

Key: Equipment Tools

Fullscale

All Bulkheads

- Set up the **round vice** (indexer?) on the **vertical mill**
- Face the part down to the required thickness
 - Note: These steps will likely be easier to program than to do manually
 - Use a **dial caliper** to measure the stock thickness and diameter and record both
 - Secure the stock in the vice
 - **Edgefind** (at ~1200 rpm), then set the center of the part at (0,0)
 - Use a **½" 2-flute endmill** to touch off the top of the part and lock the quill.
 - Move the bed out of the way of the endmill
 - Using the number you recorded for the stock thickness, move the knee up the appropriate amount to face the part
 - The 2 Avionics Bulkheads need to be 0.25" thick and the Forward and Aft Bulkheads need to be 0.375" thick
 - Example: If you measure the stock to be 0.500" thick and are making an Avionics Bulkhead, you must move the knee up $(0.5 - 0.25 =) 0.250"$
 - At an rpm of $\frac{200 \times 4}{0.5} = 1600 \text{ rpm}$, face the part, taking off ~0.020 per pass
 - Before altering your setup, double-check the thickness of your bulkhead

Note: from this point, the bulkhead designs will diverge. Be sure to follow the relevant procedures.

Forward Bulkhead

- Use one of the 0.375" thick pieces
- Use a **center drill** to mark holes
 - At (0,0)
 - At 1" above (forward of from where you are standing) the part's center
- Eye Bolt
 - Use a **6.6mm drill bit** to drill a hole in the center of the part (at (0,0)) at an rpm of $\frac{200 \times 4}{0.259843} = 3075 \text{ rpm}$
 - M6 eye bolt
- Manufacturing jig hole
 - Use a **⅛" drill bit** to drill a hole 1" above the center of the part at an rpm of $\frac{200 \times 4}{0.125} = 6400 \text{ rpm}$
- Remove the part from the vise and place it into the **Forward Bulkhead Manufacturing Jig** such that the bulkhead aligns with the jig's pegs
- Either remove the round vice or move to another machine with a **standard vice**
- Place the manufacturing jig/bulkhead into the vice perpendicular such that the 6"x6" face of the part is facing you (at the front of the machine)
 - Use a **mechanical stop** when securing the part in the vice to increase manufacturing speed

- M4 Holes
 - Edgefind (at~1200 rpm), set the center of the part at (0,0)
 - This should align with the perpendicular holes in the jig
 - Use a center drill to mark a hole at (0,0)
 - The jig may be too thick for this. If it is, ignore this step
 - Place a 3.3mm drill bit into the mill
 - Set the plunge depth to 0.5"
 - With the mill not running, touch the drill to the part
 - Lock the quill
 - Set the quill stop
 - Raise the quill
 - Raise the knee 0.5"
 - Drill the hole at an rpm of $\frac{200*4}{0.118} = 6770 \text{ rpm}$
 - Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat these steps until all four sides of the part have a hole at its center
 - Use an M4x0.70 tap (in the vertical mill to decrease likelihood of breaking a tap) to tap the hole
 - Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat this step until all four sides of the part have a threaded M4x0.70 hole at its center
- Remove the part from the mill and inspect it. Ensure that the applicable above steps have been followed
- Use dial calipers to check the diameter of your bulkhead
- If necessary, turn the part down to a 6" diameter circle on the lathe
 - Turn the jaws of the lathe such that the pieces of the jaws that protrude furthest in the machine's Z direction are toward the spindle's axis of rotation
 - Use a live center to FIRMLY press the part against the jaws
 - The live center should be pressing into the eye bolt hole on the forward and aft bulkheads
 - Place a shop towel between the part and the jaws
 - With the machine off, LIGHTLY touch the turning tool to the edges of the part. Set this as your measured diameter in the X direction.
 - Back the cutting tool away (in the X and Z directions) such that the rotation of the part clears the cutting tool in both the X and Z directions.
 - GRADUALLY turn the part down to 3" radius by making passes at it with the turning tool at an rpm of $\frac{200*4}{6} = 133 \text{ rpm}$ (preferably considerably less)

Aft Bulkhead

- Use one of the 0.375" thick pieces
- Use a center drill to mark holes according to dimensional drawing
 - Because the holes are defined according to angles and radii, program the holes for use with the center drill and drill bits later

- 1x at (0,0) (for center bushing)
 - 1x for eye bolt hole
 - 3x for airbrake paddle screws
 - 2x for wiring hole Connector
- Center Bushing bolt hole
 - Use a 6.6mm drill bit to drill a hole in the center of the part (at (0,0)) at an rpm of $\frac{200*4}{0.259843} = 3075 \text{ rpm}$
 - Note: 6.6mm=0.259843"
 - M6 bolt
- Eye bolt hole
 - Use a 6.6mm drill bit to drill a hole at an rpm of $\frac{200*4}{0.259843} = 3075 \text{ rpm}$
 - Note: 6.6mm=0.259843"
 - M6 Eye bolt
- Airbrake paddle holes
 - Metric: Use a 6.6mm drill bit to drill 3 holes (or use the bolt hole pattern) at an rpm of $\frac{200*4}{0.259843} = 3075 \text{ rpm}$
 - M6 screws
- Wire connector holes
 - Use a #43 drill bit to drill the holes at an rpm of $\frac{200*4}{0.089} = 8900 \text{ rpm}$
 - Before moving on, go ahead and use a #4-40 tap (in the mill for stability... BE CAREFUL!) so that you don't have to find the hole again
- Wire Connector Hole
 - Use a 1/8" end mill and program a rectangular pocket through the part according to the dimensional drawing
 - $\frac{200*4}{0.125} = 6400 \text{ rpm}$
 - Note: The dimensions in the drawing are for programming the pocket
- BEFORE REMOVING THE BULKHEAD FROM THE VISE use a sharpie to mark a vertical line at the right of the part. This line should be on the right side of an airbrake paddle hole
- Remove the part from the vise and place it into the Aft Bulkhead Manufacturing Jig such that the bulkhead aligns with the jig's pegs
 - The line you drew should line up with a slot on the inside of the manufacturing jig. This ensures that the bulkhead is oriented correctly. Both the slot and the line should be facing you.
- Either remove the round vice or move to another machine with a standard vice
- Place the manufacturing jig/bulkhead into the vice perpendicular such that the 6"x6" face of the part is facing you (at the front of the machine)
 - Use a mechanical stop when securing the part in the vice to increase manufacturing speed
- M4 Holes
 - Edgefind (at~1200 rpm), set the center of the part at (0,0)
 - This should align with the perpendicular holes in the jig

- Use a **center drill** to mark a hole at (0,0)
 - The jig may be too thick for this. If it is, ignore this step
- Place a **3.3mm drill bit** into the mill
- Set the plunge depth to 0.5"
 - With the mill not running, touch the drill to the part
 - Lock the quill
 - Set the quill stop
 - Raise the quill
 - Raise the knee 0.5"
- Drill the hole at an rpm of $\frac{200*4}{0.118} = 6770 \text{ rpm}$
- Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat these steps until all four sides of the part have a hole at its center
- Use an **M4x0.70 tap** (in the **vertical mill** to decrease likelihood of breaking a tap) to tap the hole
- Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat this step until all four sides of the part have a threaded M4x0.70 hole at its center
- Inspect the part to ensure that the applicable above steps have been followed. Remove the part from the mill.
- Use dial calipers to check the diameter of your bulkhead and test its fit
- If necessary, turn the part down to a 6" diameter circle on the **lathe**
 - Turn the jaws of the lathe such that the pieces of the jaws that protrude furthest in the machine's Z direction are toward the spindle's axis of rotation
 - Use a live center to FIRMLY press the part against the jaws
 - The live center should be pressing into the eye bolt hole on the forward and aft bulkheads
 - Place a **shop towel** between the part and the jaws
 - With the machine off, LIGHTLY touch the **turning tool** to the edges of the part. Set this as your measured diameter in the X direction.
 - Back the cutting tool away (in the X and Z directions) such that the rotation of the part clears the cutting tool in both the X and Z directions.
 - GRADUALLY turn the part down to 3" radius by making passes at it with the **turning tool** at an rpm of $\frac{200*4}{6} = 133 \text{ rpm}$ (preferably considerably less)

Forward and Aft AVIONICS Bulkheads

- Use one of the 0.25" round stock pieces
- Secure "round vise" in standard vise and secure material stock in round vise
- Slot pattern for Avionics board
 - Make a 2 plunge cuts using a **0.25" 2-flute endmill** (might be easier to program)
- **Center Drill** various holes according to **dimensional drawing**
 - 2x M10 Lead screw holes
 - 2x Black Powder Cup mounting holes

- 1x Wire hole
 - AFT ONLY
 - 2x Wire Connector Holes
- MUST center drill for a “hole” at (0,0) for lathe operations later
- Make Holes
 - 2x M10 Lead Screw Holes (medium fit)
 - Use an 11mm drill bit at an rpm of $\frac{200*4}{0.433071} = 1847 \text{ rpm}$ (or less)
 - Note: Cutting speed for aluminum is 200 SFPM; 11mm=0.433071”
 - 2x Black Powder Cup mounting holes
 - Use a #36 (0.107”) drill bit at an rpm of $\frac{400*4}{0.107} = 14950 \text{ rpm}$ (or less)
 - Wire hole(s)
 - Use a 3/16” (0.1875”) drill bit at an rpm of $\frac{200*4}{0.1875} = 7470 \text{ rpm}$ (or less)
- AFT ONLY
 - Wire Connector Hole
 - Use a 1/8” end mill and program a rectangular pocket through the part according to the dimensional drawing
 - $\frac{200*4}{0.125} = 6400 \text{ rpm}$
 - Note: The dimensions in the drawing are for programming the pocket
- Ensure that the above steps have been followed before removing the part from the vise!
- If necessary, turn the part down to a 6” diameter circle on the lathe
 - Measure and record the current bulkhead diameter
 - Turn the jaws of the lathe such that the pieces of the jaws that protrude furthest in the machine’s Z direction are toward the spindle’s axis of rotation
 - Use a live center to FIRMLY press the part against the jaws
 - The live center should be pressing into the center drilled “hole” on the forward and aft avionics bulkheads
 - Place a shop towel between the part and the jaws
 - With the machine on, LIGHTLY touch the turning tool to the edge of the part. Set the X direction value to the value you recorded for the part’s current diameter.
 - GRADUALLY turn the part down to a 3” radius
 - $\frac{200*4}{6} = 133 \text{ rpm}$
- Use the lathe and turning tool to turn a 1/8” (Z direction) lip into the part such that the smaller section diameter of the part is 5.83” in diameter (2.915” in radius). This smaller diameter should be located on the same side as the avionics board slots

ALL BULKHEADS

- Check that the part slides into the body tube. Gradually turn off more material with the lathe and turning tool until you are subjectively satisfied with the fit of the part
- Clean up your work area or face the *CONSEQUENCES*

Key: Equipment Tools

Subscale

All Bulkheads

- Set up the round vice (indexer?) on the vertical mill
- Edgefind (at ~1200 rpm) on the bulkhead and center drill a divot in the center
 - Or continue to drill a hole of the required size for the forward and aft bulkheads
- Flip the bulkhead around and do the same to the other side
 - It's pretty important that the holes
- Flip the jaws around on the lathe
- Face the part down to the required thickness
 - Use a dial caliper to measure the stock thickness and diameter and record both
 - Use the live center to press the stock against the chuck FIRMLY
 - Use a shop towel between the work and the chuck
 - Using the number you recorded for the stock thickness, face the part down to the required thickness
 - The 2 Avionics Bulkheads need to be 0.25" thick and the Forward and Aft Bulkheads need to be 0.375" thick
 - At an rpm of $\frac{200*4}{4} = 200 \text{ rpm}$ or LESS, face the part, taking off ~0.010 per pass down to a ~1/2" circle around the live center
- Avionics Bulkheads:
 - Before moving on, turn the lip
 - If this gives you trouble, then you can do the step with a circular profile on the lathe later
- Turn the part down to its required diameter about 2/3 of the way down the part, then flip it over and do the same to the last third
- Check the bulkhead's fit into the body tube before moving on and make adjustments as necessary
- Move to the vertical mill and the round vise. Edgefind and set the center of the part to be (0,0)

Note: from this point, the bulkhead designs will diverge. Be sure to follow the relevant procedures.

Forward Bulkhead

- Use one of the 0.375" thick pieces
- Face off the circle that was used on the lathe with the live center
- Use a center drill to mark holes
 - At (0,0)
 - At 1" above (forward of from where you are standing) the part's center
- Eye Bolt
 - Use a 6.6mm drill bit to drill a hole in the center of the part (at (0,0)) at an rpm of $\frac{200*4}{0.259843} = 3075 \text{ rpm}$
 - M6 eye bolt

- Manufacturing jig hole
 - Use a $\frac{1}{8}$ " drill bit to drill a hole 1" above the center of the part at an rpm of $\frac{200*4}{0.125} = 6400 \text{ rpm}$
- Remove the part from the vise and place it into the Forward Bulkhead Manufacturing Jig such that the bulkhead aligns with the jig's pegs
- Either remove the round vice or move to another machine with a standard vice
- Place the manufacturing jig/bulkhead into the vice perpendicular such that the 4" diameter face of the part is facing you (at the front of the machine)
 - Use a mechanical stop when securing the part in the vice to increase manufacturing speed
- M4 Holes
 - Edgefind (at~1200 rpm), set the center of the part at (0,0)
 - This should align with the perpendicular holes in the jig
 - Use a center drill to mark a hole at (0,0)
 - The jig may be too thick for this. If it is, ignore this step
 - Place a 3.3mm drill bit into the mill
 - Set the plunge depth to 0.5"
 - With the mill not running, touch the drill to the part
 - Lock the quill
 - Set the quill stop
 - Raise the quill
 - Raise the knee 0.5"
 - Drill the hole at an rpm of $\frac{200*4}{0.118} = 6770 \text{ rpm}$
 - Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat these steps until all four sides of the part have a hole at its center
 - Use an M4x0.70 tap (in the vertical mill to decrease likelihood of breaking a tap) to tap the hole
 - Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat this step until all four sides of the part have a threaded M4x0.70 hole at its center
- Remove the part from the mill and inspect it. Ensure that the applicable above steps have been followed
- Use dial calipers to check the dimensions of your bulkhead

Aft Bulkhead

- Use one of the 0.375" thick pieces
- Face off the circle that was used on the lathe with the live center
- Use a center drill to 7 mark holes according to dimensional drawing
 - Because the holes are defined according to angles and radii, program the holes for use with the center drill and drill bits later
 - 1x at (0,0) (for center bushing)
 - 1x for eye bolt hole

- 3x for airbrake paddle screws
 - 2x for wiring hole Connector
- Center Bushing bolt hole
 - Use a 6.6mm drill bit to drill a hole in the center of the part (at (0,0)) at an rpm of $\frac{200*4}{0.259843} = 3075 \text{ rpm}$
 - Note: 6.6mm=0.259843"
 - M6 bolt
- Eye bolt hole
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 - Metric: Use a 6.6mm drill bit to drill 3 holes (or use the bolt hole pattern) at an rpm of $\frac{200*4}{0.259843} = 3075 \text{ rpm}$
 - M6 screws
- Wire connector holes
 - Use a #43 drill bit to drill the holes at an rpm of $\frac{200*4}{0.089} = 8900 \text{ rpm}$
 - Before moving on, go ahead and use a #4-40 tap (in the mill for stability... BE CAREFUL!) so that you don't have to find the hole again
- Wire Connector Hole
 - Use a 1/8" end mill and program a rectangular pocket through the part according to the dimensional drawing
 - $\frac{200*4}{0.125} = 6400 \text{ rpm}$
 - Note: The dimensions in the drawing are for programming the pocket
- BEFORE REMOVING THE BULKHEAD FROM THE VISE use a sharpie to mark a vertical line at the right of the part. This line should be on the right side of an airbrake paddle hole
- Remove the part from the vise and place it into the Aft Bulkhead Manufacturing Jig such that the bulkhead aligns with the jig's pegs
 - The line you drew should line up with a slot on the inside of the manufacturing jig. This ensures that the bulkhead is oriented correctly. Both the slot and the line should be facing you.
- Either remove the round vice or move to another machine with a standard vice
- Place the manufacturing jig/bulkhead into the vice perpendicular such that the 4" diameter face of the part is facing you (at the front of the machine)
 - Use a mechanical stop when securing the part in the vice to increase manufacturing speed
- M4 Holes
 - Edgefind (at~1200 rpm), set the center of the part at (0,0)
 - This should align with the perpendicular holes in the jig
 - Use a center drill to mark a hole at (0,0)
 - The jig may be too thick for this. If it is, ignore this step

- Place a 3.3mm drill bit into the mill
- Set the plunge depth to 0.5"
 - With the mill not running, touch the drill to the part
 - Lock the quill
 - Set the quill stop
 - Raise the quill
 - Raise the knee 0.5"
- Drill the hole at an rpm of $\frac{200*4}{0.118} = 6770 \text{ rpm}$
- Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat these steps until all four sides of the part have a hole at its center
- Use an M4x0.70 tap (in the vertical mill to decrease likelihood of breaking a tap) to tap the hole
- Rotate the part 90 degrees clockwise (or counter-clockwise so long as you're consistent) and repeat this step until all four sides of the part have a threaded M4x0.70 hole at its center
- Inspect the part to ensure that the applicable above steps have been followed. Remove the part from the mill.

Forward and Aft AVIONICS Bulkheads

- Use one of the 0.25" round stock pieces
- Face off the circle that was used on the lathe with the live center
- Secure "round vise" in standard vise and secure material stock in round vise
- Slot pattern for Avionics board
 - Make a 2 plunge cuts using a 0.25" 2-flute endmill (might be easier to program)
- Center Drill various holes according to dimensional drawing
 - 2x M10 Lead screw holes
 - 2x Black Powder Cup mounting holes
 - 1x Wire hole
 - AFT ONLY
 - 2x Wire Connector Holes
- Make Holes
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 - Use an 11mm drill bit at an rpm of $\frac{200*4}{0.433071} = 1847 \text{ rpm}$ (or less)
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 - 2x Black Powder Cup mounting holes
 - Use a #36 (0.107") drill bit at an rpm of $\frac{200*4}{0.107} = 7470 \text{ rpm}$ (or less)
 - Wire hole(s)
 - Use a 3/16" (0.1875") drill bit at an rpm of $\frac{200*4}{0.1875} = 7470 \text{ rpm}$ (or less)
- AFT ONLY
 - Wire Connector Hole

- Use a $\frac{1}{8}$ " end mill and program a rectangular pocket through the part according to the dimensional drawing

- $\frac{200 \times 4}{0.125} = 6400 \text{ rpm}$

- Note: The dimensions in the drawing are for programming the pocket

- Ensure that the above steps have been followed before removing the part from the vise!

ALL BULKHEADS

- Check that the part slides into the body tube. Gradually turn off more material with the lathe and turning tool until you are subjectively satisfied with the fit of the part
- Clean up your work area or face the *CONSEQUENCES*