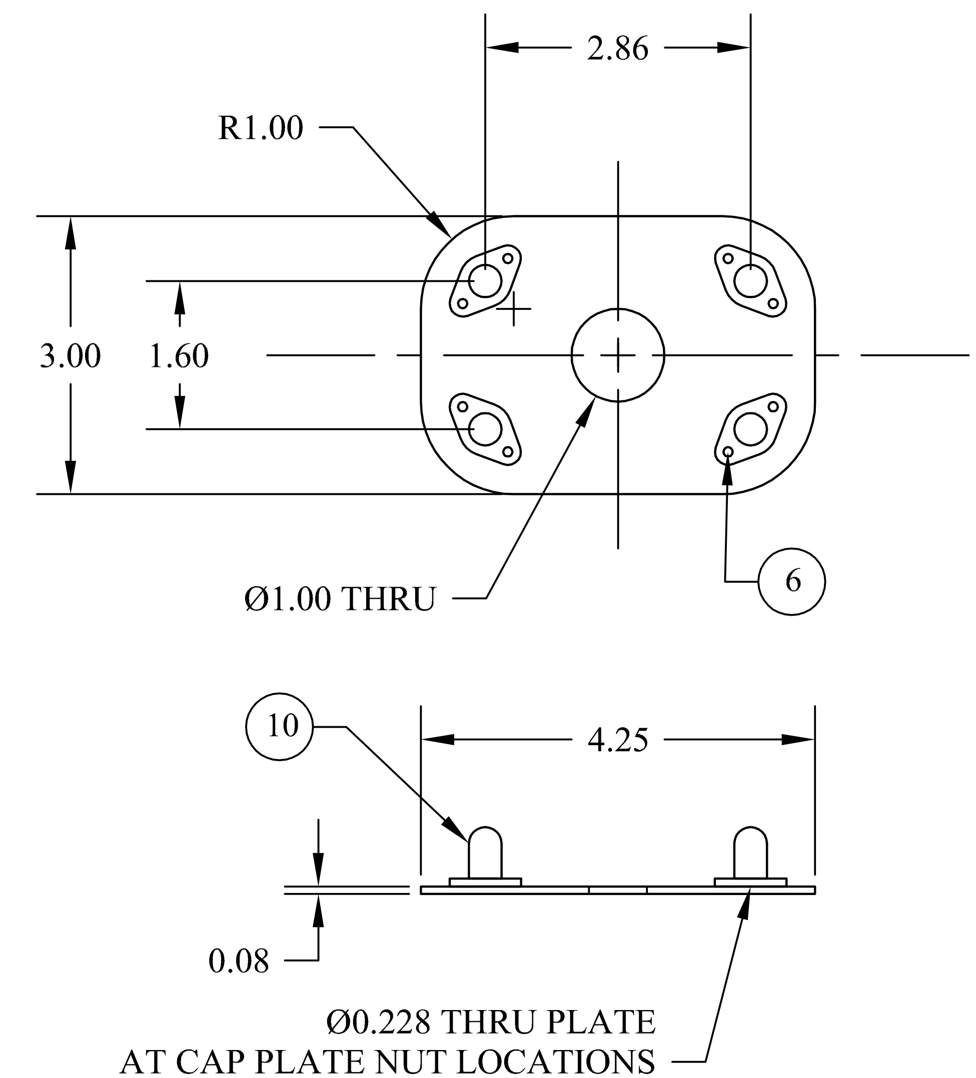


-9, GASKET

DRAWN MTL	12OCT05	SIZE B	DWG NO. 67705AVAPS1217	REV. IR
CHECK MTL	12OCT95	SCALE 1/2	FILE sonde uhf ant install.dwg	SHEET 3/3



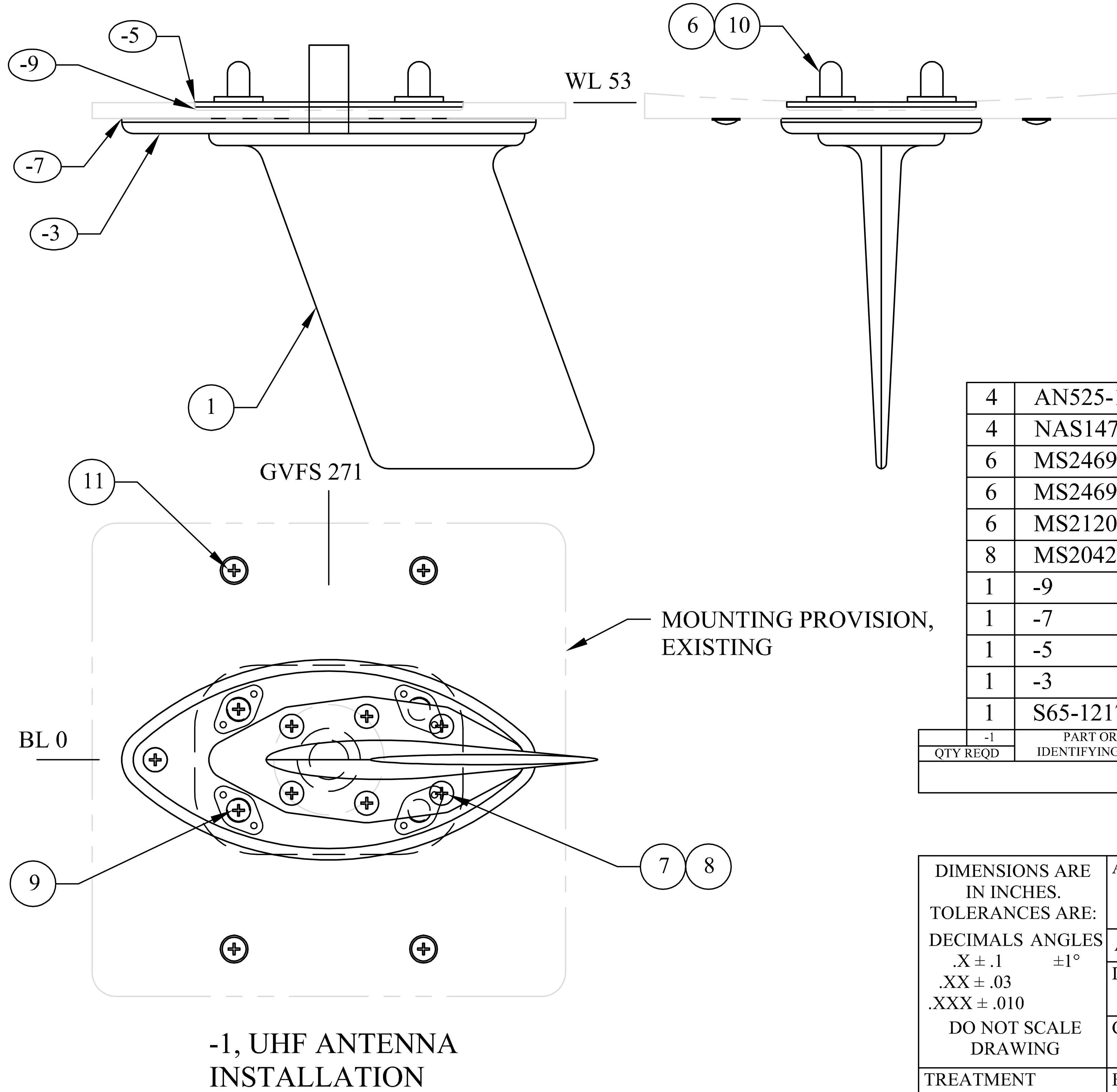
-3, ADAPTER PLATE



-5 CONNECTOR PLATE

DRAWN MTL	12OCT05	SIZE B	DWG NO. 67705AVAPS1217			REV. IR
CHECK MTL	12OCT95	SCALE 1/2	FILE sonde uhf ant install.dwg			SHEET 2/3

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



NOTES:
1. INTERPRET DRAWING PER STANDARD PRACTICE.
2. REMOVE ALL BURRS AND SHARP EDGES.
3. IDENTIFY PARTS IAW NCAR RAF PS-11-010.
4. (△) FINISH PARTS IAW NCAR RAF PS-20-010.

QTY REQD -1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO.
4	AN525-10	Screw, Wasker Hd, 0.190-32	Stl, Cad Plt	11
4	NAS1473A3	Nut, Plate, Cap, 0.190-32	Stl	10
6	MS24694S56	Screw, Flush Hd, 0.190-32 x 7/8	Stl, Cad Plt	9
6	MS24694S48	Screw, Flush Hd, 0.190-32 x 3/8	Stl, Cad Plt	8
6	MS21209-F1-10S	Insert, Helical, 0.190-32 x 1D	Stl	7
8	MS20426AD3	Rivet, Csk, Flat Hd, 3/32	Al Aly	6
1	-9	Gasket, Connector Plate	Si Rubber, ZZ-R-765	5
1	-7	Gasket , Adapter Plate	Si Rubber, ZZ-R-765	4
1	-5	Connector Plate	2024-T3 Al Aly Pl	3
1	-3	Adapter Plate	2024-T3 Al Aly Pl	2
1	S65-1217	UHF Antenna	Sensor Systems Inc.	1

PARTS LIST

DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:
DECIMALS .X ± .1, .XX ± .03, .XXX ± .010; ANGLES ±1°
DO NOT SCALE DRAWING

TREATMENT: NONE
FINISH: (△ 4)

ACCOUNT KEY: 144560

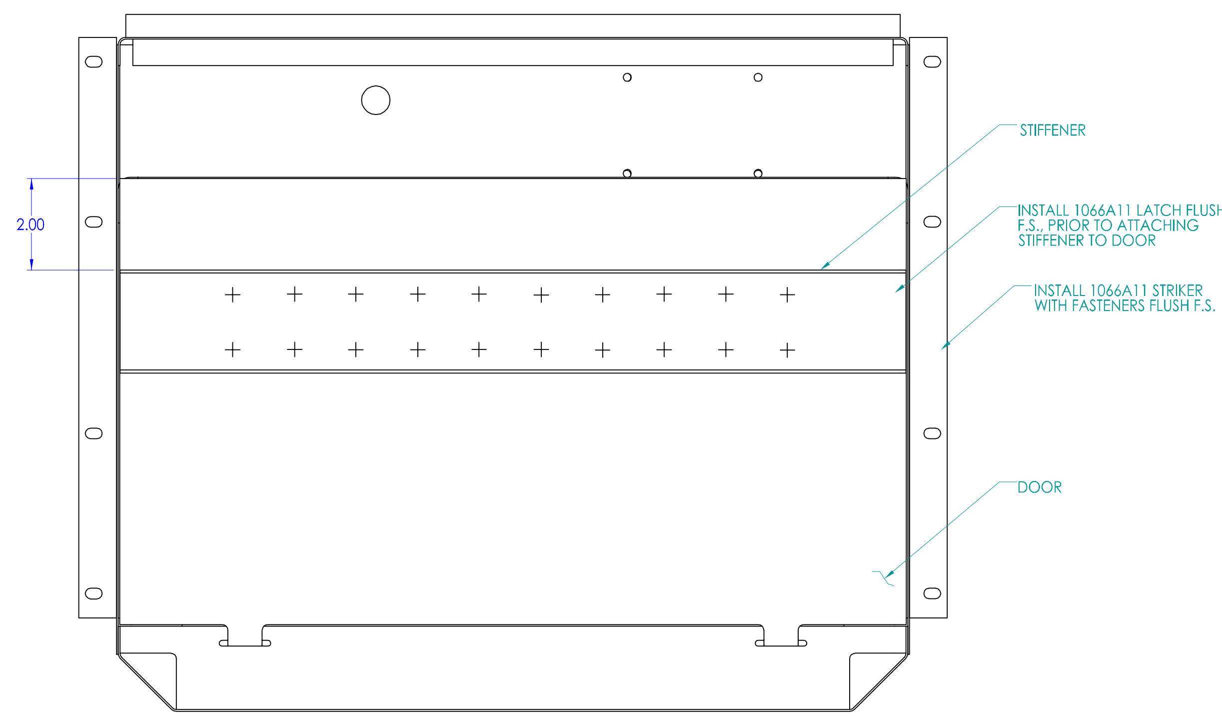
APPROVALS		DATE
DRAWN	MTL	12OCT05
CHECK	MTL	12OCT05
ENGRG	MTL	12OCT05

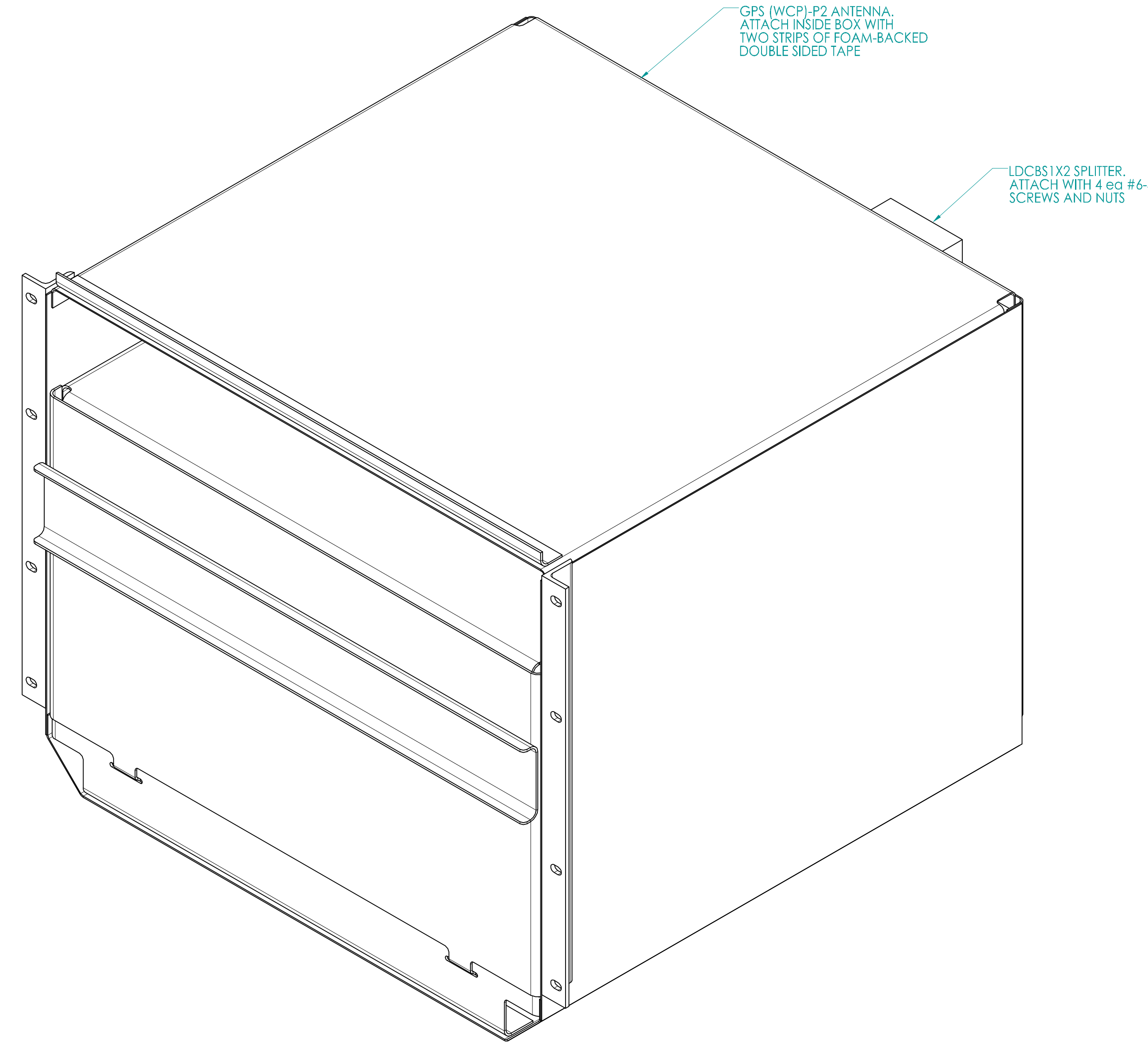
NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
10802 AIRPORT COURT
BROOMFIELD, COLORADO 80021

TITLE
AVAPS UHF ANTENNA INSTALLATION - GV

SIZE: B | DWG NO.: 67705AVAPS1217 | REV.: IR

SCALE: 1/2 | FILE: sonde uhf ant install.dwg | SHEET: 1/3





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NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

STORAGE BOX ASSEMBLY
A/APS RACK

SIZE	CAGE CODE	DWG NO.	REV
D	0SEF6	67705AVAPS-2	NC

SCALE 1:2 SHEET 4 of 4