	Pixel Disk Ring and Global Support Production Plan

ATLAS Project Document	*Institute Document*	*ted:* **05/02/2002**	*Page:* **1 of**
ATL-IP-QA-0010		*ified:*	*Rev.* **1**

ATLAS PIXEL DISK SUPPORT RING AND GLOBAL SUPPORT PRODUCTION PLAN

The production plan for the ATLAS pixel disk support rings and the ATLAS pixel global support structures are presented.

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Distribution List

History of Changes			
Rev. No.	*Date*	*Pages*	*Description of changes*

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1 Introduction

This note and the attached appendices summarize the production plans for the Disk Ring Supports of the ATLAS Pixel System and Pixel Global Support Frame. The Disk Support Ring is illustrated below in Figure 1. It supports eight disk sectors holding pixel modules. The disk sectors are located and held by three mounting holes per sector. The Disk Support Ring is attached at four points to the Pixel Global Support Frame.

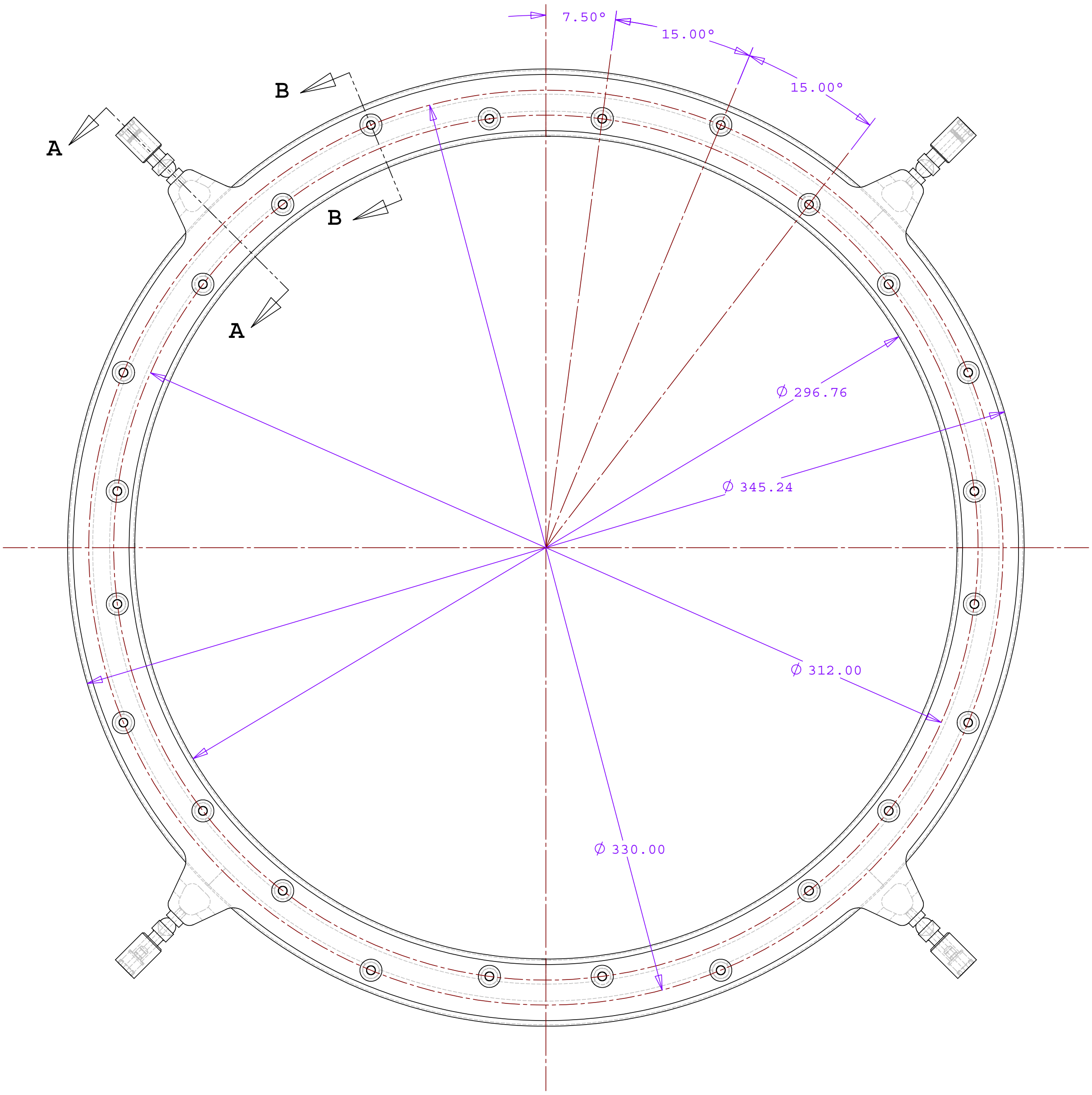

Figure 1. Disk Ring Support with nominal dimensions.

The global support frame consists of a flat-panel space frame in three sections - a barrel section and two, identical disk sections as shown in Figure 2. These sections are joined to make the complete frame.

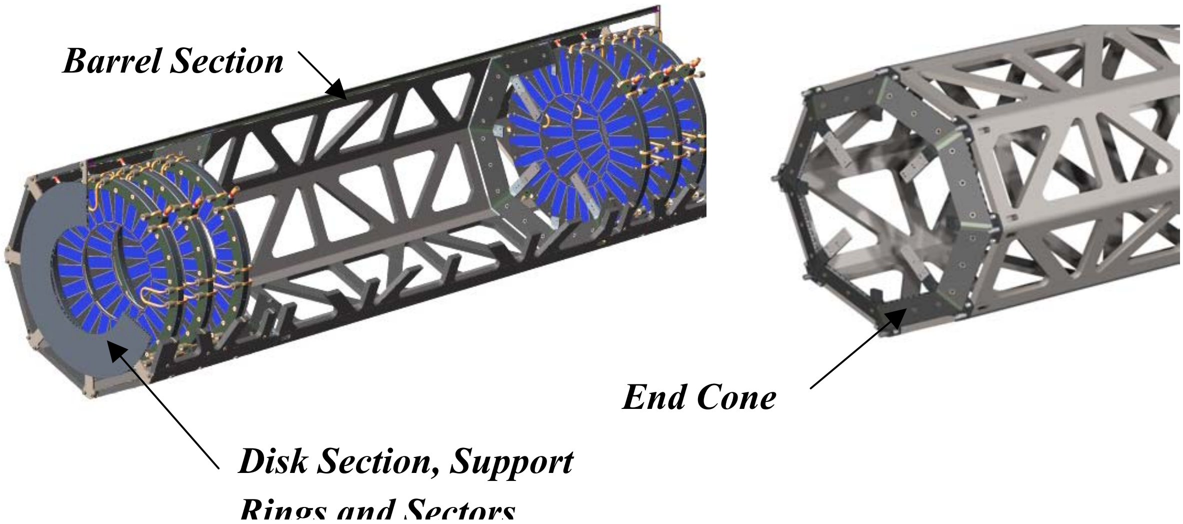

Figure 2. ATLAS Pixel global support frame, which consists of three sections - barrel and two disk sections. The barrel and two disk sections are shown joined on the left. One of the support cones for the barrel shells is shown in the right model.

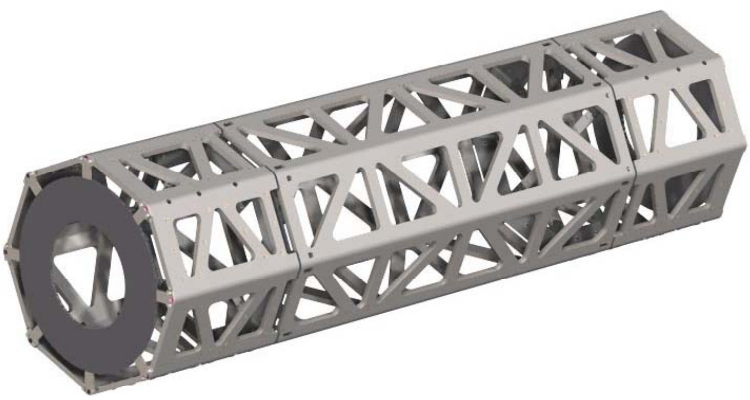

Figure 3: Solid Model of the Global Support Structure, illustrating all of the components exclusive of the Disk Support Rings. Elements contained in this view are the two disk sections with two end plates, and the barrel section with two end cones.

Figure 4 is a view of the ATLAS Pixel Detector with location of the disks denoted.

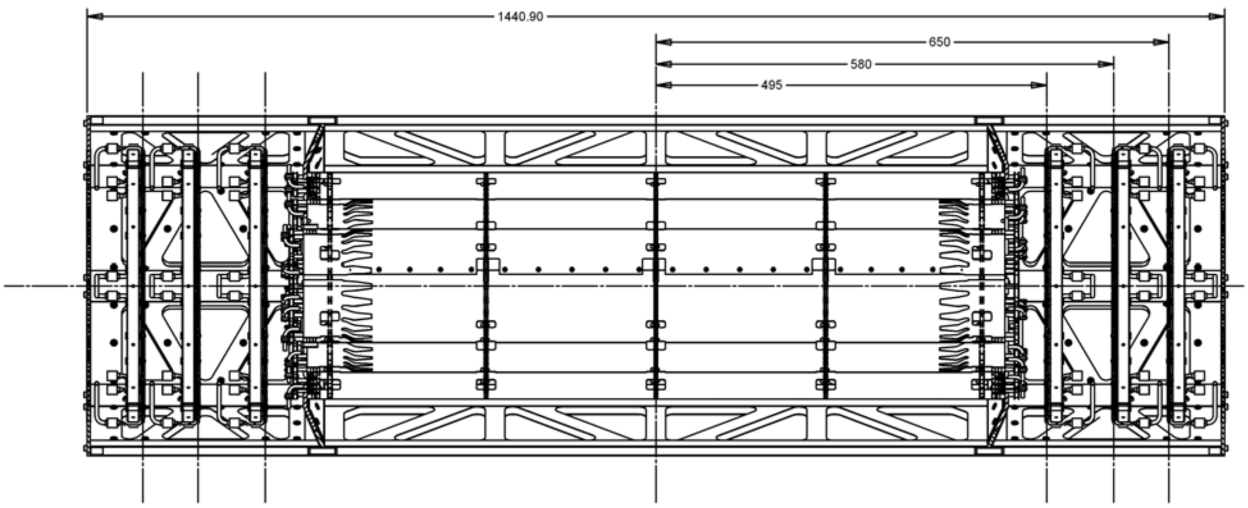

Figure 4: Cross-section of the ATLAS Pixel Detector Global Support Structure. Illustration depicts the Disk Region and Barrel Region with two barrel layers (L1 andL2). Dimensions are in mm.

2 Background

The requirements and interfaces for the Disk Support Rings and the Global Support Frame were reviewed in July 2001. The documents(http://edmsoraweb.cern.ch:8001/cedar/doc.info?cookie=884786&document_id=316092&version=1) presented then remain valid. There have been no significant changes to requirements since the review in July 2001. There have been minor changes to interfaces to take into account small modifications in dimensions of the internal pixel components(eg. the barrel shells) and the support of the Global Support Frame. Critical interfaces are summarized in ATL-IP-ES-0045. This note presents only the production plans for the Disk Support Rings and the Global Support Frame.

3 Production Overview

We present here a brief overview of the proposed production plan. The Disk Support Rings and the Global Support Frame will be provided by the United States. All procurements related to these items will be handled by Lawrence Berkeley National Laboratory.

3.1 Disk Support Rings

The disk support rings will be produced in three phases. Phase I is the production of C-channels meeting specifications. The C-channels are the most demanding fabrication item. Phase II is the fabrication of one pre-production ring. Phase III is the fabrication of all production rings(currently six). The fixed-price contract for Phase I and Phase II was placed in November 2001. The scheduled date for completion of Phase I is 7-March-2002. The scheduled date for completion of Phase II is 4-April-2002. These elements are currently on schedule but the schedule is tight. The contract for Phase III will be placed after inspection of the pre-production ring, which is planned to be completed by the end of April 2002. Production of the Disk Support Rings is planned to be completed by October 2002.

The documents controlling the fabrication and inspection of the Disk Ring components and final assemblies are given in Appendix A("Procurement Plan for the ATLAS Pixel Detector Disk Support Rings", HTN-106210-0005) and Appendix B("Process Control Inspection 432mm Disk Support Ring", HTN-106210-0006). A list of drawings related to the Disk Support Rings is also given in Appendix A. These drawings will be posted on EDMS and undergo a formal approval before the production (Phase III) begins.

3.2 Global Support Frame

The production of the Global Support Frame is planned to occur in two major phases: production of tooling and production of sub-components and assembly of the final frame elements. We plan to have a separate contract (or contracts) for the fabrication of tooling. The tooling will be provided to a vendor (or vendors) for fabrication of the major subcomponents of the Global Support Frame. A maximum of two vendors is planned for the fabrication of sub-components and assembly of the Global Support Frame Elements, and one vendor is preferred. The document controlling the fabrication of the Global Support Frame is given in Appendix C (HTN-106210-0007-DRAFT) -A list of drawings for tooling, sub-components and assembly is given in Appendix D. These drawings will be posted on EDMS and undergo a *formal approval before the production begins. We have sent a letter along with Appendix D to prospective composite vendors requesting expressions of interest to begin the procurement process.*

3.3 Production Schedule

The critical milestones from our baseline schedule established last year are shown inFigure 5. The trial assembly period includes machining holes in the Global Support Frame for insertion of the Disk Support Rings.

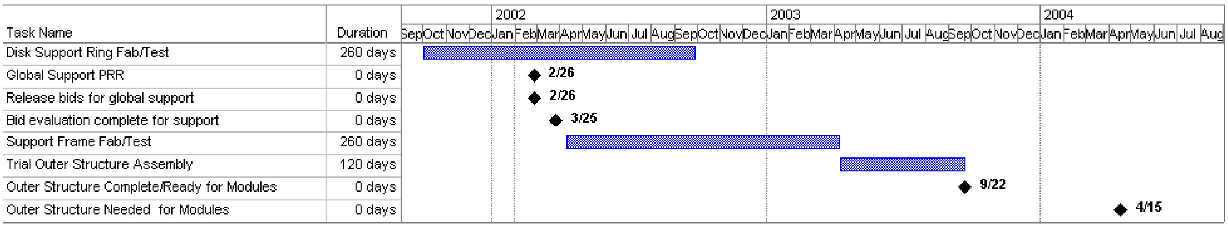

Figure 5. Critical durations and milestones from baseline schedule established last year.

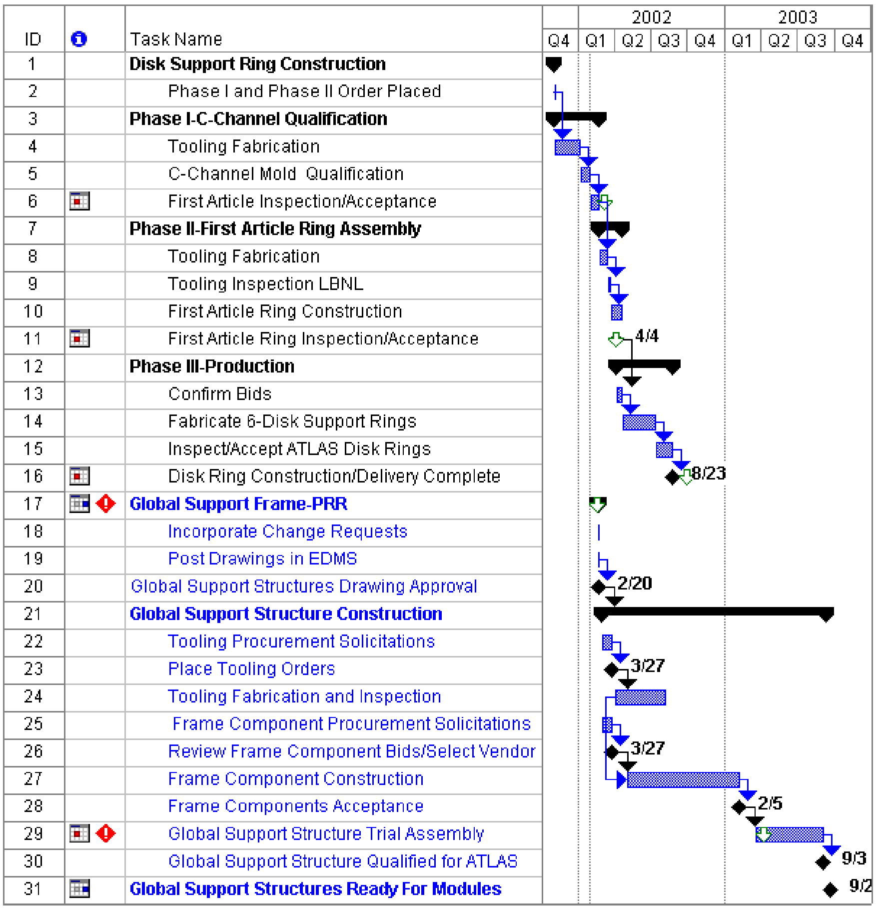

Figure 6: Current project schedule for the Disk Support Ring and Global Support Structure elements for the ATLAS Pixel Detector.

Figure 6 depicts the current estimated times for completion and delivery of the critical composite structural components comprising the support for the Pixel Disk Sectors and the primary structure, the Global Supports. Based on our best estimates derived from experience with prototype construction, the schedule is very tight. At present we are working on the qualification of tooling for producing the Disk Support Ring. Assuming that all tasks progress as outlined, we see that delivery by April 2002 of the first ring is very tight. The first ring is critical to making progress in the assembly and checkout of the first disk assembly. With regards to the Global Support Structures, again we see the schedule is tight. To mitigate this situation we are proceeding with letters of inquiry to potential vendors regarding the forthcoming *procurements. The intent of this interaction to shorten somewhat the nine months estimated for producing and evaluating the intricate frame components. The issue is to establish as-built interface dimensions, needed for finalizing the internal barrel structure dimensions. In this manner, we will lower the cost of producing the Global Support Structures by eliminating expensive and troublesome final machining. Note that the "Global Support Structure Trial Assembly" given in Figure 6 does not include insertion of the Disk Support Rings.*

HYTEC INCORPORATED

Appendix A
Procurement Plan for the ATLAS Pixel Detector Disk Support Rings

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September 19,2001

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Abstract

This document outlines the procurement plan for the subject composite ring, which is used to support an array of 8-pixel disk sectors. This plan covers the fabrication and inspection of the production rings, as well as the qualification of the production tooling.

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Revision Log

Rev.	Date	Author(s)	Summary of Revisions/Comments
-	Month date, year		Initial release.

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1. Introduction

It is desired that the ATLAS Pixel Detector Disk Support Ring production be accomplished in three phases (reference LBNL Drawing 21F5224). The first phase is concerned with setting the appropriate "toe-in" dimensions for the matched metal/rubber mold used to fabricate the ring C-Channels. The second phase is the assembly of a pre-production ring, which is used to qualify part acceptance. This phase confirms the quality of all tooling to be used in the final production of 6-disk support rings. Phase 3 is concerned with the production of 6-rings, which are delivered to the ATLAS Pixel Detector Project

2. Work Statement

2.1 **Phase 1-*Fabrication of Qualified C-Channels for Phase 2***

The vendor shall: (1) procure the necessary materials, and (2) fabricate the matched metal molds for producing the C-Channels segments, inner and outer, 2-each. Prior to molding the C-Channels, the molds will be inspected by the vendor and the inspection records submitted to LBNL[1] for production approval. Vendor shall then mold and final machine sets of 2-each C-Channels, 2 inner and 2 outer. The vendor shall: (1) inspect the C-Channels, (2) recommend mold rework, if necessary, and (3) submit this information with recommendations to LBNL. Based on concurrence with LBNL the vendor shall modify, as required, the inner and outer mold inserts to eliminate "toe-out" of the C-Channel skirts (within "toe" limits prescribed in LBNL drawings 21F5244 and 21F5254).

After tool modifications have been accepted by LBNL, the vendor shall produce once again 2-inner and 2-outer C-Channels for final evaluation. After receiving approval from LBNL, vendor shall mold and final machine complete sets of inner (4) and outer (4) C-Channels for the Phase 2, pre-production ring.

2.2 **Phase 2-*Fabrication of Ring Component Parts and Qualification of Pre-Production Ring***

This phase consists of several parts: (1) fabrication of precision bonding tooling and alignment jigs, (2) procurement of piece parts for 7-rings (exclusive of C-Channels), and (3) the assembly of one pre-production ring. Procurement of ring piece parts is limited to machining of the carbon-carbon ring face(s), and fabricating the sector bushings and ring mount tabs. Vendor shall procure all piece parts in phase 2 and thereby secure quantity pricing.

One pre-production ring shall be assembled using the C-Channels produced in Phase 1. The vendor shall inspect the ring and submit the ring and inspection records to LBNL for review. The vendor shall document all modifications and or deviations to the assembly procedure that were utilized in producing the pre-production ring.

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[1] Or a representative designated by LBNL

2.3 **Phase 3-** ***ATLAS Pixel Detector Production Disk Support Rings***

Vendor shall: (1) mold C-Channel sets for 6 rings, and (2) assemble 6-production rings using piece parts produced in phase 2, using the assembly and QC procedures approved in Phase 2.

3. Preliminary Assembly and Inspection Procedure

The vendor shall submit a procedure outlining the plans for assembly and bonding of the ring prior to initiating the ring assembly in Phase 2. This procedure will include dimensional inspection steps.

3.1 Bond Fixture Preparation (Step 1, sheet 7)

1. A mistress gauge (fabricated by LBNL) using 5-pins is used to bond 3 sector bushings at one time. The following steps are used to set the mating bushings in the graphite tooling plate.
2. Mistress gauge installs to the graphite plate from front using two 3/16" dia. pins; the 3 brass bushings are installed and bonded from rear of plate. This is done to critically position the 3-bushing pattern to itself, and less critically to the other bushing patterns.
3. Bonding bushings in graphite plate to critical tolerances will be done by vendor.
4. √ CMM Inspection of Graphite Bond Fixture with Bushings will be done after the bushings have been bonded in place. LBNL approval is required before proceeding.

3.2 Face Sheet #1 Alignment (Step 2, sheet 6)

5. Prior to bonding – the graphite plate must be kept on a granite table during entire bonding process. Graphite plate inspected – dust, lint, dirt wiped and air-blown from surfaces.
6. Face sheet #1 is placed on graphite plate, sheet 6. √ *A height gauge will be used to determine that the face sheet is flat on the graphite plate –an inspection report will be filled out.*
7. Face sheet #1 is angularly oriented on graphite plate using four 0.281" gauge pins. Use at least 3-0.281" pins for alignment (see step 2 on sheet 6).
8. √ *All C-Channels will be inspected and approved prior to incorporating them into a composite ring.*

3.3 Bonding of C-Channels to Face Sheet #1(Step 3, sheet 5)

9. Four C-channels are clamped to their aluminum clamping tools (same process as used before for the fabrication of earlier rings).
10. The C-Channel/Clamp assemblies are positioned in place using 3/16" gauge pins. A dry run fit will be done with all C-Channels in place. C-Channels should be appropriately marked to match graphite plate (so they may be removed and replaced later).
11. √ *When dry run fit is complete, inspect using a height gauge, measure and record the height of the top flange of all the C-Channels; determine that they all are coplanar (and at the correct height).*
12. All outer C-Channels and inner C-Channels are bonded in one setup. Sequentially place the C-Channels around ring circumference. After the Outer C-Channels bond adhesive is

finished curing, bond the scab plates. This step is repeated for the inner channels. When bonding the C-Channels use a Caul plate to apply vertical force to the C-Channels. If the vendor chooses to bond one C-Channel at a time, LBNL requests notification of this change before proceeding.

13. Apply adhesive to both surfaces when bonding C-Channels (pre-test procedure to control adhesive overflow: note the face sheet's profile now falls short of C-Channel major/minor radius); do not remove this assembly from graphite plate to wipe away excess adhesive. If necessary use a hot-knife to remove excess adhesive after all ring bonding steps are complete.
14. Note there is less clearance between C-Channel flanges in this ring. Therefore it is recommended to remove the C-Channels clamp-nuts after each set of four are bonded in place - rather than trying to remove them all after the C-Channels have been bonded in place (remove the clamp nuts, but leave the pinned clamp in place to provide external support to C-Channel during bonding). Nuts for final channel are carefully removed at bushing scallop area.

3.4 Installation of Face Sheet #2 (Step 4, sheet 4)

15. Install face sheet #2. Again, 4X 0.281" pins angularly orient the second face sheet. Use at least 3- 0.281" pins for alignment. Control amount of adhesive used to prevent overflow.
16. Use the Caul plate to apply constant pressure on face sheet while bonding. Note, care must be taken with excess adhesive flowing out past face sheet and adhering to Caul plate.
17. *√ After Face sheet #2 adhesive has cured, run the height gauge around the surface of face sheet #2(an indication of ring thickness) – fill out inspection report.*
18. Mark orientation of ring on graphite fixture. Remove C-Channel clamps. Plug all C-Channel clamp holes with adhesive.
19. Remove ring and weigh ring.

3.5 Installation of the Mount Tabs, 4 places. (Step 5, sheet 3)

20. Install the ring on graphite fixture using previous angular orientation. Use height gauge to verify ring position (compare to past data) and that it is flat on graphite fixture.
21. Do a dry fit of the Mount Tabs in position and constrained by the bond blocks. Note that each bond block has a number that corresponds with its correct position on the graphite fixture.
22. The critical alignment of the Mount Tabs is done using a 0.250" (thru graphite plate) and 0.125" pin (thru bond block); the bond block is positioned by two 0.187" pins (thru the graphite plate). The 0.250" dia pin positions the Mount Tab in X, Y; the 0.12" dia pin establishes the Z elevation for the Mount Tab.
23. The Mount Tabs should now be ready for bonding. First, the Mount Tab is pinned to the bond block then inserted into position. *Care must be taken to prevent adhesive from getting into the 0.250" dia Mount Tab pin-hole (these 4X pin holes become a physical datum for the ring). See step 5 on sheet 3.

24. Once the Mount Tabs are bonded in position, remove the bond blocks. With the ring still pinned to the graphite fixture, insert four 0.125" dia. pins into the radial holes in the Mount Tabs. √ *Use a height gauge to record the height of the 4 pins - fill out inspection report.*

25. Remove the composite ring shell from the graphite plate (remove 0.250" dia. pins). Weigh ring.

3.6 Installation of the Composite Ring Bushings

26. Push 0.120" dia. pins into graphite plate bushings.

27. Install composite ring bushings on pins. Note: make sure no hair, lint or dust is in the counterbores of the graphite plate prior to installing bushings. Bushing surfaces should have been abraded and cleaned prior to bonding.

28. Push all bushings flat against counterbored surface.

29. √ *Use a height gauge to record the height of all of the tops of the bushings relative to the graphite fixture face (all bushing heads should be coplanar) – fill out inspection report.*

30. Apply adhesive on the ring facing just in the bushing area of contact and the bushing flange; now re-install composite ring shell atop bushings using correct orientation (see step 6 sheet 2).

31. √ *Using a height gauge, verify that the surface of face sheet #2 is flat against the graphite fixture by measuring the height of ring surface. Fill out an inspection report.*

3.7 Bonding of Ring Bushings (Step 7, sheet 1)

32. Put the Caul plate on ring facing #2 and to apply force during bonding. Before placing the Caul plate, inspect to see that no bushing vertical height has changed.

33. Do not remove ring assembly to remove excess adhesive; ring not to be removed until washers have been bonded in place.

3.8 Composite Ring Washers Installation (Step 7, sheet 1)

34. Bond the Composite ring washers. The Caul plate may or not be used

35. √ *After the washer adhesive is dry, use the height gauge to record each washer height from the face of the graphite plate – fill out inspection reports.*

36. Push the 24X 0.120" pins out through the back of the graphite plate, and remove the composite ring from the graphite plate.

37. Weigh and record ring mass.

3.9 Packaging of the Ring

38. The ring shall be individually sealed in a polyethylene close fitting bag and stored for shipment to LBNL. The bag shall contain a copy of the inspection records for the ring assembly. The ring serial or record number shall be clearly visible for the outside.

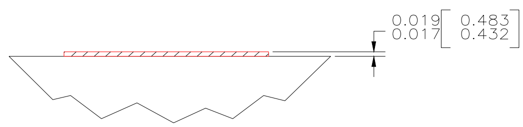
39. Ring(s) shipment to LBNL shall be in a foam-filled wooden box, with foam separators between each ring for protection.

3.10 Inspection of the Ring at LBNL

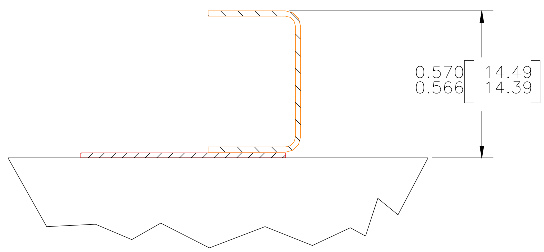
40. The ring will be inspected using a LBNL CMM inspection system. All hole positions and co-planar feature of the bushing heads will be determined. The 0.125" hole position of each Mount Tab will be determined. General dimensions to determine the "per print" ring's physical size will be taken.

3.11 Inspection Records

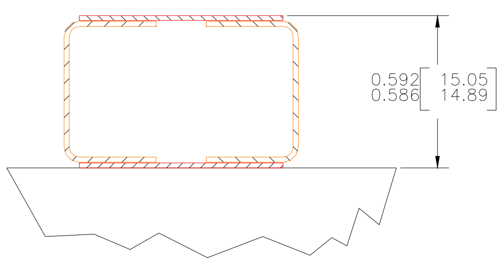
Dimensions are in inches, with [ ] enclosing dimension in mm's.



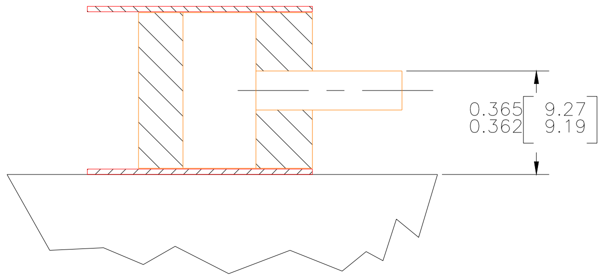
3.11.1 Inspection Record #1 – Limit Dimension for Facesheet Lying Flat on Graphite Plate



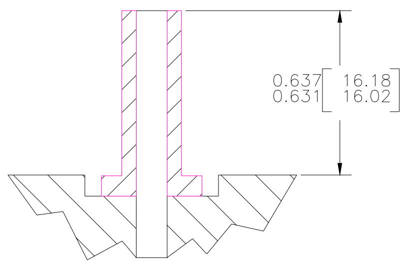
3.11.2 Inspection Record #2 – Limit Dimension for C-Channel Bonded to Ring Face Sheet



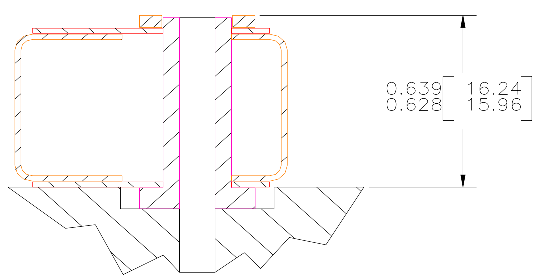
3.11.3 Inspection Record #3 – Limit Dimension for Second Face Sheet Bonded to C-Channels



3.11.4 Inspection Record #4 – Limit Dimension for Mount Tab

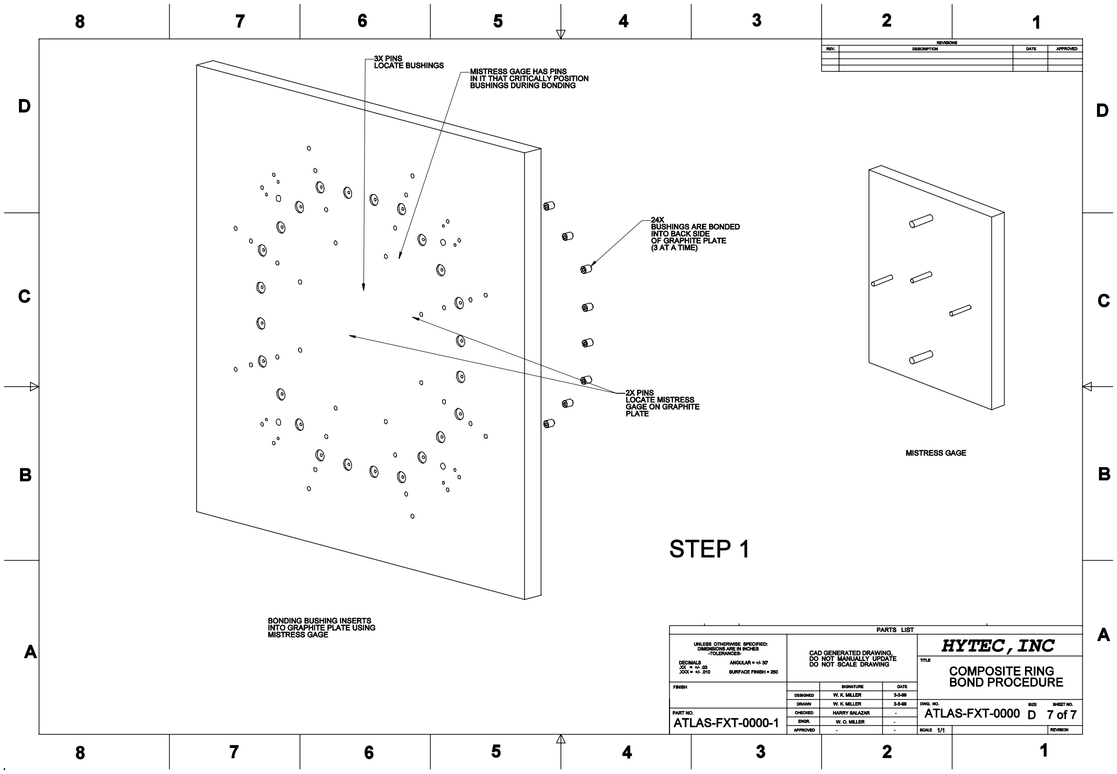


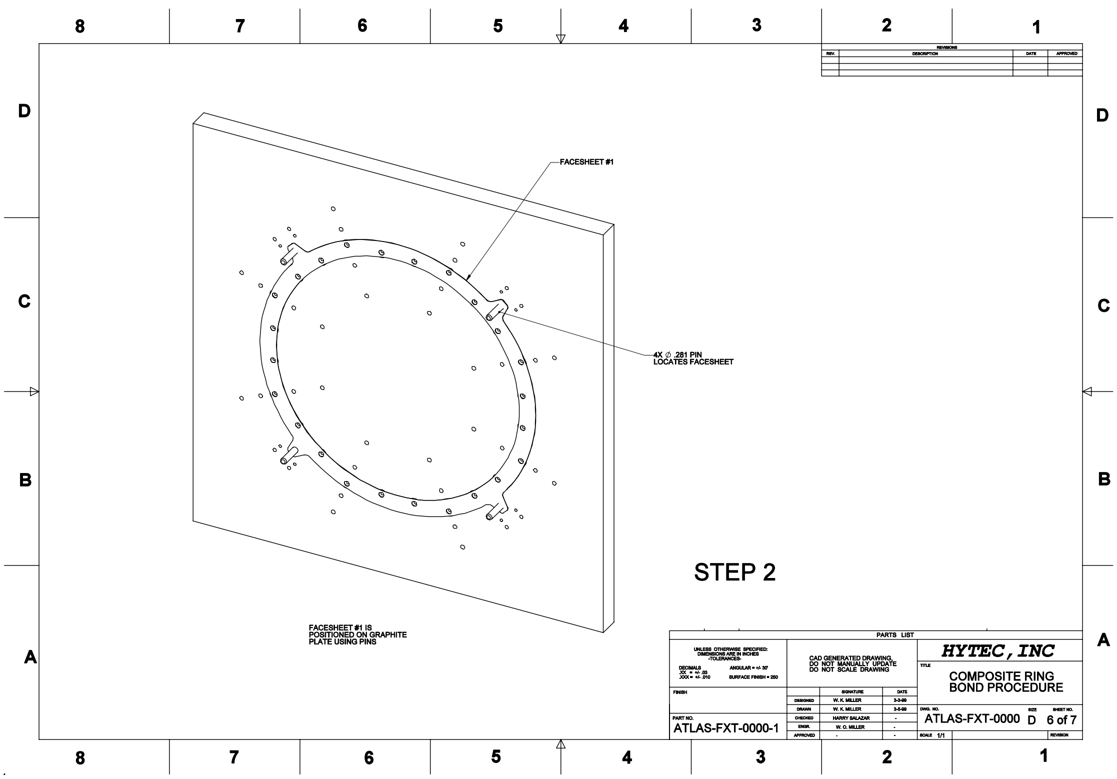
3.11.5 Inspection Record #5 – Limit Dimension for Bushing Seated in Graphite Fixture Counterbore

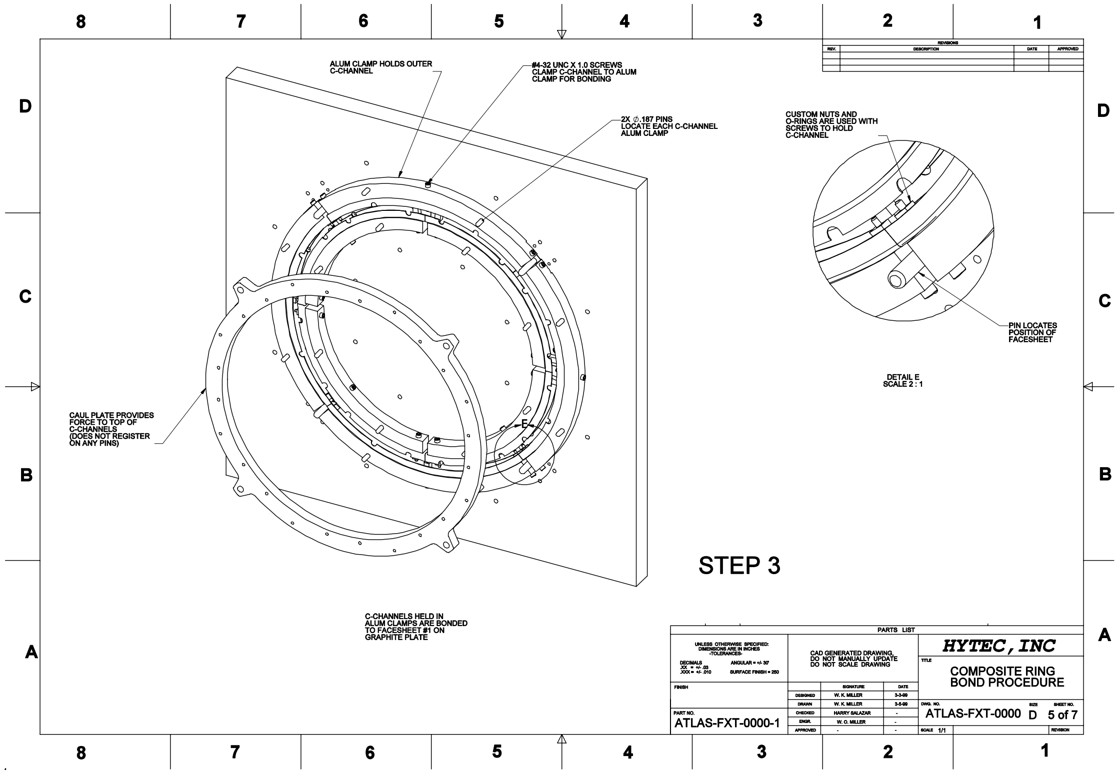


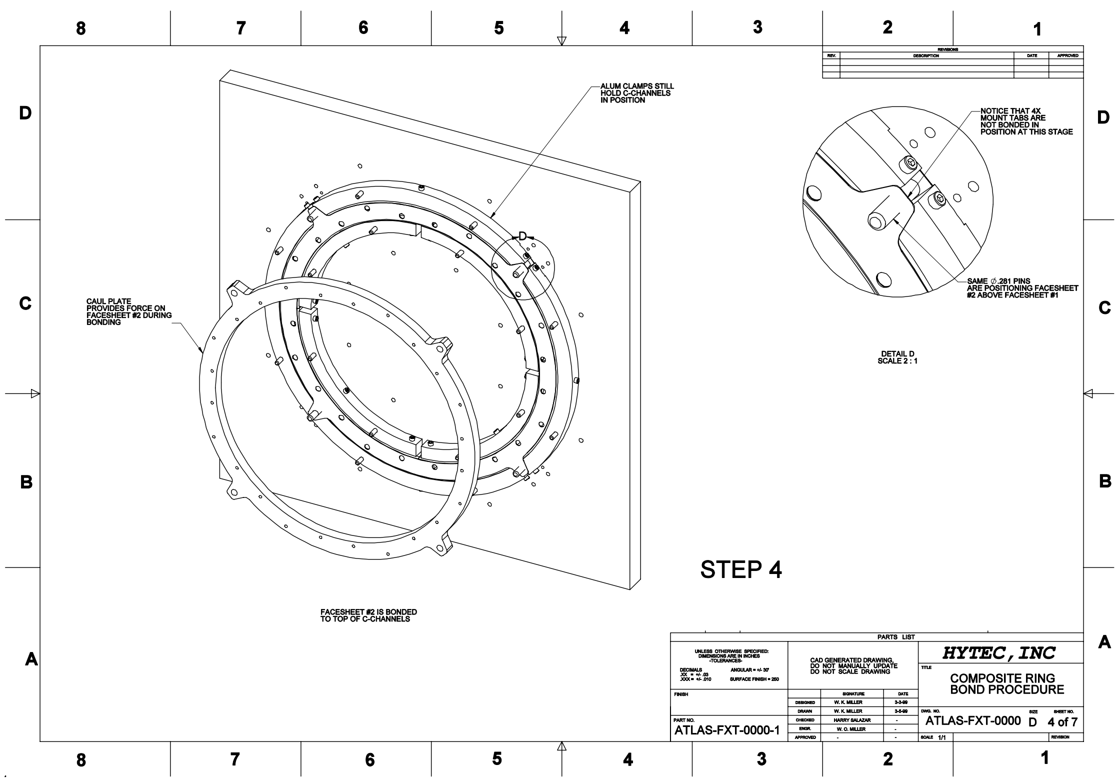
3.11.6 Inspection Record #6 – Limit Dimension for Washer Bonded to Face Sheet #2

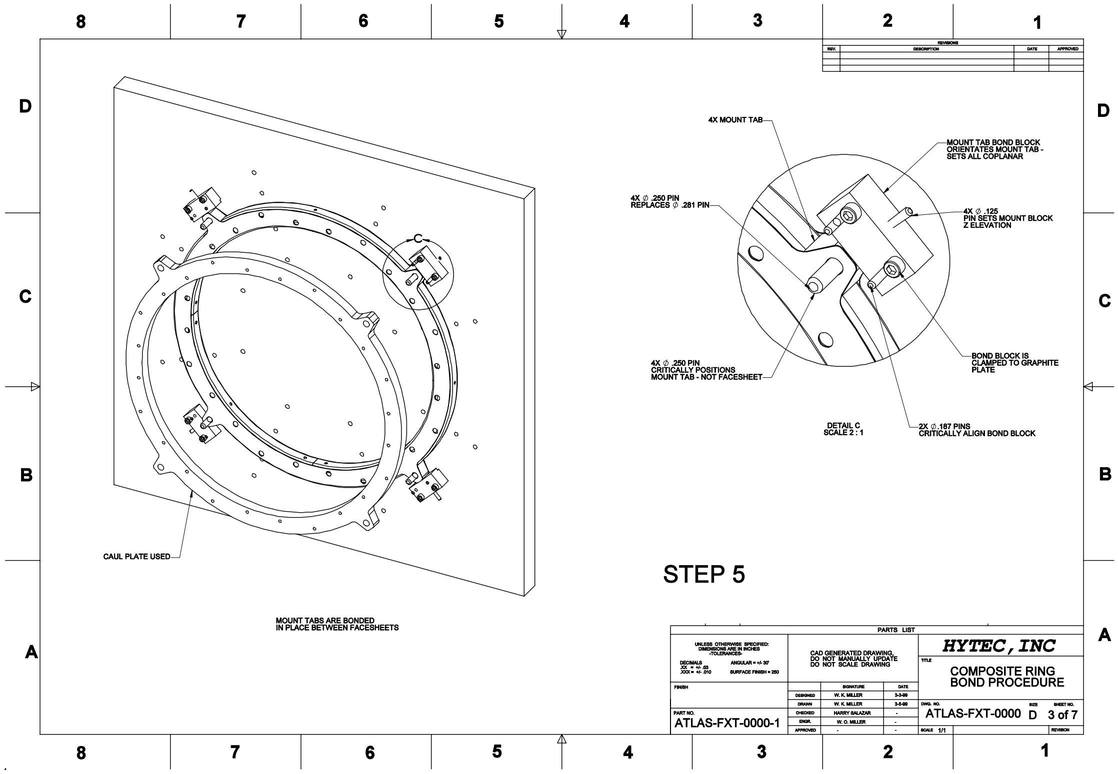
3.12 Assembly Step Illustrations






ALUM CLAMP HOLDS OUTER C-CHANNEL
#4-32 UNC X 1.0 SCREWS CLAMP C-CHANNEL TO ALUM CLAMP FOR BONDING
2X ∅.187 PINS LOCATE EACH C-CHANNEL ALUM CLAMP
CUSTOM NUTS AND O-RINGS ARE USED WITH SCREWS TO HOLD C-CHANNEL
PIN LOCATES POSITION OF FACESHEET
DETAIL E
SCALE 2 : 1
CAUL PLATE PROVIDES FORCE TO TOP OF C-CHANNELS (DOES NOT REGISTER ON ANY PINS)
STEP 3
C-CHANNELS HELD IN ALUM CLAMPS ARE BONDED TO FACESHEET #1 ON GRAPHITE PLATE
PARTS LIST
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES -TOLERANCES-
DECIMALS .XX = +/- .03 .XXX = +/- .010
ANGULAR = +/- 30'
SURFACE FINISH = 250
CAD GENERATED DRAWING, DO NOT MANUALLY UPDATE DO NOT SCALE DRAWING
HYTEC, INC
TITLE COMPOSITE RING BOND PROCEDURE
FINISH
DESIGNED W. K. MILLER 3-3-99
DRAWN W. K. MILLER 3-5-99
CHECKED HARRY SALAZAR -
ENGR. W. O. MILLER -
APPROVED - -
PART NO. ATLAS-FXT-0000-1
DWG. NO. ATLAS-FXT-0000
SIZE D
SHEET NO. 5 of 7
SCALE 1/1
REVISION


ALUM CLAMPS STILL HOLD C-CHANNELS IN POSITION
NOTICE THAT 4X MOUNT TABS ARE NOT BONDED IN POSITION AT THIS STAGE
SAME ∅.281 PINS ARE POSITIONING FACESHEET #2 ABOVE FACESHEET #1
DETAIL D
SCALE 2 : 1
CAUL PLATE PROVIDES FORCE ON FACESHEET #2 DURING BONDING
STEP 4
FACESHEET #2 IS BONDED TO TOP OF C-CHANNELS
PARTS LIST
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES -TOLERANCES-
DECIMALS .XX = +/- .03 .XXX = +/- .010
ANGULAR = +/- 30'
SURFACE FINISH = 250
CAD GENERATED DRAWING, DO NOT MANUALLY UPDATE DO NOT SCALE DRAWING
HYTEC, INC
TITLE COMPOSITE RING BOND PROCEDURE
FINISH
DESIGNED W. K. MILLER 3-3-99
DRAWN W. K. MILLER 3-5-99
CHECKED HARRY SALAZAR -
ENGR. W. O. MILLER -
APPROVED - -
PART NO. ATLAS-FXT-0000-1
DWG. NO. ATLAS-FXT-0000
SIZE D
SHEET NO. 4 of 7
SCALE 1/1
REVISION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7
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APPROVED
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C
B
A
4X MOUNT TAB
MOUNT TAB BOND BLOCK
ORIENTATES MOUNT TAB -
SETS ALL COPLANAR
4X ∅ .250 PIN
REPLACES ∅ .281 PIN
4X ∅ .125
PIN SETS MOUNT BLOCK
Z ELEVATION
C
4X ∅ .250 PIN
CRITICALLY POSITIONS
MOUNT TAB - NOT FACESHEET
BOND BLOCK IS
CLAMPED TO GRAPHITE
PLATE
DETAIL C
SCALE 2 : 1
2X ∅.187 PINS
CRITICALLY ALIGN BOND BLOCK
CAUL PLATE USED
STEP 5
MOUNT TABS ARE BONDED
IN PLACE BETWEEN FACESHEETS
PARTS LIST
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-
DECIMALS
.XX = +/- .03
.XXX = +/- .010
ANGULAR = +/- 30'
SURFACE FINISH = 250
CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING
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BOND PROCEDURE
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3-3-99
DRAWN
W. K. MILLER
3-5-99
CHECKED
HARRY SALAZAR
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ENGR.
W. O. MILLER
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APPROVED
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SCALE 1/1
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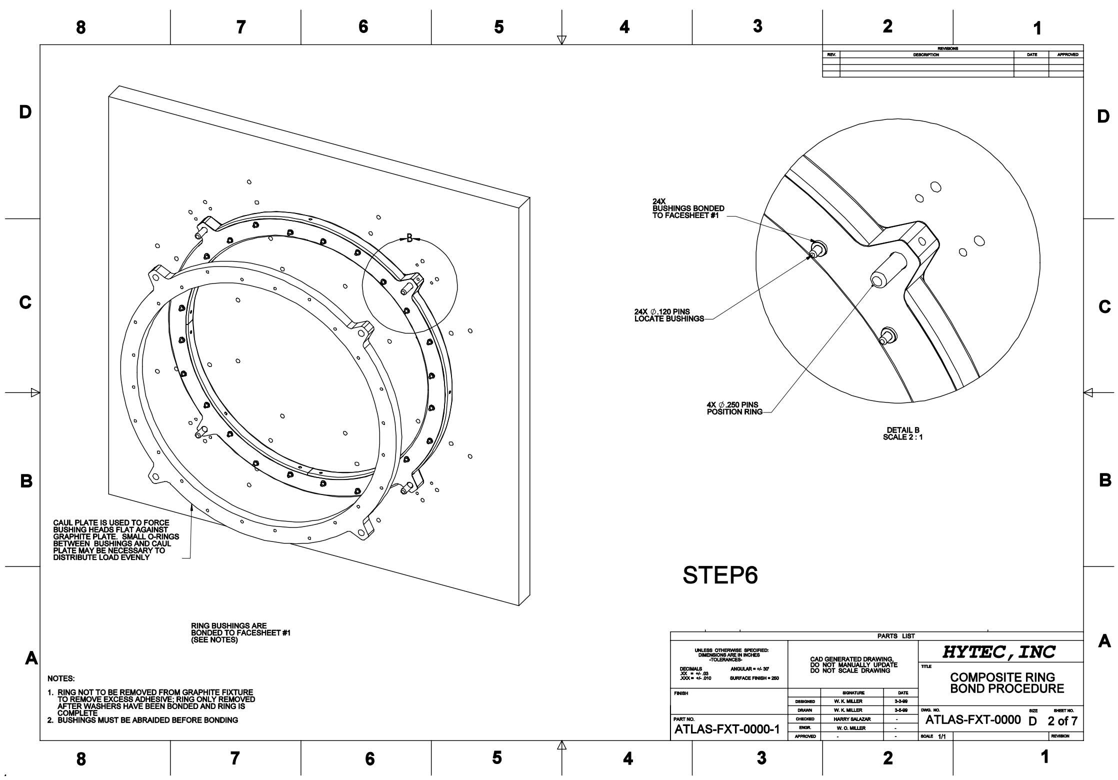
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REV.
DESCRIPTION
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APPROVED
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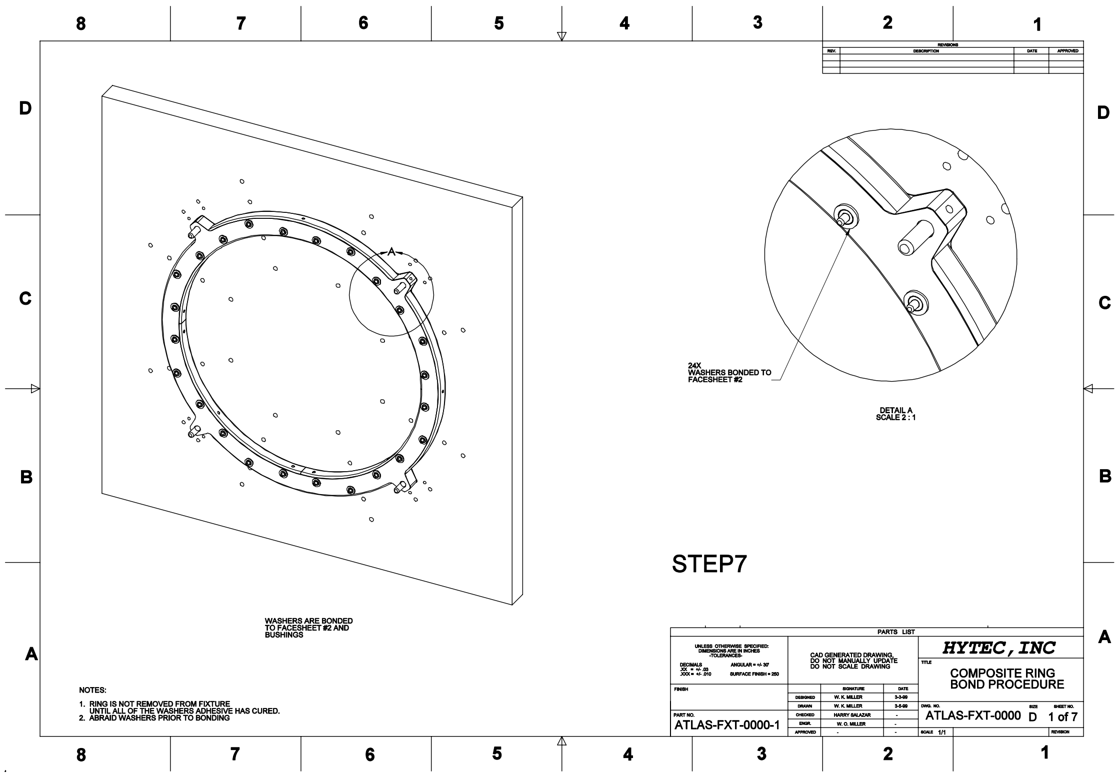
B
A
B
24X
BUSHINGS BONDED
TO FACESHEET #1
24X ∅.120 PINS
LOCATE BUSHINGS
4X ∅.250 PINS
POSITION RING
DETAIL B
SCALE 2 : 1
CAUL PLATE IS USED TO FORCE
BUSHING HEADS FLAT AGAINST
GRAPHITE PLATE. SMALL O-RINGS
BETWEEN BUSHINGS AND CAUL
PLATE MAY BE NECESSARY TO
DISTRIBUTE LOAD EVENLY
STEP6
RING BUSHINGS ARE
BONDED TO FACESHEET #1
(SEE NOTES)
NOTES:
1. RING NOT TO BE REMOVED FROM GRAPHITE FIXTURE
TO REMOVE EXCESS ADHESIVE; RING ONLY REMOVED
AFTER WASHERS HAVE BEEN BONDED AND RING IS
COMPLETE
2. BUSHINGS MUST BE ABRAIDED BEFORE BONDING
PARTS LIST
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
-TOLERANCES-
DECIMALS
.XX = +/- .03
.XXX = +/- .010
ANGULAR = +/- 30'
SURFACE FINISH = 250
CAD GENERATED DRAWING,
DO NOT MANUALLY UPDATE
DO NOT SCALE DRAWING
HYTEC, INC
TITLE
COMPOSITE RING
BOND PROCEDURE
FINISH
SIGNATURE
DATE
DESIGNED
W. K. MILLER
3-3-99
DRAWN
W. K. MILLER
3-5-99
CHECKED
HARRY SALAZAR
-
ENGR.
W. O. MILLER
-
APPROVED
-
-
PART NO.
ATLAS-FXT-0000-1
DWG. NO.
ATLAS-FXT-0000
SIZE
D
SHEET NO.
2 of 7
SCALE 1/1
REVISION



4. References

4.1 Drawing List

Project Number (ATLAS Drawing No)	LBNL Drawing No.	TITLE LINE 1	TITLE LINE 2	TITLE LINE 3
ATL-IP-ED-0059	21F5104	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	RING BOND FIXTURE ASSEMBLY
ATL-IP-ED-0060	21F5114	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	RING BOND FIXTURE PARTS
ATL-IP-ED-0060	21F5114	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	RING BOND FIXTURE PARTS
ATL-IP-ED-0061	21F5124	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	RING CAUL PLATE
ATL-IP-ED-0062	21F5134	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	C-CHANNEL CLAMP PARTS
ATL-IP-ED-0062	21F5134	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	C-CHANNEL CLAMP PARTS
ATL-IP-ED-0063	21F5144	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	RING MOUNT-TAB BOND BLOCK
ATL-IP-ED-0064	21F5154	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	C-CHANNEL MACHINING CLAMPS
ATL-IP-ED-0064	21F5154	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	C-CHANNEL MACHINING CLAMPS
ATL-IP-ED-0065	21F5164	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE ASSEMBLY
ATL-IP-ED-0066	21F5174	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS

ATL-IP-ED-0066	21F5174	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0066	21F5174	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0067	21F5184	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0067	21F5184	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0067	21F5184	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0067	21F5184	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	OUTER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0068	21F5194	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE ASSEMBLY
ATL-IP-ED-0069	21F5204	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0069	21F5204	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0069	21F5204	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0070	21F5214	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0070	21F5214	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0070	21F5214	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0070	21F5214	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING TOOLING	INNER C-CHANNEL MOLD FIXTURE PARTS
ATL-IP-ED-0071	21F5224	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING	RING ASSEMBLY
ATL-IP-ED-0071	21F5224	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING	RING ASSEMBLY
ATL-IP-ED-0072	21F5234	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING	RING FACE SHEET
ATL-IP-ED-0073	21F5244	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING	OUTER C-CHANNEL
ATL-IP-ED-0074	21F5254	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING	INNER C-CHANNEL
ATL-IP-ED-0075	21F5264	ATLAS PIXEL DETECTOR	SECTOR MOUNTING RING	RING MOUNT-TABS AND SECTOR MOUNT BUSHINGS

Appendix B
Process Control Inspection
432mm Disk Support Ring

William K. Miller, W. O. Miller
September 28, 2001

Abstract

This document outlines the minimum inspection steps deemed necessary to ensure that the Disk Support Ring and ring components have been fabricated in accordance with the Procurement Plan for the ATLAS Pixel Detector Disk Support Rings, HTN-106210-0005, and other applicable specifications set forth by Lawrence Berkeley National Laboratory (LBNL). The controlling LBNL document is drawing 21F5224.

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1. Introduction

Specific process control techniques are necessary to produce a "per print" 432mm Disk Support Ring. HYTEC has outlined key inspection steps, techniques, and nominal dimensions (based upon individual part tolerances and fabrication tolerance stack-up) expected for a deliverable product.

The first half of this document details inspection steps required for Phase 1 (fabrication of the ring's inner and outer C-Channels), and steps that complement those outlined for Phase 2, contained in the Procurement Plan for the Atlas Pixel Detector Disk Support Ring [1]. It is believed that adopting and enacting an inspection process control along the lines outlined here, or an equivalent procedure, will provide the necessary structure to successfully produce high quality in the 6 production rings planned in Phase 3.

2. Phase 1 – Inspection of Ring's Inner/Outer C-Channels

HYTEC and Allcomp have produced C-Channels for two rings in a past SBIR program. The C-Channels were produced using a different process than currently planned. It is believed that improved C-Channels will result from the revised compression molding process. Qualification of the new channels will use inspection steps based upon this prior experience. Achieving high dimensional quality in the C-Channels is essential to the production of a quality composite ring. In this regard, it is important not to produce a set of channels (inner and outer), which have different widths, or that possess an in-grained twist. It is expected that either of these conditions will lead to ring twisting. The unfortunate result will be that all of the Pixel Detector Sector mounting bushings would be twisted out of position. This condition, if sufficiently severe, would result in the final product being rejected.

The "per print" specifications for the ring's inner and outer C-Channels are shown on LBNL drawings 21F524, and 21F525. The critical features of the C-Channels are (1) the major physical radius (the web profile of the C-Channel that defines the outer and inner physical dimensions of the ring), (2) the width of the C-Channel, (3) toe in/out condition channel legs, and (4) the perpendicularity of the channels.

There are other potential non-conformities that may be fabricated into the molded channel, which are not cited. It is important to realize that not all non-conformities, when found, will necessarily result in a particular C-Channel being rejected. This document attempts to focus on key potential non-conformities prior to fabrication, to establish an awareness mindset, in the hopes of producing a "near-perfect" C-Channel.

2.1 C-Channel Specifications (defined by drawings 21F524, and 21F525)

An acceptable C-Channel should have these features:

- Web of the C-Channel must be perpendicular to its legs better than 0.5°.
- Outside radius to outside radius width to be within 0.548-0.546in.
- No toe out of C-Channel face. Toe in of 1° across the face (6 mils) is acceptable (as described in note 7 of the drawings).
- The major physical radius of C-Channel must be "per print."
- In-grained twist of .002" per inch/.008" max per arc length is acceptable.
- Aesthetics is important; the C-Channel must be smooth and continuous in appearance. Devoid of cracks, frays, and major non-conformities.

2.2 Determination of Potential Nonconformities

This section presents acceptable C-Channel "parameters". We attempt to explain why specific non-conformities are unacceptable, and identify techniques for inspecting the critical dimensions, and possible corrections to identified problems.

2.2.1 Channel Web Not Perpendicular to Side Face

The desire to have a C-Channel web perpendicular to its face(s) is to facilitate assembly. The vertical web is pulled to an aluminum half-ring, which positions the C-Channel during bonding. Out-of-perpendicularity, as accentuated in Figure 1, will likely result in built-in stress at bonding, leading to ring twist in the free state. Figure 1 shows an example of the channel web not being perpendicular to the channel legs even though both of the channel legs and width are within tolerance. Drawing 21F524 and 21F525 define that the channel web must be perpendicular to the channel's legs within 0.5° or 5 mils.

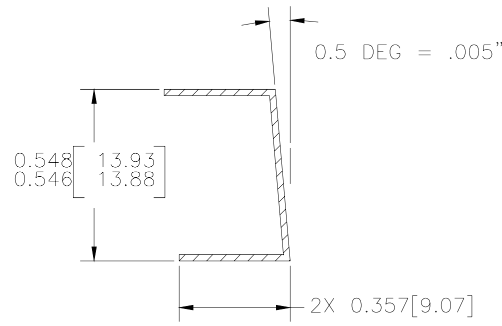

Figure 1. C-Channel web not perpendicular to its face.

2.2.1.1 <u>Inspection for Channel Web Perpendicularity</u>
A molded C-Channel (pre-machined) can be set (unrestrained) on a granite table. A machinist's square or gauge block is placed against the web of the channel. If a gap is exhibited between the parts, feeler gauges may be used to determine the extent. Sweep the gauge block around the entire radius of the part (90° active arc length). Flip the C-Channel over and repeat this process for the other side. If a feeler gauge of greater than .005" can be placed between the two parts, the C-Channel is rejected.

2.2.2 Channel Width

All C-Channels must have a closely controlled specific height (see drawing 21F524, 21F525 and Figure 2) to create a flat co-planar surface for face sheet #2. Another reason is that all of the individual bushing parts are machined to a specific width to match the correct C-Channel width. The acceptable channel width is shown in Figure 2; a channel outside of these limits may be rejected.

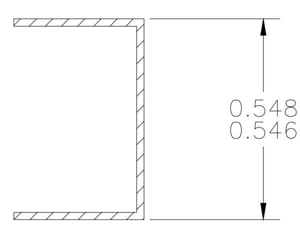

Figure 2. C-Channel width specification.

2.2.2.1 <u>Channel Width Inspection</u>
The width of the C-Channel may be measured using a caliper. No fewer than 10 measurements should be taken across the arc length of the channel. Alternately, the channel can be restrained on a granite table and measurements can be recorded using a height gauge.

2.2.3 Channel Leg Toe In/Out

The C-Channel legs in their as-molded condition are very rigid. It takes a lot of force to push a channel face inward. Any attempt to force a C-Channel to a perfect shape during bonding would result in a strain in the finished composite ring. Therefore C-Channel toe out is unacceptable and will result in rejection. In contrast, C-Channels may have a slight toe in condition. Any slight gap produced by the "toe-in" condition may be filled with adhesive (when bonding to a face sheet), which should not result in a residual strained. LBNL drawings 21F524 and 21F525 specify a leg toe in of 1° or 6 mils is acceptable (note 7).

2.2.3.1 <u>Channel Face Toe Inspection</u>

Each side of the C-Channel toe-in can be measured using a feeler gauge (C-Channel restrained flat on a granite table). It may be cause for rejection of a C-Channel, if a feeler gauge of greater than 6 mils can be inserted between the C-Channel and granite table. Any condition greater than 6mils requires approval.

A toe in/toe out condition can be corrected by adjusting the female mold spring-back angle. This condition will be experimentally corrected during Phase 1 of the project.

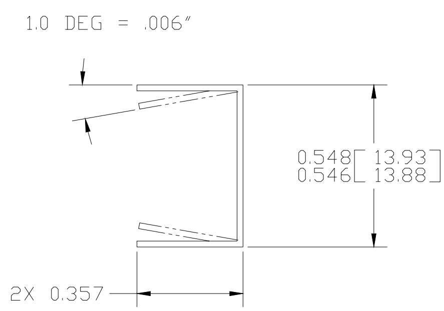

Figure 3. C-Channel toe in/out specifications.

2.2.4 Channel Web Radius

The C-Channel is inherently stiff in a direction normal to its outer radius. It takes considerable force to bend it to a different than as-molded radius. Therefore, it is extremely important for its major physical radius to be per specification (see drawings 21F524 and 21F525). Any attempt in constraining the C-Channel outer radius for bonding into the assembly will result in an as-bonded assembly that has serious strain.

2.2.4.1 <u>Channel Web Radius Inspection</u>

The physical radius of the C-Channel will have to be measured (unrestrained) using a go/no go template or equivalent. Any deviation from the correct radius may be corrected by adjusting the mold. All deviations should be adjusted in Phase 1.

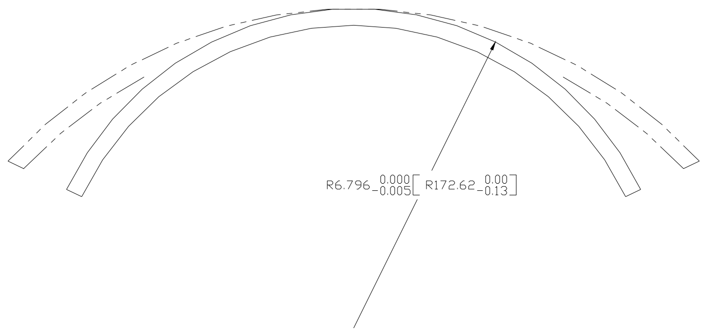

Figure 4. C-Channel major radius

2.2.5 Channel In-grained Twist

In an unrestrained condition, a C-Channel may have the correct width and acceptable toe specifications, but it may exhibit an in-grained twist. Ingrained twist is most likely produced by a slight irregularity in the lay-up of the prepreg layers. If the channel passes other specifications, it can be constrained (it is not inherently stiff to twisting) during the bonding process. There should be little bonded stress as a result of constraining a twisted C-Channel.

2.2.5.1 <u>Channel In-grained Twist Inspection</u>

In-grained twist may be measured with the C-Channel lying unrestrained on a granite table. Insert feeler gauges at one end of the C-Channel. In-grained twist of less than .002"/in and not more than 0.008" per total arc length is acceptable.

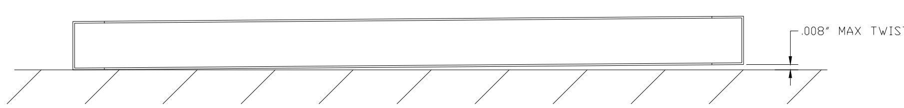

Figure 5. C-Channel with in-grained twist

2.2.6 Other Nonconformities

2.2.6.1 <u>Thickness Variations</u>

Material thickness variations may be present in the C-Channel. Channel side face thickness measurements should be taken at various angular positions around the C-Channel for both legs. C-Channel drawings specify 0.5 mm as the C-Channel material thickness. The material thickness tolerances are dependent up the fiber content specified in the C-Channel material callout. A variation in thickness may be due to uneven silicone rubber pressure on the prepreg material during curing. Some random thickness variations are acceptable; if considerable thickness variations are found during Phase 1, the condition should be investigated for correction. Thickness variations in the excess of 20% of thickness will require approval before proceeding.

2.2.6.2 <u>Cracking or Fraying at Channel Edges</u>
Cracking or fraying at machined edges is due to the improper tools (carbide or tungsten tips are necessary) used during the machining process. In most cases, machining thin molded or sheet carbon material should be sandwiched between aluminum plates (the part should be constrained). Cracking or fraying is not acceptable, but is avoidable with proper machining practices.

2.2.6.3 <u>C-Channel Aesthetics</u>
The C-Channel should be free of major non-conformities and be visually "perfect."

2.2.7 Summary of C-Channel Inspection

The cause of most of these problems can be identified and corrected. Some problems will be a result of improper mold dimensions, but this will be corrected in Phase 1. Other problems exhibited, may be a result of the silicone plug not applying enough pressure to the prepreg during curing, or being misaligned during molding.

C-Channel wall thickness measurements will be recorded and this information will be used to ensure that the fiber volume fraction is correct.

3. Phase 2 – Bonding of the Composite Disk Support Ring

All of the individual parts for the disk support ring including: face sheets, mount tab, bushings and washers must be inspected and certified by the appropriate machine shop prior to delivering the components to the ring assembly area. All recorded dimensions for the piece parts must be supplied with the parts in a "traveler" package. A fully assembled and inspected disk support ring will include a similar traveler, unique to each ring, and this traveler will provide traceability to the piece part travelers.

A bond fabrication procedure (as a part of the Procurement Plan Document [1]) has been submitted by HYTEC to LBNL for their review. Once released, it is a binding document that must be followed step by step. The procedure will be reviewed and revised prior to Phase 3 of the ring fabrication effort. There should be no need for revision during the Phase 3 fabrication of the 6 production rings. As a part of the procedure, inspection documents (notations in the traveler document) will be processed for each inspection step.

Discrete inspection steps have been inserted through the ring assembly task to better understand what deviation or tolerance stack-up may have led to an out of specification condition. Common quality control practices should be implemented, such as always using the same inspector throughout a ring's fabrication (or even throughout the entire project) to maintain repeatable inspection readings. Any problems or questions should be immediately reported to HYTEC for review.

This document does not address all procedural steps as a whole, but rather reference the step as part of the Procurement Plan Document - PPD. We stress specific inspection points throughout the assembly task, and identify the anticipated fabrication dimensions at said points.

3.1 432mm Sector Mount Ring Assembly Specifications (defined in drawing 21F522)

The following is a written translation of the dimensions and tolerances shown on LBNL drawing 21F522:

- The 3 bushings for mounting each sector are a pattern. It is important to critically position them to each other within ∅0.001. This will be done with a critical pattern machined into a mistress gauge supplied by LBNL. A secondary task is to less critically position each 3-bushing pattern relative to the entire bushing pattern within ∅0.005".
- All bushing heads are to be coplanar within 0.002" when the ring is unrestrained.
- All four of the mount tab ∅3.50 mm holes are to be coplanar within 0.005".
- The composite disk support ring width is to be less than 15 mm (to provide clearance for sector tube services).
- The ring shell should be bonded together in the most strain free condition possible.

3.2 Mistress Gauge

A mistress gauge will be supplied by LBNL for the purpose of critically positioning and bonding the brass bushings into the back of the graphite plate.

The mistress gauge has two discrete 2-hole patterns in it. The first 2-hole pattern is used to critically position and hold three brass bushings relative to themselves within 0.001" during bonding. The second 2-hole pattern is used to position the mistress gauge on the graphite fixture during the bonding process. Gauge pins are used to transfer the tight positioning of the 3-hole pattern in the mistress gauge to the position of the brass bushings in the graphite fixture plate.

After bonding, the graphite fixture plate with the brass bushings bonded in place will be inspected using a CMM by LBNL.

3.3 Inspection Steps During Bond Fabrication

The following inspection steps are derived from the Procurement Plan for the Atlas Pixel Detector Disk Support Ring

3.3.1 Facesheet #1 on Graphite Bond Plate

Any time anything is placed on the graphite plate, it should be visually and physically inspected. Small bumps of adhesive may have temporarily adhered to its flat surface. By running a hand over important flat "zones" (area where the face sheet lies flat on the plate), bumps may be felt. Air should be blown over the entire surface to remove grit, lint, hair, and dirt that may have collected on its surface. A hair (hair is 0.003" thick) is thick enough to prevent the bushings from being coplanar during bonding).

The face sheet material has a specified thickness (see LBNL drawing 21F523) of 0.483-0.432 mm. After a face sheet has been positioned using no less than 3 pins in the mount tab holes (∅7.50 mm), it should be tapped (with a finger) to see if it is lying flat on the plate, especially in the areas immediately surrounding the pins.

Inspection to prove the face sheet is seated flat shall be done using a height gauge (see step 6 in PPD). The height gauge base should be sitting in the center of the graphite plate. It's gauge point, after being zeroed on the graphite plate, should read .483-.432 mm (see Figure 6).

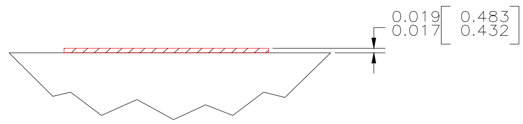

Figure 6. Face sheet flat on graphite plate

Note: Drawings and notes MUST be prepared showing the position of each serialized part in the assembly (face sheets, C-Channels, and mount tabs). Therefore if deviations are noted, one can trace back through the serialized inspection reports to determine if the problem is a result of the bond procedure or a part tolerance. This process MUST be carried out for each bonding step in the fabrication process (with the exception of the location of individual bushings and washers).

3.3.2 C-Channels Bonded to Facesheet #1

The face sheet has been inspected, and is lying flat on the graphite plate. Each C-Channel has been individually inspected and approved (per LBNL drawing 21F524 and 21F525). Knowing the limit dimensions for each we can determine (see Table 1):

	MAX	mm		MIN	mm
C-CHANNEL WIDTH	0.548	13.93		0.546	13.88
ADHESIVE BOND WIDTH	0.003	0.08		0.003	0.08
FACESHEET THICKNESS	0.019	0.48		0.017	0.43
TOTAL DIMENSION	0.570	14.49		0.566	14.39

Table 1. C-Channel and Face Sheet #1 Limit Dimension

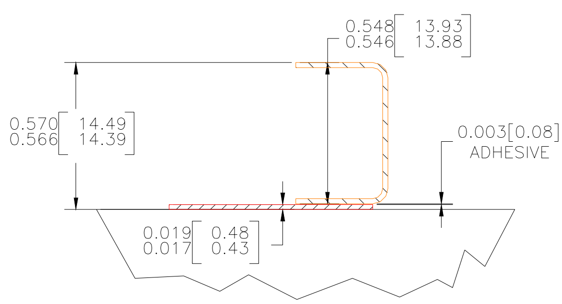

Figure 7. C-Channel bonded to face sheet

Therefore, the limit dimension for step 11 in the PPD document is 14.48-14.38 mm (see Figure 7). If the face sheet and C-Channels have been inspected and approved, any deviation from this limit dimension will be a result of a varying adhesive thickness or an unbalanced applied load from the Caul plate.

3.3.3 Face Sheet #2 Bonded to C-Channels

Table 2 shows the tolerance stack up for the bonding of face sheet #2 to the C-Channels. Figure 8 shows the sketch of the assembly.

Approximately 6 inspection measurements should be taken on each C-Channel unless a deviation is determined, then at least 10 measurements should be recorded. These measurements can be used to map elevation deviations that will later help in forecasting problems.

This corresponds with inspection step 17 of the PPD document. Because each part has a tolerance associated with it, the tolerance as the assembly is put together increases. The limit dimension measured from the graphite plate to the top of face sheet #2 is 15.04-14.88 mm.

Once again, a height gauge is used for making measurements. The base of the height gauge is placed in the center of the graphite plate.

	MAX	mm		MIN	mm
C-CHANNEL WIDTH	0.548	13.93		0.546	13.88
ADHESIVE BOND WIDTH	0.006	0.152		0.006	0.15
FACESHEET THICKNESS	0.038	0.97		0.034	0.86
TOTAL DIMENSION	0.592	15.05		0.5864	14.89

Table 2. C-Channel and Face Sheets Limit Dimension

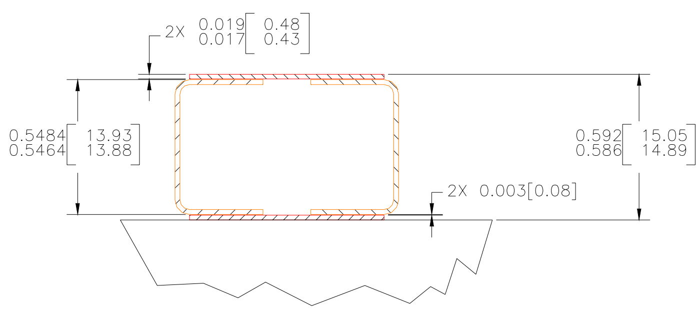

Figure 8. Face sheet #2 bonded to C-Channels.

3.3.4 Installing the Mount Tabs

Before installing the mount tabs, a visual inspection should be done to determine if adhesive has flowed out and will interfere with the installation of the mount tab. Some light scraping with a "hot knife" may be necessary to remove unwanted adhesive on the face sheet material. The assembly should not be removed from the graphite plate unless absolutely necessary; if necessary, retain the original angular orientation of the ring, and re-inspect the ring to determine that it is flat on the graphite plate (see inspection step 3.3 for correct limit dimension).

After the mount tabs have been bonded in position, insert a ∅3.5 mm pin into the ends of each mount tab. Is there enough room for the height gauge in the corner of the graphite fixture? Place the height gauge on the granite table. Re-zero the gauge so that the top of the graphite plate is zero. Using that new zero reference, measure to the top of the pin. The point being that they should all be coplanar.

Figure 9 shows the limit dimension for the mount tab being 9.29-9.21 mm.

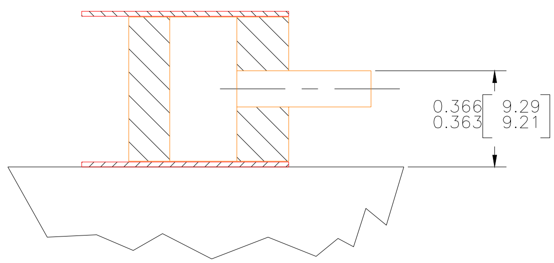

Figure 9. Mount tab measurement.

3.3.5 Bushing

Bonding the bushings heads coplanar is one of the primary objectives of the disk support ring design. Prior to installing any bushing be sure to inspect each counterbore for sand, hair, or lint. The planarity of these bushings is affected by the variations in the counterbores in the graphite plate. The graphite plate will be inspected by HYTEC to verify that the individual 24-counterbores are machined to the correct depth. Of equal importance is to determine that each bushing is completely seated against the counterbore shoulder.

3.3.6 Installing the Bushings

Table 3 and Figure 10 show the limit dimension for a bushing seated in its counterbore. This dimension is measured by a height gauge (height gauge base on the graphite plate). The height gauge knife-edge should be re-zeroed for calibration on the graphite plate (not the granite table as done in step 3.4). The dimension measured from the top of the bushing to the face of the graphite plate should be 16.18-16.03 mm.

		mm			mm
BUSHING	0.717	18.21		0.712	18.08
COUNTERBORE DEPTH	0.082	2.08		0.081	2.05
TOTAL DIMENSION	0.635	16.13		0.6311	16.03

Table 3. Bushing Installed on Pin and Located in Counterbore

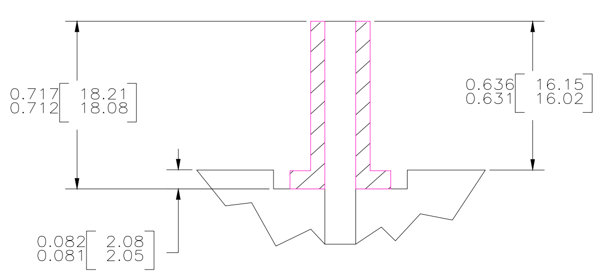

Figure 10. Bushing located in counterbore.

3.3.6.1 <u>Bonding the Bushings to Ring Shell</u>

After the 24 bushings are in place and have been inspected to make sure they are correctly seated in place. After adhesive has been applied to each surface, and the ring has been re-positioned, re-check to see that the ring is correctly seated on the graphite plate. The measured values should closely correspond with the inspection measurements recorded in step 3.3.

3.3.7 Bond Washers to Face Sheet #2

After the washers have been bonded in place, an inspection (see step 35 PPD document) is done to determine planarity of the washers. Table 4 and Figure 11 show the calculations and the final limit dimension.

Any variation outside of the limit dimension may be a result of the adhesive bondline being greater than 0.003". The dimension recorded should be within 16.23-15.95 mm.

		mm			mm
SHELL WIDTH	0.592	15.05		0.586	14.89
ADHESIVE WIDTH	0.003	0.08		0.003	0.08
WASHER WIDTH	0.044	1.13		0.039	1.00
TOTAL DIMENSION	0.640	16.25		0.6287	15.97

Table 4. Washer installed in Place

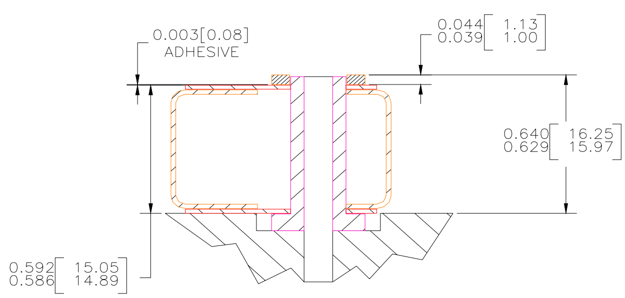

Figure 11. Final dimension when washer is bonded in place

4. Inspection Summary

These inspection steps are an indicator as to how well the ring bonding operation is proceeding. Naturally, if excess adhesive is used in the initial stages of the bonding, the measured dimension will increase accordingly. Any time a predicted inspection measurement is not within limits, immediately investigate to determine what caused the deviation. Determine if a change in the process control is needed to correct such a future deviation. This type of investigation is the key to understanding the necessary processes to produce a "deliverable article."

After Phase 2 is complete - a procedure, design, and inspection review meeting will be conducted. The meeting will serve to summarize, make recommendations and consider improvements or any necessary changes to be implemented prior to initiating Phase 3. The appropriate changes will be made to the procedure and inspection processes. After these changes are made we do not anticipate any deviations from the approved procedure will be necessary. At this point final production approval will be granted.

5. References

[1] Procurement Plan for the ATLAS Pixel Detector Disk Support Rings, HYTEC HTN-106210-0005

Appendix C
ATLAS Pixel Detector Global Support Structure Procurement and QC Plan

William O. Miller
1/16/2002

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Abstract

The Production and QC Plans for the Global Support Frame, comprising the outer frame elements, 2-end cones, and 2-end plates, are presented. The elements comprise an integrated, lightweight, stable structure for the ATLAS Pixel Detector. In this capacity, the Global Support Frame provides direct support and critical mounting interfaces for the ATLAS Pixel Detector Local Supports (ref. ATL-IP-0005). The intended distribution of this technical note is to the Production Readiness Review team composed of the ATLAS-LHC management.

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Revision Log

Rev.	Date	Author(s)	Summary of Revisions/Comments
0	01/30/2002		Initial draft released.

Table of Contents

1. Introduction

The ATLAS Pixel Detector staff has designed and prototyped many aspects of a lightweight frame structure for supporting the pixel detector modules. Starting from within the module location in detector-space out to the external 4-point support of the frame[1], the support concept has been broken into discrete manageable structures. In this connection, the pixel modules are supported on *Local Support Structures*, which are turn connected to a *Global Support Structure* through individual mounts. This document is concerned with specifying the production and inspection plans for only the Global Support Structure. Similar requirements for the *Local Support Structures* and the mounts that interconnect the two are discussed elsewhere.

The Global Support Frame is a structure constructed, for all practical considerations, entirely from composite materials. The only non-composite material is the very thin embedded threaded-inserts for making structural connections, and their respective metallic fasteners[2]. The Global Support Structure weight is nominally 2.85kg; physically, the frame is nominally 1.44m long with its extremity inscribed by a 0.432m diameter. A cut-away of the structure with the basic internal elements is shown in Figure 1. The total mass of this assembly with appended services is nominally 27kg.

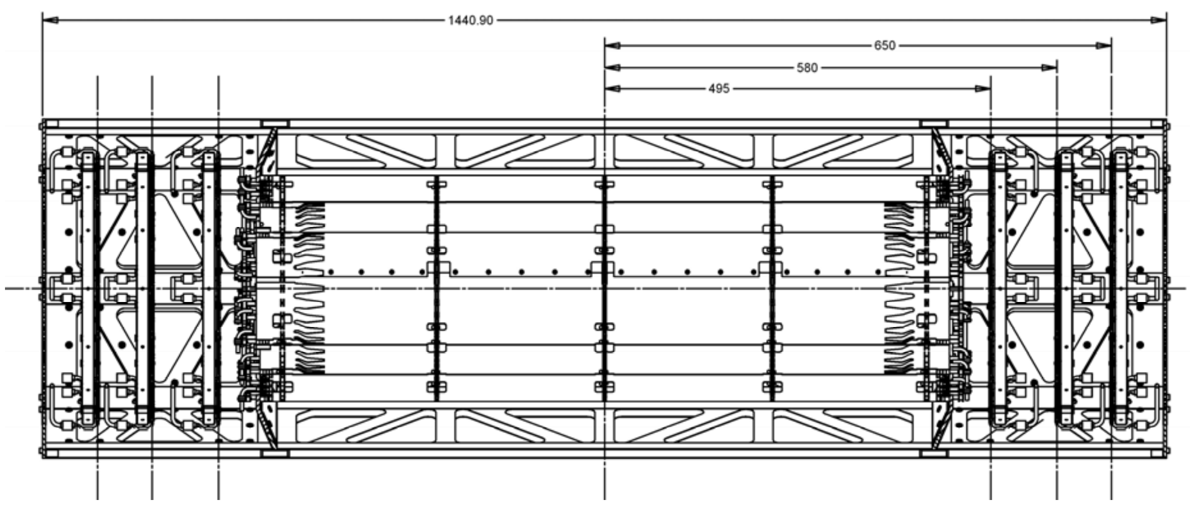


Figure 1: Drawing of the ATLAS Pixel Detector, illustrating the Barrel Section and the 2-Disk Regions, one at each end. Dimensions are in mm.

[1] Support provided by the SCT via the ATLAS Pixel Detector Support Tube
[2] Fasteners that connect the outer frame sections most likely will be metallic. Tests with composite fasteners have not been performed as of this date.

2. Description

2.1 General Global Support Structure Description

The outer frame structure of the Global Support Frame consists of a flat-panel space frame in three sections - a barrel section and two, identical disk sections as shown in Figure 2. These sections are joined in a final assembly operation, Figure 3, after all the components have been installed and the services are in place. Between the disk and barrel section are mounted two end cones, used for supporting the three inner pixel layers (barrel arrangement). The 6-disk support rings and associated disk sectors, which are shown in Figure 2, are not part of the Global Support Structure procurement package.

The sandwich panel is the primary structural element of the frame. It is composed of quasi-isotropic facings (K1392U/Bryte EX1515) and a honeycomb core (ULTRACOR-GF). The nominal sandwich thickness is 10mm, with a nominal facing thickness of 0.43mm. Panel light weighting is achieved by a simple routing operation after bonding. A room temperature curing adhesive (HYSOL 9396) is used for all bonding operations to avoid leaving residual stresses in the completed structure.

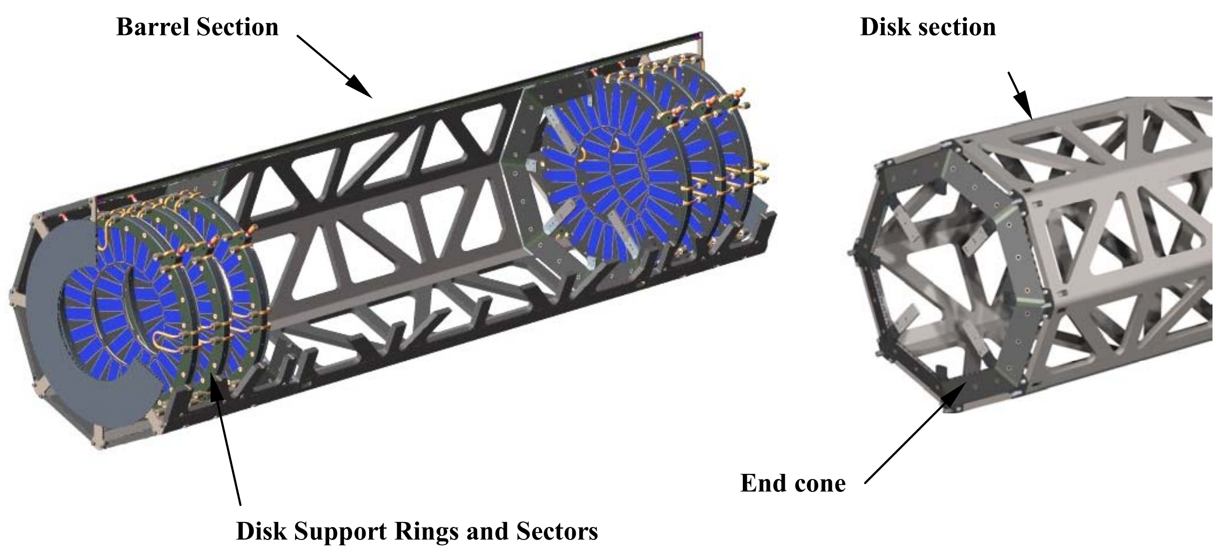


Figure 2: ATLAS Pixel Global Support Structure, which consists of three sections - barrel and two disk sections. The barrel and two disk sections are shown joined on the left. One of the support cones for the barrel shells is shown in the right model. End closure plates are not shown in this view.

Short thin hollow tubes, which are bonded into the barrel section stiffening tubes, precisely align the outer frame sections. The barrel section stiffening tubes (corner tube) run full length and terminate in the corner block assembly. The short alignment tube connection to the corner structural tube is shown in an exploded view of Figure 4.

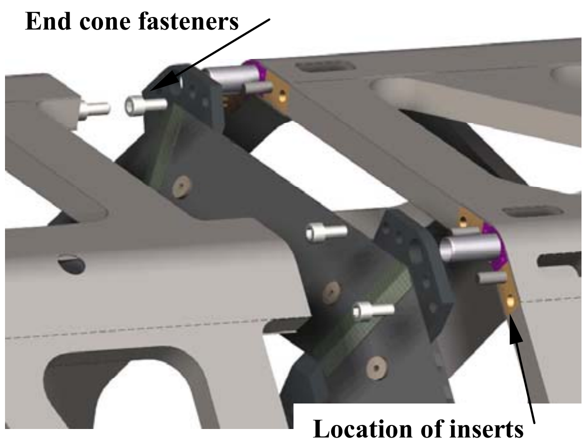


Figure 3: View of End Cone to Barrel Frame Section connection. Connection from barrel frame section to disk frame section follows similar pattern.

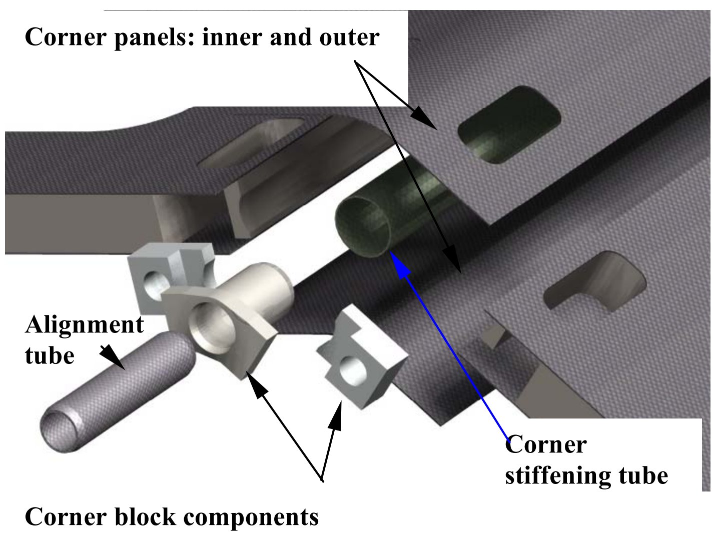


Figure 4: Exploded view of Barrel Section Frame corner joint design, illustrating the inner tube, outer and inner corner splices, and the corner block components.

The Stiffening Corner Tube and the Alignment Tube are formed using the same fiber/cyanate ester resin combination as used in the constructing the faces on the flat panels (K1392U/Bryte EX1515). The Corner Blocks are constructed with woven cloth and cyanate ester resin (YSH50/RS-3 by YLA).

The sandwich End Plate used to provide radial stiffness of the two ends of the frame is depicted in Figure 5.

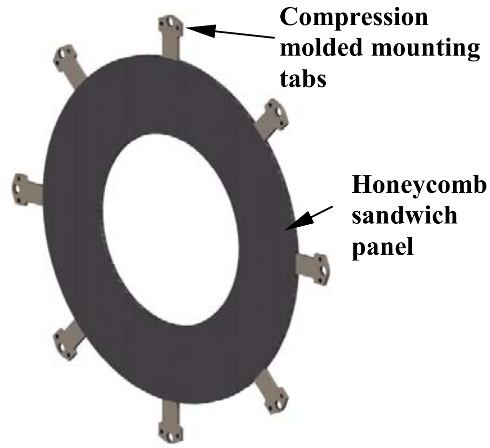


Figure 5: End Plate for providing radial stiffness to the outer frame structure of the Global Support Structure. Mounting tabs connect to the corner blocks in the disk frame structure.

Figure 6 depicts the complete structural assembly, with the end plates that provide a radial stiffness enhancement to the lightweight frame structure.

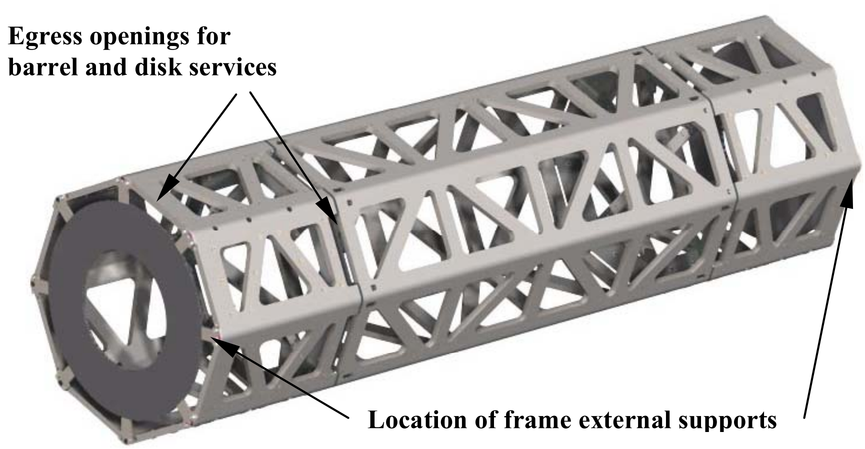


Figure 6: Illustration of the assembled Global Support Structure components exclusive of the detectors, detector local supports, and services. Connection to Pixel Detector Support Tube is provided at the four mid-plane corners.

2.2 Overview of Assembly Tooling Concepts

Lawrence Berkeley National Laboratory[3] (LBNL) will supply specialized tooling needed for constructing the individual components that comprise the Global Support Structure to the composite fabricator, who in turn will produce all of the indicated structures. The tooling suite will comprise assorted compression molds for the attachment brackets, tooling for producing the honeycomb sandwiches used in the outer frame, end cones and end plates, and the bonding fixtures for producing final sub-assemblies. Thus far, the project has successfully achieved the

[3] In conjunction with engineering assistance from HYTEC, Inc.

desired part quality without requiring machining of the final-bonded sub-assemblies, i.e., a frame section, or end cone. Post machining of the bonded assemblies is to be discouraged, primarily because of cost, but also due to the extreme difficulty in establishing a suitable datum for controlling all the features.

Machining of the compression molded parts is required to achieve final part thickness and datum hard points for positioning the component during bonding. The placement of these machining orders will be the responsibility of the composite fabricator.

Pre-qualified fixtures will be delivered to the composite fabricator with inspection reports attesting to the accuracy of precision tooling features. The source of the inspection will be inspection reports from tooling vendors and CMM measurements taken by LBNL. By the virtue, that LBNL supplies the tooling does not relieve the composite fabricator from complying with dimensions controlling final part features.

The next sections provide an overview of the assembly tooling that will be manufactured and delivered to the composite fabricator for assembling the precision structures.

2.2.1 Tooling Concept Used for Bonding End Cones

A bonding fixture machined from graphite material, Figure 7, will be provided with a precision machined octagonal flat pattern, which positions the 8-pre-assembled flat sandwich panels. Precision tooling holes in the graphite plate and the sandwich panel are used to locate each element. In addition, tooling holes are provided to register the outer and inner compression molded mounting tabs. The comparatively low thermal expansion of the graphite material limits distortion from room temperature variations during bonding. Also, a room temperature curing HYSOL 9396 is used to eliminate dimensional changes during bonding.

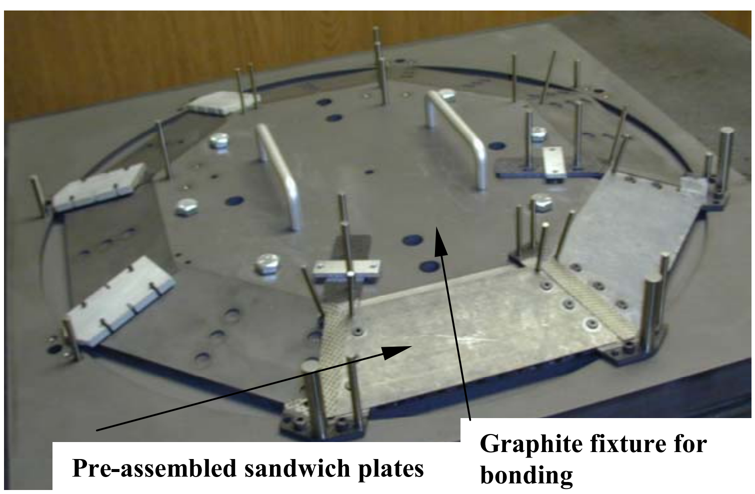


Figure 7: Graphite bonding fixture used to assemble a 500mm diameter end cone. Various pins shown were used to index the sandwich plates and compression molded mounting tabs. Two sandwich plates are shown.

The G/F honeycomb must be trimmed to a trapezoidal pattern with cutouts for the corner mounting plates. A fixture for bonding the flat sandwich panels that sets the position of the honeycomb pattern while bonding the face sheets will be provided.

The fixture concept shown above will be adapted for positioning the flat annular end plate in place, during construction of the End Plate assembly.

2.2.2 Frame Section Bonding

The outer frame structure octagonal pattern is achieved by bonding together 8-lightweight sandwich panels using a precision aluminum bond fixture, Figure 8. The fixture incorporates precision dowel patterns at each end plate that are used for constraining the position of the Corner Stiffening Tubes and the Corner Block elements, Figure 9. Of primary importance, the fixture ensures proper and precise coordination of the mounting orientation (patterns) at the two ends of the frame. A dowel pin passing through the fixture top and bottom plate slides into the frame Corner Stiffening Tube opening, Figure 9. Smaller diameter dowel pins, indexed by the fixture plate, constrain the position of the Corner Block elements. The Corner Blocks are composed of three elements, two Panel Corner Block Assemblies (pre-bonded in the panels), and the Vertex Joint Assembly, which joins and positions the two panels together.

All frame sections, regardless of length, are produced with the same basic bonding fixture. A long and short center tube extension, Figure 8, is provided for the two frame lengths, a short for the disk region and a long tube for the barrel section. Both center tubes have precision indexing features to maintain the alignment of the two end plates.

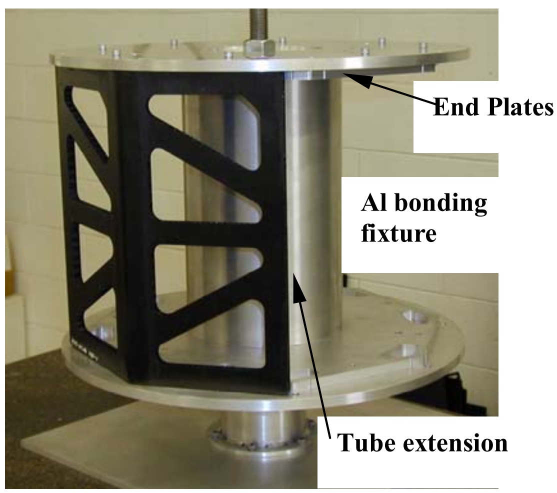


Figure 8: Photograph of the Aluminum bonding fixture used to construct the prototype of the disk section.

Figure 9 is a photograph of the frame prototype depicting the various corner elements. The corner region composed of these elements is constrained flat during bonding with threaded fasteners engaging the Corner Block inserts.

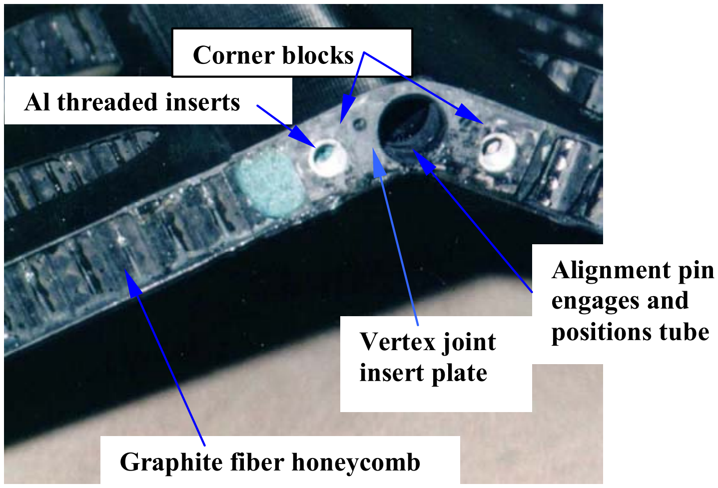


Figure 9: End view of the bonded corner block assembly

Figure 10 depicts use of the alignment dowel pins in positioning the Corner Blocks and the Corner Stiffening Tubes during the bonding process. The small and large diameter dowel pins position and stabilize all of the components during bonding, exclusive of the 8-Inner and 8-Outer Corner Panels, which are added after the frame section adhesive has cured.

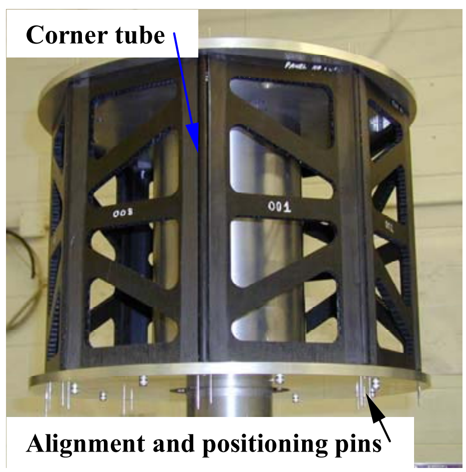


Figure 10: Photograph of disk frame prototype nearing completion of the assembly bonding task. Outer Vertex Corner Splices are not in place, exposing the Corner Vertex Tube.

3. Requirements

3.1 Overview of Assembly Requirements and Issues

A detailed assembly procedure will be prepared by the composite fabricator and approved by LBNL before commencing the assembly. The procedure will be of sufficient detail as to provide the planned steps and sequence of bonding, including a description of the surface preparation for bonded surfaces. The tasks delineated in the following paragraphs are intended to provide an overview of the tooling equipment concept(s) and shall not be construed of relieving the composite fabricator's responsibility of producing the requested procedures.

3.1.1 Outer Frame Sections

The procedures that follow describe techniques used in producing the first article prototypes, and the contractor shall use same as a guide. This information is not intended to replace the drawing requirements or material specifications, nor dimensions called-out on the face of the drawings.

Cure temperature for all composites are to be in accordance with material supplier specifications. (For example: Curing temperature in accordance with Bryte Technology specifications for EX1511 is 250°F. Post curing of Bryte material is optional).

The procedure that follows is for the short frame section; similar steps will be performed to assemble the barrel frame section.

3.1.2 End Section Assembly LBNL 21F665

3.1.2.1 <u>Molding End Section Stiffening Tube Drawing LBNL 21F673 and Vertex Joint Insert Tube LBNL 21F677</u>

a. Centerless ground round stock (with appropriate mold release) is used as the mandrel. The tube is a 6-layer composite constructed using Mitsubishi fiber K1392U and Bryte Technology EX1515 cyanate ester prepreg. The fiber orientation per layer is given by LBNL 21F673 and LBNL 21F677; the desired fiber volume fraction is 60%. Note: The End Section Stiffening Tube Drawing LBNL 21F673 is a shorter version of the long Stiffener Tube LBNL 21F653. The mold for producing these tubes is the same, LBNL 21F711.

b. After the 6-layers are consolidated on the mandrel, they are sandwiched between their respective 2- female mold plates, reference tooling LBNL 21F711 and LBNL 21F713. Heat and pressure are applied to the mold to cure the individual composite tubes. After curing the tube is withdrawn from the mandrel.

c. Removing one layer over a short section of the inner diameter of the Corner Stiffening Tube is permitted, if deemed necessary, to accept the Frame Joining Pin. This step was not found to be necessary in the prototype.

3.1.2.2 <u>Molding End Section Panel Outer Corner Drawing LBNL 21F671 and End Section Panel Inner Corner Drawing LBNL 21F672</u>

b. The fiber orientation used for each prepreg layer, and specified cured volume fraction for both the inner and outer corner stiffener is specified in their respective drawings. Both reinforcement stiffeners are constructed using the same procedures as the sandwich facings for the flat panel.

c. The unitape material is draped over, or inside (depending which stiffener is being processed) the controlling mold surface, 21F705 for the Inner Panel Corner and 21F708 for the Panel Outer Corner. Pressure for the molding process is provided with a conformable silicone rubber plug, which is installed before closing the mold cavity.

d. The mold cavity is clamped together; heat is applied to the mold to cure the prepreg. The silicone rubber plug expands during the curing operation, supplying the necessary force to consolidate the laminate.

e. A post machining process is necessary to trim the stiffeners width to the final outer profile. There shall be no machining of the End Section Panel Corner stiffener(s) thickness; the specified thickness must be achieved by the molding process. Achieving the specified thickness is an indicator that the desired fiber volume fraction has been achieved.

3.1.2.3 Molding End Section Panel Outer Corner Block Material for Parts LBNL 21F674-1 and LBNL 21F674-2

This is a simple compression molding of sheet material from YSH50/RS-3 prepreg. No special tooling is required. Prototype parts were produced with a temperature controlled hydraulic press.

The sheet material must be cut to size and machined to the dimensions defined by their respective drawings. The precision hole pattern in the corner blocks is critical to the location of these parts.

3.1.2.4 End Section Face Sheet Drawing LBNL 21F668 Construction for Sandwich Panels

The face sheet material description is specified on LBNL drawing 21F668. It is suggested that large laminates first be produced to reduce the processing time for achieving individual frame sandwich panels. Processing of prepreg material to achieve quasi-isotropic 6-ply laminates is well established. The general requirements for the ATLAS Global Support Structure panels are panel uniformity and fiber volume fraction, and free of defects. Specific inspection steps and material property measurements are referenced in 4.

3.1.2.5 Bonding Sandwich Panels in Preparation for Constructing Sub- Panel-1 and –2, LBNL 21F666 and LBNL 21F667

a. Panel Corner Blocks Preparation. - A threaded aluminum insert is bonded into each corner block LBNL 21F674 and 21F675 forming Corner Block subassemblies –1 and –2, reference LBNL 21F670 and LBNL 21F679 respectively. Care shall be exercised to concentrically position the AL insert in the hole.

b. The first face sheet (LBNL 21F668) is positioned in the mold cavity, reference 21F700. [The vertex Corner Blocks LBNL 21F670 and LBNL 21F679 are inserted next, 2 each required for a sub-panel assembly, reference 21F666 for Panel-1 and 21F667 for Panel-2. (Note: there are four Sub-Panel configurations LBNL21F667-1 and -2 required for the End Section Assembly. This description applies to bonding both types of sub-panels)]

c. Apply HYSOL 9396 adhesive to the Corner Block LBNL 21F670 surface being exposed to the face sheet. The corner blocks are precisely positioned with respect to the bonding fixture cavity wall using a 1.5mm diameter pin and a custom machined shoulder bolt. In this manner, the corner block is fixed in six degrees of orientation.

d. Prep the ULTRACOR honeycomb. Note: The sandwich core material is to be ordered and supplied pre-cleaned from ULTRACOR ready for bonding, so care must be exercised to maintain this state.

e. After the Corner Blocks are in place, apply HYSOL 9396 to one face of the pre-trimmed ULTRACOR honeycomb core; now place the core in the bonding fixture, with adhesive face down. All honeycomb panels adhesive joints, throughout the Global Support Structure, shall have an equivalent areal density of $100 g/m^2$, $+30/-0 g/m^2$. This value shall be obtained by weighing the panels, throughout the processing steps.

f. It is recommended at this point to apply pressure to the honeycomb core with the pressure plate and cure the adhesive. After curing, HYSOL 9396 is applied to the open honeycomb face and the assembly is placed again in the bonding fixture face down. The pressure plate is used to develop uniform bonding of the last face sheet. Bonding of both face sheets at the same time may result in questionable attachment of one face sheet. *(Composite fabricator is encouraged to conduct trial test to qualify the procedure used to apply adhesive to the honeycomb core).*

g. Flat Panel Internal Profile-LBNL 21F668. - After curing, the sandwich panels are routed to lower the installed mass; the geometry of the cutouts shall be in accordance with drawing LBNL 21F668.

3.1.2.6 <u>Bonding End Section Assembly LBNL 21F665 Sheets –1 through -4.</u> –*It is highly recommended that a dry fit of all parts be performed before proceeding with the final bonding operation. The assembly fixture and alignment pins can used to place all the critical elements, thus confirming that all earlier bonding and machining steps were performed properly.*

a. Vertex Joint Assembly LBNL 21F669 Preparation. -Each Vertex Corner Joint Plate LBNL 21F678 has a Vertex Corner Insert Tube LBNL 21F677 pre-bonded into it, using HYSOL 9396 adhesive. Precautions must be taken to obtain a concentric bond, since the inside diameter of this tube is used as an indexing feature in the final assembly of the frame.

b. The bonding fixture structure is assembled per LBNL 21F687; the top circular plate is left off the assembly.

c. The eight corner Vertex Joint Assemblies LBNL 21F669, are positioned on the fixture's lower circular plate. Two 1.5mm diameter pins are used to critically position them.

d. The 8-sandwich panels (4 each Sub-Panels-1 LBNL 21F666 and 4 each Sub-Panels-2 LBNL 21F667) are positioned in an alternating pattern, one at time. Bonded surfaces must be properly prepped and with HYSOL 9396 adhesive applied. As the panels are added, they are lightly clamped in place using C-Clamps (between the lower octagon plate holes and the outside of the panels. The –1 and –2 Corner Blocks LBNL 21F670 and LBNL 21F679 in each panel also register on the 1.5mm diameter pins used to position the lower vertex plate assemblies.

e. Eight 9.093mm diameter pins are installed through the lower circular plate and into the vertex plate tube, reference Vertex Joint Assembly LBNL 21F669. These pins are used to establish the critical positioning of the Vertex Joint Assembly and corner Stiffening Tubes LBNL 21F673.

f. The 8-Vertex Joint Assemblies LBNL 21F669 at the opposite end of the frame are installed in position into the sub-panels from above. At this point, the 1.5mm diameter pins are used to align the Vertex Joint Assemblies as before.

g. The top circular plate is lowered over the fixtures top octagon plate. All 1.5mm diameter pins are installed into the vertex plate assemblies. All 9.093mm diameter pins are installed in the top circular plate, thus positioning the vertex plate assemblies. At this point all elements to be bonded at properly indexed and constrained by alignment pins.

h. After curing the frame sections and after adding the Core Filler material around the Stiffening Tubes 21F673, reference 21F665, the Inner and Outer Panel Corner strips 21F671 and 21F672 are adhesively bonded.

3.1.3 Central Section Assembly LBNL 21F651

The procedure for constructing the central barrel frame section closely parallels the tasks delineated for the End Section LBNL 21F665. One additional tube must be molded, a Frame Joining Pin LBNL 21F658. The procedure for producing this tube is the same as 3.1.2.1.

3.1.4 End Cones LBNL 21F720 and LBNL 21F734

3.1.4.1 End Cone Flat Panels LBNL 21F722

The following is a description of the procedure used to bond the ULTRACOR honeycomb core and composite facings together. The honeycomb bond fixture is controlled by LBNL 21F750. HYSOL EA9396 room temperature curing adhesive is used throughout.

a. Trim the honeycomb core supplied by ULTRACOR to the dimensions shown on LBNL 21F21722 in preparation for bonding. The sandwich core material is to be ordered and supplied pre-cleaned from ULTRACOR ready for bonding, so care must be exercised to maintain this state.

b. The first face sheet (dimensions defined by LBNL 21F722) is positioned in fixture (using two 3mm diameter pins); HYSOL 9396 adhesive (100g/m^2) is then applied to the honeycomb core, followed by positioning the core on the face sheet. Composite fabricator is encouraged to conduct a trial test (s) to qualify the procedure used to apply adhesive to the honeycomb core.

c. Four *temporary* aluminum corner inserts are installed in place to center the honeycomb core; a pressure plate with a sheet of silicone rubber is used to provide uniform pressure on the aluminum blocks and honeycomb, while the adhesive cures.

d. This bonded sub-assembly is then removed from the fixture. The second face sheet is positioned in the bonding fixture (in the same manner as the first face sheet).

e. Adhesive is applied to the honeycomb core in a controlled manner; now the sub-assembly (face sheet and honeycomb core) is positioned onto the bottom face sheet. The cover plate is again used to distribute an even load to the core while the assembly is cured.

f. Locating features are machined into this bonded sub-assembly while it is held in the bonding fixture. Bushing holes are machined through the face sheets and honeycomb (the cover plate has the drill bushings installed in it for this purpose).

g. The bonded assembly is removed from the fixture. Three Threaded Insert Body LBNL21F734 bushings with adhesive pre-applied are then positioned on the fixture, the bonded sub-assembly is re-inserted. Next, the Threaded Insert Washer LBNL 21F26 is added completing the bonding to the panel.

h. The End Cone Flat Panel LBNL 21F722 is complete and ready for bonding in the final assembly.

3.1.4.2 End Cone Assembly-*Applies to Side A-LBNL 21F720 and Side C-LBNL 21F734*

The bonding fixture, LBNL 21F745, for achieving the octagonal, conical end cone pattern uses machined features to precisely position and hold the 8-Flat Panels[4] LBNL 21F722, 8-Outer Corner Vertex LBNL 21F725 mounting pads, and 8-Inner Corner Vertex tabs (LBNL 21F727, 21F728, 21F729, and 21F730) during bonding. In this connection, a *precise* dowel-pin hole pattern, machined in the fixture, positions the 8-Outer Corner Vertex LBNL 21F725 mounting pads and 8-Inner Corner Vertex tabs respectively, with respect to the Flat Panels. Other dowel holes, which are less critically located, set the location of the flat panels; while allowing some float with respect to the outer mounting plates and inner tabs.

The final bonding step calls for all 8-flat panels, and the 16 plates to be bonded simultaneously, using HYSOL 9396 adhesive. *It is strongly advised that a dry-fit check of all parts be made before attempting to bring all the parts together with wet-adhesive*. The graphite-

[4] Description for Side A-End Cone. Assembly of Side C-End Cone would follow a similar pattern.

bonding fixture has been constructed in two parts, to facilitate the fit-up process of the panels with the mounting tabs.

The 8-Corner Stiffeners LBNL 21F723 are then bonded on adjacent flat panels using HYSOL 9396. The end cone assembly is then removed from the graphite plate, turned over, and then 8- Corner Stiffeners LBNL 21F723 are bonded on the inside surface, at the corner between adjacent honeycomb panels.

3.1.5 Stiffening Plate Assembly LBNL 21F770 (Frame End Plate)

The process for bonding the Stiffening Plate Assembly LBNL21F770 (sheet 2) is simplified to some extent, since it is in principle a one-piece sandwich structure with 8-Vertex Tabs. The bonding fixture, LBNL 21F775, controls the exact placement of the Vertex Tabs, holding the tabs in a common plane while bonding with HYSOL 9396.

3.1.5.1 Stiffening Plate Face Sheet –LBNL 21F772

The face sheet for the stiffening plate assembly uses the same material and consolidation procedure as for the Frame Sections face sheets. After the laminate has been cured and inspected for defects it must be machined to the circular pattern shown in LBNL 21F772. Prior to bonding, the face sheet must be cleaned to remove any contaminants and the bonded surface prepped.

3.1.5.2 Sandwich Core ULTRACOR

The honeycomb core is supplied in two pieces; it must be trimmed before bonding and spliced after bonding to the face sheet. The honeycomb is trimmed to provide radial cutouts for the insertion of the Vertex Tabs LBNL21F771, as well as cut to a circular pattern to fit ½ of the annular pattern described by LBNL 21F772. To protect the honeycomb against damage, the honeycomb will be clamped between two sacrificial plates, and then machined.

The annular sandwich plate for the end plate is bonded using HYSOL 9396. The adhesive (100 g/m^2) is applied to the core-bonded surface in the same manner as used for the flat sandwich panels. Care must be exercised to avoid over wetting the honeycomb core.

3.2 Materials

Carbon dusting in a charged-particle detector application with exposed electronics is of concern. Broken fragments of composite materials containing carbon or graphite fibers are not acceptable. After completing the frame sections, end cones, and end plates, the components of the global support frame will be coated with Parylene (0.008-0.012 mm thick) to contain conducting carbon dust or fragments. LBNL shall be responsible for sub-contracting the Parylene coating step. The composite fabricator shall be responsible for ensuring the completed parts are clean, free of contaminants (mold release) and package suitably to maintain cleanliness.

3.2.1 Lightweight Composite Facings

All sandwich facings for the Global Support Structure will use unitape prepreg (K1392U fiber/EX1515 resin, 90 g/m^2) from Bryte Technology. The unidirectional properties normalized to 60% fiber fraction are:

Table 1: Published Bryte Technology properties for K1392U/EX1515 Unitape normalized to 60% fiber fraction

0° Direction Tensile		90° Direction Tensile		0° Direction Compressive		0° Direction Flexural	
Strength	**Modulus**	**Strength**	**Modulus**	**Strength**	**Modulus**	**Strength**	**Modulus**
(MPa/ksi)	**(GPa/Msi)**	**(MPa/ksi)**	**(GPa/Msi)**	**(MPa/ksi)**	**(GPa/Msi)**	**(MPa/ksi)**	**(GPa/Msi)**
1951/283	**438/63.5**	**28/4**	**5/0.7**	**400/58**	**429.5/62.**	**669/97**	**337.1/48.9**

Prior to producing laminates for the sandwich facings, the composite fabricator shall construct and test unidirectional tensile specimens, testing for tensile modulus and strength. The average test results for 5-tensile specimens taken from 0° direction shall be within +/- 5% of the published Bryte Technology properties.

To qualify the quasi-isotropic laminates used for the facings the composite fabricator shall perform a similar set of 5-tensile tests, testing for tensile modulus. The average modulus obtained from these tests shall be 156.5 GPa (22.7 Msi) +/-5%.

3.2.2 Graphite Fiber Honeycomb Core

The graphite fiber honeycomb for all of the sandwich structures for the Global Support Structure shall be obtained from ULTRACOR, Inc. (formerly YLA Cellular). The material used to produce the core is XN50 woven cloth with a cyanate ester resin, density 0.048g/cm^3 and a cell size of 0.635cm (1/4in.). The published properties are:

Table 2: Sandwich Core Properties

Ultracore Product Code	Construction Materials	Compressive Properties (ASTM C365)		Plate Shear (ASTM C273)			
				L-Direction		W-Direction	
		Strength (kPa/psi)	Modulus (MPa/ksi)	Strength (kPa/psi)	Modulus (MPa/ksi)	Strength (kPa/psi)	Modulus (MPa/ksi)
UCF-83-1/4-3.0	**XN50/CE resin**	**1793/260**	**214/31**	**1538/223**	**421/61**	**848/123**	**214/31**

A simple density measurement will be performed prior to using the sandwich core. The value must agree with the published density within +/-10%.

3.2.3 Thick Multi-layer Composite Support Pads and Mounting Tabs

YSH50, graphite fiber woven cloth impregnated with YLA RS-3 cyanate ester resin will be used to construct mounting tabs for the End Cone, End Plates, and the Vertex Corner Blocks for the frame sections. The component drawings contain specifications for fiber orientation, fiber volume fraction, and layer thickness. Critical surfaces are machined to achieve specified finished dimensions. The composite fabricator is required to provide documentation (traveler for each part) on the materials used, number of layers, etc., which will be used to estimate the fiber volume fraction of the finished parts. Before proceeding with molding all of the components, the composite fabricator will perform an acid digestion test on one molded part to verify process control.

4. Quality Control

This section provides and overview of dimensions and information that the composite fabricator shall measure and record after completing the assembly and bonding operation. All information shall be placed in a traveler that accompanies the part to its destination.

A detailed inspection procedure (QC Plan) will be prepared by the composite fabricator and approved by LBNL. The procedure will include the planned in-process inspection steps and final inspection of the completed assemblies. The description in the following paragraphs is intended to provide an overview of the final inspection required, and shall not be construed to imply the final scope developed by the composite fabricator.

4.1 Global Support Frame Outer Frame Sections

4.1.1 End Section

a. <u>Flatness of two end surfaces and overall length</u>. Place end section on surface plate, using height gage measure the height of the 8-Vertex Corners. Variations in the height dimensions are used to indicate planarity and parallelism to opposite face. Repeat by inverting the end section; review measurements looking for Vertex Corner Block contact points out of specification.

b. <u>Corner Hole Locations.</u> Inspect the Vertex Corner hole pattern, at both ends, using one of the locating plates taken from the bonding fixture. Demonstrate simultaneously that all 8-alignment pins used to position the eight corner tubes will fit.

c. <u>Weight</u>. Record the frame section weight.

d. <u>Package</u>. Package End Sections in individually sealed polyethylene bags

e. <u>Coating Verification</u>. LBNL shall verify that the Paralyene coating step has been completed and a certification is included in the traveler package.

4.1.2 Barrel Section

f. <u>Flatness of two end surfaces and overall length</u>. The center section has 8-tubes protruding from the Vertex Corner Blocks, so it is not possible to place this frame section directly on the surface plate. On three of the Vertex Corner blocks use precision blocks to hold the frame above the surface plate. Now, using a height gage measure the height to the 8-Vertex Corners (upper). Variations in the height dimensions are used to indicate planarity and parallelism to opposite face. Repeat by inverting the end section; review measurements looking for Vertex Corner Block contact points out of specification.

g. <u>Protuding Tube Locations.</u> Inspect the Vertex Corner Tube pattern, at each end, using one of the locating plates taken from the bonding fixture. Demonstrate simultaneously that all 8-alignment pins used to position the eight corner tubes will fit.

h. <u>Weight</u>. Record the frame section weight.

i. <u>Package</u>. Package Barrel Frame Section in a sealed polyethylene bag

j. Coating Verification. LBNL shall verify that the Paralyene coating step has been completed and a certification is included in the traveler package.

4.1.3 End Cone "A" and "C"

a. Outer Mounting Surface Flatness and Mounting Tab Thickness. Place the End Cone flat mounting surface on a surface plate. Using precision shims determine that 8-Mounting tabs are co-planar within print dimensions. Measure the thickness of each mounting tab; verify uniformity and thickness to print.

b. Inner Mounting Tabs and Hole Locations. Using coordinate measuring machine (CMM) setup the End Cone for inspection of hole locations, and flatness of the Inner Mounting Tabs. The setup shall be based on defining the part axis as the center of the outer 8-hole pattern.

c. Weight. Record the End Cone (s) weight.

d. Package. Package End Cones "A" and "C" in a sealed polyethylene bag.

e. Coating Verification. LBNL shall verify that the Paralyene coating step has been completed and a certification is included in the traveler package.

4.1.4 End Plate

a. Flatness End Surface and Mounting Tab Thickness. Place the End Plate mounting surface on a surface plate. Using precision shims determine that 8-Mounting tabs are co-planar within print dimensions. Measure the thickness of each mounting tab; verify uniformity and thickness to print, as well as looking for Mounting Tabs contact points out of specification.

b. Global Support Frame Mount Hole Locations. Using coordinate measuring machine (CMM) setup and inspect the End Plate hole locations, and flatness of the Inner Mounting Tabs. The setup shall be based on defining the part axis as the center of the outer 8-hole pattern. Locate the hole pattern for the 4-Mount Pads; verify print dimensions.

c. Weight. Record the End Plate weight.

d. Package. Package End Plates individually sealed polyethylene bags.

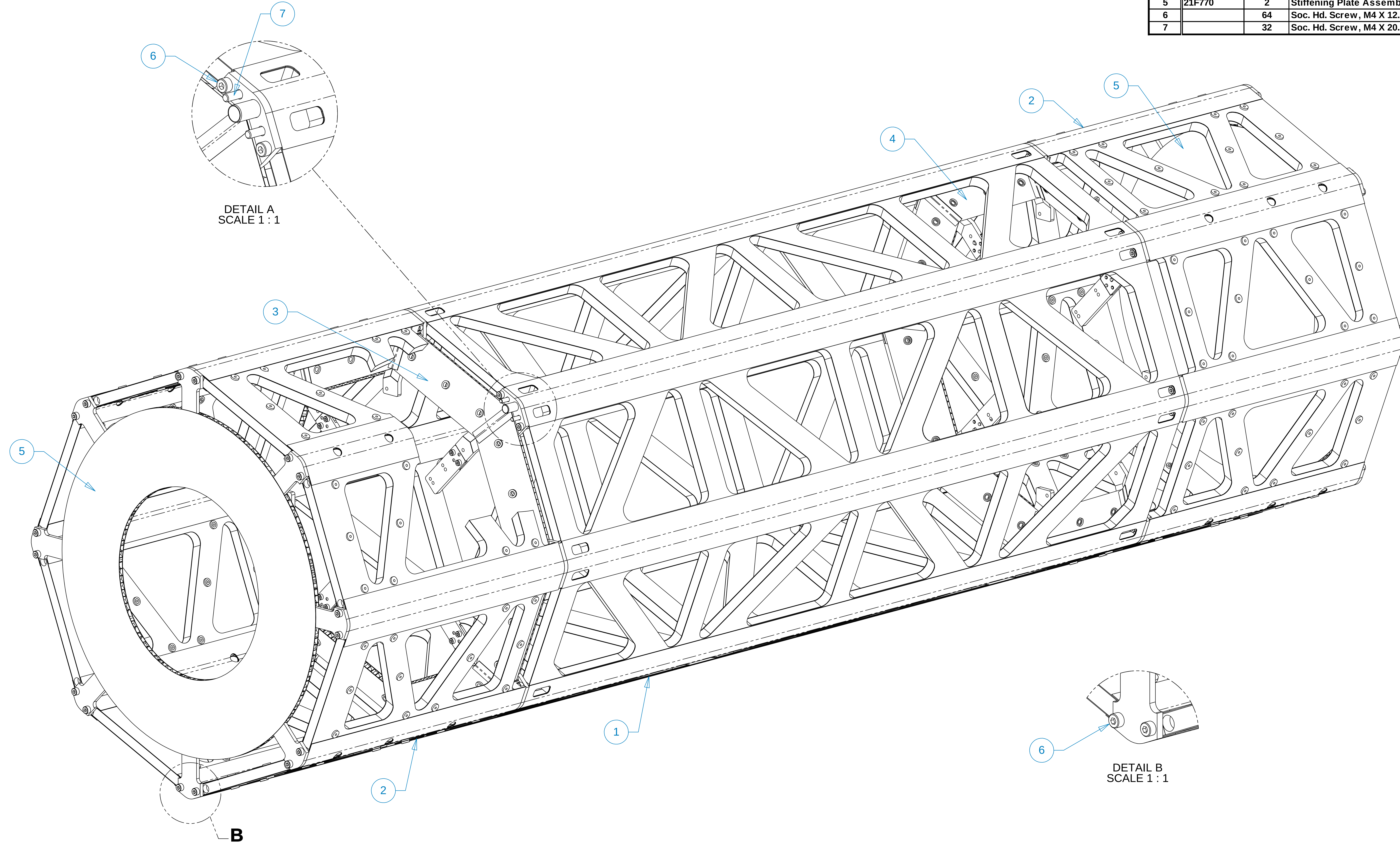
e. Coating Verification. LBNL shall verify that the Paralyene coating step has been completed and a certification is included in the traveler package.

5. Appendix A

Top assembly drawings for the Global Support Structure and assembly tooling are provided for reference. A detail drawings package will be supplied to each prospective bidder in the request for quote.

DWG. NO. 21F650 SIZE 1 REV. 1 SH. 1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F651	1	Central Section Assembly	
2	21F665	2	Outer Section Assembly	
3	21F720	1	A Side End Cone Assembly	
4	21F734	1	C Side End Cone Assembly	
5	21F770	2	Stiffening Plate Assembly	
6		64	Soc. Hd. Screw, M4 X 12.0 lg	
7		32	Soc. Hd. Screw, M4 X 20.0 lg	



THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.5 | FRAC. ± 1/64 | X.XX ± 0.25 | ANGLES ± 30' | X.XXX± 0.013 | FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
ACCT NO. | NO. REQD
DEL TO
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith DATE 1/25/2002
CHK BY CKD BY DATE 1/25/2002
APR BY APPROVED DATE 1/25/2002

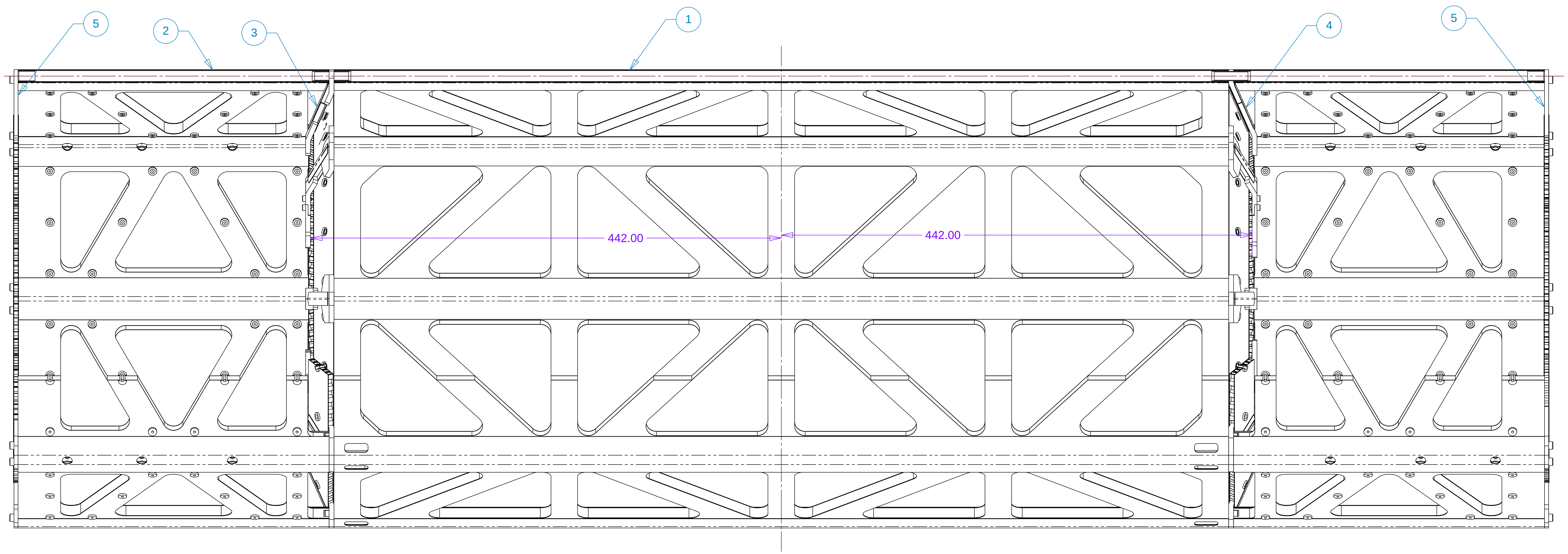
SER NO.
DATE ISSD
DATE REQD
US ATLAS SILICON SUBSYSTEM (LOGO)

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS
PIXEL DETECTOR
SPACEFRAME ASSEMBLY

MICROFILMED: | DWG. TYPE ASSEM | SHOWN ON nnXnnn | SCALE: 1:2 | DO NOT SCALE PRINTS
SHEET 1 OF 3
PATENT CLEAR: | DESIGN ACCT. NO. P1AP-11 | CATEGORY CIDE AP6250 | DWG. NO. 21F650 | SIZE | REV. 1

DWG. NO.	SIZE	REV.	SH.
21F650		1	2



REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES	
X.X ± 0.5	FRAC. ± 1/64
X.XX ± 0.25	ANGLES ± 30'
X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW THREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5m & B46.1

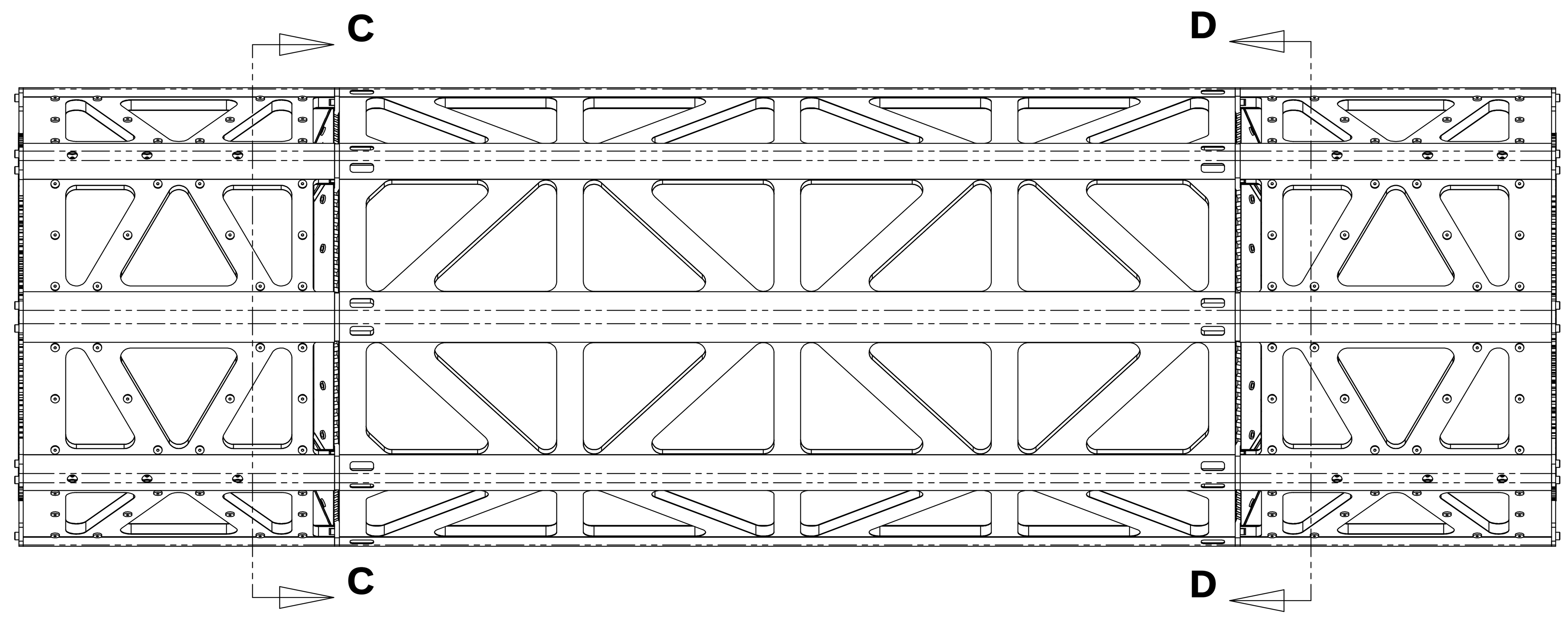
SHOP ORDERS

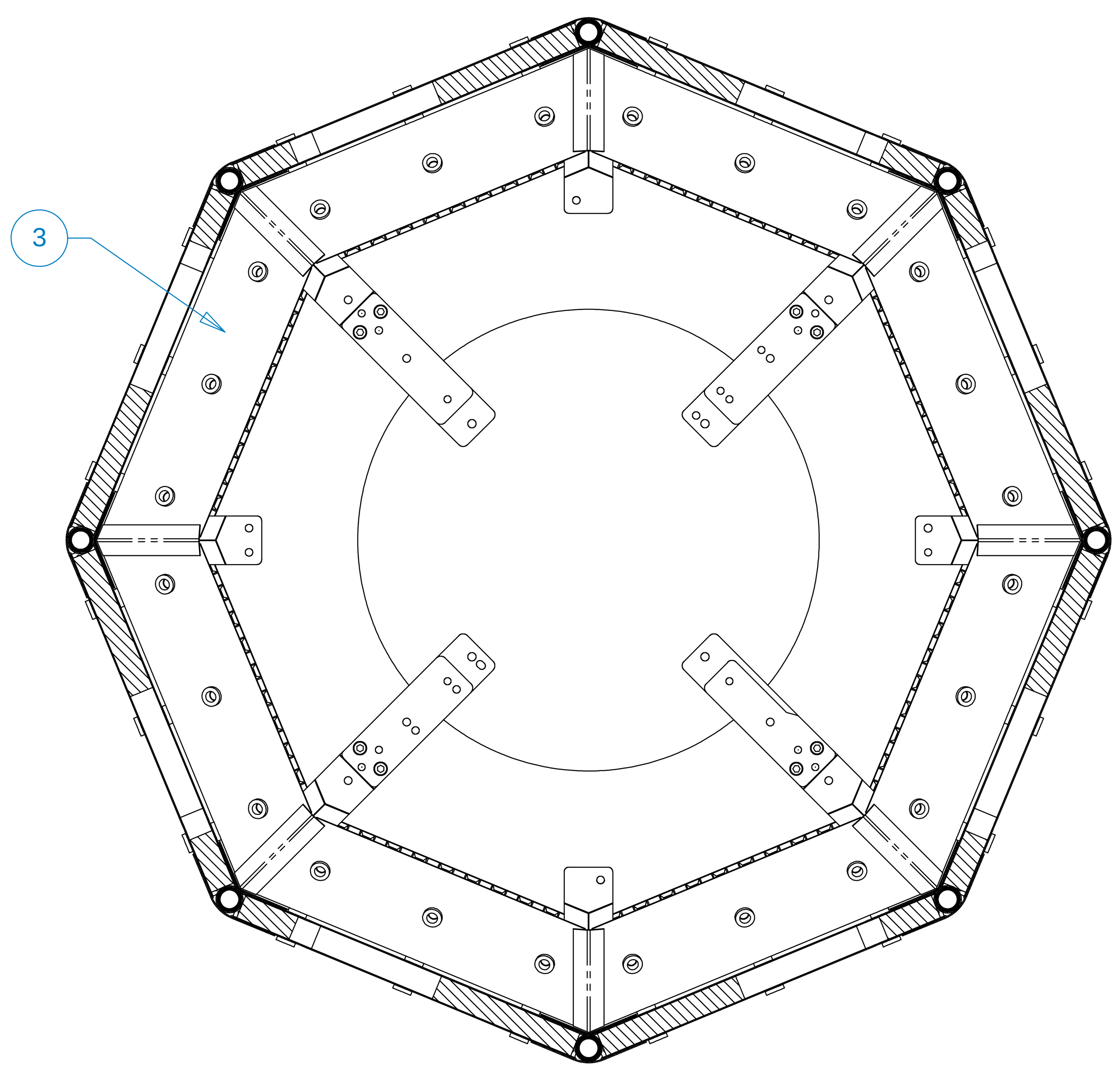
ACCT NO.		NO. REQD	SER NO.
DEL TO			DATE ISSD
SURFACE TREATMENT			DATE REQD
IDEN METHOD	TAG		
PROJECT NUMBER	ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM		
DWG BY	Roger Smith		DATE 1/25/2002
CHK BY	CKD BY		DATE 1/25/2002
APR BY	APPROVED		DATE 1/25/2002

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

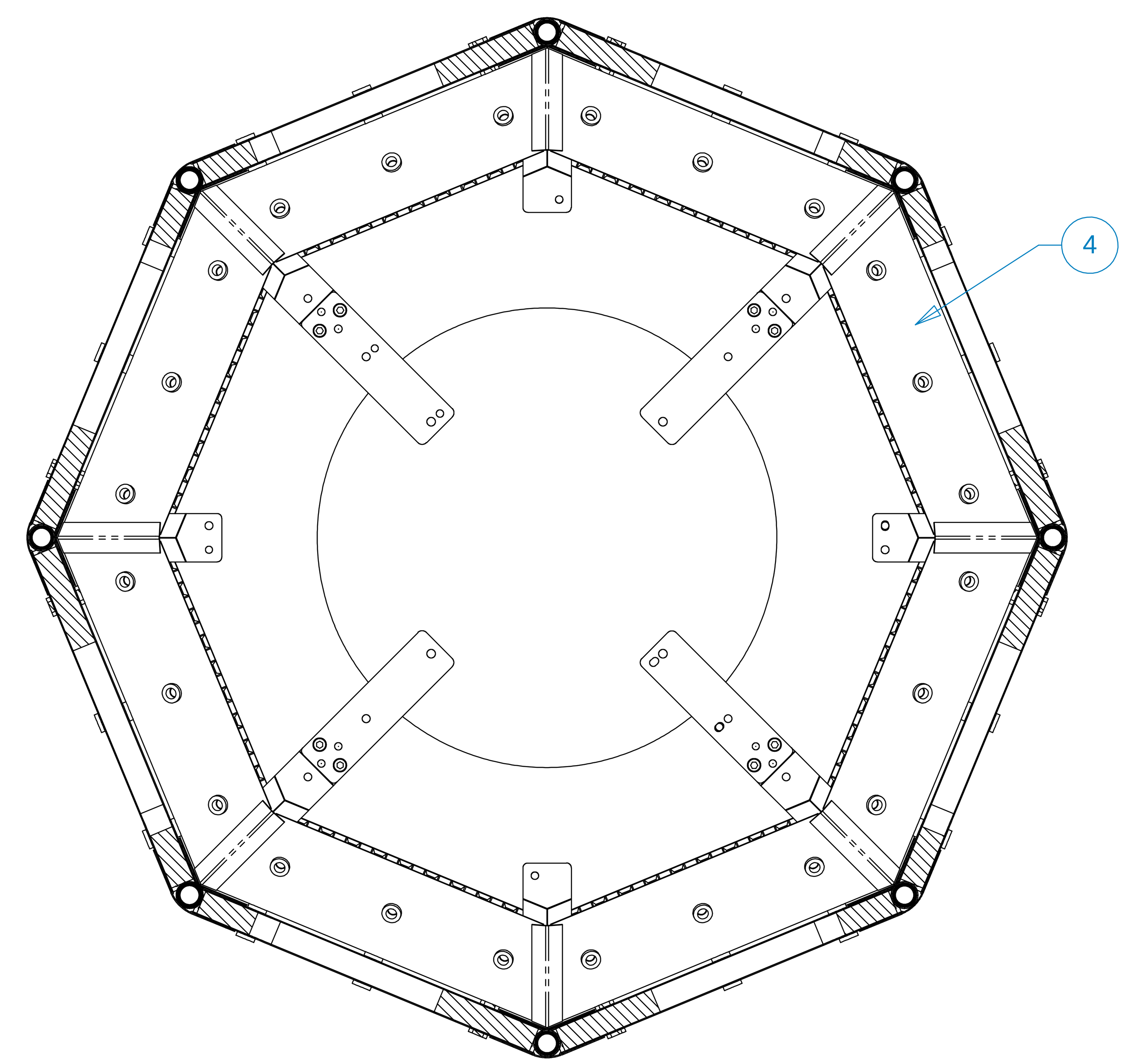
ATLAS
PIXEL DETECTOR
SPACEFRAME ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:2	DO NOT SCALE PRINTS
	PART	nnXnnn	SHEET 2 OF 3	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F650 SIZE	REV. 1





SECTION C-C
C SIDE
SCALE 1 : 2



SECTION D-D
A SIDE
SCALE 1 : 2

REV | DWG | CHK | ZONE | DATE | CHANGES

UNLESS OTHERWISE SPECIFIED
TOLERANCES
X.X ± 0.5 | FRAC. ± 1/64
X.XX ± 0.25 | ANGLES ± 30'
X.XXX± 0.013 | FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
ACCT NO. | NO. REQD
DEL TO
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith | DATE 1/25/2002
CHK BY CKD BY | DATE 1/25/2002
APR BY APPROVED | DATE 1/25/2002

SER NO.
DATE ISSD
DATE REQD
US ATLAS SILICON SUBSYSTEM (LOGO)

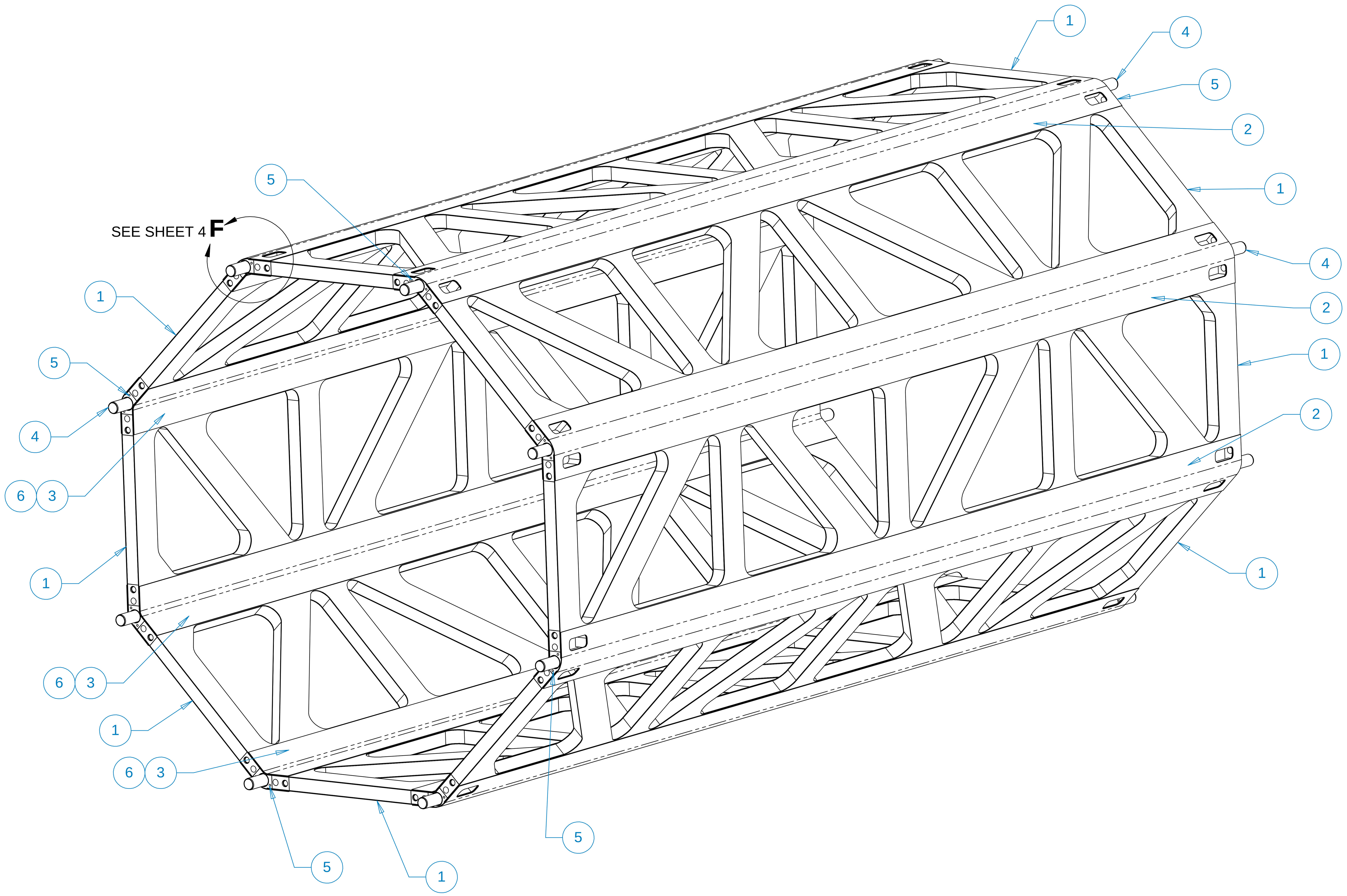
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS
PIXEL DETECTOR
SPACEFRAME ASSEMBLY

MICROFILMED: | DWG. TYPE PART | SHOWN ON nnXnnn | SCALE: 1:4 | DO NOT SCALE PRINTS
SHEET 3 OF 3
PATENT CLEAR: | DESIGN ACCT. NO. P1AP-11 | CATEGORY CIDE AP6250 | DWG. NO. 21F650 | SIZE | REV. 1

DWG. NO. 21F651 SIZE REV. 1 SH. 1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F562	8	SUB PANEL ASSEMBLY	
2	21F654	8	PANEL OUTER CORNER	
3	21F655	8	PANEL INNER CORNER	
4	21F658	16	FRAME JOINING PIN	
5	21F669	8	VERTEX JOINT ASSEMBLY	
6	21F653	4	VERTEX STIFFENER TUBE	



THIRD ANGLE PROJECTION

REV | DWG | CHK | ZONE | DATE | CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.5 | FRAC. ± 1/64 | X.XX ± 0.25 | ANGLES ± 30' | X.XXX± 0.013 | FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
SER NO.
ACCT NO. | NO. REQD | DATE ISSD
DEL TO | DATE REQD
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith DATE 1/28/2002
CHK BY CKD BY DATE 1/28/2002
APR BY APPROVED DATE 1/28/2002

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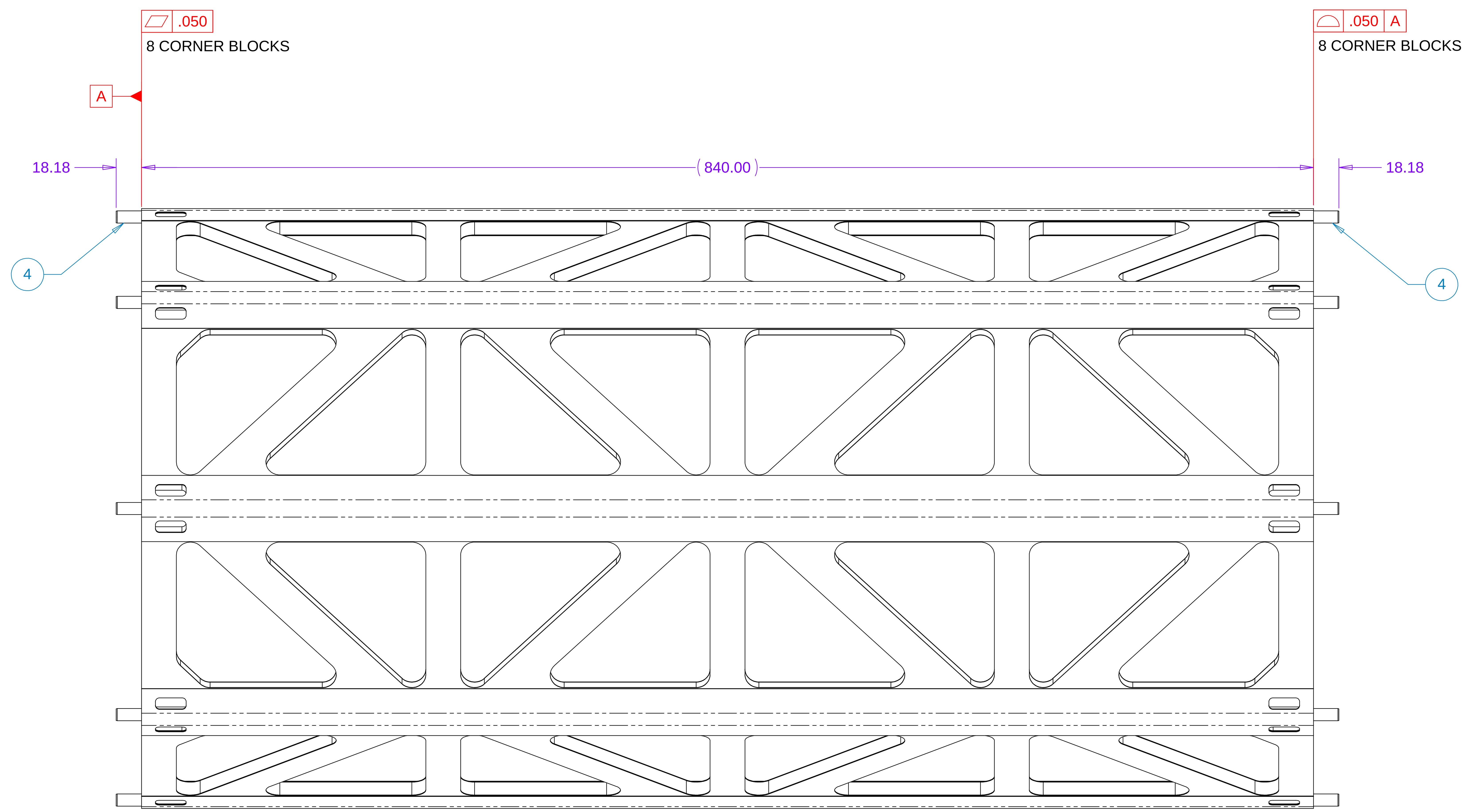
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS
PIXEL DETECTOR
CENTRAL SECTION ASSEMBLY

MICROFILMED: | DWG. TYPE ASSEM | SHOWN ON nnXnnn | SCALE: 1:2 | DO NOT SCALE PRINTS
SHEET 1 OF 4
PATENT CLEAR: | DESIGN ACCT. NO. P1AP-11 | CATEGORY CIDE AP6250 | DWG. NO. 21F651 | SIZE | REV. 1

DWG. NO. 21F651 SIZE REV. 1 SH. 2
A
B
C
1
6.03°
3.01°
45.00°
∅ 430.00
∅ 376.95
∅ 418.00
∅ 411.39
B
SEE SHEET 4
C
SEE SHEET 4
A
SEE SHEET 3
8X OD ITEM 4
∅ .050 Ⓜ Ⓟ 18 A B C
12X THRU HOLES
∅ .050 Ⓜ Ⓟ 18 A B C
THIRD ANGLE PROJECTION
REV DWG CHK ZONE DATE
CHANGES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
X.X ± 0.5
FRAC. ± 1/64
X.XX ± 0.25
ANGLES ± 30'
X.XXX± 0.013
FINISH 1.6
DO NOT SCALE PRINT
THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1
SHOP ORDERS
ACCT NO.
NO. REQD
DEL TO
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith
DATE 1/28/2002
CHK BY CKD BY
DATE 1/28/2002
APR BY APPROVED
DATE 1/28/2002
SER NO.
DATE ISSD
DATE REQD
US ATLAS SILICON SUBSYSTEM (LOGO)
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY
ATLAS
PIXEL DETECTOR
CENTRAL SECTION ASSEMBLY
MICROFILMED:
DWG. TYPE ASSEM
SHOWN ON nnXnnn
SCALE: 1:1
DO NOT SCALE PRINTS
SHEET 2 OF 4
PATENT CLEAR:
DESIGN ACCT. NO. P1AP-11
CATEGORY CIDE AP6250
DWG. NO. 21F651
SIZE
REV. 1

DWG. NO. 21F651 SIZE REV. 1 SH. 3



SECTION A-A

REV	DWG	CHK	ZONE	DATE	CHANGES

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.
DEL TO		DATE ISSD
SURFACE TREATMENT		DATE REQD
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICONE SUBSYSTEM		
DWG BY Roger Smith		DATE 1/28/2002
CHK BY CKD BY		DATE 1/28/2002
APR BY APPROVED		DATE 1/28/2002

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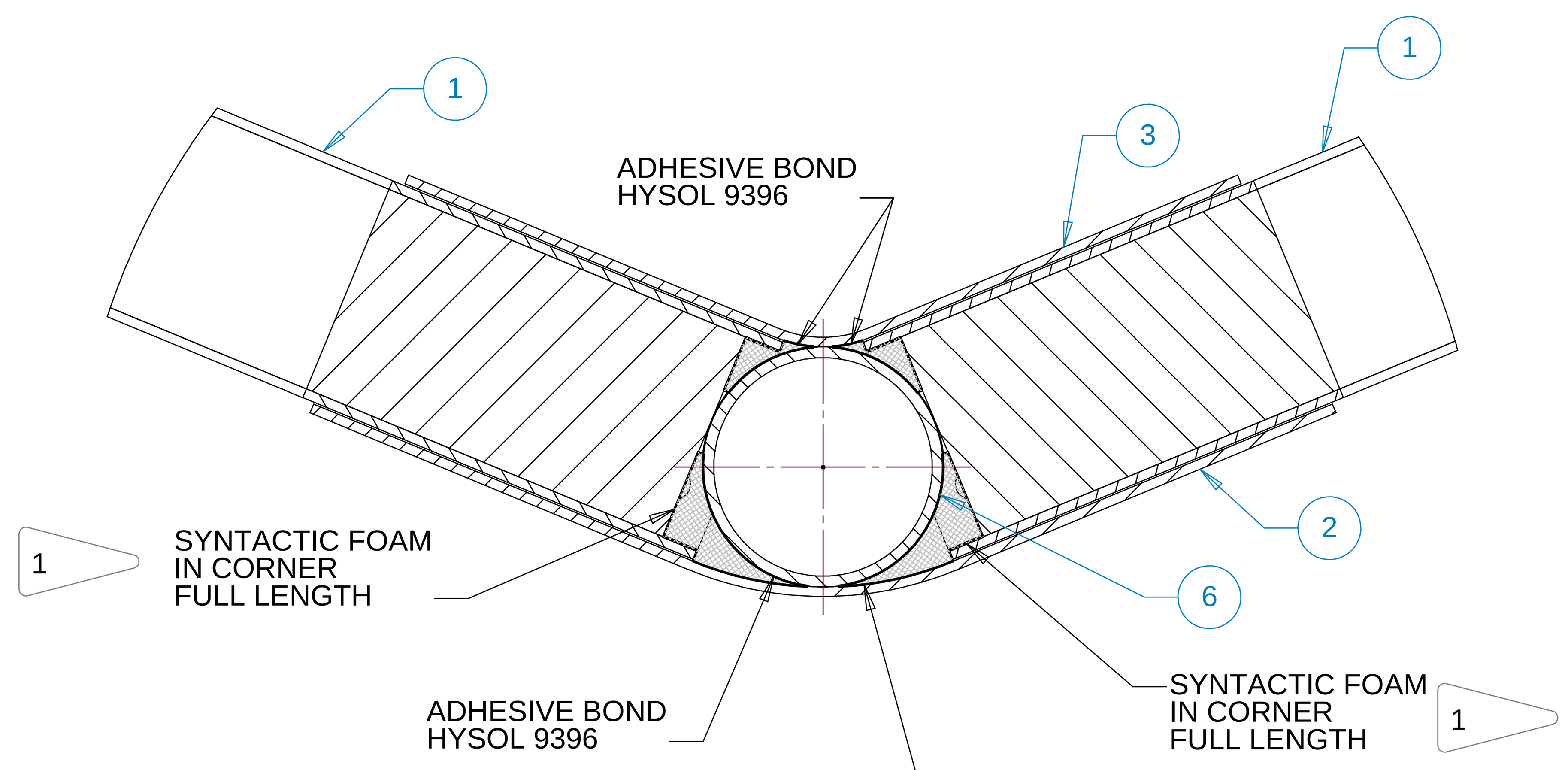
UNIVERSITY OF CALIFORNIA - BERKELEY

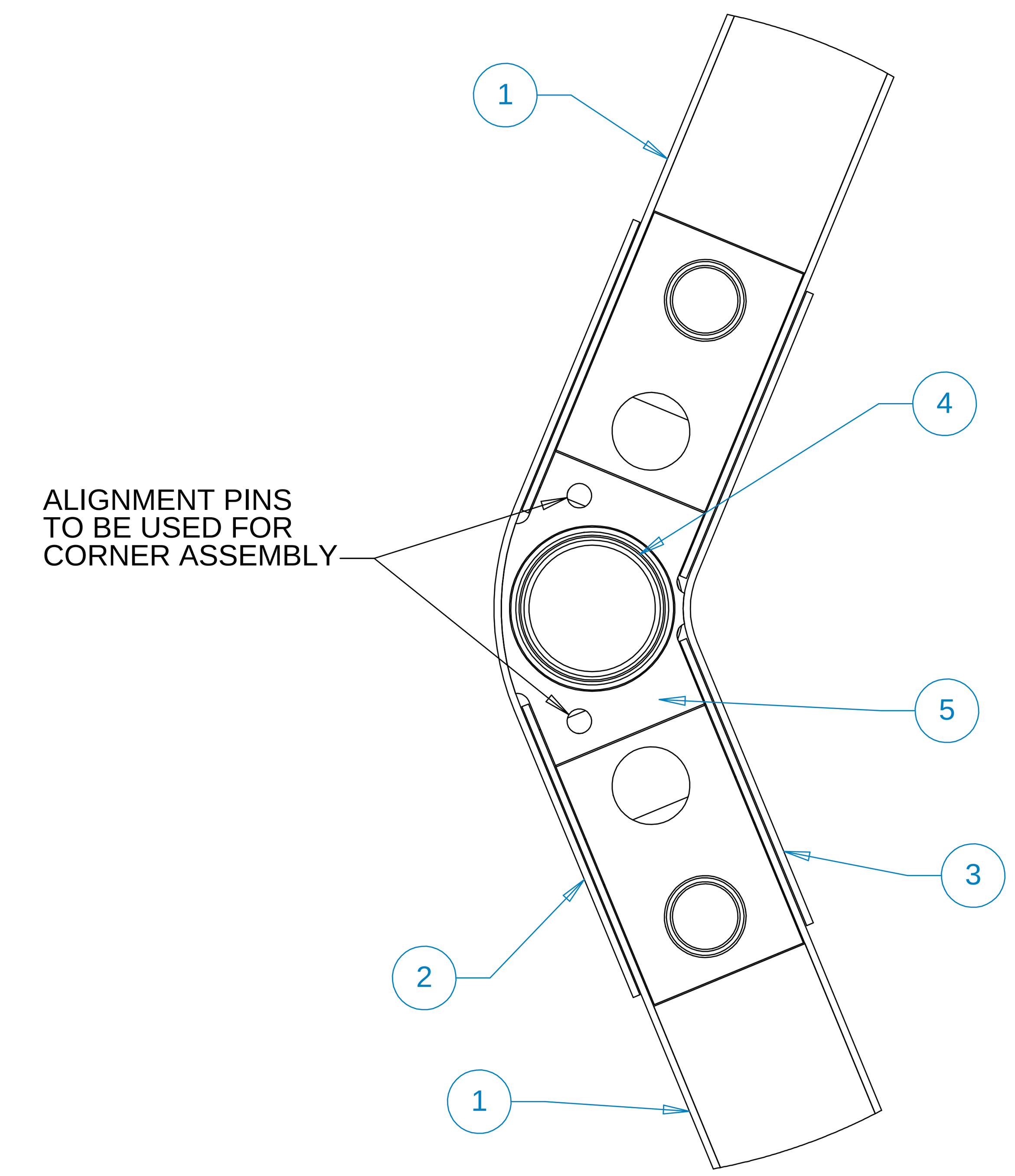
ATLAS
PIXEL DETECTOR
CENTRAL SECTION ASSEMBLY

MICROFILMED:	DWG. TYPE ASSEM	SHOWN ON nnXnnn	SCALE: 1:2	DO NOT SCALE PRINTS
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F651 SIZE	REV. 1

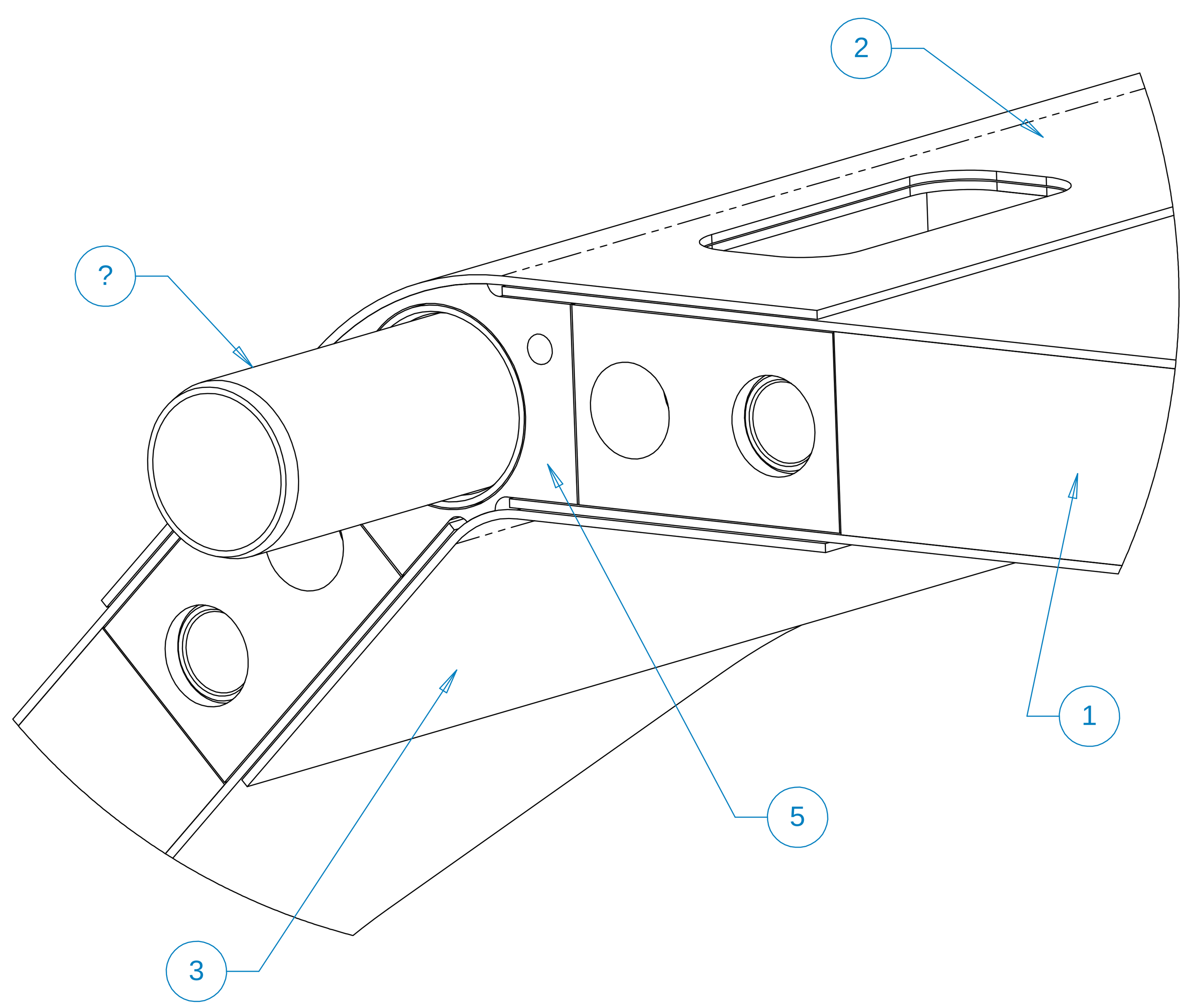
SHEET 3 OF 4



DETAIL C
TYP 8 X
SCALE 4 : 1



DETAIL B
TYP 8X
SCALE 3 : 1



DETAIL F
TYP 8X BOTH ENDS
SCALE 4 : 1

1 Epon 815 with DETA resin glass micro balloon filled syntactic foam with equivalent density 0.25 g/cc +15% - 0%.

THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.	
DEL TO		DATE ISSD	
SURFACE TREATMENT		DATE REQD	
IDEN METHOD	TAG		
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)	
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM		
DWG BY	Roger Smith	DATE 1/28/2002	
CHK BY	CKD BY	DATE 1/28/2002	
APR BY	APPROVED	DATE 1/28/2002	

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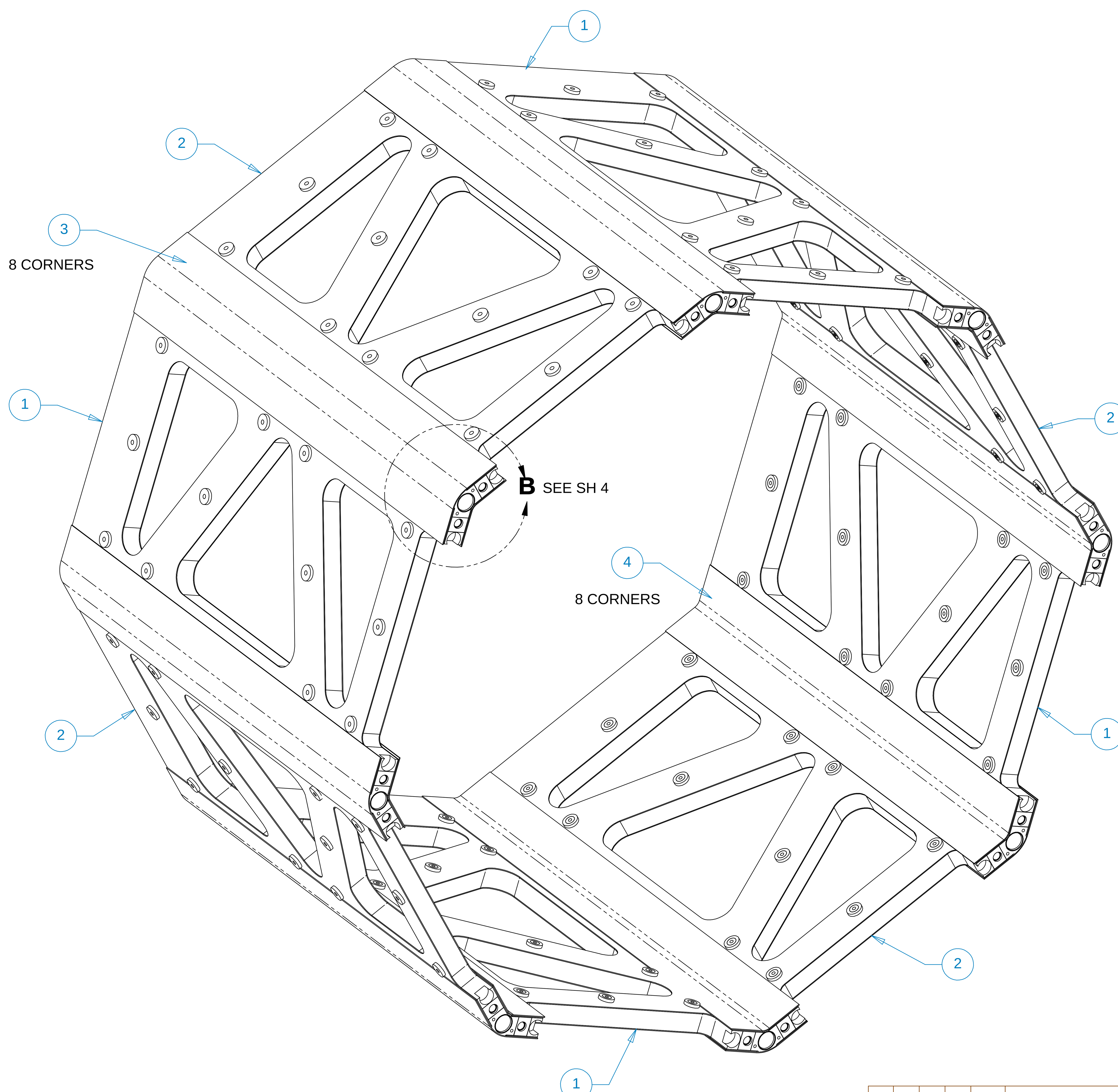
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS
PIXEL DETECTOR
CENTRAL SECTION ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:2	DO NOT SCALE PRINTS
	ASSEM	nnXnnn	SHEET 4 OF 4	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. 21F651 SIZE	REV.
	P1AP-11	AP6250		1

DWG. NO. 21F665 SIZE REV. 1 SH. 1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F666	4	SUB PANEL ASSEMBLY-1	
2	21F667	4	SUB PANEL ASSEMBLY-2	
3	21F672	8	PANEL OUTER CORNER	
4	21F671	8	PANEL INNER CORNER	
5	21F669	16	VERTEX JOINT ASSEMBLY	
6	21F673	8	VERTEX STIFFENER TUBE	



Volume = 2387007.9 cubic millimeters

THIRD ANGLE PROJECTION

REV DWG CHK ZONE DATE CHANGES

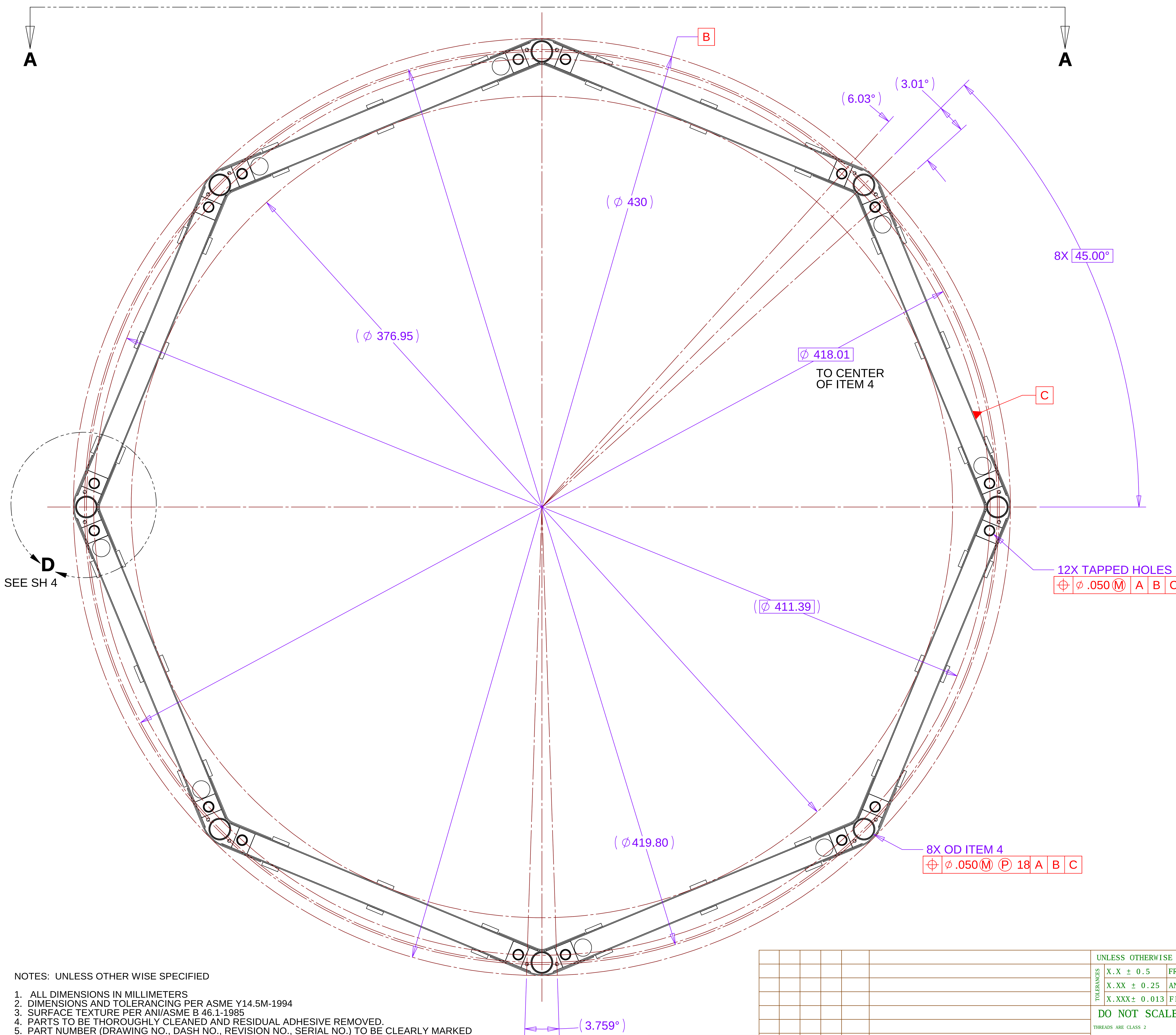
UNLESS OTHERWISE SPECIFIED
TOLERANCES
X.X ± 0.5 FRAC. ± 1/64
X.XX ± 0.25 ANGLES ± 30'
X.XXX ± 0.013 FINISH 1.6
DO NOT SCALE PRINT
THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
SER NO.
ACCT NO. / NO. REQD / DATE ISSD
DEL TO / DATE REQD
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith DATE 1/28/2002
CHK BY CKD BY DATE 1/28/2002
APR BY APPROVED DATE 1/28/2002

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
END SECTION
ASSEMBLY

MICROFILMED:
PATENT CLEAR:
DWG. TYPE ASSEM
SHOWN ON nnXnnn
DESIGN ACCT. NO. P1AP-11
CATEGORY CIDE AP6250
SCALE: 3:4
DO NOT SCALE PRINTS
SHEET 1 OF 4
DWG. NO. 21F665 SIZE REV. 1



NOTES: UNLESS OTHER WISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED AND RESIDUAL ADHESIVE REMOVED.
5. PART NUMBER (DRAWING NO., DASH NO., REVISION NO., SERIAL NO.) TO BE CLEARLY MARKED ON THE PART ITSELF.

6. USE HYSOL ADHESIVE EA 9396

THIRD ANGLE PROJECTION

ITEM	PART NO	REQD	DESCRIPTION	MATERIAL

DWG. NO. 21F665 SIZE REV. 1 SH. 2

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO. | NO. REQD | DEL TO | SURFACE TREATMENT | IDEN METHOD TAG | PROJECT NUMBER ATL-IP-ED-XXXX | PROJECT NAME US ATLAS SILICONE SUBSYSTEM

DWG BY	Roger Smith	DATE 1/28/2002
CHK BY	CKD BY	DATE 1/28/2002
APR BY	APPROVED	DATE 1/28/2002

SER NO. | DATE ISSD | DATE REQD

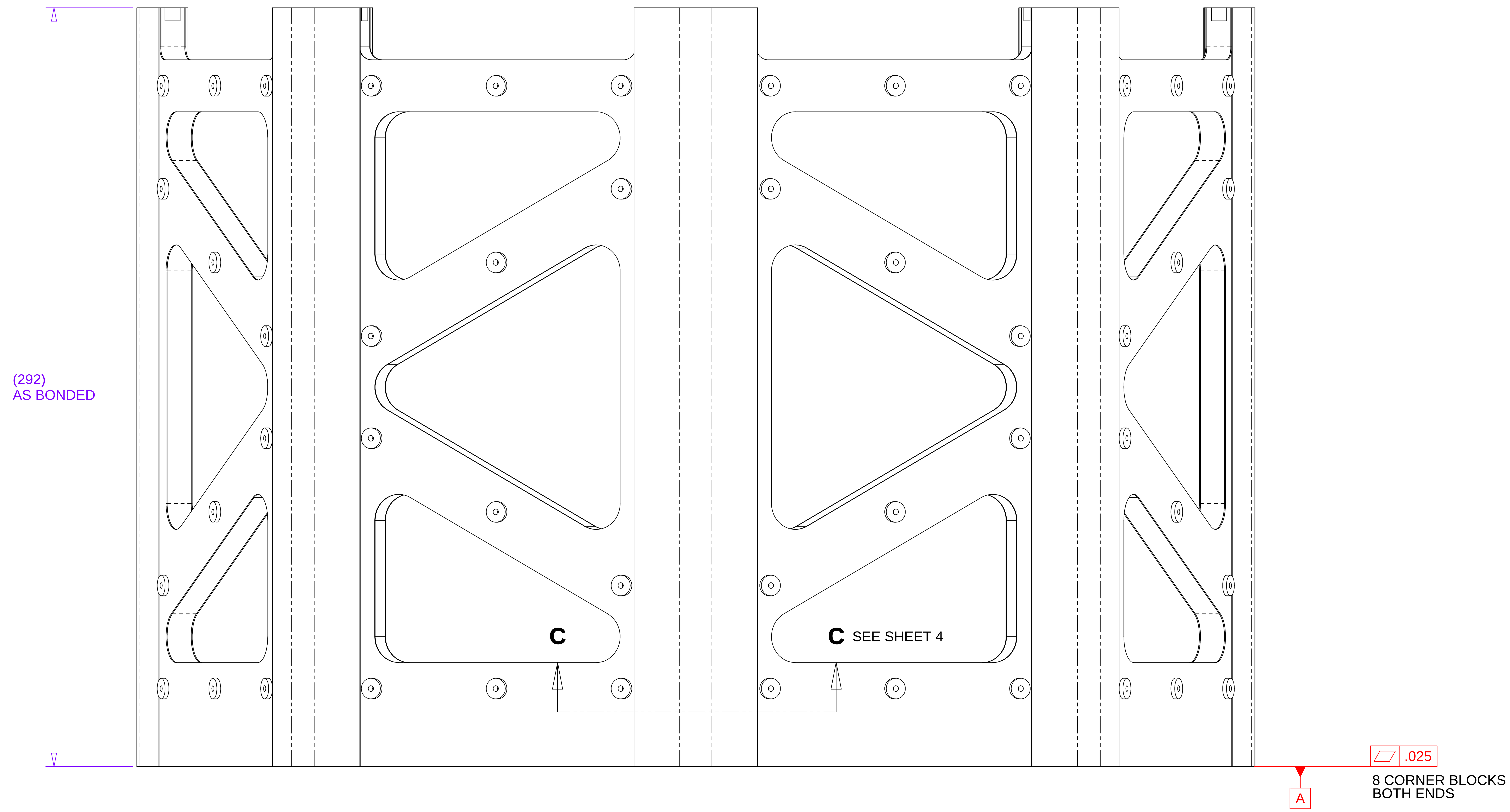
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
END SECTION
ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	nnXnnn	SHEET 2 OF 4	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F665	SIZE REV. 1

DWG. NO.	SIZE	REV.	SH.
21F665		1	3

ITEM	PART NO	REQD	DESCRIPTION	MATERIAL



DETAIL A-A

THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW THREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

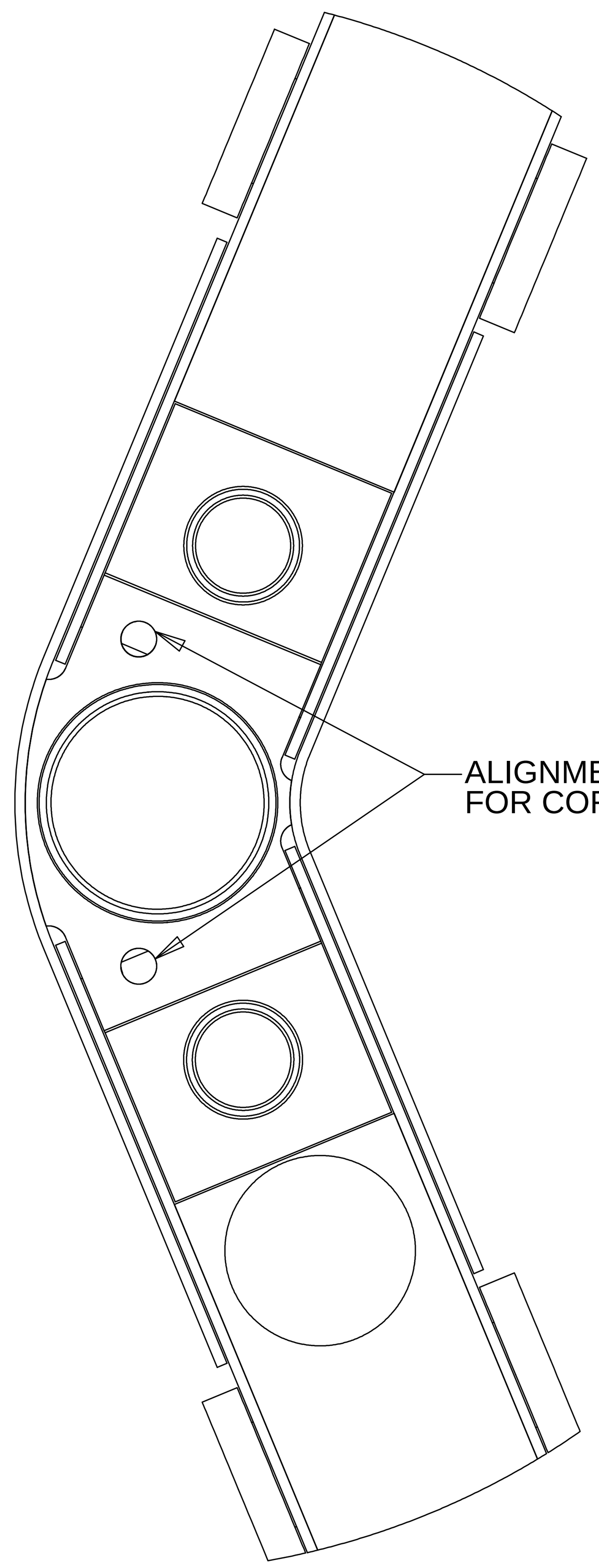
ACCT NO.	NO. REQD	SER NO. / DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD	TAG	
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM	
DWG BY	Roger Smith	DATE 1/28/2002
CHK BY	CKD BY	DATE 1/28/2002
APR BY	APPROVED	DATE 1/28/2002

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

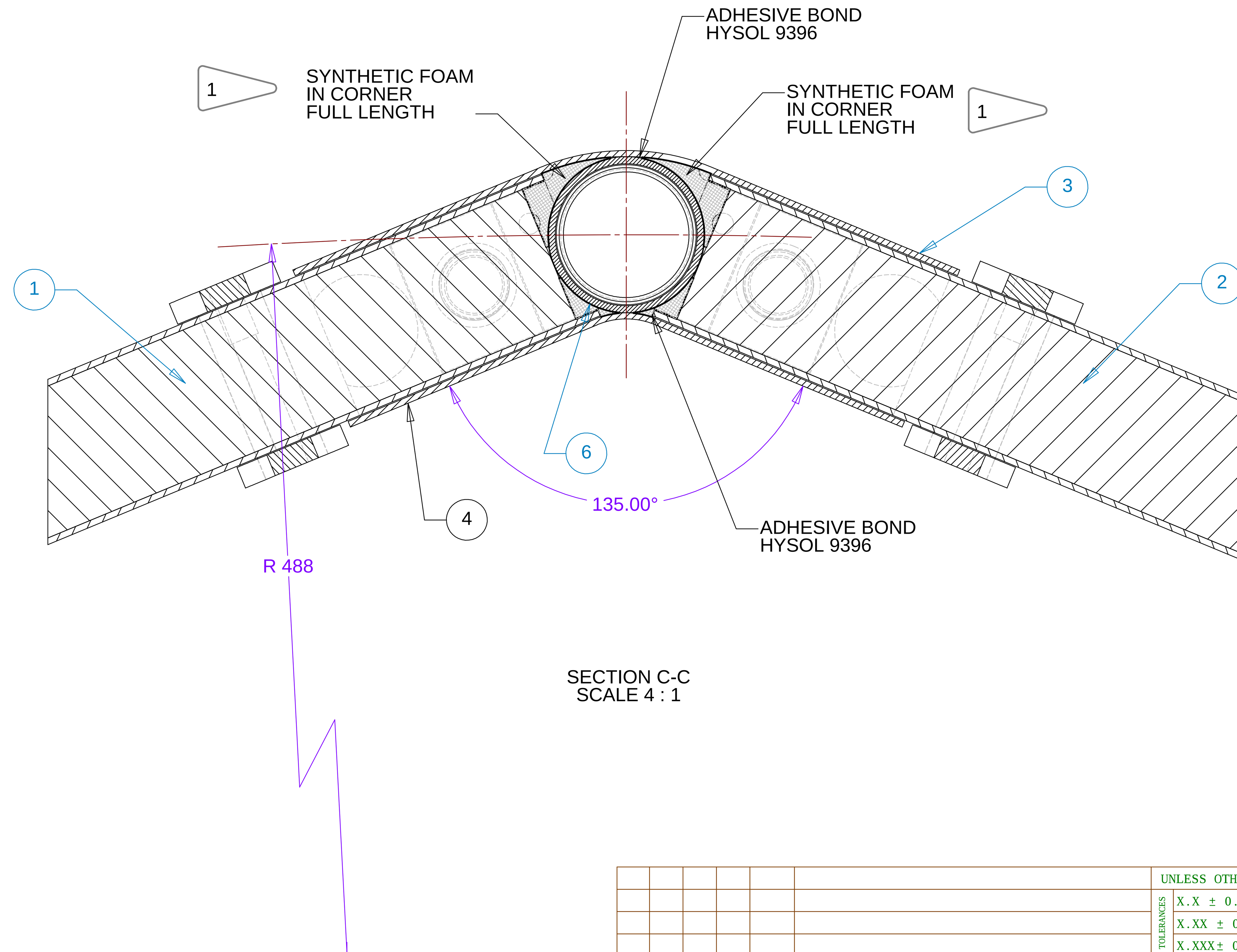
ATLAS PIXEL DETECTOR
END SECTION
ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	nnXnnn	SHEET 3 OF 4	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. 21F665 SIZE	REV. 1
	P1AP-11	AP6250		

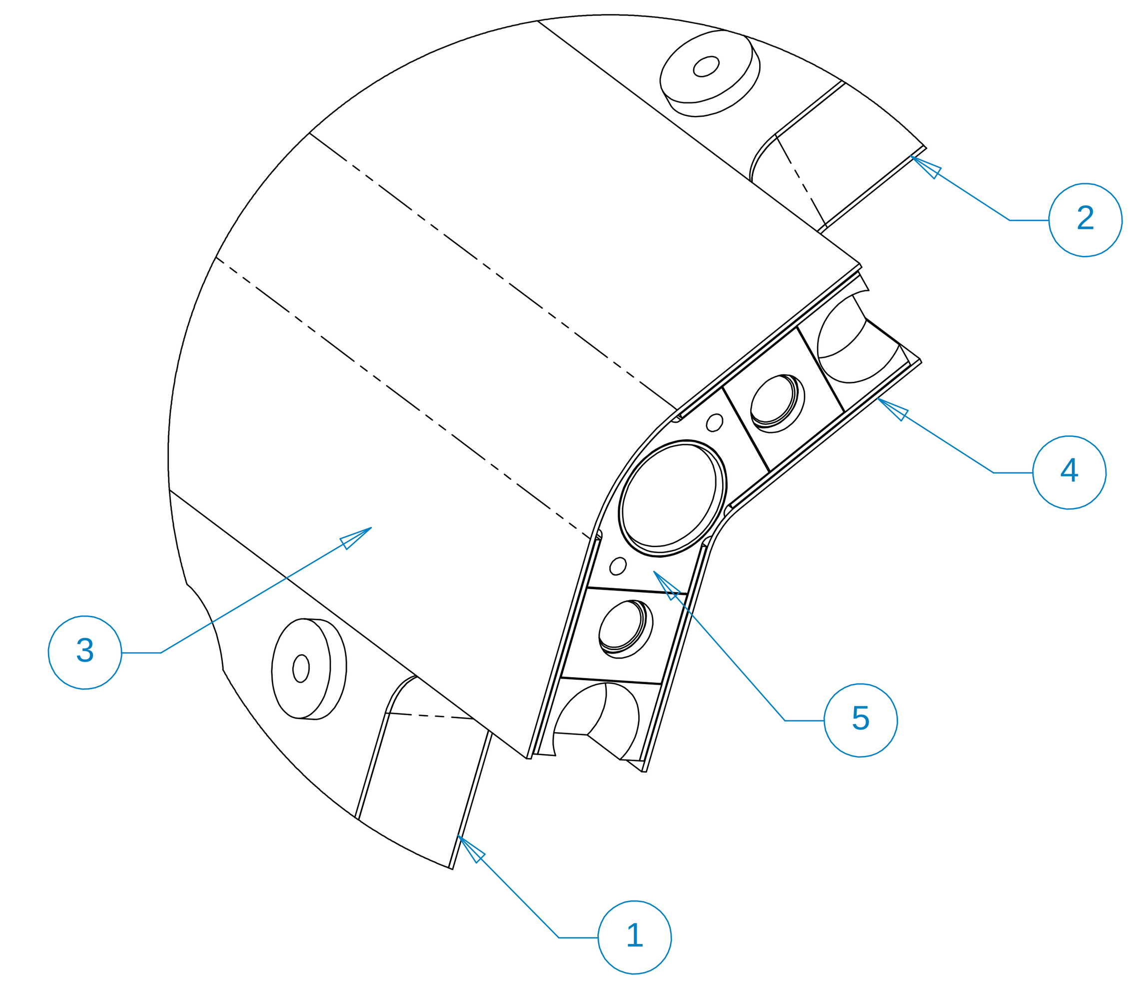
DWG. NO. 21F665 SIZE REV. 1 SH. 4



DETAIL D
SCALE 4 : 1



SECTION C-C
SCALE 4 : 1



DETAIL B
SCALE 2 : 1

1 Epon 815 with DETA resin glass micro balloon filled syntactic foam with equivalent density 0.25 g/cc +15% - 0%.

THIRD ANGLE PROJECTION

REV | DWG | CHK | ZONE | DATE | CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO. | NO. REQD
DEL TO
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith DATE 1/28/2002
CHK BY CKD BY DATE 1/28/2002
APR BY APPROVED DATE 1/28/2002

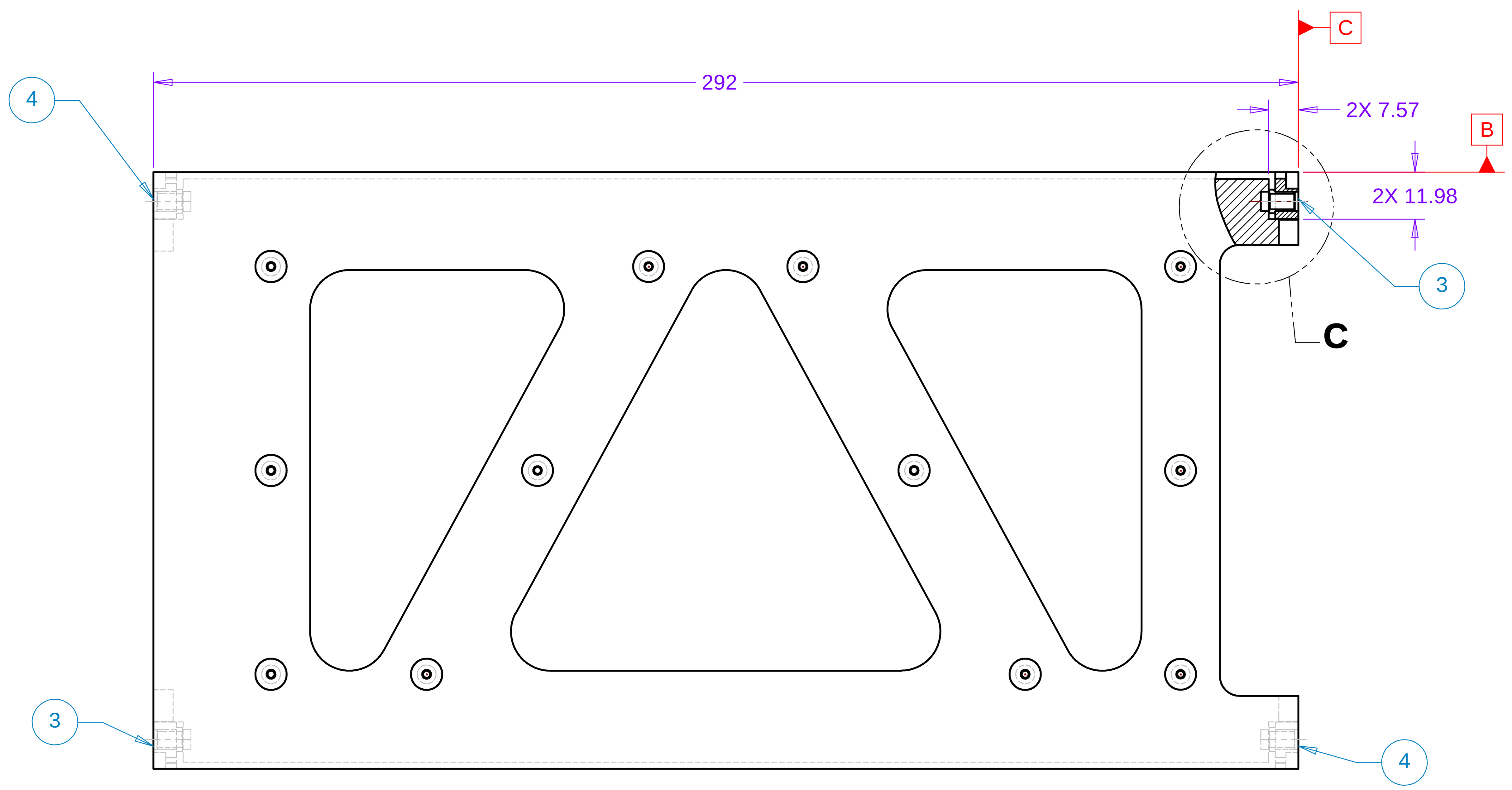
SER NO.
DATE ISSD
DATE REQD
US ATLAS SILICON SUBSYSTEM (LOGO)

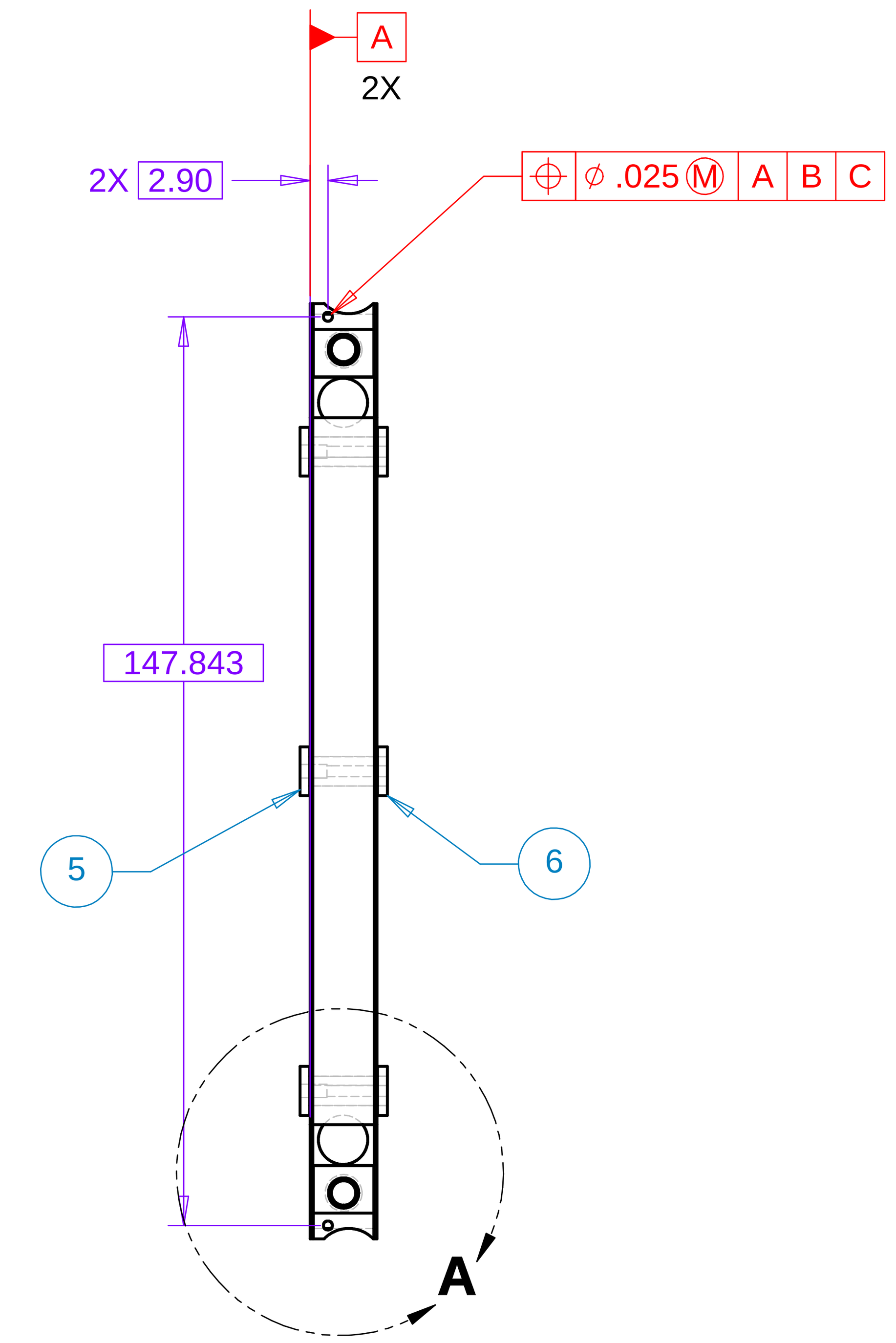
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
END SECTION
ASSEMBLY

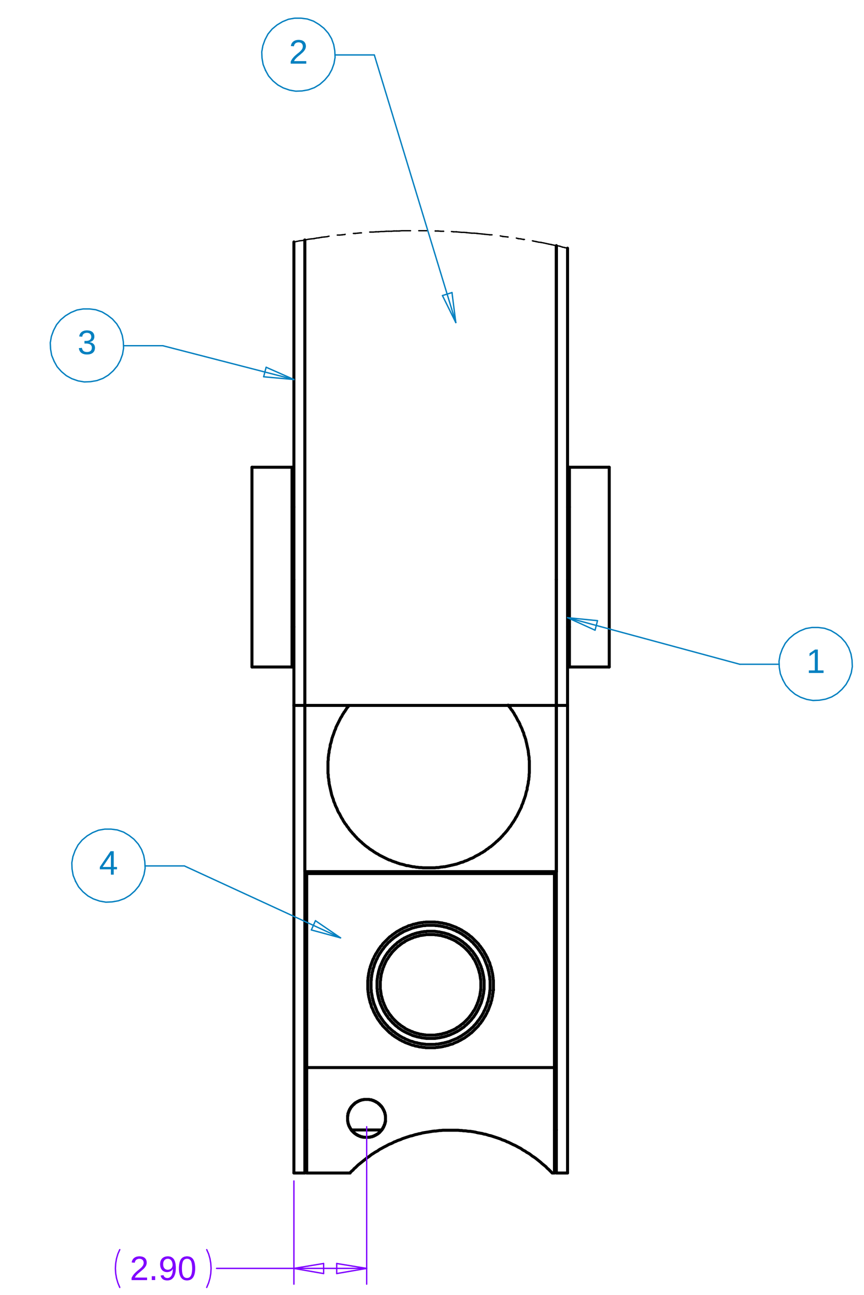
MICROFILMED: | DWG. TYPE ASSEM | SHOWN ON nnXnnn | SCALE: 1:2 | DO NOT SCALE PRINTS
SHEET 4 OF 4
PATENT CLEAR: | DESIGN ACCT. NO. P1AP-11 | CATEGORY CIDE AP6250 | DWG. NO. 21F665 | SIZE | REV. 1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F668	1	OUTER PANEL LAMINATE	
2		AR	HONEYCOMB CORE	ULTRACOR Inc. UCF-83-1/4-2.5
3	21F670	2	CORNER BLOCK-1 ASSEMBLY	
4	21F679	2	CORNER BLOCK-2 ASSEMBLY	
5	21F724	12	Treaded Insert Body	
6	21F733	12	Insert Washer	

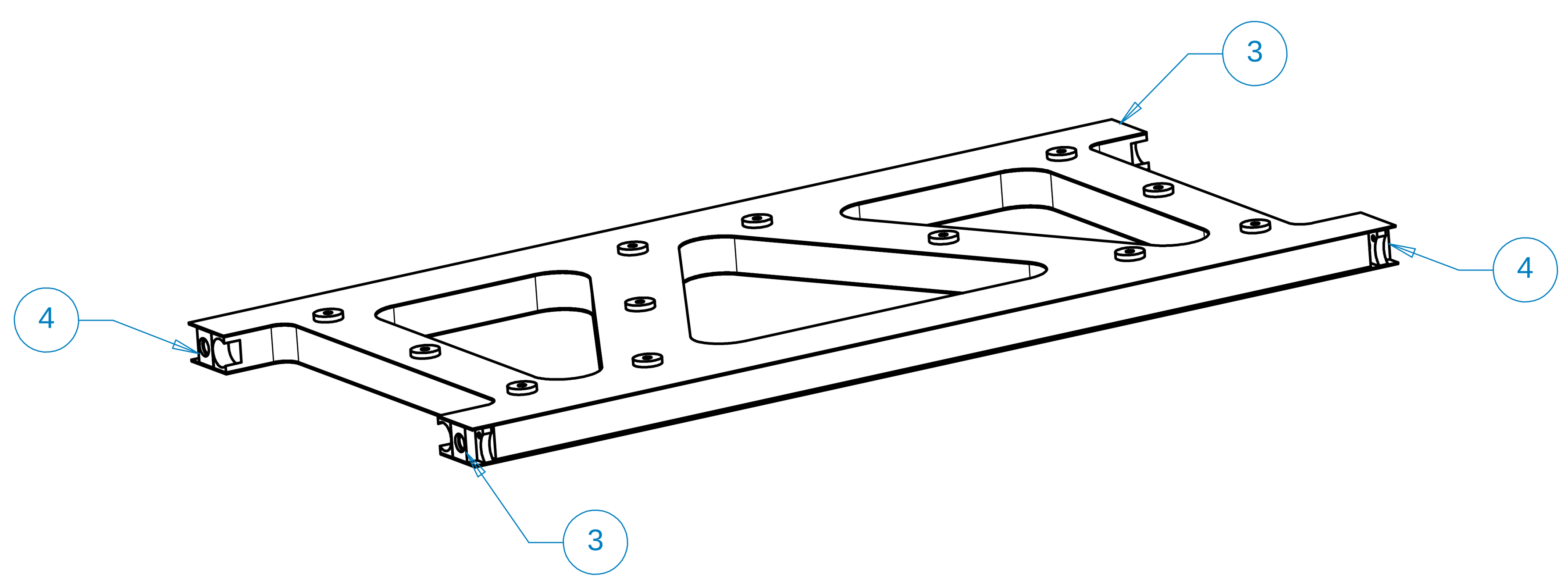


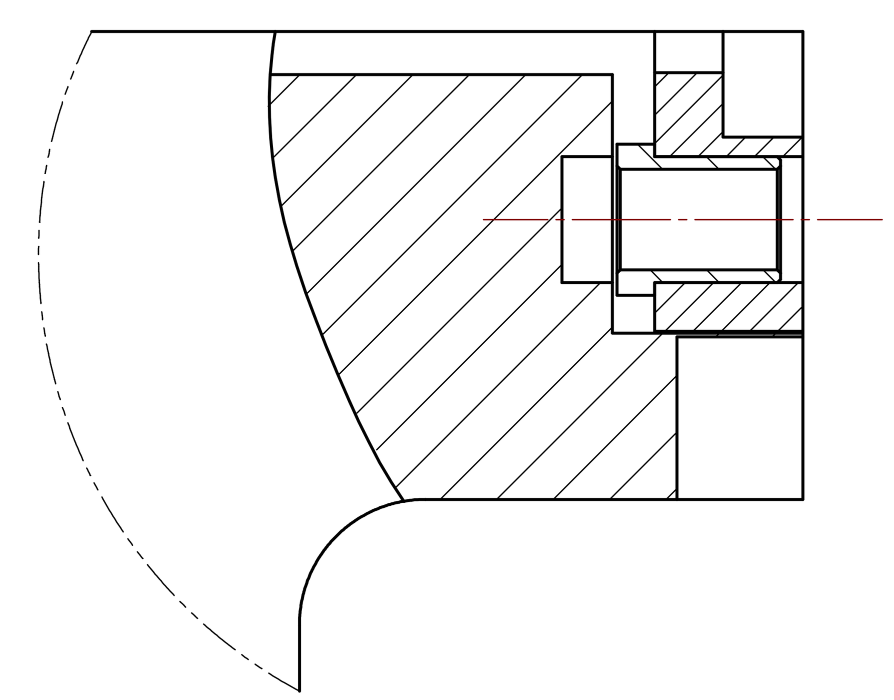


VIEW
SCALE 1:1



DETAIL A
SCALE 4 : 1





DETAIL C
SCALE 4 : 1

NOTES: UNLESS OTHER WISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED AND PREPPED FOR BONDING, NO MACHINE OILS ALLOWED.
5. PART NUMBER (DRAWING NO., DASH NO., REVISION NO., SERIAL NO.) TO BE CLEARLY MARKED ON THE PART ITSELF.

6. USE HYSOL ADHESIVE EA 9396.

THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.5 | FRAC. ± 1/64 | X.XX ± 0.25 | ANGLES ± 30' | X.XXX± 0.013 | FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
SER NO.
ACCT NO. | NO. REQD | DATE ISSD
DEL TO | DATE REQD
SURFACE TREATMENT
IDEN METHOD: TAG
PROJECT NUMBER: ATL-IP-ED-XXXX
PROJECT NAME: US ATLAS SILICONE SUBSYSTEM
DWG BY: Roger Smith | DATE 1/28/2002
CHK BY: CKD BY | DATE 1/28/2002
APR BY: APPROVED | DATE 1/28/2002

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

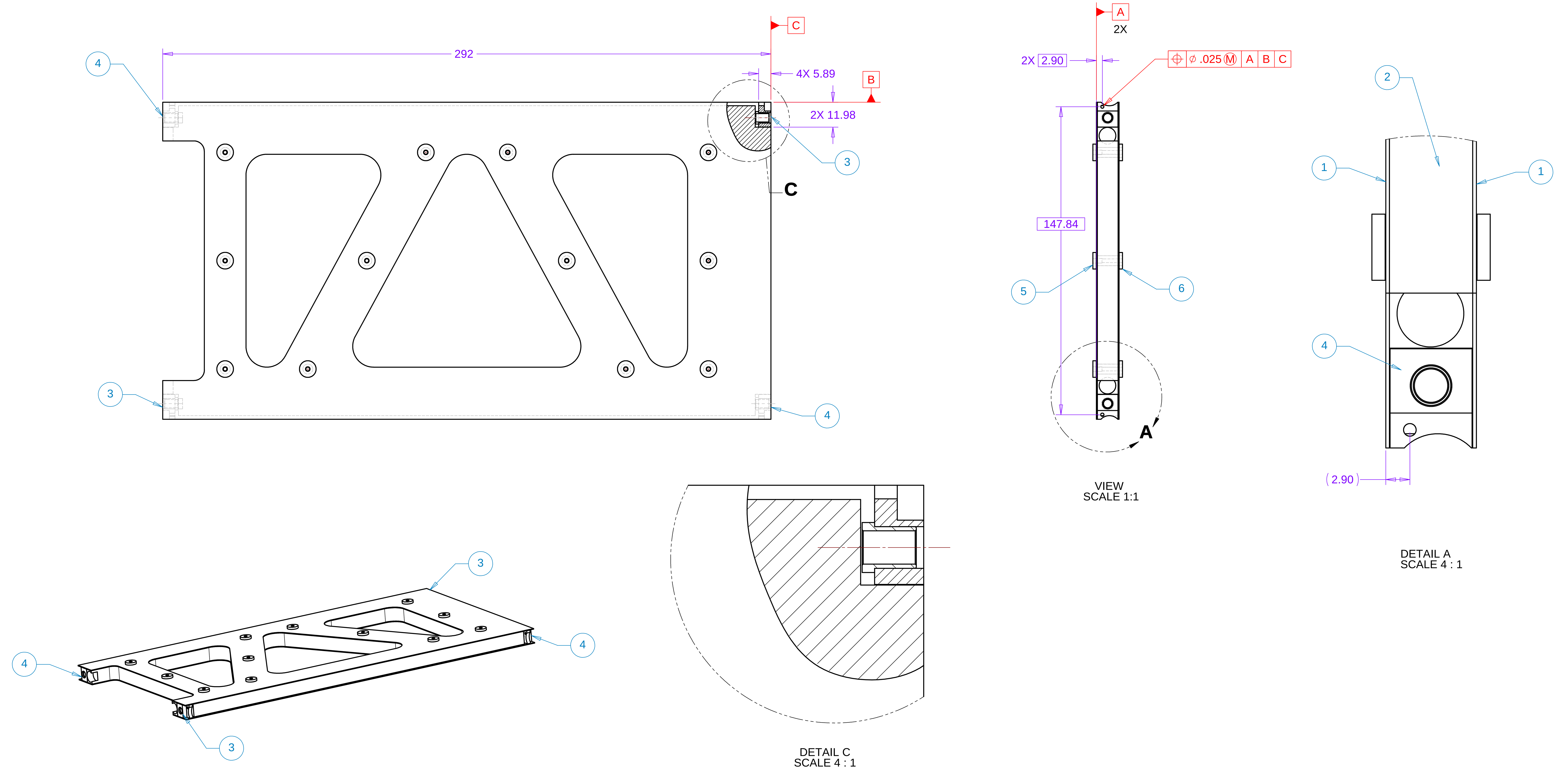
ATLAS PIXEL DETECTOR
8 SIDED END SECTION
SUB PANEL-1

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:2	DO NOT SCALE PRINTS
	PART	nnXnnn	SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F666 SIZE	REV. 1

DWG. NO. 21F666 SIZE | REV. 1 | SH. 1

DWG. NO. 21F667 SIZE REV. 1 SH. 1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F668	1	OUTER PANEL LAMINATE	
2		AR	HONEYCOMB CORE	ULTRACOR Inc. UCF-83-1/4-2.5
3	21F670	2	CORNER BLOCK-1 ASSEMBLY	
4	21F679	2	CORNER BLOCK-2 ASSEMBLY	
5	21F724	12	Treaded Insert Body	
6	21F733	12	Insert Washer	



NOTES: UNLESS OTHER WISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED AND PREPPED FOR BONDING, NO MACHINE OILS ALLOWED.
5. PART NUMBER (DRAWING NO., DASH NO., REVISION NO., SERIAL NO.) TO BE CLEARLY MARKED ON THE PART ITSELF.

6. USE HYSOL ADHESIVE EA 9396.

THIRD ANGLE PROJECTION

REV | DWG | CHK | ZONE | DATE | CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.5 | FRAC. ± 1/64 | X.XX ± 0.25 | ANGLES ± 30' | X.XXX± 0.013 | FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
ACCT NO. | NO. REQD
DEL TO
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
PROJECT NAME US ATLAS SILICONE SUBSYSTEM
DWG BY Roger Smith DATE 1/28/2002
CHK BY CKD BY DATE 1/28/2002
APR BY APPROVED DATE 1/28/2002

SER NO.
DATE ISSD
DATE REQD
US ATLAS SILICON SUBSYSTEM (LOGO)

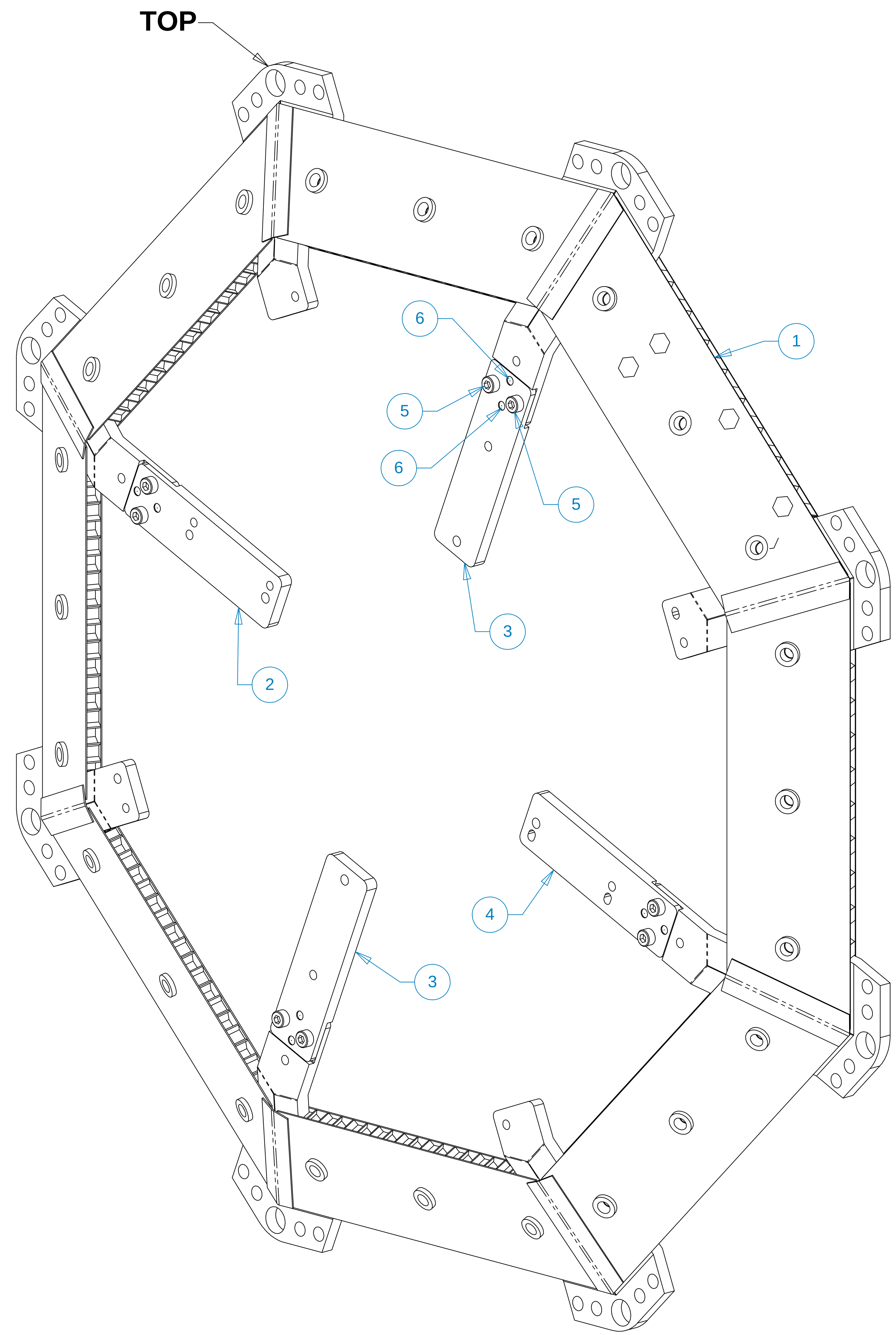
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
8 SIDED END SECTION
SUB PANEL-2

MICROFILMED: | DWG. TYPE PART | SHOWN ON nnXnnn | SCALE: 1:2 | DO NOT SCALE PRINTS
SHEET 1 OF 1
PATENT CLEAR: | DESIGN ACCT. NO. P1AP-11 | CATEGORY CIDE AP6250 | DWG. NO. 21F667 | SIZE | REV. 1

DWG. NO.	SIZE	REV.	SH.
21F720		1	1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F721	1	Flat Panel Assembly	
2	21F731	1	Inner Vertex Inline Holes & Slots	
3	21F732	1	Inner Vertex Inline Holes & Pinholes	
4	21F733	1	Inner Vertex Inline Holes	
5		8	Soc Hd Screw, M3 X 5.0 lg	SST
6		8	Taper Pin, M3 X 6.0 lg	SST



THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.5 · FRAC. ± 1/64 · X.XX ± 0.25 · ANGLES ± 30' · X.XXX± 0.013 · FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO. · NO. REQD · SER NO. · DATE ISSD · DEL TO · DATE REQD · SURFACE TREATMENT

IDEN METHOD: TAG
PROJECT NUMBER: ATL-IP-ED-XXXX
US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME: US ATLAS SILICONE SUBSYSTEM
DWG BY: Roger Smith · DATE 1/30/2002
CHK BY: CKD BY · DATE 1/30/2002
APR BY: APPROVED · DATE 1/30/2002

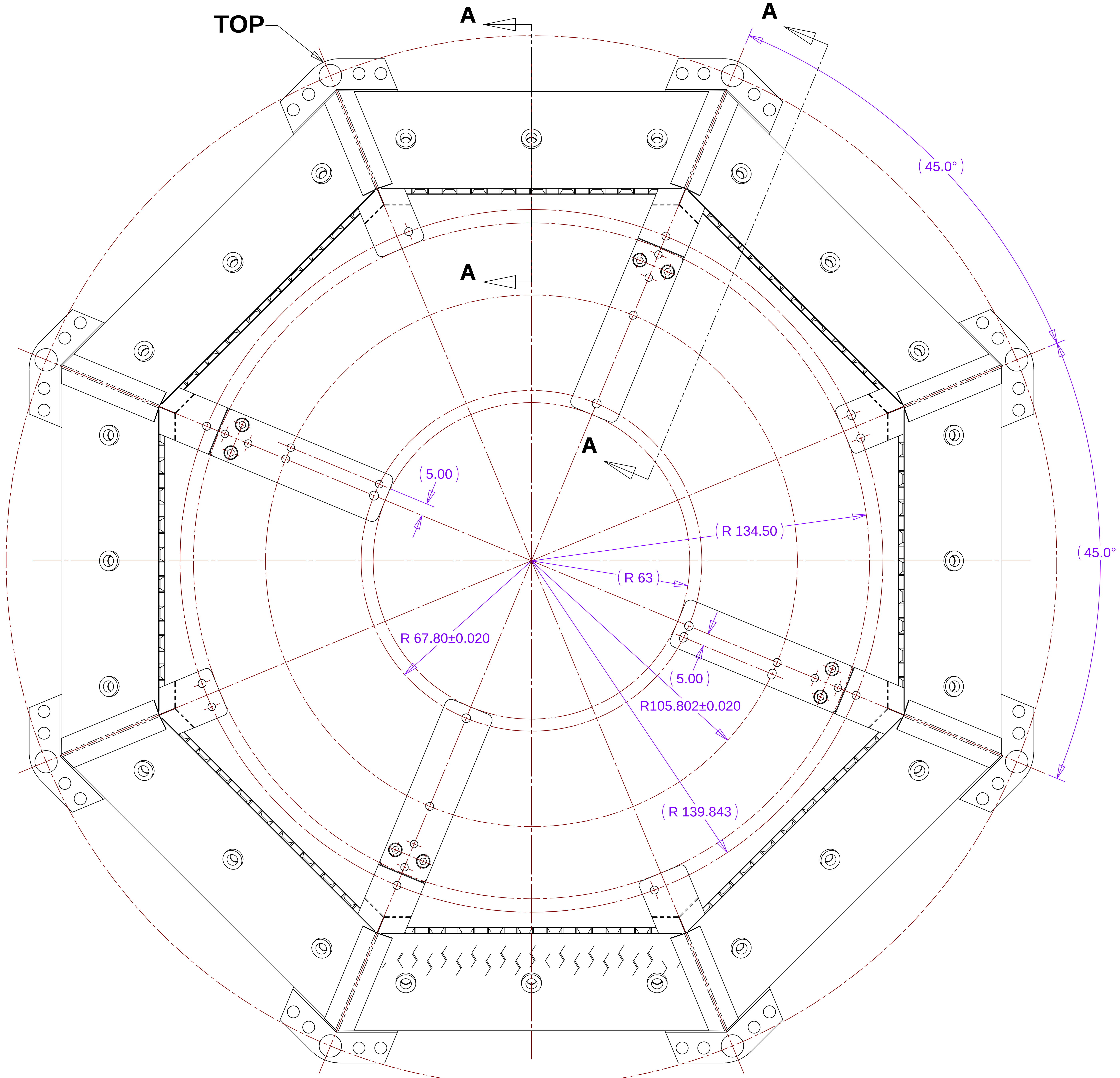
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

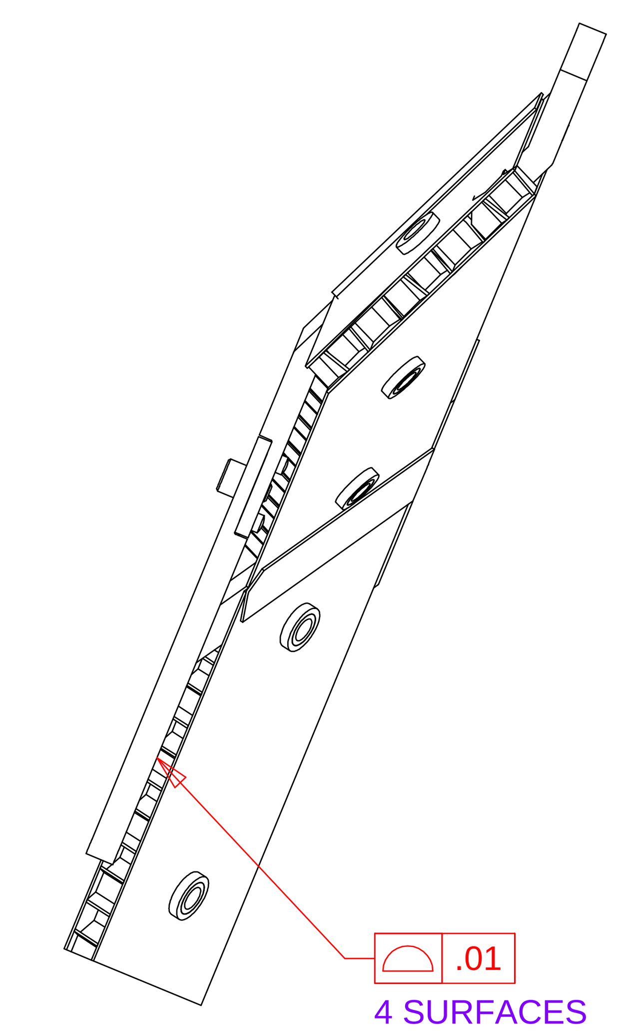
LBNL ATLAS
A SIDE END CONE ASSEMBLY

MICROFILMED:
DWG. TYPE: ASSEM
SHOWN ON: nnXnnn
SCALE: 1:1
DO NOT SCALE PRINTS
SHEET 1 OF 2
PATENT CLEAR:
DESIGN ACCT. NO.: P1AP-11
CATEGORY CIDE: AP6250
DWG. NO.: 21F720
SIZE
REV.: 1

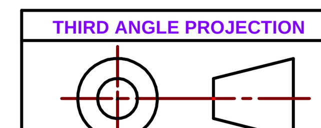
DWG. NO.	SIZE	REV.	SH.
21F720		1	2

ITEM	PART NO	REQD	DESCRIPTION	MATERIAL





SECTION A-A



REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
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CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO. / DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD	TAG	
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM	
DWG BY	Roger Smith	DATE 1/30/2002
CHK BY	CKD BY	DATE 1/30/2002
APR BY	APPROVED	DATE 1/30/2002

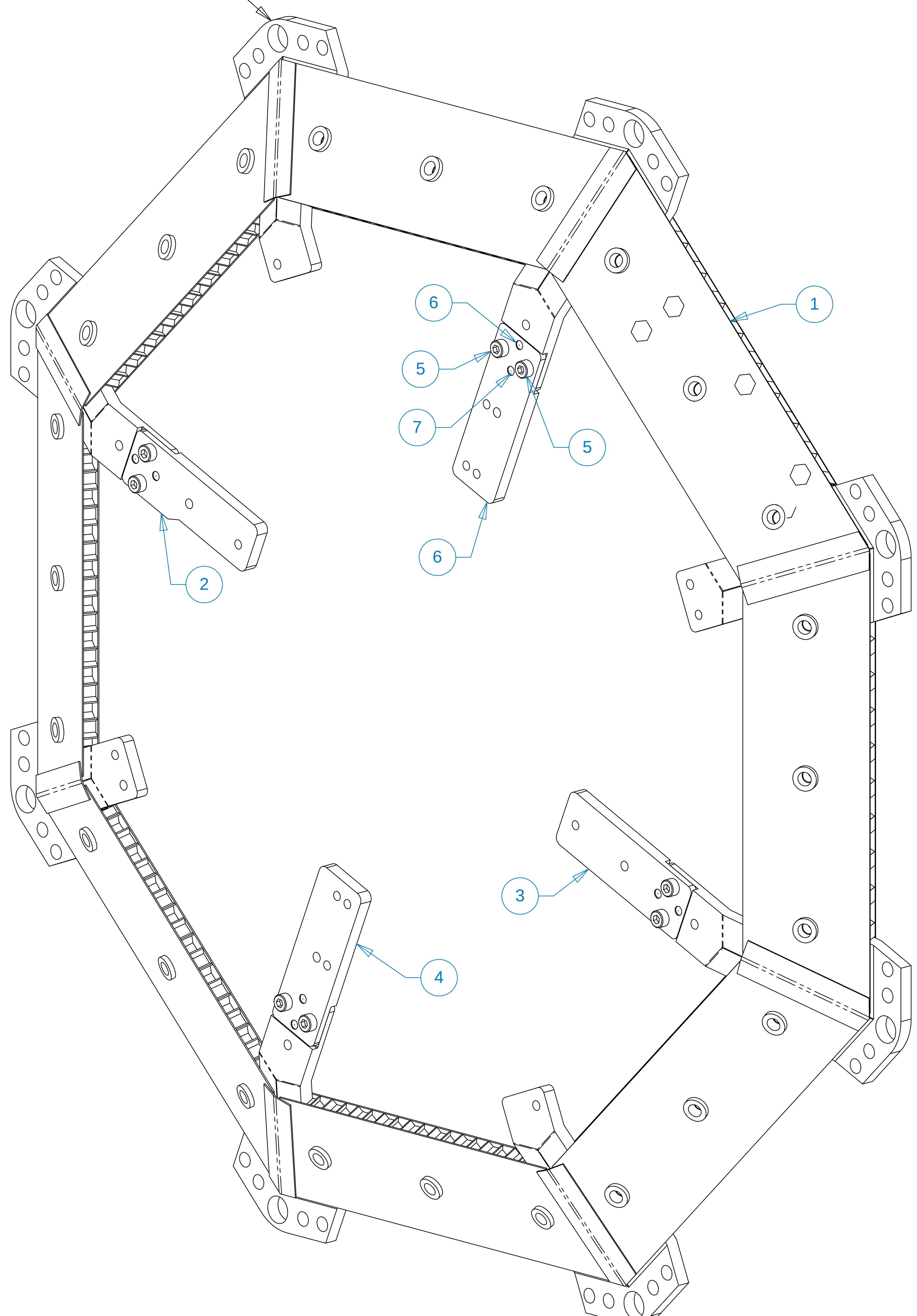
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

LBNL ATLAS
A SIDE END CONE ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	nnXnnn	SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F720 SIZE	REV. 1

DWG. NO.	SIZE	REV.	SH.
21F734		1	1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL
1	21F736	1	Flat Panel Assembly	
2	21F738	1	Inner Vertex One Hole with Notch	
3	21F739	1	Inner Vertex One Hole	
4	21F740	1	Inner Vertex Two Hole	
5		8	Soc Hd Screw, M3 X 5.0 lg	SST
6		8	Taper Pin, M3 X 6.0 lg	SST



THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW THREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.
		DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD	TAG	
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM	
DWG BY	Roger Smith	DATE 1/30/2002
CHK BY	CKD BY	DATE 1/30/2002
APR BY	APPROVED	DATE 1/30/2002

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

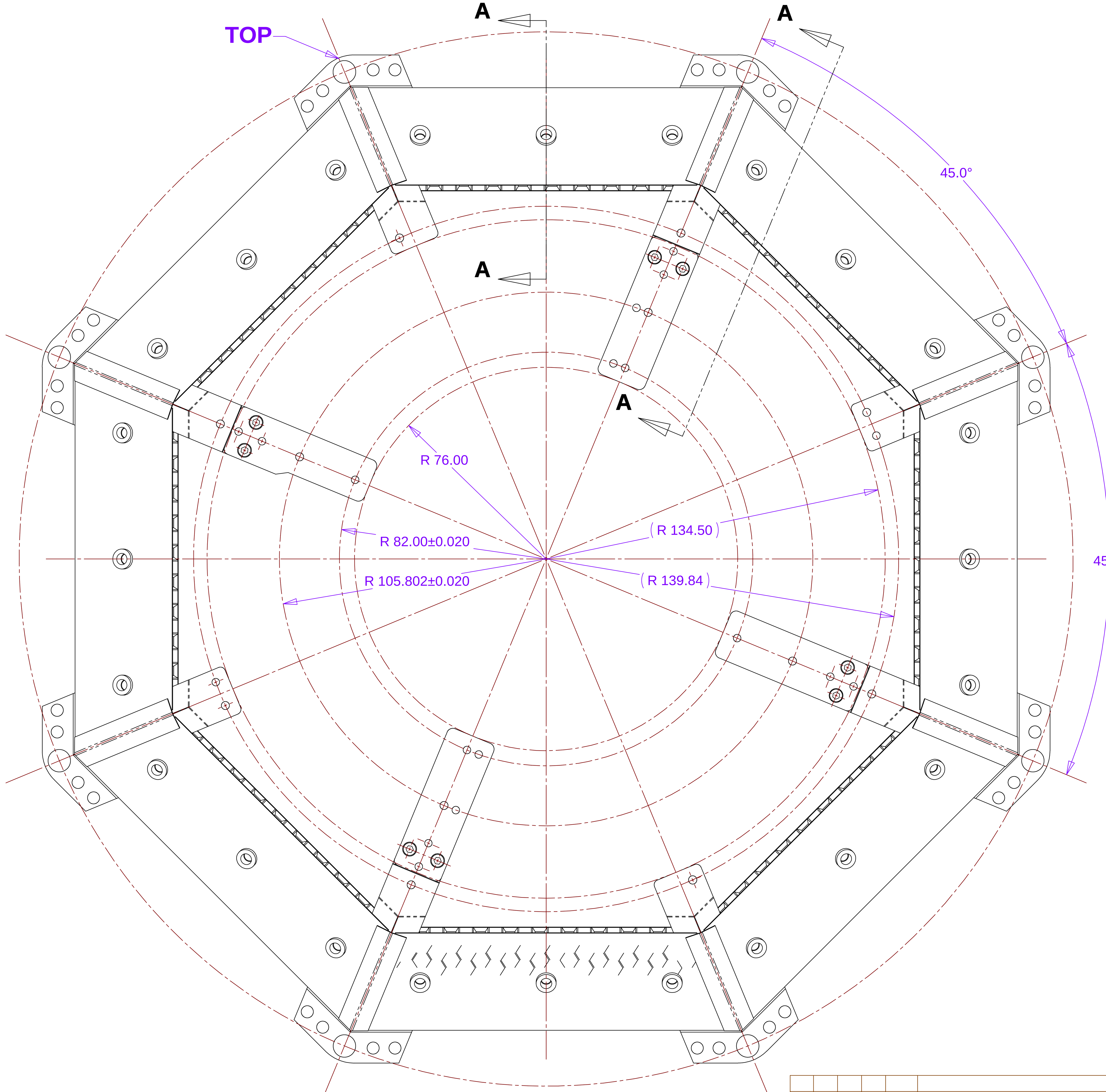
UNIVERSITY OF CALIFORNIA - BERKELEY

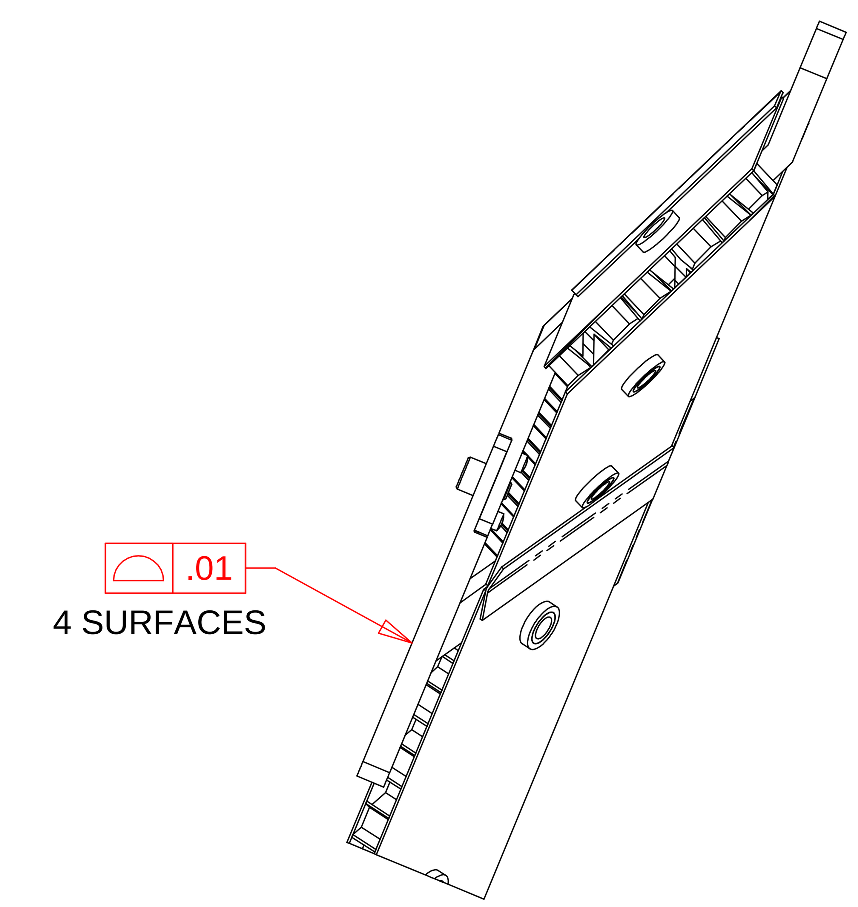
LBNL ATLAS
C SIDE END CONE ASSEMBLY

MICROFILMED:	DWG. TYPE ASSEM	SHOWN ON nnXnnn	SCALE: 1:1	DO NOT SCALE PRINTS
			SHEET 1 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F734 SIZE	REV. 1

DWG. NO.	SIZE	REV.	SH.
21F734		1	2

ITEM	PART NO	REQD	DESCRIPTION	MATERIAL





SECTION A-A

THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW THREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.		NO. REQD	
DEL TO			
SURFACE TREATMENT			
IDEN METHOD	TAG		
PROJECT NUMBER	ATL-IP-ED-XXXX		
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM		
DWG BY	Roger Smith	DATE	1/30/2002
CHK BY	CKD BY	DATE	1/30/2002
APR BY	APPROVED	DATE	1/30/2002

SER NO. | DATE ISSD | DATE REQD

US ATLAS SILICON SUBSYSTEM (LOGO)

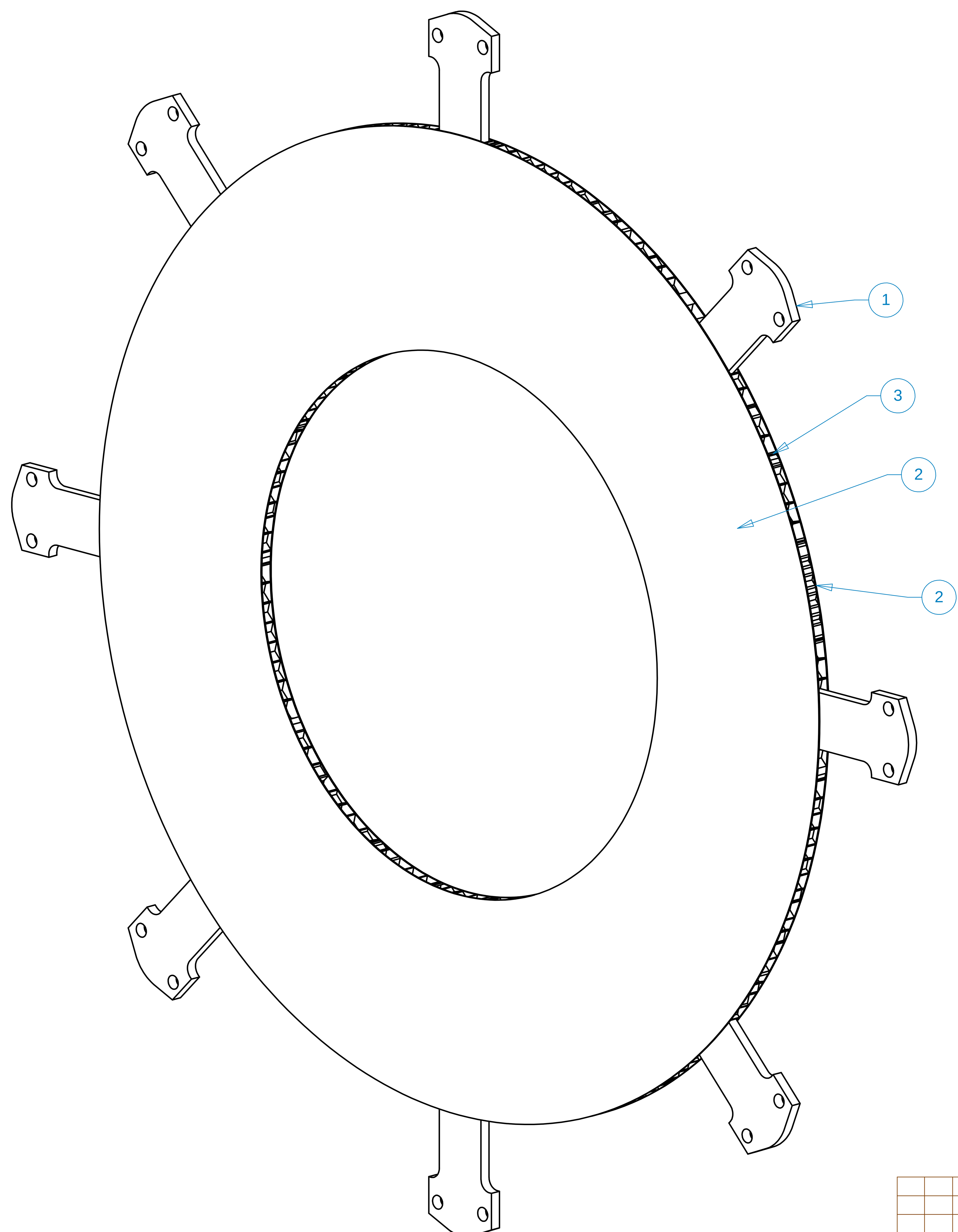
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

LBNL ATLAS
C SIDE END CONE ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	nnXnnn	SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F734 SIZE	REV. 1

DWG. NO.	SIZE	REV.	SH.
21F770		1	1

ITEM NO.	PART NUMBER	QTY.	DESCRIPTION	MATERIAL
1	21F771	8	Vertex Tab	
2	21F772	2	Face Sheet	
3		AR	Honeycomb Core	ULTRACOR Inc. UCF-83-1/4-2.5



THIRD ANGLE PROJECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES	
X.X ± 0.5	FRAC. ± 1/64
X.XX ± 0.25	ANGLES ± 30'
X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.
DEL TO		DATE ISSD
SURFACE TREATMENT		DATE REQD
IDEN METHOD	TAG	
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICONE SUBSYSTEM	
DWG BY	Roger Smith	DATE 1/28/2002
CHK BY	CKD BY	DATE 1/28/2002
APR BY	APPROVED	DATE 1/28/2002

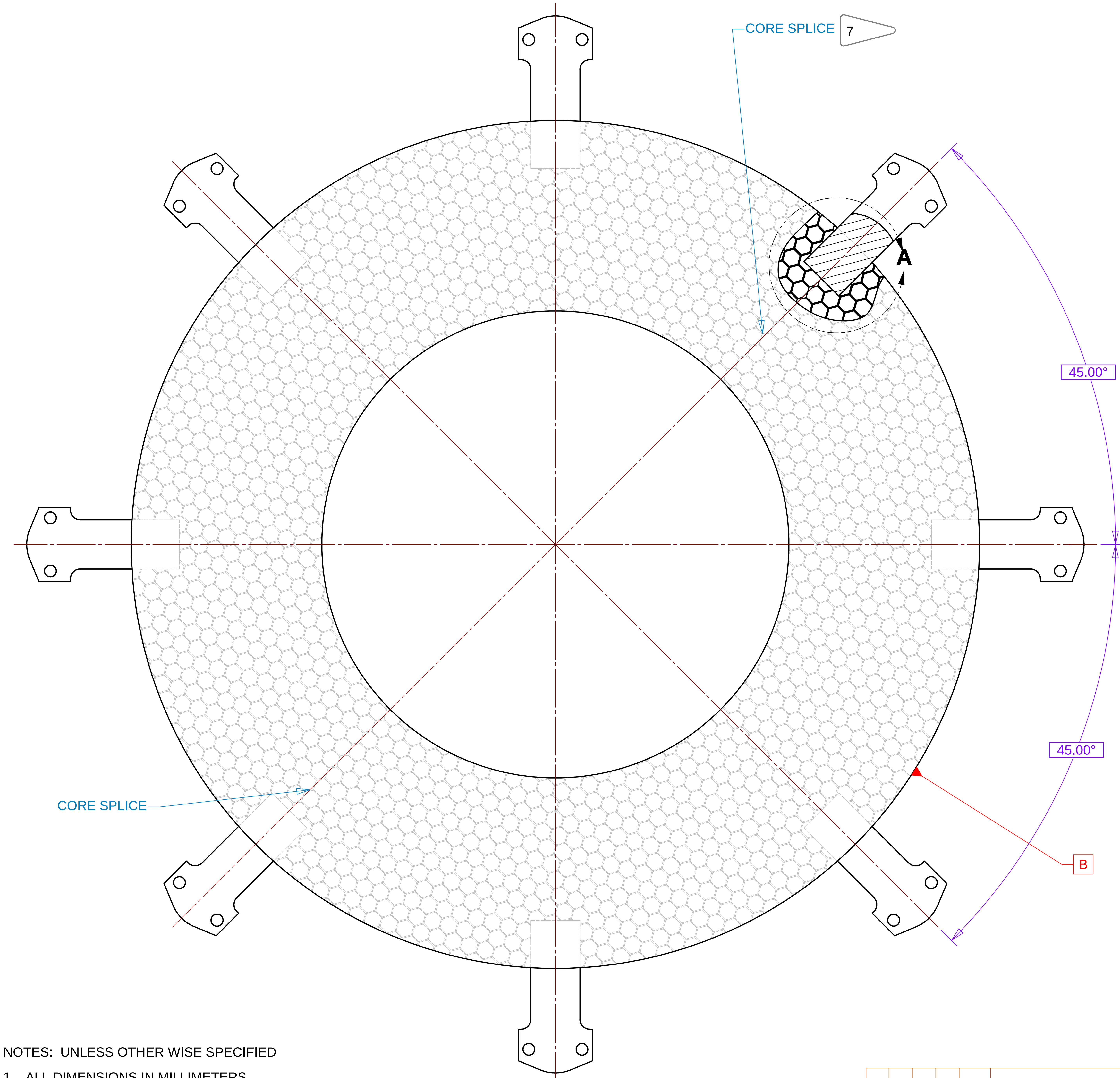
ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

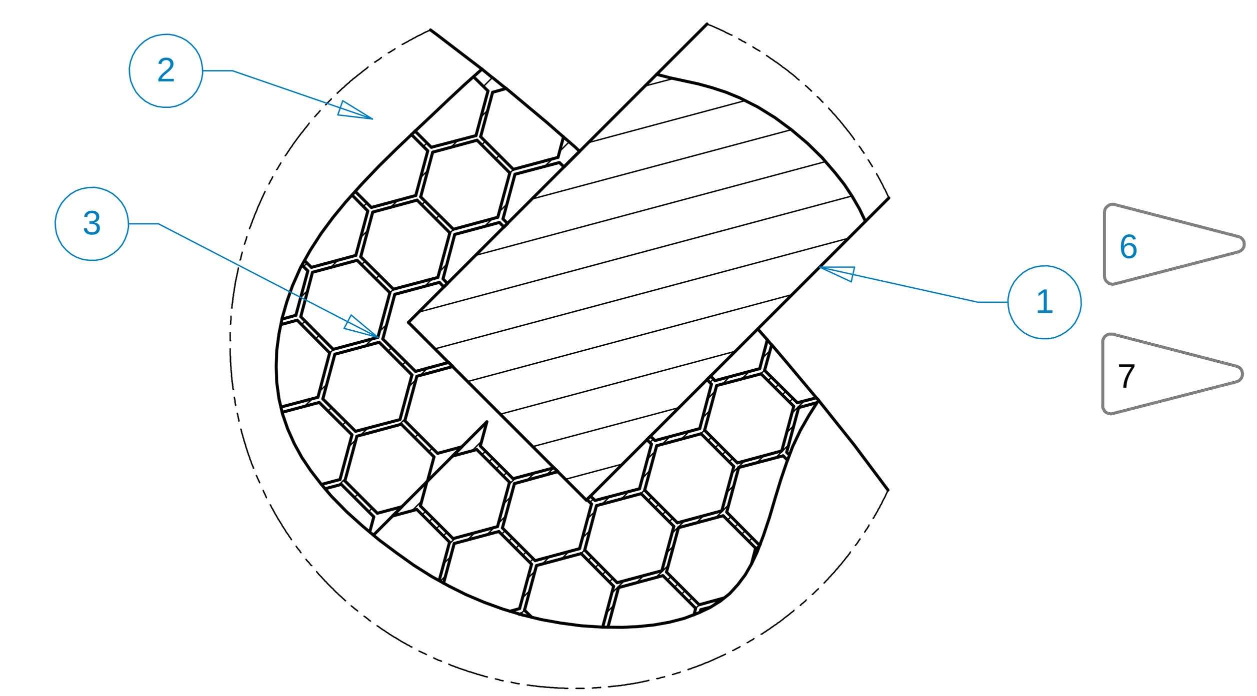
LBNL ATLAS
STIFFENING PLATE
ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	nnXnnn	SHEET 1 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. SIZE	REV.
	P1AP-11	AP6250	21F770	1

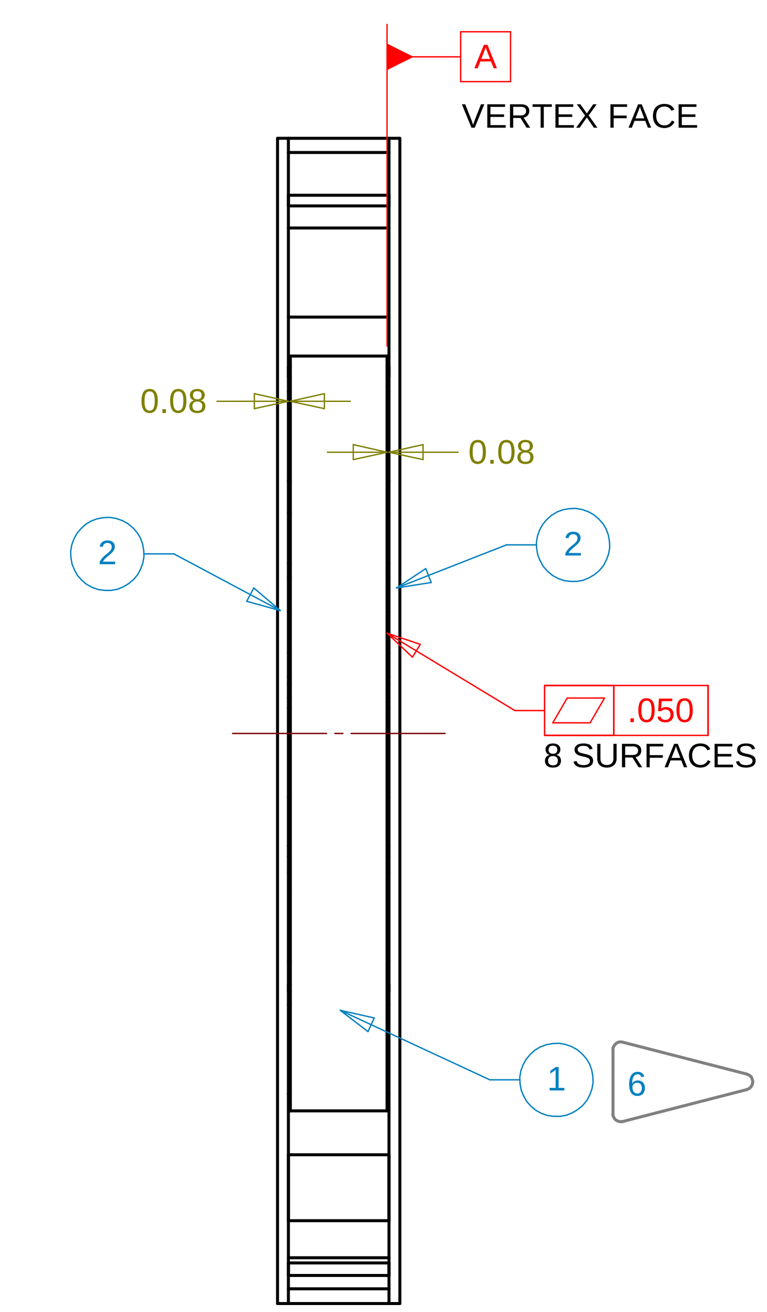
DWG. NO.	SIZE	REV.	SH.
21F770		1	2

DESCRIPTION	MATERIAL	MAT. LOCATION





DETAIL A
SCALE 2 : 1



SECTION B-B
SCALE 4 : 1

NOTES: UNLESS OTHER WISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED AND RESIDUAL ADHESIVE REMOVED.
5. PART NUMBER (DRAWING NO., DASH NO., REVISION NO., SERIAL NO.) TO BE CLEARLY MARKED ON THE PART ITSELF.

6 APPLY HYSOL EA 9396 TO JOIN ITEMS 1, 2 & 3

7 Core fill adjacent cells using HYSOL 9396 / glass microballoon syntactic foam 0.25 g/cc density +15% -0%.

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED		SHOP ORDERS	SER NO.
TOLERANCES	X.X ± 0.5 / FRAC. ± 1/64	ACCT NO. / NO. REQD	DATE ISSD
	X.XX ± 0.25 / ANGLES ± 30'	DEL TO	DATE REQD
	X.XXX± 0.013 / FINISH 1.6	SURFACE TREATMENT	
DO NOT SCALE PRINT		IDEN METHOD TAG	
THREADS ARE CLASS 2		PROJECT NUMBER ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)
CHAMFER ENDS OF ALL SCREW THREADS 30°		PROJECT NAME US ATLAS SILICONE SUBSYSTEM	
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS		DWG BY Roger Smith	DATE 1/28/2002
BREAK EDGES .016 MAX. ON MACHINED WORK		CHK BY CKD BY	DATE 1/28/2002
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE		APR BY APPROVED	DATE 1/28/2002
IN ACCORDANCE WITH ASME Y14.5m & B46.1			

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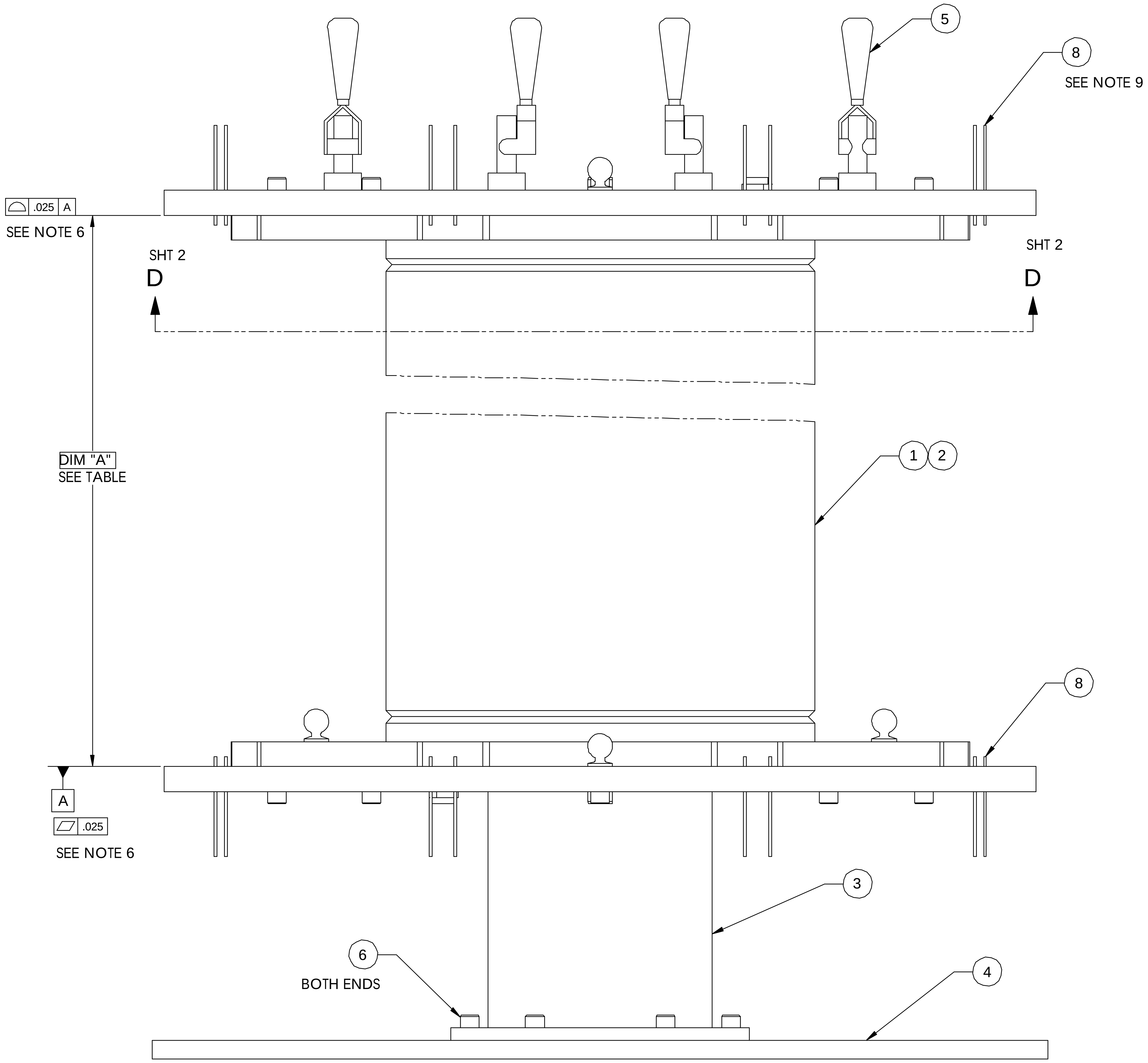
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

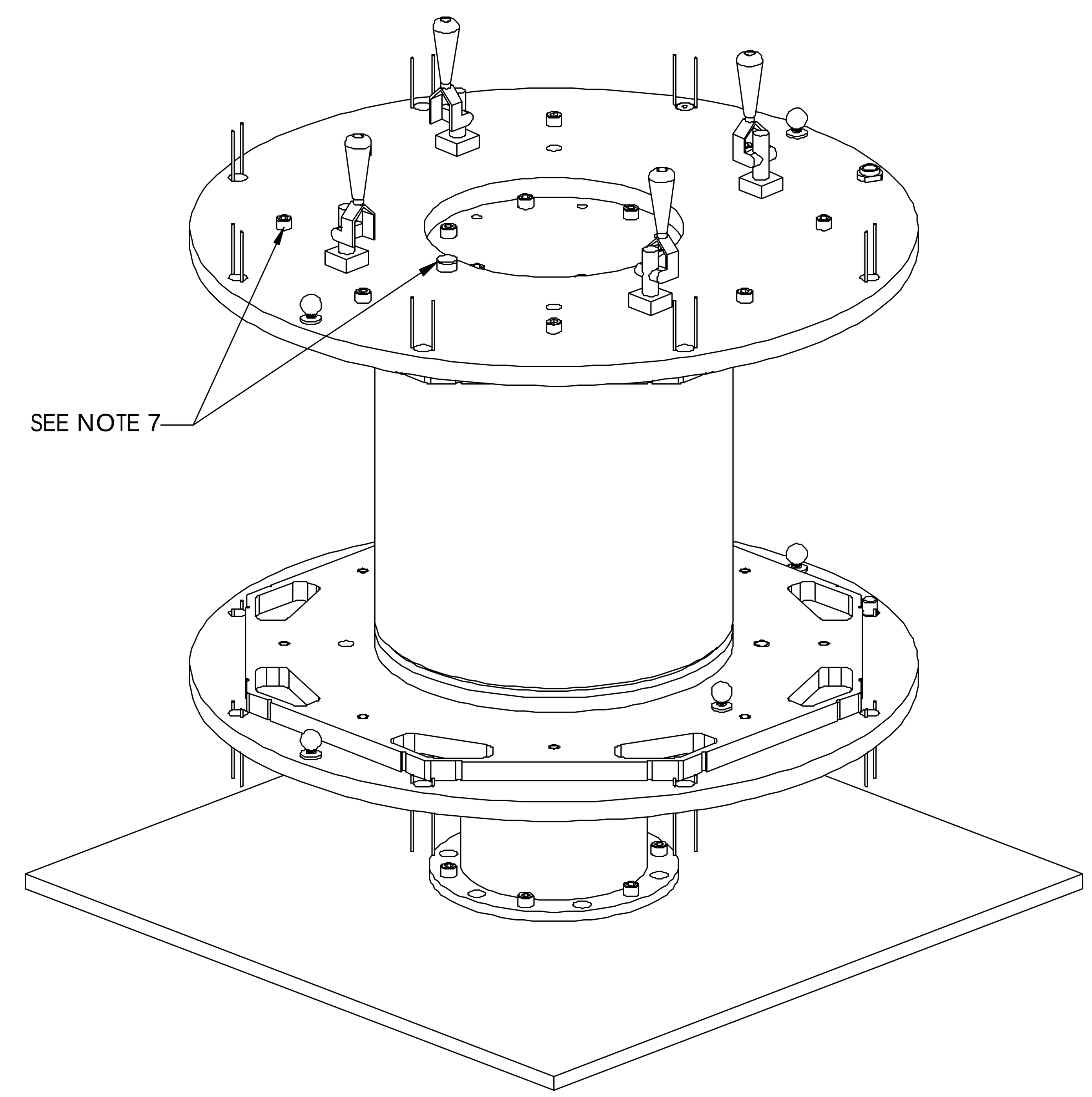
LBNL ATLAS
STIFFENING PLATE
ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	PART	nnXnnn	SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F770	SIZE / REV. 1

DWG. NO.	SIZE	REV.	SH.
21F687 4		-	1

ITEM	PART NO.	REQD	REQD	DESCRIPTION	MATERIAL
9	21F695-3		16	JOINING PIN CENTERING BUSHING	
8		32	32	1.5mm DIA GROUND PIN	STEEL
7	21F695-1	16	16	CAPTIVE PIN	
6		12	12	1/4-20 UNC-2B SOCKET HEAD CAPSCREW	STEEL
5		4	4	TOGGLE CLAMP	
4	21F694	1	1	BOND FIXTURE BASEPLATE	
3	21F693	1	1	BOND FIXTURE TUBE BASEPLATE STAND	
2	21F688-3		1	CENTRAL SECTION BOND FIXTURE SUB-ASSY ALIGNMENT	
1	21F688-1	1		END SECTION BOND FIXTURE SUB-ASSY ALIGNMENT	
PART NO.		-1	-3		





NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS
5. TORQUE SOCKET HEAD CAP SCREWS TO 24.3 in-Lbs (2.0 ft-Lbs.) MAX
6. DIMENSIONS AND TOLERANCES ARE BASED UPON INDIVIDUAL PART TOLERANCES; AND ARE REFERENCE
7. SCREWS ARE REMOVED; TOGGLE CLAMPS ARE USED TO LEVER TOP PLATE OFF FOR ASSEMBLY REMOVAL AFTER BONDING
8. 1.5mm DIA. PINS ARE USED TO ALIGN ASSEMBLY PANELS IN POSITION
9. CAPTIVE PIN IS USED TO CRITICALLY POSITION VERTEX JOINT ASSEMBLY (21F676) DURING BONDING
10. JOINING PIN CENTERING BUSHING IS USED TO BOND FRAME JOINING PIN (21F660) DURING A SECONDARY BONDING PROCESS
11 SEE DWG 21F650 AND 21F665 FOR BONDING ADHESIVE SPECIFICATIONS

PART NO.	DIM "A"	ASSEMBLY
-1	275.400	END SECTION
-3	840.000	CENTRAL SECTION

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.	
DEL TO		DATE ISSD	
SURFACE TREATMENT		DATE REQD	
IDEN METHOD TAG			
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)	
PROJECT NAME	US ATLAS SILICON SUBSYSTEM		
DWG BY	W. K. MILLER	DATE	5/8/2001
CHK BY	BILL WILDS	DATE	5/31/2001
APR BY	E. ANDERSSEN	DATE	????

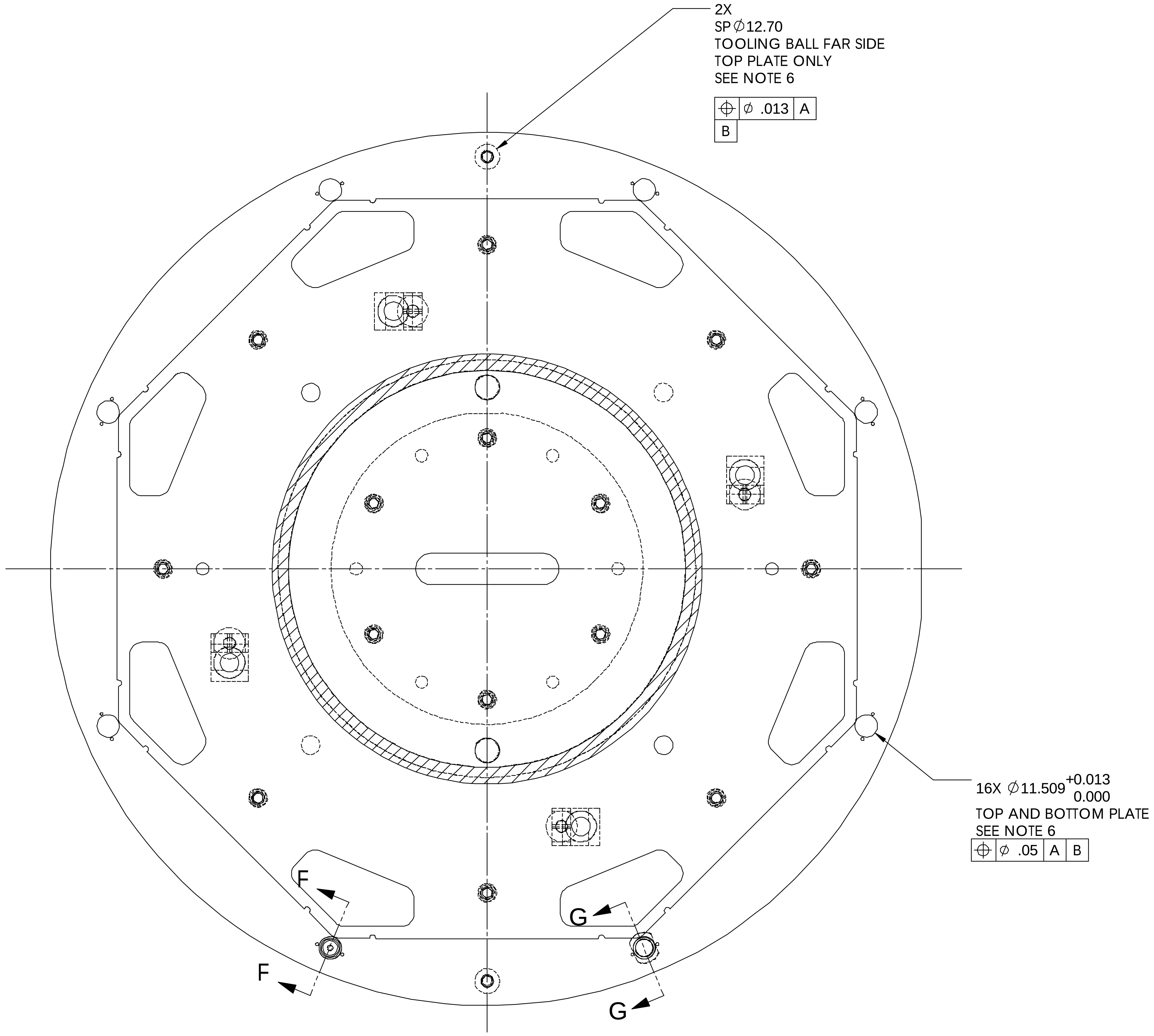
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
SPACEFRAME END AND CENTRAL SECTION
BONDING FIXTURE ASSEMBLY

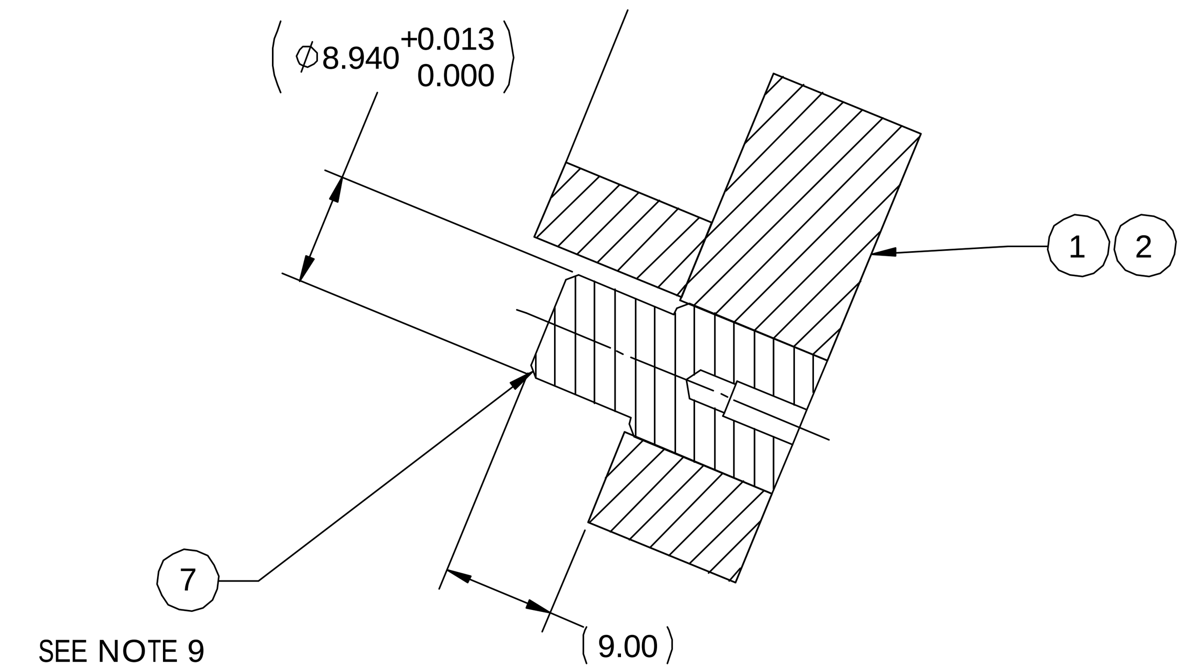
MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1.5	DO NOT SCALE PRINTS
	ASSEM	N/A	SHEET 1 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. / SIZE	REV.
	P1AP-11	AP6250	21F687 4	-

DWG. NO.	SIZE	REV.	SH.
21F687 4		-	2

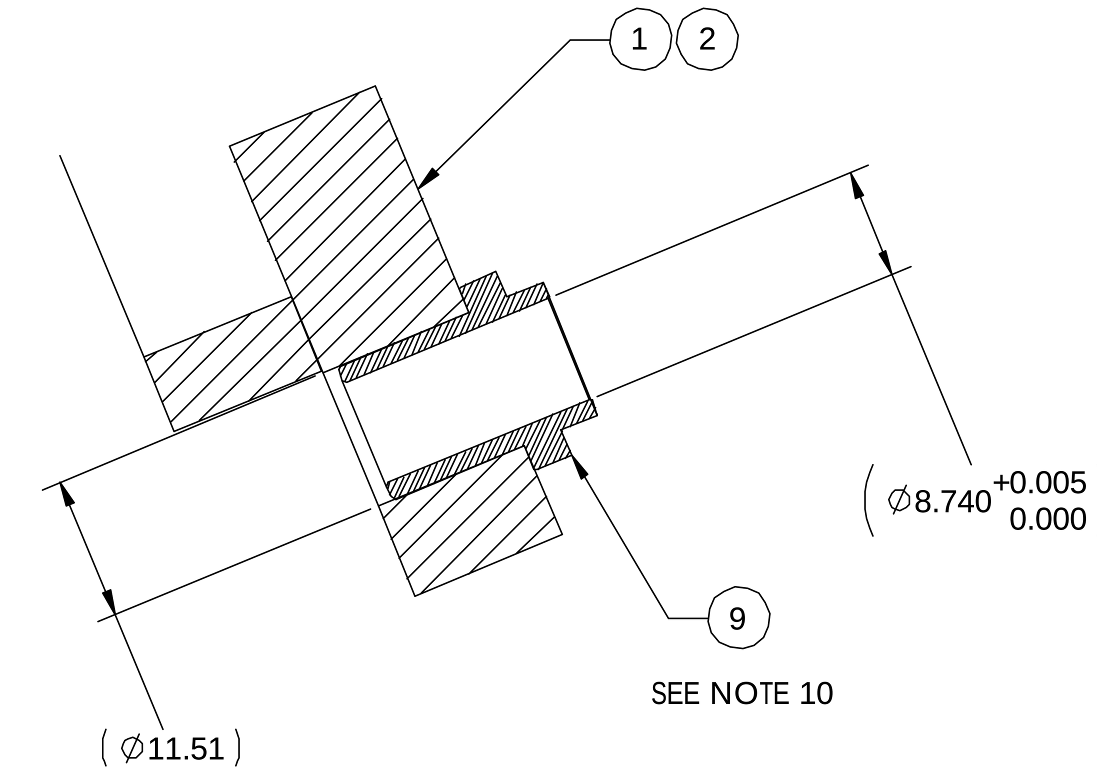
ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL



SECTION D-D
SCALE 1 : 1.5



SECTION F-F
SCALE 2 : 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEANED TO REMOVE ALL OIL, GREASE, DIRT AND CHIPS
5. TORQUE SOCKET HEAD CAP SCREWS TO 24.3 in-Lbs (2.0 ft-Lbs.) MAX
6. DIMENSIONS AND TOLERANCES ARE BASED UPON INDIVIDUAL PART TOLERANCES; AND ARE REFERENCE
7. SCREWS ARE REMOVED; TOGGLE CLAMPS ARE USED TO LEVER TOP PLATE OFF FOR ASSEMBLY REMOVAL AFTER BONDING
8. 1.5mm DIA. PINS ARE USED TO ALIGN ASSEMBLY PANELS IN POSITION
9. CAPTIVE PIN IS USED TO CRITICALLY POSITION VERTEX JOINT ASSEMBLY (21F676) DURING BONDING
10. JOINING PIN CENTERING BUSHING IS USED TO BOND FRAME JOINING PIN (21F660) DURING A SECONDARY BONDING PROCESS
11 SEE DWG 21F650 AND 21F665 FOR BONDING ADHESIVE SPECIFICATIONS

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED		
TOLERANCES	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS		SER NO.
ACCT NO.	NO. REQD	DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		US ATLAS SILICON SUBSYSTEM (LOGO)
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

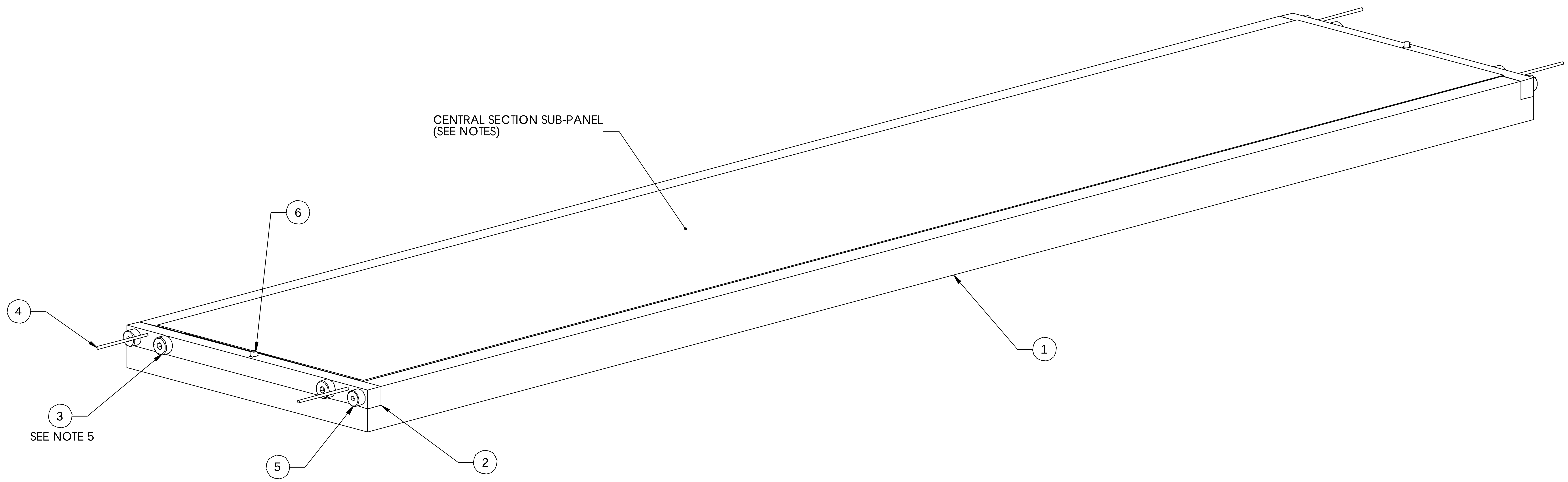
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
SPACEFRAME END AND CENTRAL SECTION
BONDING FIXTURE ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1.5	DO NOT SCALE PRINTS
	ASSEM	N/A	SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. 21F687 4 SIZE	REV.
	P1AP-11	AP6250	21F687 4	-

DWG. NO. 21F699 4 | SIZE | REV. - | SH. 1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
6		2	3.0 mm DIA. GAGE PIN	
5		4	M5 X .8 SOCKET HEAD CAP SCREW X 15 LONG	
4		4	1.50 mm DIA. GAGE PIN	
3	21F704	4	PANEL BOND FIXTURE MODIFIED SCREW	
2	21F702	2	CENTRAL SECTION PANEL BOND FIXTURE END PLATE	
1	21F701-3	1	CENTRAL SECTION PANEL BOND FIXTURE BASEPLATE	



NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS IN MILLIMETERS
2. FIXTURE USED TO FABRICATE SUB-PANEL 1 AND SUB-PANEL 2 (PART 21F652)
3. SUB-PANEL ASSEMBLIES SHOWN IN THEIR PRE-MACHINED STATE
4. SEE PANEL DRAWINGS FOR ADHESIVE REQUIREMENTS
5. TORQUE SCREW TO 11 in-Lbs. MAX
6. DIMENSIONS, TOLERANCES, AND DATUMS BASED UPON INDIVIDUAL PARTS; SOME ARE REFERENCE

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.
DEL TO		DATE ISSD
SURFACE TREATMENT		DATE REQD
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
SPACEFRAME CENTRAL SECTION
SUB-PANEL BOND FIXTURE

MICROFILMED:	DWG. TYPE ASSEM	SHOWN ON N/A	SCALE: 1:1.25	DO NOT SCALE PRINTS
			SHEET 1 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F699 4 SIZE	REV. -

NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS IN MILLIMETERS
2. FIXTURE USED TO FABRICATE SUB-PANEL 1 AND SUB-PANEL 2 (PART 21F652)
3. SUB-PANEL ASSEMBLIES SHOWN IN THEIR PRE-MACHINED STATE
4. SEE PANEL DRAWINGS FOR ADHESIVE REQUIREMENTS
5. TORQUE SCREW TO 11 in-Lbs. MAX
6. DIMENSIONS, TOLERANCES, AND DATUMS BASED UPON INDIVIDUAL PARTS; SOME ARE REFERENCE

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES	
X.X ± 0.5	FRAC. ± 1/64
X.XX ± 0.25	ANGLES ± 30'
X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS
SER NO.
ACCT NO. | NO. REQD | DATE ISSD
DEL TO | DATE REQD
SURFACE TREATMENT
IDEN METHOD TAG
PROJECT NUMBER ATL-IP-ED-XXXX
US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM
DWG BY W. K. MILLER DATE 5/8/2001
CHK BY BILL WILDS DATE 5/31/2001
APR BY E. ANDERSSEN DATE ????

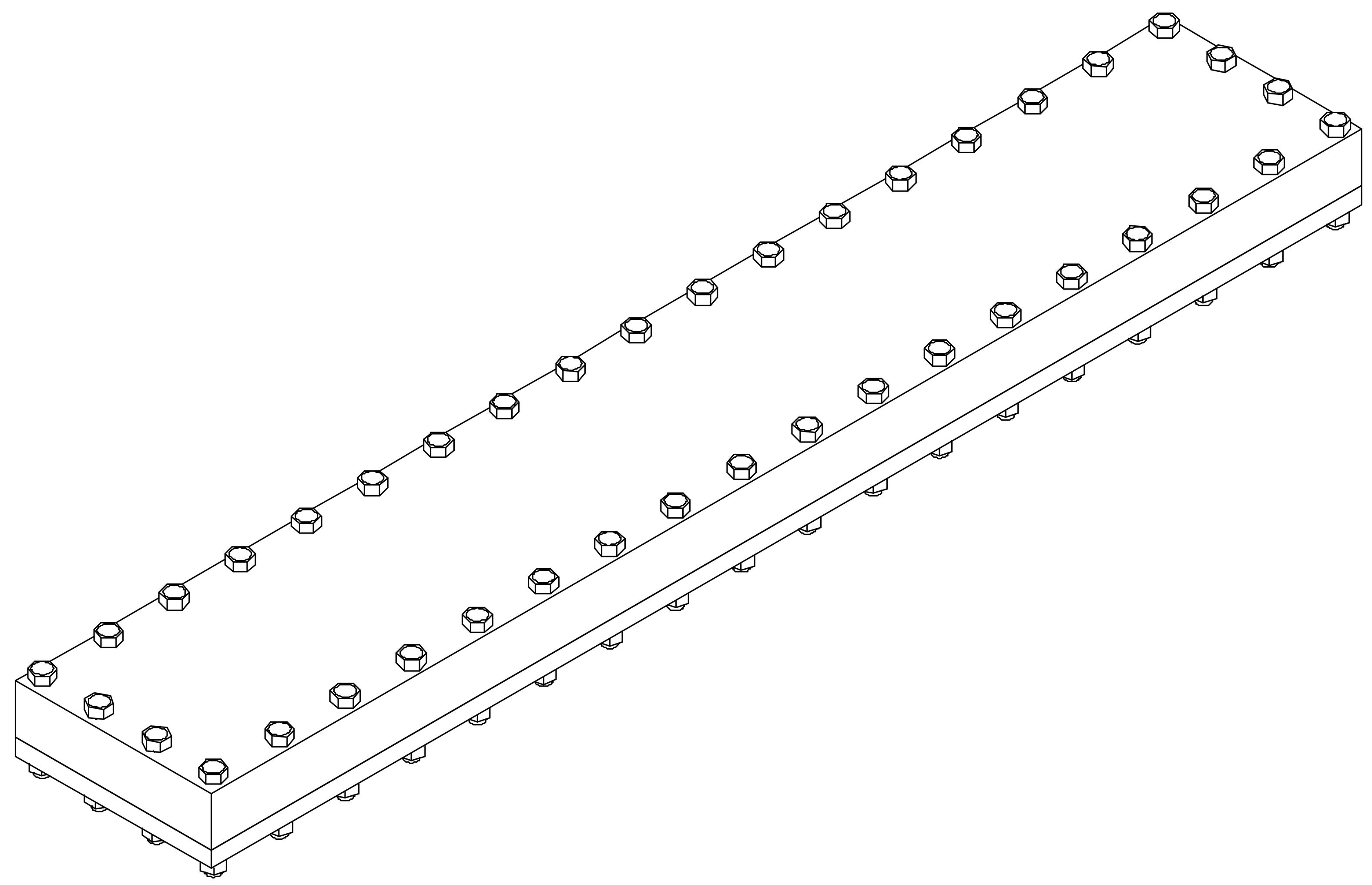
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

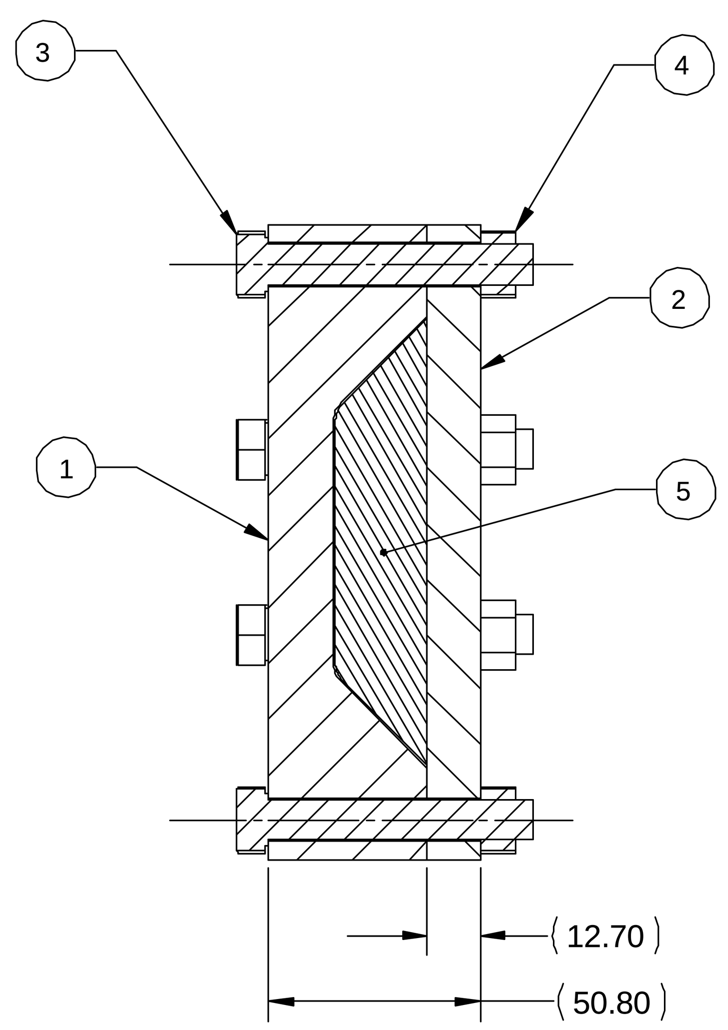
ATLAS PIXEL DETECTOR
SPACEFRAME CENTRAL SECTION
SUB-PANEL BOND FIXTURE

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE:	DO NOT SCALE PRINTS
	ASSEM	N/A	1.5:1	
			SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. / SIZE	REV.
	P1AP-11	AP6250	21F699 4	-

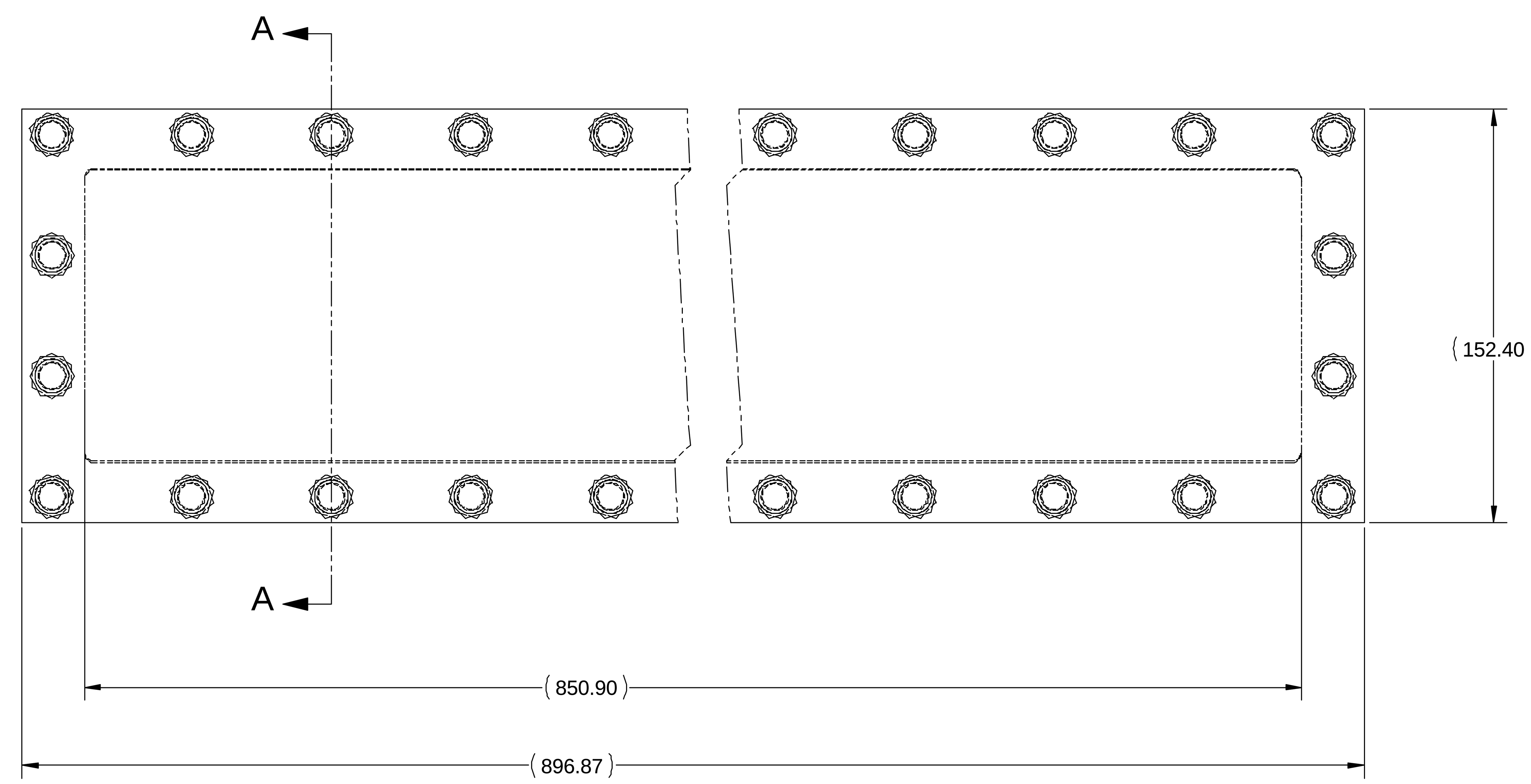
DWG. NO.	SIZE	REV.	SH.
21F705	4	-	1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
5		1	INNER VERTEX STIFFENER SILICONE MOLD INSERT	
4		40	3/8-16 UNC-2A HEX NUT	STEEL
3		40	3/8-16 UNC-2A HEX BOLT	STEEL
2	21F707	1	INNER VERTEX STIFFENER MOLD COVERPLATE	
1	21F706	1	INNER VERTEX STIFFENER MOLD CAVITY	





SECTION A-A
SCALE 1 : 1.5



NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS IN MILLIMETERS
2. ASSEMBLY USED TO MOLD THE INNER CORNERS FOR SPACEFRAME CENTRAL AND END SECTION (PARTS 21F659 AND 21F674)
3. ASSEMBLY WEIGHS 100 Lbs.

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS			SER NO.
ACCT NO.		NO. REQD	DATE ISSD
DEL TO			DATE REQD
SURFACE TREATMENT			
IDEN METHOD	TAG		
PROJECT NUMBER	ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICON SUBSYSTEM		
DWG BY	W. K. MILLER		DATE 5/8/2001
CHK BY	BILL WILDS		DATE 5/31/2001
APR BY	E. ANDERSSEN		DATE ????

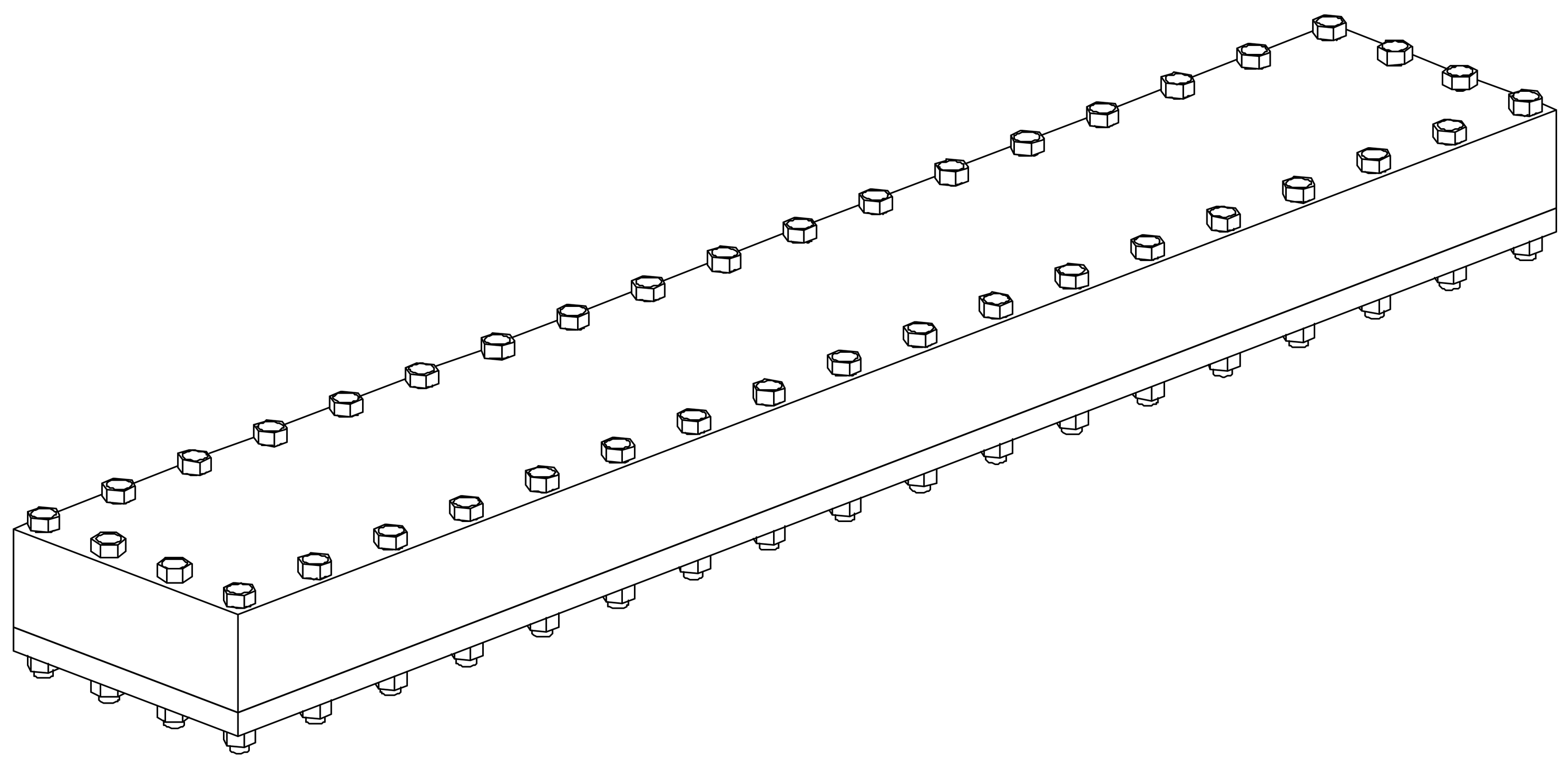
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

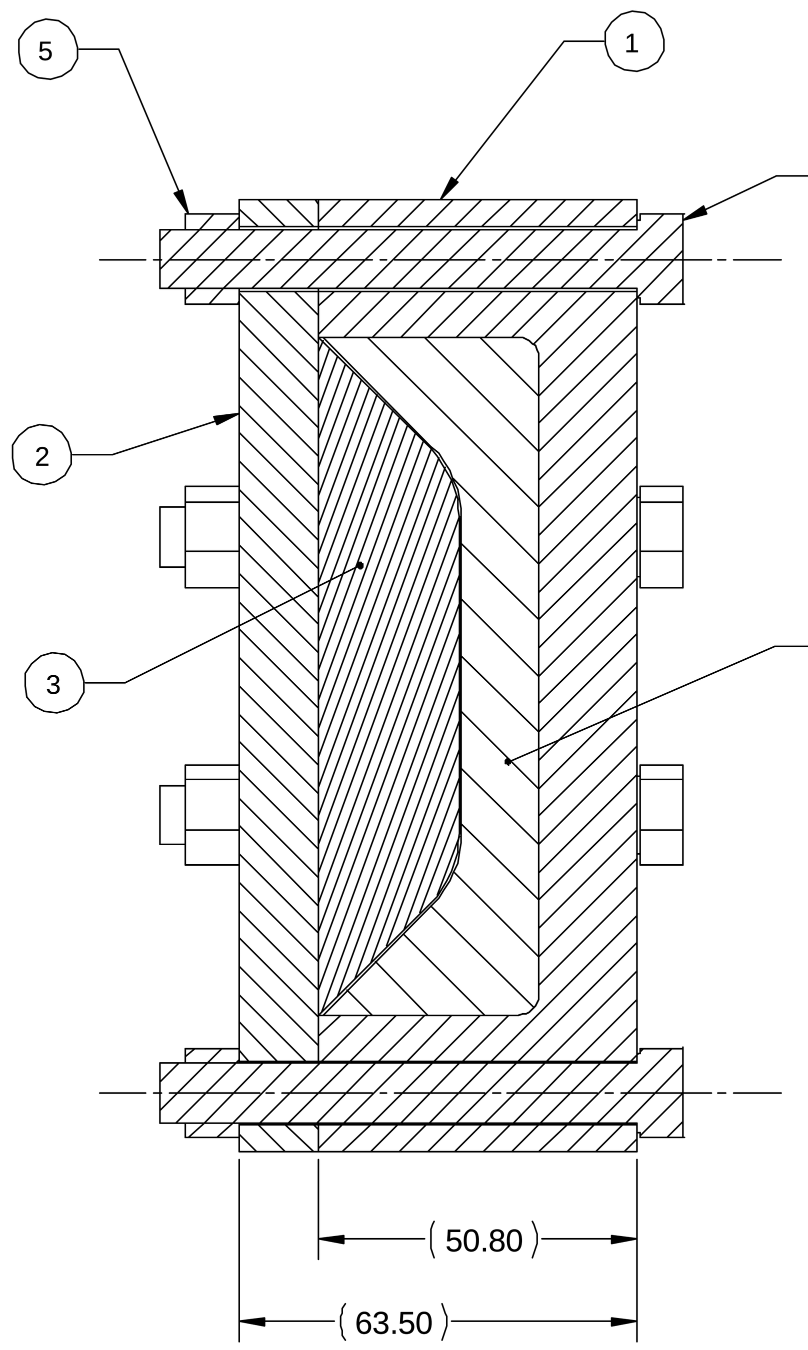
ATLAS PIXEL DETECTOR
SPACEFRAME
INNER STIFFENER MOLD ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1.5	DO NOT SCALE PRINTS
	ASSEM	N/A	SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. SIZE	REV.
	P1AP-11	AP6250	21F705 4	-

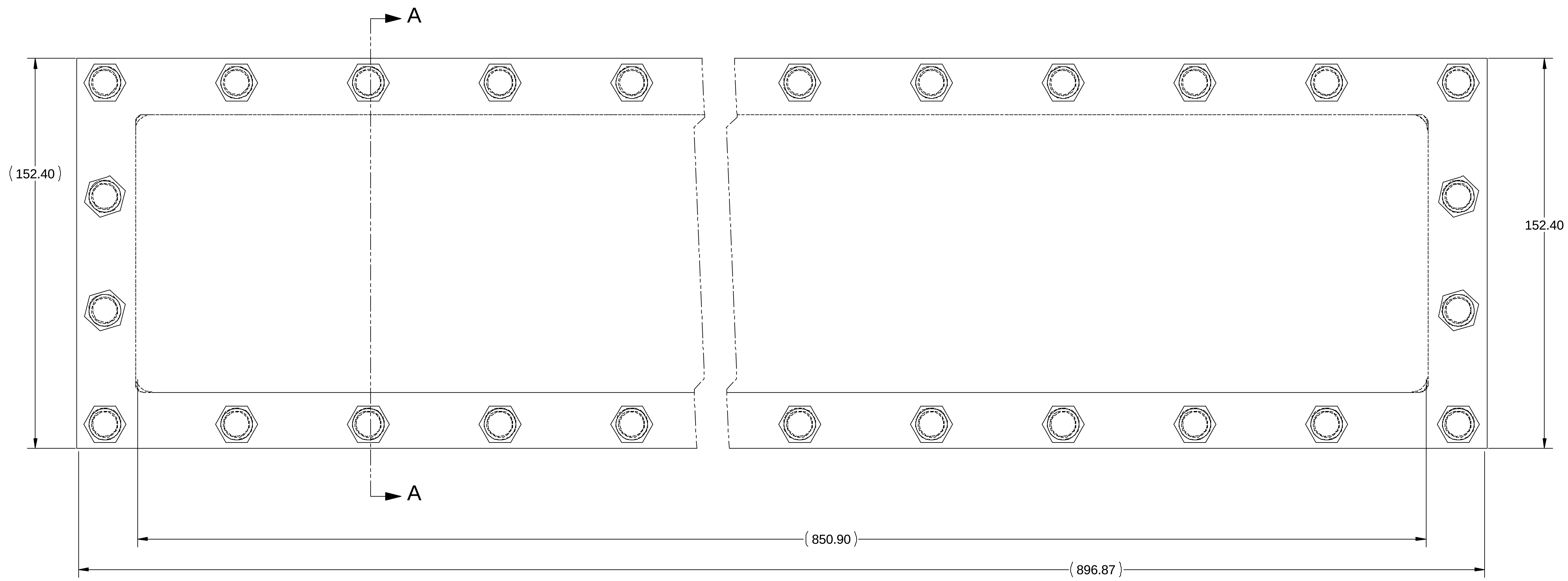
DWG. NO.	SIZE	REV.	SH.
21F708	4	-	1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
6		1	OUTER VERTEX STIFFENER SILICONE MOLD INSERT	
5		40	3/8-15 UNC-2B HEX NUT	STEEL
4		40	3/8-16 UNC-2A HEX BOLT X 2 1/2 LONG	STEEL
3	21F710	1	OUTER VERTEX STIFFENER MOLD INSERT	
2	21F707	1	INNER VERTEX STIFFNER MOLD COVERPLATE	
1	21F709	1	OUTER VERTEX STIFFENER MOLD CAVITY	





SECTION A-A
SCALE 1 : 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS IN MILLIMETERS
2. ASSEMBLY USED TO MOLD THE OUTER CORNERS FOR SPACEFRAME THE CENTRAL AND END SECTION (PART 21F658 AND 21F675)
3. ASSEMBLY WEIGHS 130 Lbs.

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS		SER NO.
ACCT NO.	NO. REQD	DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

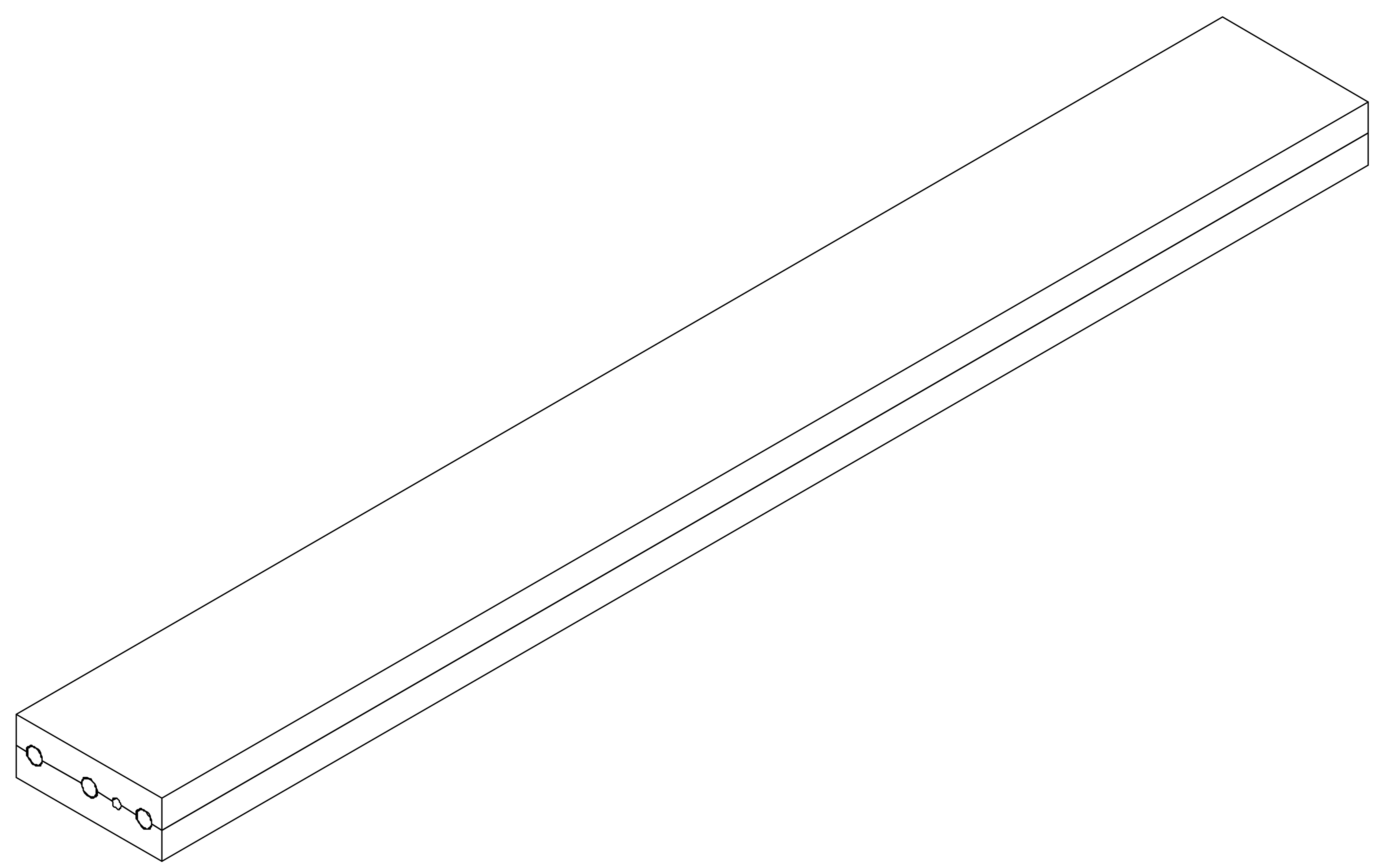
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

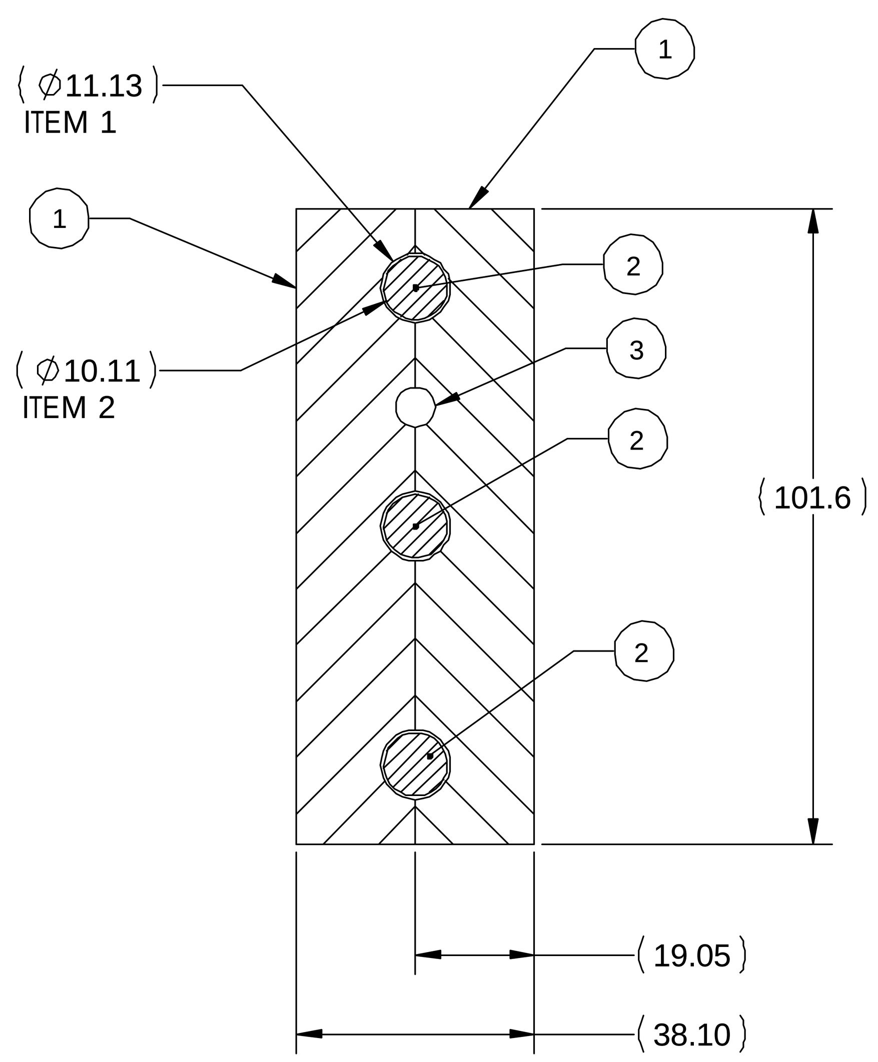
ATLAS PIXEL DETECTOR
SPACEFRAME
OUTER STIFFENER MOLD ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	N/A	SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. 21F708 / SIZE 4	REV.
	P1AP-11	AP6250	21F708 4	-

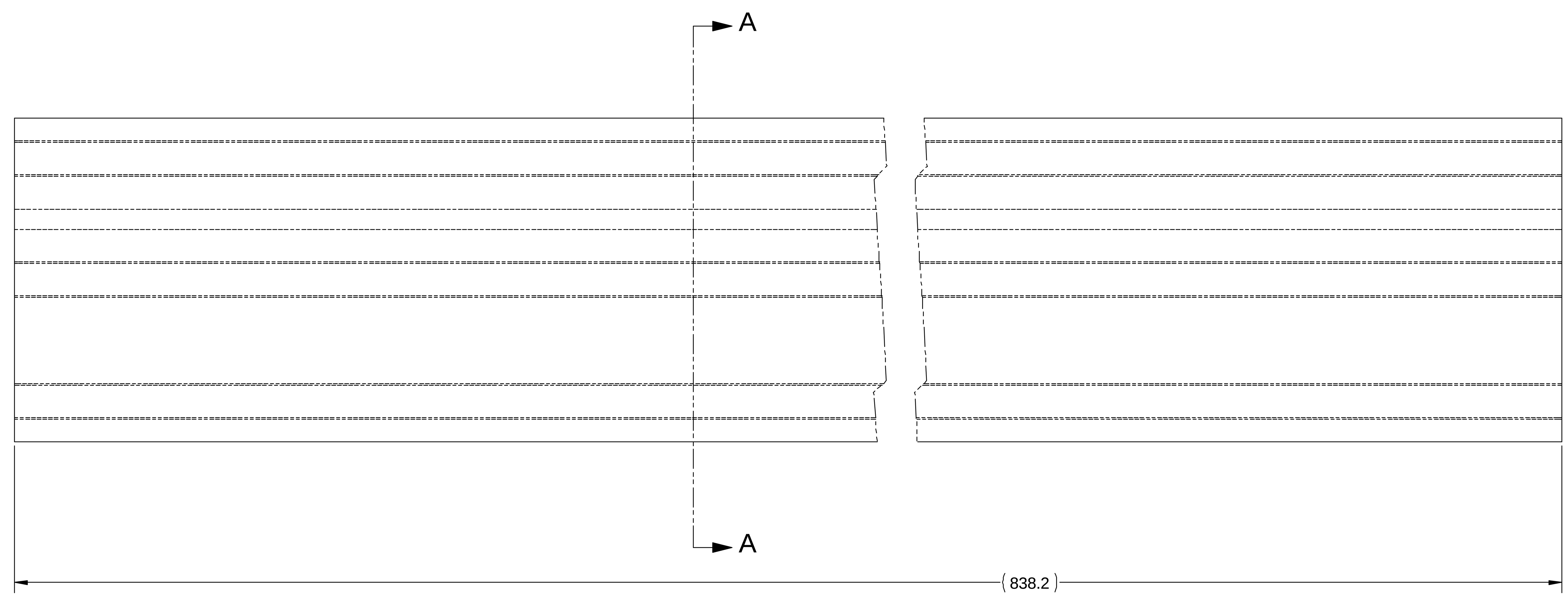
DWG. NO.	SIZE	REV.	SH.
21F711 4		-	1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
3	21F715-9	1	6.35 DIA. MOLD ALIGNMENT ROD	STEEL
2	21F715-7	3	VERTEX STIFFENING TUBE MANDREL	STEEL
1	21F712	2	VERTEX STIFFENING TUBE MOLD CAVITY	STEEL





SECTION A-A
SCALE 1 : 1



NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS IN MILLIMETERS
2. MOLD USED TO FORM VERTEX STIFFENER TUBES (PART 21F657 AND 21F679)

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW THREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS		
ACCT NO.	NO. REQD	SER NO. / DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

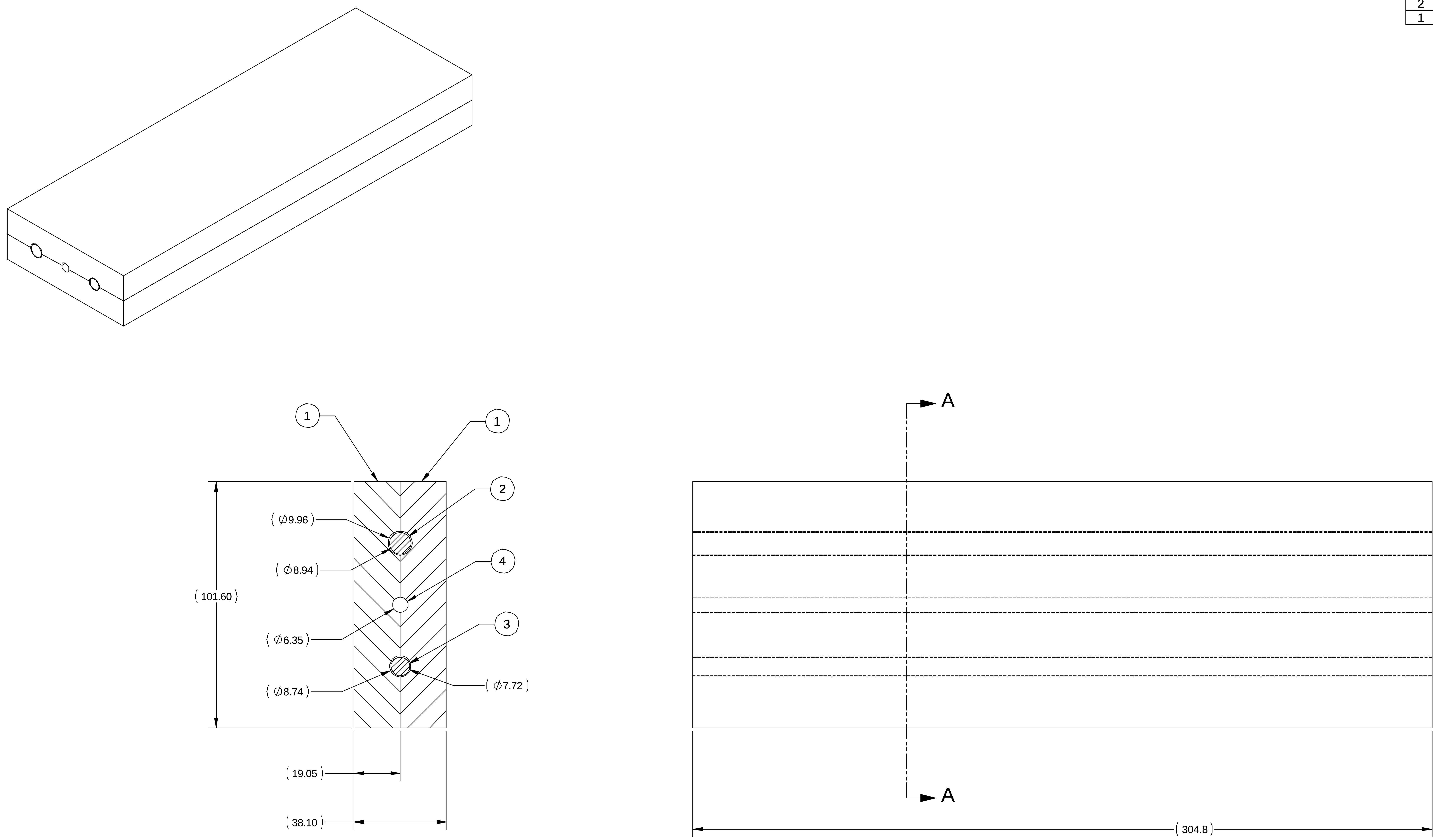
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
SPACEFRAME
STIFFENING TUBE MOLD ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1	DO NOT SCALE PRINTS
	ASSEM	N/A	SHEET 1 OF 1	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F711 4 SIZE	REV. -

DWG. NO.	SIZE	REV.	SH.
21F713 4		-	1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
4	21F713-3	1	MOLD ALIGNMENT ROD	STEEL
3	21F713-5	1	VERTEX JOINING PIN MANDREL	STEEL
2	21715-1	1	VERTEX JOINT INSERT MANDREL	STEEL
1	21F713	2	VERTEX TUBE INSERT MOLD CAVITY	STEEL



SECTION A-A
SCALE 1 : 1

NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS IN MILLIMETERS
2. MOLD USED TO FORM VERTEX JOINT INSERT AND VERTEX JOINING PIN

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES	
X.X ± 0.5	FRAC. ± 1/64
X.XX ± 0.25	ANGLES ± 30'
X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO. / DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD	TAG	
PROJECT NUMBER	ATL-IP-ED-XXXX	US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME	US ATLAS SILICON SUBSYSTEM	
DWG BY	W. K. MILLER	DATE 5/8/2001
CHK BY	BILL WILDS	DATE 5/31/2001
APR BY	E. ANDERSSEN	DATE ????

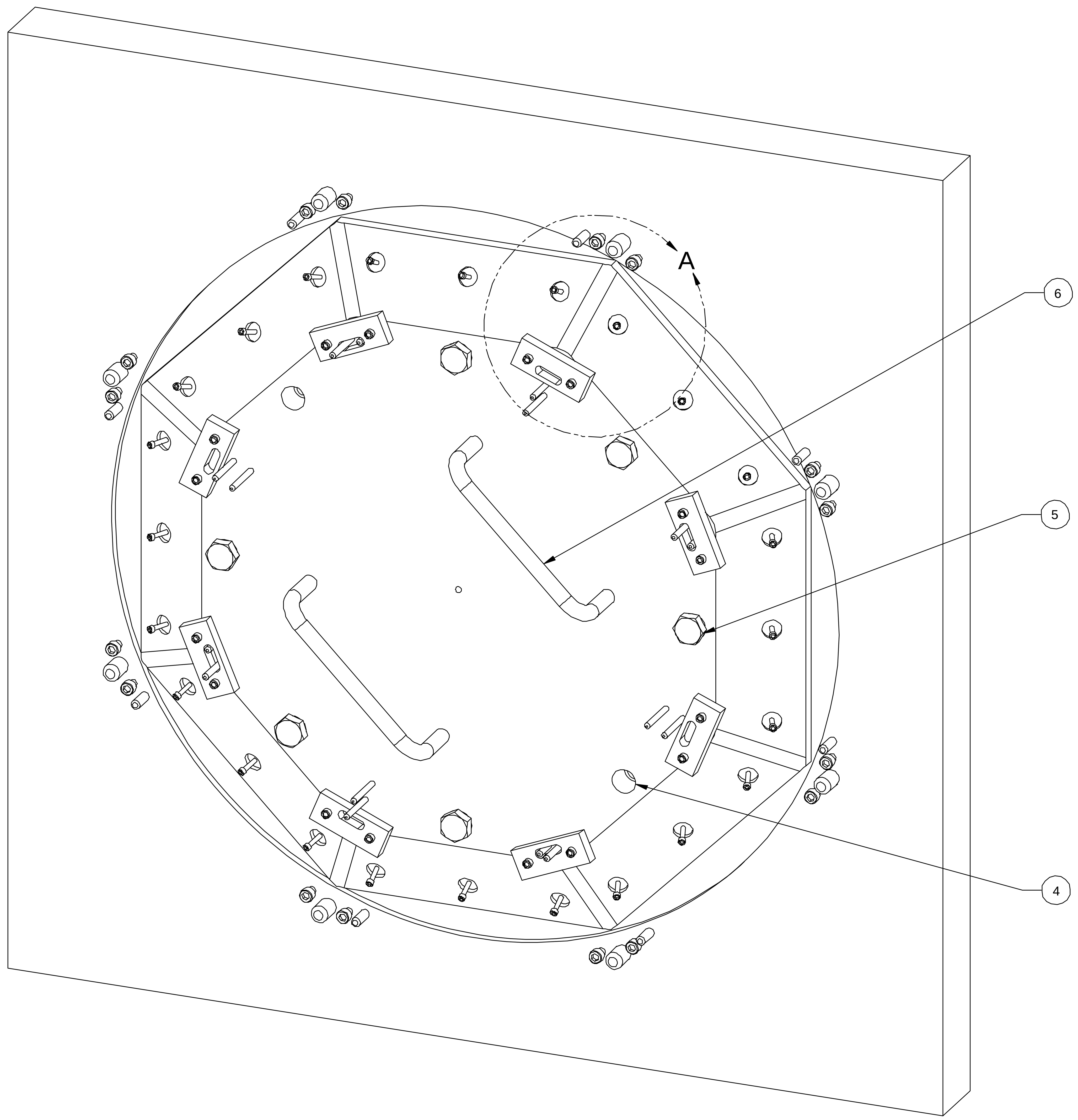
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

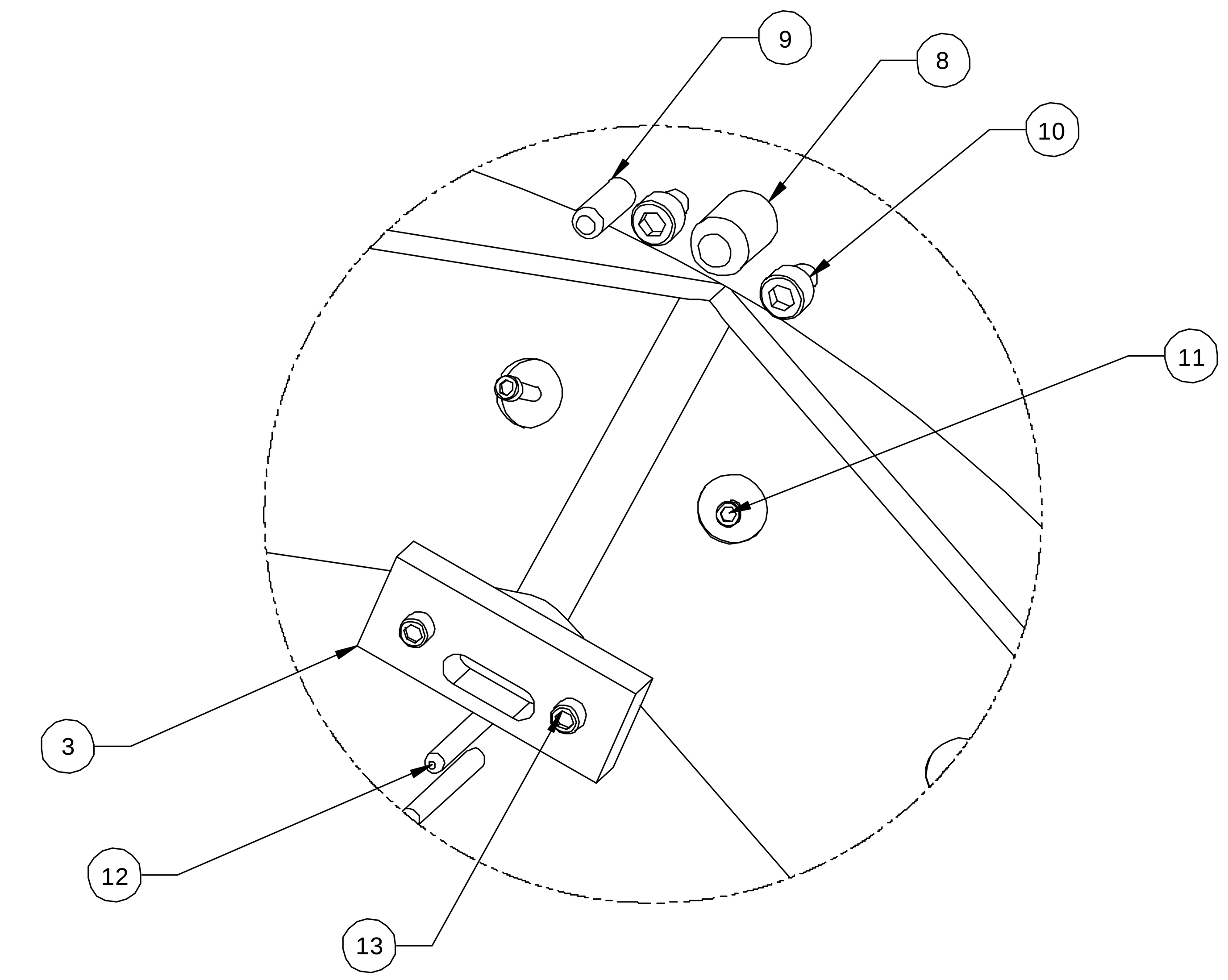
ATLAS PIXEL DETECTOR
SPACEFRAME
VERTEX TUBE MOLD ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE:	DO NOT SCALE PRINTS
	ASSEM	N/A	1:1	SHEET 1 OF 1
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. / SIZE	REV.
	P1AP-11	AP6250	21F713 4	-

DWG. NO.	SIZE	REV.	SH.
21F746	4	-	1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
14		4	3.00 DIA. GAGE PIN X 25.4 LONG	STEEL
13		16	M3 X .50 SOCKET HEAD CAP SCREW X 25.4 LONG	STEEL
12		12	3.30 DIA. GAGE PIN X 25.4 LONG	STEEL
11		24	#2-56 UNC-2A SOCKET HEAD CAP X .375 LONG	STEEL
10		16	M4 X .7 SOCKET HEAD CAP SCREW X 8.0 LONG	STEEL
9		8	4.80 DIA. GAGE PIN X 25.4 LONG	STEEL
8		8	8.91 DIA. GAGE PIN X 25.4 LONG	STEEL
7		4	#8-32 UNC-2A SOCKET HEAD CAP SCREW	STEEL
6		2	4" HANDLE, BLACK ANODIZE ALUM	ALUM
5		6	M8 X 38.1 HEX HEAD BOLT	STEEL
4		2	1/2" DIA. DOWEL PIN	STEEL
3	21F749	8	ENDCONE BOND FIXTURE- INNER VERTEX CLAMP	ALUM
2	21F748	1	ENDCONE BOND FIXTURE - TOP PLATE	GRAPHITE
1	21F747	1	ENDCONE BOND FIXTURE - BOTTOM PLATE	GRAPHITE





DETAIL A
SCALE 1.25 : 1

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEAN FROM OIL, GREASE, DIRT AND CHIPS
5. ALL TOLERANCES ARE REFERENCE; BASED UPON INDIVIDUAL PART TOLERANCES
6. APPLY LESS THAN 1/3 RECOMMENDED TORQUE RATING FOR INDIVIDUAL SCREWS TO PREVENT PULLING HELICOILS OUT OF GRAPHITE
7. INSERT PINS INTO HOLES TO 2X DIA. DEPTH ONLY TO ALLOW FOR EASY REMOVAL

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES	
X.X ± 0.5	FRAC. ± 1/64
X.XX ± 0.25	ANGLES ± 30'
X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.
DEL TO		DATE ISSD
SURFACE TREATMENT		DATE REQD
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

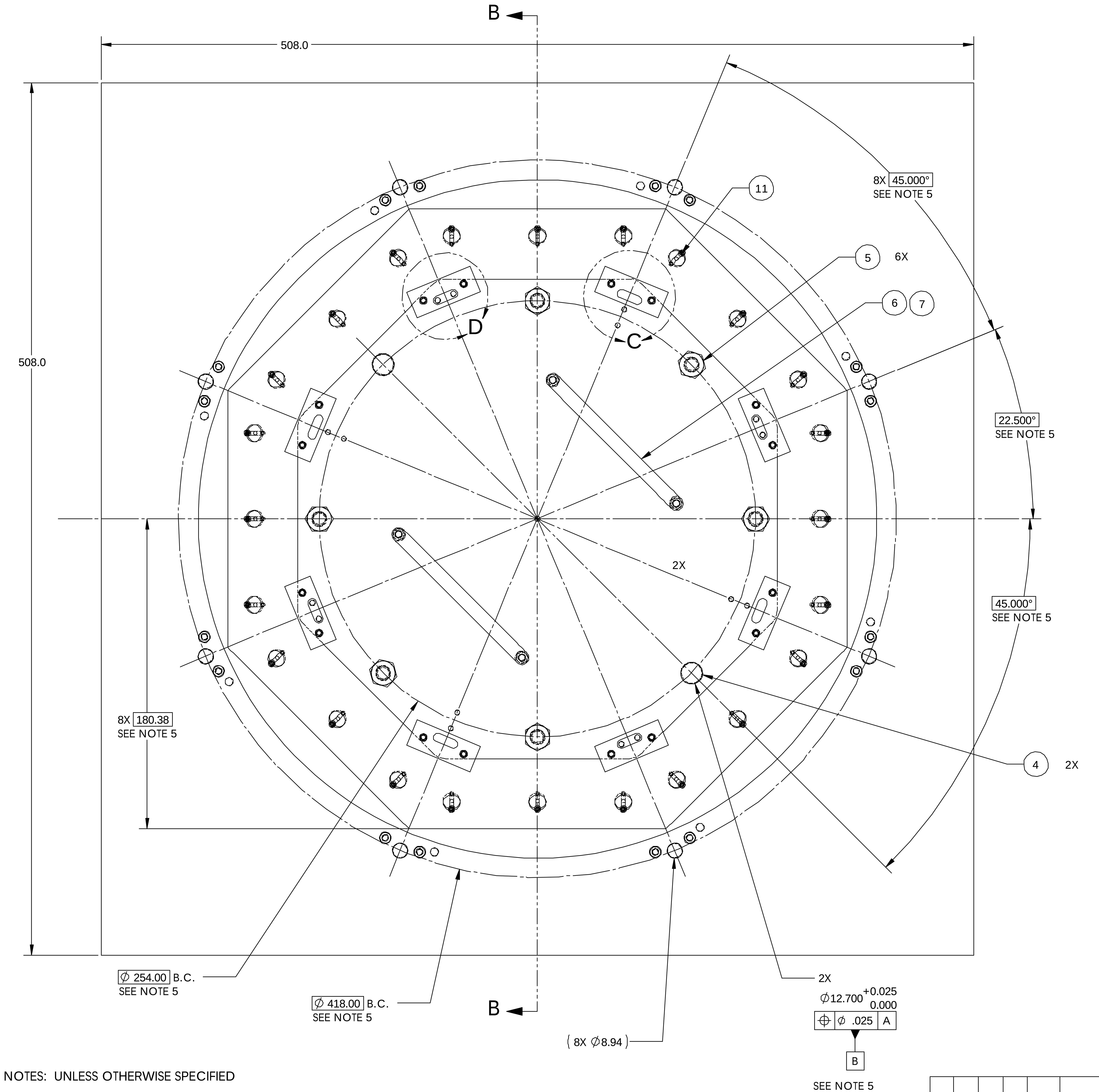
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

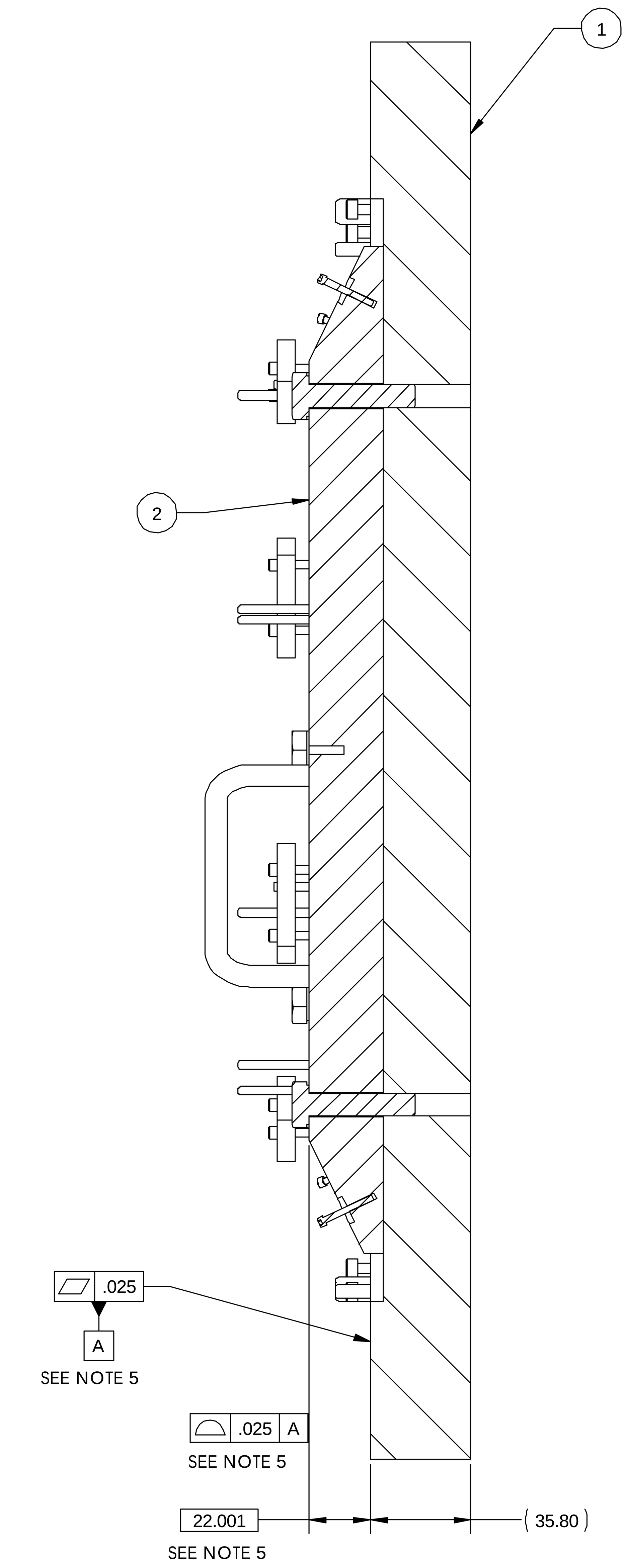
ATLAS PIXEL DETECTOR
SIDE "A" AND "C" ENDCONE
BONDING FIXTURE

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1.5	DO NOT SCALE PRINTS
	ASSEM	21F745	SHEET 1 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. 21F746	SIZE 4 / REV. -
	P1AP-11	AP6250		

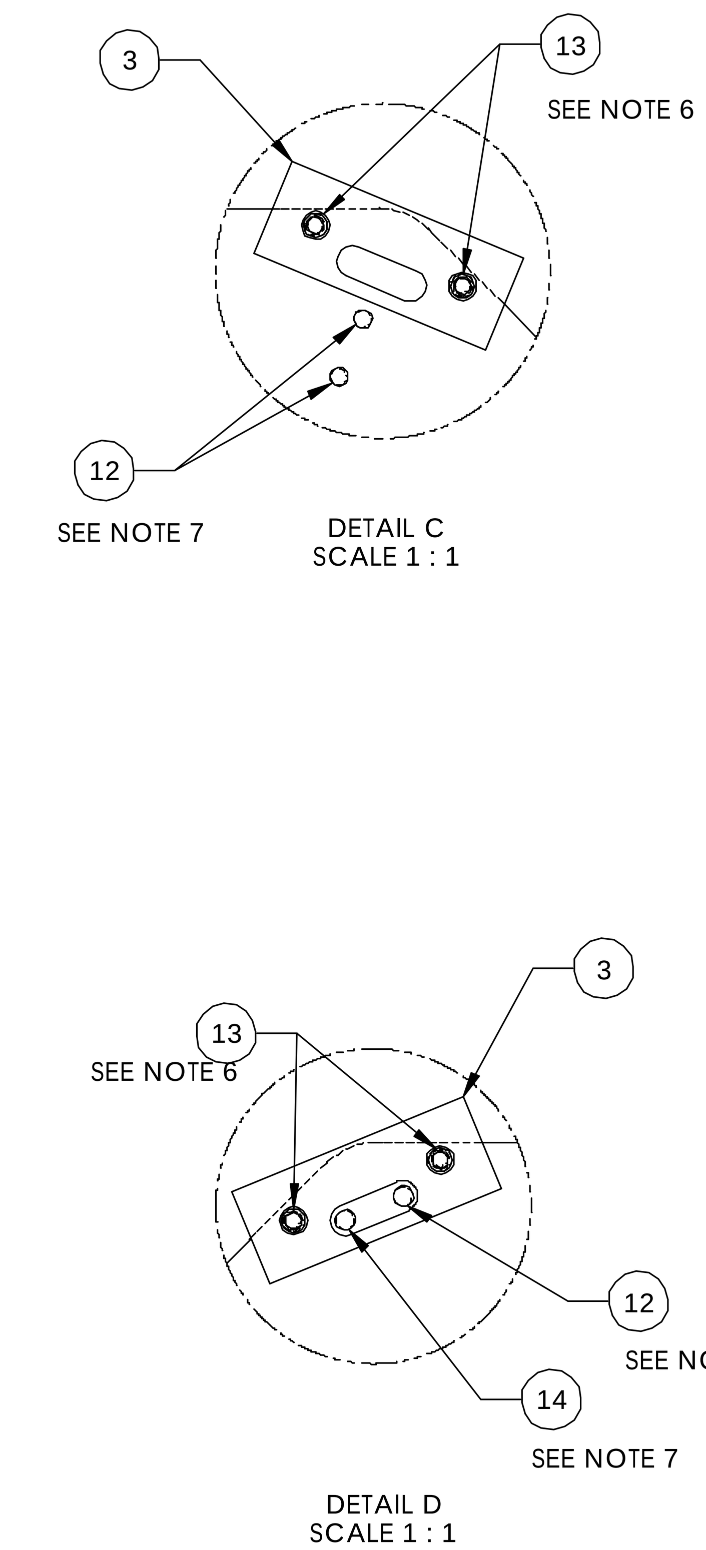
DWG. NO.	SIZE	REV.	SH.
21F746	4	-	2

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL





SECTION B-B
SCALE 1 : 1.5



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEAN FROM OIL, GREASE, DIRT AND CHIPS
5. ALL TOLERANCES ARE REFERENCE; BASED UPON INDIVIDUAL PART TOLERANCES
6. APPLY LESS THAN 1/3 RECOMMENDED TORQUE RATING FOR INDIVIDUAL SCREWS TO PREVENT PULLING HELICOILS OUT OF GRAPHITE
7. INSERT PINS INTO HOLES TO 2X DIA. DEPTH ONLY TO ALLOW FOR EASY REMOVAL

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO.	NO. REQD	SER NO.
DEL TO		DATE ISSD
SURFACE TREATMENT		DATE REQD
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

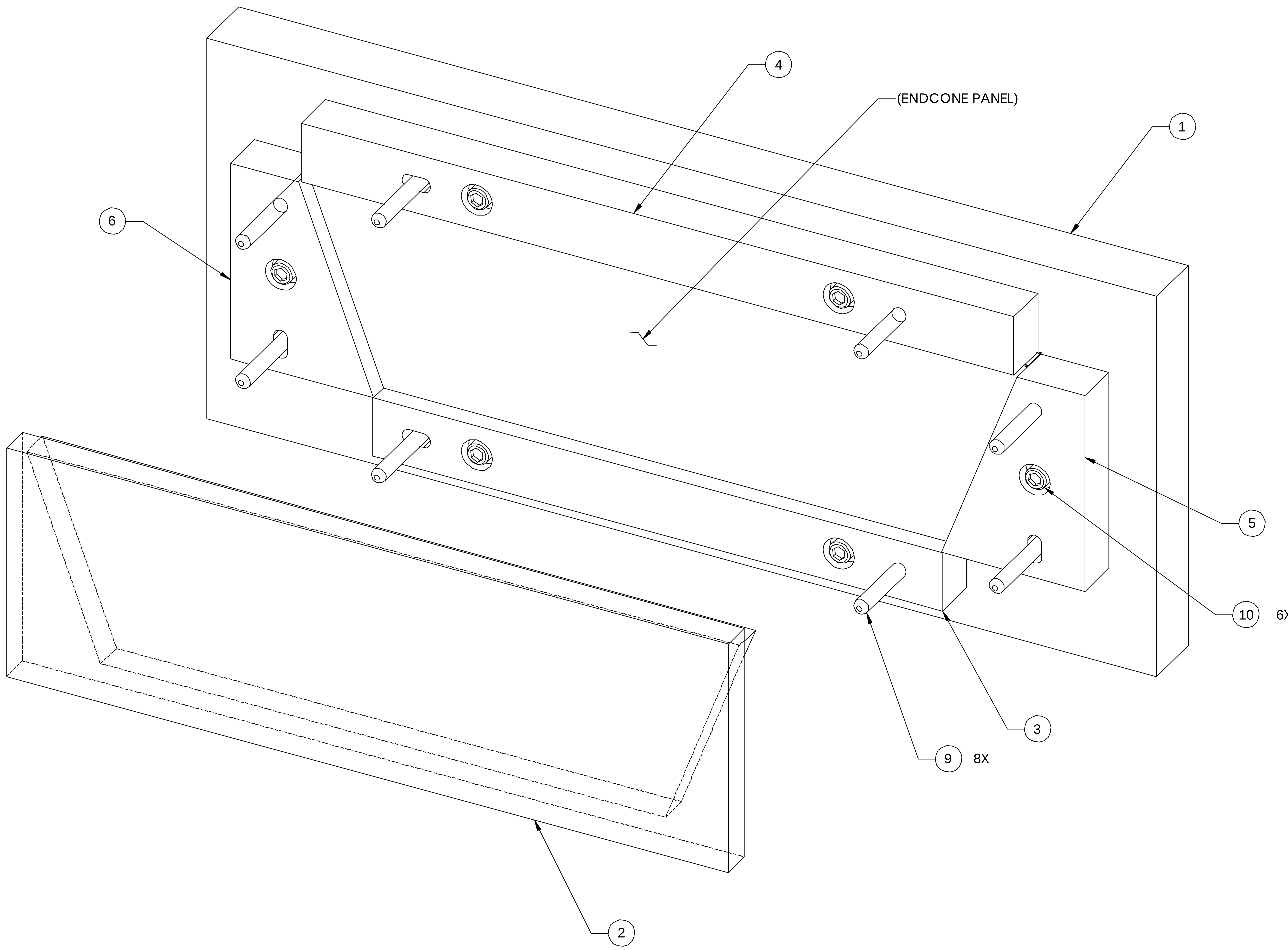
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
SIDE "A" AND "C" ENDCONE
BONDING FIXTURE

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE: 1:1.5	DO NOT SCALE PRINTS
	ASSEM	21F745	SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. SIZE	REV.
	P1AP-11	AP6250	21F746 4	-

DWG. NO.	SIZE	REV.	SH.
21F750	4	-	1

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
10		6	M3 X .50 SOCKET HD CAP SCREW X 12.7	STEEL
9		8	3.18 mm DIA. GAGE PIN	STEEL
8	21F756-3	2	BOND FIXTURE TEMPORARY INSERT #2	ALUM
7	21F756-1	2	BOND FIXTURE TEMPORARY INSERT #1	ALUM
6	21F755-3	1	BOND FIXTURE CAVITY PLATE	ALUM
5	21F755-1	1	BOND FIXTURE CAVITY PLATE	ALUM
4	21F754	1	BOND FIXTURE CAVITY PLATE	ALUM
3	21F753	1	BOND FIXTURE CAVITY PLATE	ALUM
2	21F752	1	BOND FIXTURE PRESSURE PLATE	ALUM
1	21F751	1	BOND FIXTURE BASEPLATE	ALUM



NOTES: UNLESS OTHERWISE SPECIFIED

1. SEE PART FOR ADHESIVE SPECIFICATIONS

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2

CHAMFER ENDS OF ALL SCREW THREADS 30°

CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS

BREAK EDGES .016 MAX. ON MACHINED WORK

REMOVE BURRS, WELD SPLATTER & LOOSE SCALE

IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

ACCT NO. | NO. REQD | SER NO. | DATE ISSD

DEL TO | DATE REQD

SURFACE TREATMENT

IDEN METHOD TAG

PROJECT NUMBER ATL-IP-ED-XXXX

US ATLAS SILICON SUBSYSTEM (LOGO)

PROJECT NAME US ATLAS SILICON SUBSYSTEM

DWG BY W. K. MILLER — DATE 5/8/2001

CHK BY BILL WILDS — DATE 5/31/2001

APR BY E. ANDERSSEN — DATE ????

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

UNIVERSITY OF CALIFORNIA - BERKELEY

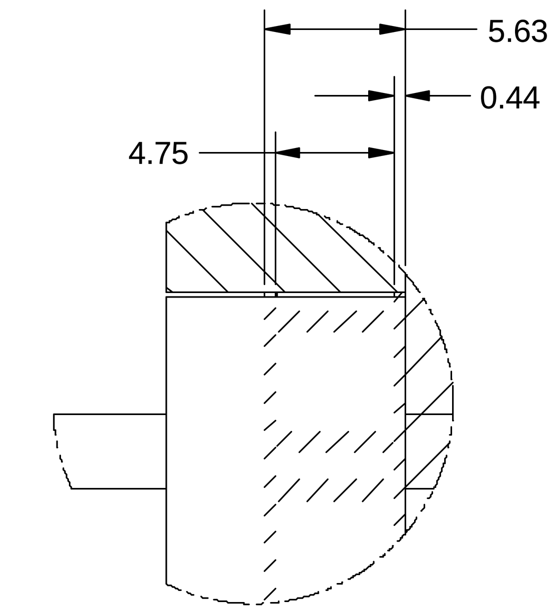
ATLAS PIXEL DETECTOR
ENDCONE PANEL
BOND FIXTURE ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE:	DO NOT SCALE PRINTS
	ASSEM	N/A	2:1	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. / SIZE	REV.
	P1AP-11	AP6250	21F750 4	-

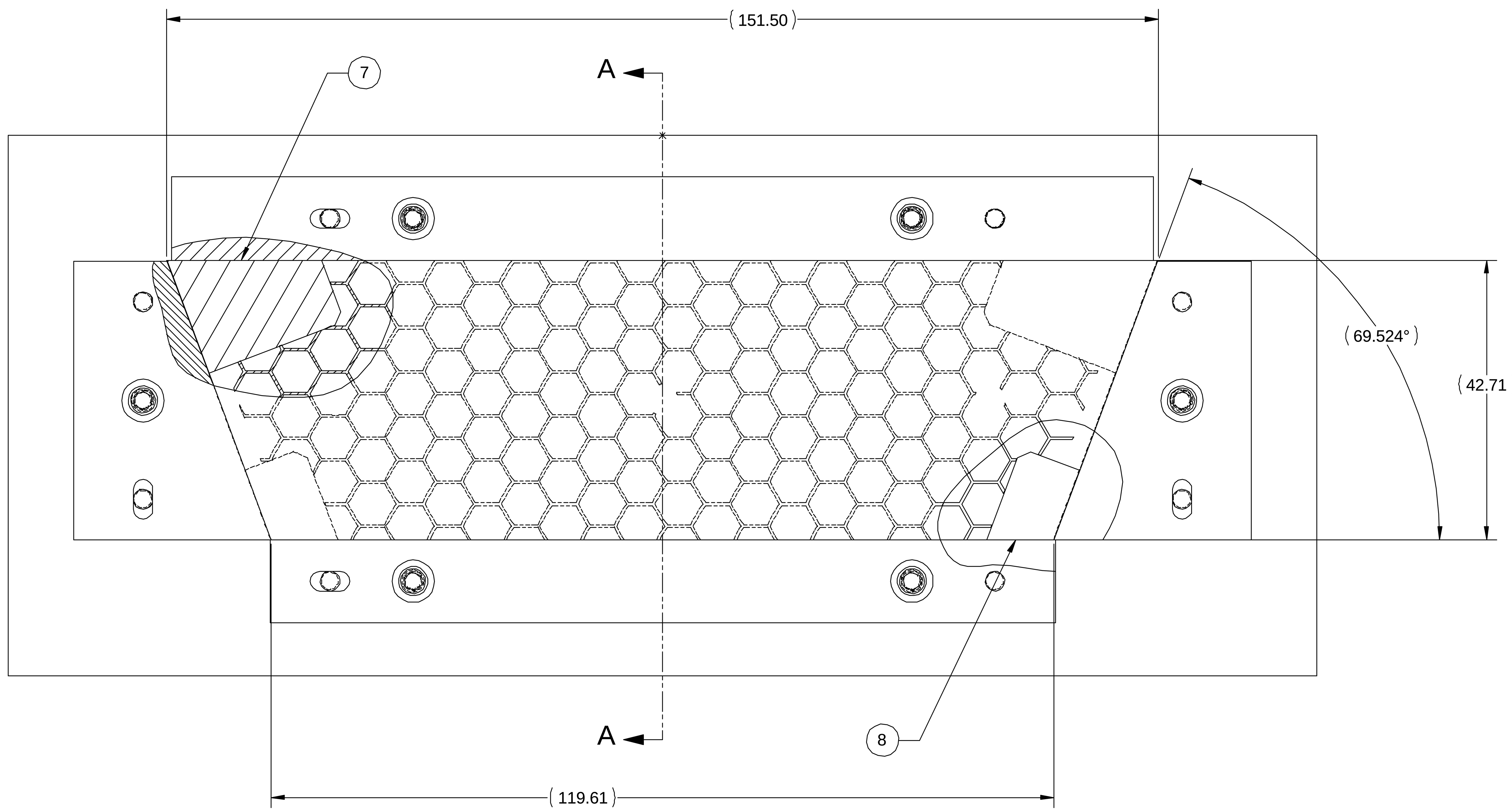
SHEET 1 OF 2

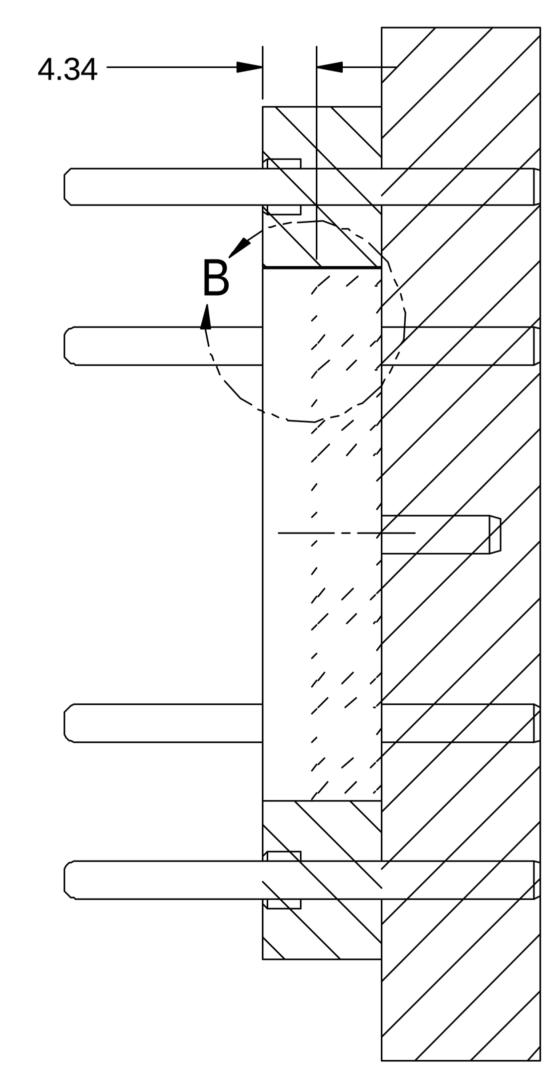
DWG. NO.	SIZE	REV.	SH.
21F750	4	-	2

ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL



DETAIL B
SCALE 4 : 1





SECTION A-A
SCALE 2 : 1

ITEM 2 NOT SHOWN

NOTES: UNLESS OTHERWISE SPECIFIED

1. SEE PART FOR ADHESIVE SPECIFICATIONS

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X ± 0.5	FRAC. ± 1/64
	X.XX ± 0.25	ANGLES ± 30'
	X.XXX ± 0.013	FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS		SER NO.
ACCT NO.	NO. REQD	DATE ISSD
DEL TO		DATE REQD
SURFACE TREATMENT		
IDEN METHOD TAG		
PROJECT NUMBER ATL-IP-ED-XXXX		US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM		
DWG BY W. K. MILLER		DATE 5/8/2001
CHK BY BILL WILDS		DATE 5/31/2001
APR BY E. ANDERSSEN		DATE ????

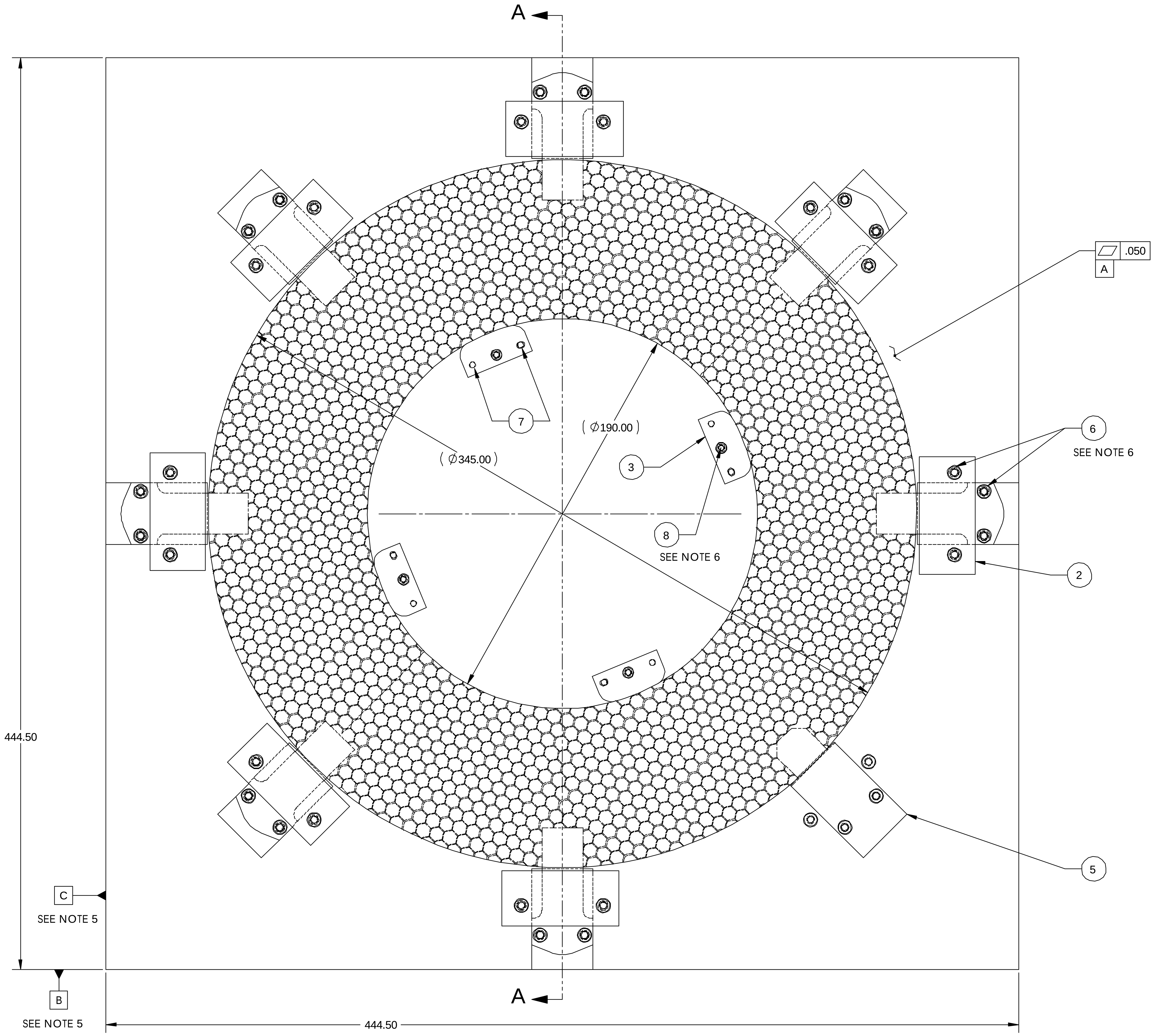
ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

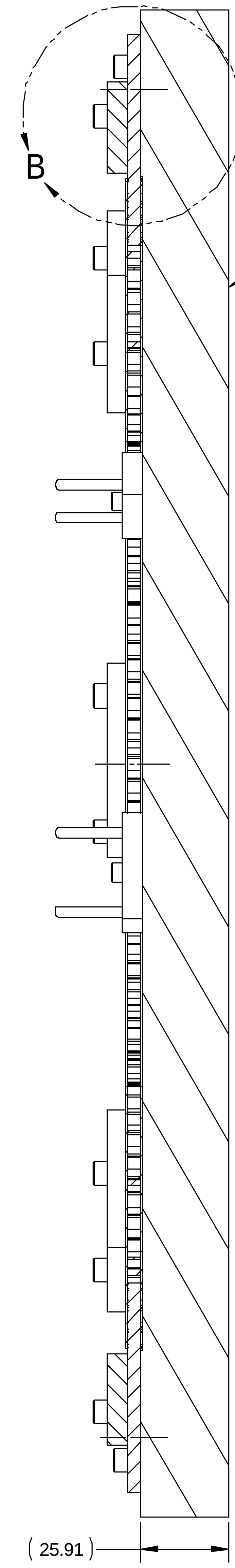
ATLAS PIXEL DETECTOR
ENDCONE PANEL
BOND FIXTURE ASSEMBLY

MICROFILMED:	DWG. TYPE ASSEM	SHOWN ON N/A	SCALE: 2:1	DO NOT SCALE PRINTS
			SHEET 2 OF 2	
PATENT CLEAR:	DESIGN ACCT. NO. P1AP-11	CATEGORY CIDE AP6250	DWG. NO. 21F750 SIZE 4	REV. -

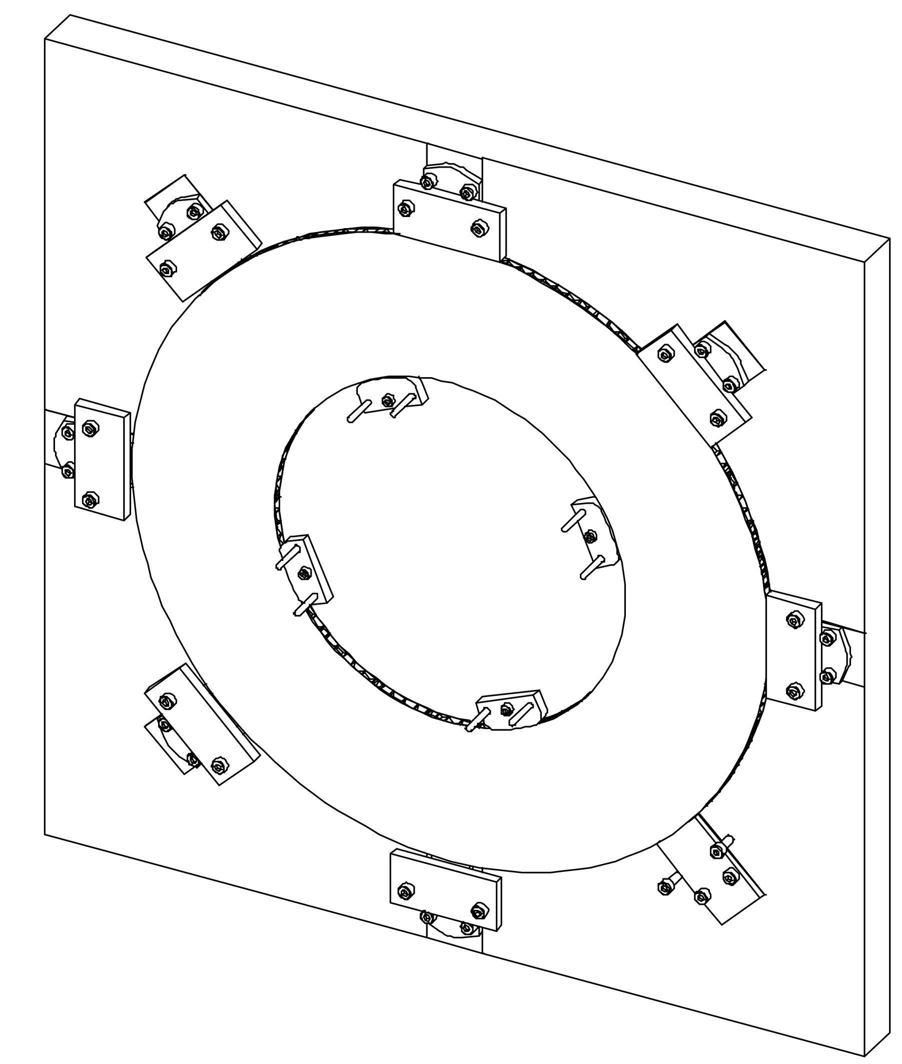
DWG. NO.	SIZE	REV.	SH.
21F775 4		-	1

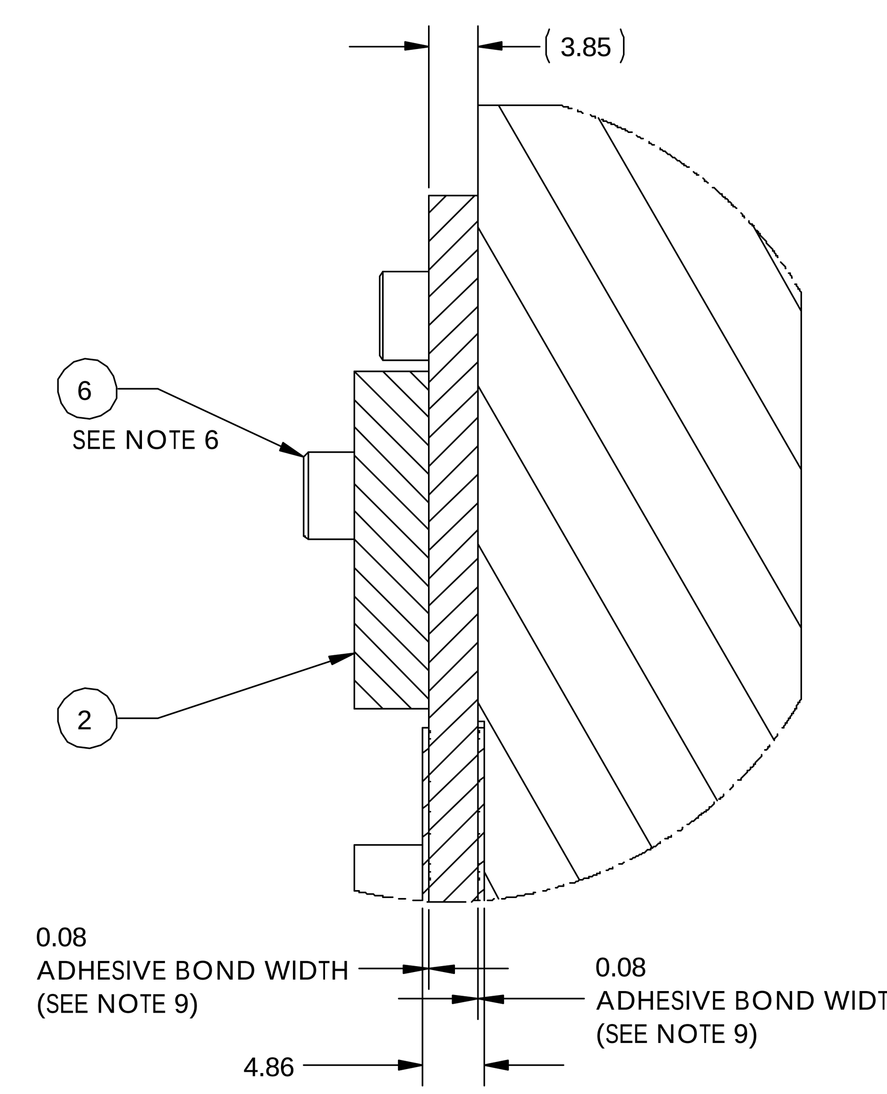
ITEM	PART NO.	REQD	DESCRIPTION	MATERIAL
8		4	M3 X .50 SOCKET HEAD CAP SCREW X 12.7	STEEL
7		8	3.00 DIA. GAGE PIN	STEEL
6		32	M4 X .7 SOCKET HEAD CAP SCREW X 12.7 LONG	STEEL
5	21F779	8	END STIFFENER HONEYCOMB ALIGNMENT BLOCK	ALUM
4	21F778	1	END STIFFENER CAUL PLATE (NOT SHOWN)	ALUM
3	21F777	4	END STIFFENER FACESHEET ALIGNMENT BLOCK	ALUM
2	21F777	8	END STIFFENER VERTEX PLATE CLAMP	ALUM
1	21F776	1	END STIFFENER BOND FIXTURE PLATE	GRAPHITE





SECTION A-A





DETAIL B
SCALE 2 : 1

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS IN MILLIMETERS
2. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994
3. SURFACE TEXTURE PER ANI/ASME B 46.1-1985
4. PARTS TO BE THOROUGHLY CLEAN FROM OIL, GREASE, DIRT AND CHIPS
5. ALL TOLERANCES ARE REFERENCE; BASED UPON INDIVIDUAL PART TOLERANCES
6. APPLY LESS THAN 1/3 RECOMMENDED TORQUE RATING FOR INDIVIDUAL SCREWS TO PREVENT PULLING HELICOILS OUT OF GRAPHITE
7. INSERT PINS INTO HOLES TO 2X DIA. DEPTH ONLY TO ALLOW FOR EASY REMOVAL
8. SPRAY MOLD RELEASE ON GRAPHITE PLATE IS ACCEPTABLE, TAPE IS PROHIBITED
9. HYSOL 9396 ADHESIVE WITH 3 MIL GLASS BEADS TYP FOR BOND JOINTS, SEE FABRICATION PROCEDURE DOCUMENT FOR EXACT SPECIFCATIONS

REV	DWG	CHK	ZONE	DATE	CHANGES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X ± 0.5 | FRAC. ± 1/64 | X.XX ± 0.25 | ANGLES ± 30' | X.XXX ± 0.013 | FINISH 1.6

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5m & B46.1

SHOP ORDERS

SER NO. | ACCT NO. | NO. REQD | DATE ISSD | DEL TO | DATE REQD | SURFACE TREATMENT | IDEN METHOD TAG

PROJECT NUMBER ATL-IP-ED-XXXX
US ATLAS SILICON SUBSYSTEM (LOGO)
PROJECT NAME US ATLAS SILICON SUBSYSTEM
DWG BY W. K. MILLER DATE 5/8/2001
CHK BY BILL WILDS DATE 5/31/2001
APR BY E. ANDERSSEN DATE ????

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA - BERKELEY

ATLAS PIXEL DETECTOR
SPACEFRAME END STIFFENER
BOND FIXTURE ASSEMBLY

MICROFILMED:	DWG. TYPE	SHOWN ON	SCALE:	DO NOT SCALE PRINTS
	ASSEM	N/A	1:1.25	
PATENT CLEAR:	DESIGN ACCT. NO.	CATEGORY CIDE	DWG. NO. / SIZE	REV.
	P1AP-11	AP6250	21F775 4	-

SHEET 1 OF 1

Appendix D - ATLAS Pixel Detector-Global Supports Drawings

LBNL Dwg	Description
21F650	**Spaceframe Assy**
21F651	**Central Section Assembly**
21F652	Central Section Sub Panel Assy
21F653	Central Section Stiffening Tube
21F654	Central Section Panel Outer Corner
21F655	Central Section Panel Inner Corner
21F656	Central Section Panel Corner Block-1
21F657	Central Section Panel Corner Block-2
21F658	Frame Joining Pin
21F659	Central Section Sub Panel Inner Face Sheet
21F660	Central Section Sub Panel Outer Face Sheet
21F665	**End Section Assembly**
21F666	End Section Sub Panel -1
21F667	End Section Sub Panel -2
21F668	End Section Sub Panel Face Sheet
21F669	Vertex Joint Assembly
21F670	End Section Panel Corner Block -1 Assembly
21F671	End Section Panel Inner Corner
21F672	End Section Panel Outer Corner
21F673	End Section Stiffening Tube
21F674	End Section Panel Corner Block -1
21F675	End Section Panel Corner Block -2
21F676	Corner Block Threaded Insert
21F677	Vertex Joint Insert
21F678	Vertex Joint Plate
21F679	End Section Panel Corner Block -2 Assembly
21F720	**A Side End Cone Assy**
21F721	A side End Cone Frame
21F722	End Cone Flat Plate Panel Assembly
21F723	End Cone Corner Stiffener
21F724	End Cone Treaded Insert Body
21F725	End Cone Outer Corner Vertex
21F726	End Cone Treaded Insert Washer
21F727	End Cone Inner Vertex Long End
21F728	End Cone Inner Vertex One Hole A Side
21F729	End Cone Inner Vertex Two Hole A Side
21F730	End Cone Inner Vertex Hole & Slot A side
21F731	End Cone Inner Vertex Inline Hole & Slot
21F732	End Cone Mount Pad Two Hole with Pinhole
21F733	End Cone Mount Pad Inline Holes
21F734	**C Side End Cone Assembly**
21F735	C side End Cone Frame
21F736	End Cone Inner Vertex Two Hole C Side
21F737	End Cone Inner Vertex One Hole C Side
21F738	End Cone Mount Pad One Hole with Notch
21F739	End Cone Mount Pad One Hole
21F740	End Cone Mount Pad Two Hole C Side
21F770	**Stiffening Panel Assembly**
21F771	Vertex Tab
21F772	Face Sheet

ATLAS Pixel Detector-Tooling Drawings, Global Supports

LBNL-Drawing	
21F687	**End Section Bond Fixture Assembly**
21F688	**Spaceframe Bond Fixture Sub-Assembly**
21F689	Tube Weldment
21F690	**Spaceframe Bond Fixture Two Plate Pre-Alignment**
21F691	Fixture Sub-Panel Orientation Plate
21F692	Fixture Vertex Corner Joint Alignment Plate
21F693	Fixture Tube Baseplate Stand
21F694	Fixture Baseplate
21F695-1	Custom tooling pin
21F695-3	Joining Pin Centering Bushing
21F699	**Central Section Sub Panel Bonding Fixture Assembly**
21F700	**End Section Sub Panel Bonding Fixture Assembly**
21F701-1	End Section Sub Panel Bond Fixture Base
21F701-3	Central Section Sub Panel Bond Fixture Base
21F702	Central Section Sub Panel Bond Fixture End Plate
21F703	End Section Sub Panel Bond Fixture End Plate
21F704	Sub Panel Bond Fixture Shoulder Screw
21F705	**Inner Vertex Stiffener Molded Assembly**
21F706	Inner Vertex Stiffener Mold Cavity
21F707	Inner Vertex Stiffener Mold Cavity Coverplate
21F708	**Outer Vertex Stiffener Molded Assembly**
21F709	Outer Vertex Stiffener Mold Cavity
21F710	Outer Vertex Stiffener Mold Insert
21F711	**Vertex Stiffening Tube Mold Cavity Assembly**
21F712	Vertex Stiffening Tube Mold Cavity
21F713	**Vertex Joint Tube Mold Cavity Assembly**
21F714	Vertex Joint Tube Mold Cavity
21F715-1	Centerless Ground Roundstock - Joint Insert Mandrel
21F715-3	Centerless Ground Roundstock -Mold Alignment Rod - Short
21F715-5	Centerless Ground Roundstock Joining Pin Mandrel
21F715-7	Centerless Ground Roundstock - Stiffening Tube Mandrel
21F715-9	Centerless Ground Roundstock - Mold Alignment Rod - Long
21F745	**"A" Side Endcone on Bond Fixture Assembly**
21F746	**Endcone Bond Fixture Assembly**
21F747	Bottom Graphite Plate
21F748	Top Graphite Plate
21F749	Vertex Inner Plate Clamp
21F750	**Panel in Bond Fixture Assembly**
21F751	Bond Fixture Baseplate
21F752	Bond Fixture Coverplate
21F753	Bond Fixture Cavity Plate - Top
21F754	Bond Fixture Cavity Plate - Bottom
21F755-1	Bond Fixture Cavity Plate - Right Side
21F755-2	Bond Fixture Cavity Plate - Left Side
21F756-1	Temporary Bond Insert #1
21F756-3	Temporary Bond Insert #2
21F759	**Corner Vertex Plate Mold Assembly**
21F760	Vertex plate Mold Baseplate
21F761	Vertex plate Mold Press Plate
21F762	Vertex plate Mold Side Plate
21F763	Vertex plate Mold End Plate
21F775	**End Stiffener Bond Fixture Assembly**
21F776	End Stiffener Bond Fixture Plate
21F777	End Stiffener Bond Fixture Clamps
21F778	End Stiffener Bond Fixture Caul Plate
21F779	End Stiffener Bond Honeycomb Alignment Plate