P5 NPOI Capstone

Project Management Assignment

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DISCLAIMER

This report was prepared by students as part of a university course requirement. While considerable effort has been put into the project, it is not the work of licensed engineers and has not undergone the extensive verification that is common in the profession. The information, data, conclusions, and content of this report should not be relied on or utilized without thorough, independent testing and verification. University faculty members may have been associated with this project as advisors, sponsors, or course instructors, but as such they are not responsible for the accuracy of results or conclusions.

EXECUTIVE SUMMARY

Many components require maintenance or repair, especially the heart of NPOI, the Fast Delay Lines (FDL). The Snoots contain custom vacuum windows allowing stellar light to enter and exit of the FDL tanks. The FDL tank Seal Plates also allow the metrology beam into and out of the tank which allows for highly accurate measurements of cart positions, on the order of a nanometer. These inner tank components from time to time must be repaired. This entails the front and/or rear seal plates to be moved/stowed and FDL tank inners worked on in an appropriate clean environment. Then all components must be reinstalled easily. Over the course of Fast Delay Line (FDL) use, there is need for periodic maintenance within the vacuum tanks confining the FDL Carts. On the front of the FDL's there are seal plates which capture snoots to relay the light in and out of the inner room. These seal plates and snoots use many features which take long lengths of time to disassemble and assemble. This issue is apparent on the front and rear of the tanks, although the rear seal plates do not have optical pass throughs. Reducing the use of large tools (gantry crane) and quantity of technicians needed to complete this task would be most beneficial to the Opto-Mechanical Group (OMG) at NPOI. The goal of this project is to streamline these procedures to make it faster and easier to perform maintenance on the FDL's.

There are two main aspects of the design, the front and rear seal plates, along with the snoot fixture. This plate will be light weighted but cutting out a significant portion of the unused space, to adhere to the customer need of weight. The polycarbonate windows will have an o-ring to help seal, along with a hat to fix it to the plate. The snoots will be welded onto the plate itself, while the metrology windows will be held in place by a hat that will fasten it to the plate. The rear seal plate uses the same size aluminum plate (2-in thick, 22-in diameter) and functions very similar to the front seal plate. The key difference is that the rear seal plate must have two sight ports, that allow the customer to view inside the FDL. Like the front seal plate, this plate will also be light weighted to meet the constraint of the customer. The snoot fixture involved a simpler implementation than the seal plates. The function of the snoot fixutre is to stabilize the snoots, as well as provide the ability for slight adjustments. This will be done by fixing a solid base to the existing frame at NPOI, while having a plate that the snoots will be fixed to, that will be able to move in all the required directions. The finalized CAD models are included in section 5. The simulations run in solid works proved that our design functions and adheres to the constraints of the client.

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1 Reflection

After a semester of working on the Capstone project, team 5 had done and achieved different requirements for the project. In this section, the team would review all the parts that the team had done as well as the team's plan for the future of this project.

1.1 Introduction

The Navy Precision Optical Interferometer (NPOI) is a large astronomical observation station, created by the Navy Research Lab. The goal of NPOI is to observe faint, double, and triple stars, using the siderostat stations and use of the delay and combining lab. The 2022-2023 NPOI capstone will be based on the Fast Delay Lines (FDL), specifically the seal plates and snoots. The project includes designing rear seal plates, front seal plates with snoots, a snoot adjustment fixture, and a snoot split design. The team will design a simple rear seal plate to hold the moderate FDL vacuum, as well as integrate sight ports in the seal plate for easy inspection. The front seal plate will seal vacuum, hold the stellar and metrology snoots, and integrate view ports for easy inspection. The seal plates will also need to have a weight of 35 lbs. or less. The snoots must have an inner room fixture, allowing adjustment (pitch and yaw), as well as holding the last section of the snoot split design. The inner room section of the snoot will be stationary when accessing the front of the FDL's. The split snoot design is a sectional tube which will be easily able to have sections removed for access in removing the front seal plate. The combination of these four objectives is to create a FDL seal plate system which one technician can assemble and disassemble with ease.

The sponsor of this project Jim Clark is interested in completing this design project because of maintenance requirements of the FDL's, along with the need for keeping the interferometer on sky nightly. The maintenance requirements for the FDL's are ribbon cable replacement, voice coil tuning, piezo tuning, bearing replacement, and leaf spring replacement. These maintenance items must be repaired in a quick and efficient time frame, allowing the seal plates to be less than 35 lbs., allowing any single technician the option to vent and disassemble an FDL individually. As well as removing the use of the gantry crane completely. This allows the small staff at NPOI to work on issues in parallel, instead of one at a time. Removing the gantry crane from the FDL room will also remedy the issue of tripping hazards within the FDL room, due to the gantry crane tracks. The use of the sectional snoot allows for ease of disassembly of the snoots and removes a lengthy step once fully reassembled. Alignment of the snoots will be removed using sectional snoots, this allows for the inner room section of snoot to be fixed, allowing the team to keep alignments of snoots through disassembly and reassembly. The remedy of these issues will allow the client and stakeholders to more easily maintain the FDL's, remove safety issues in the FDL room, and reduce the number of needed alignments during FDL maintenance.

1.2 Sucesses

For last semester, the team had done the following in order to fulfill the NPOI capstone requirements:

1. The team had made the CAD model for the actual objects that the team wanted to build. There will be more adjustments in the future for the actual object to be used.
2. The team met with the client Jim Clark to confirm all the requirements for the front and back seal plates as well as the snoot adjustment and holders. Moreover, all the required materials have been purchased and are ready to use in this final semester.

1.3 Room for Improvement

This semester, the NPOI team is facing some unwanted scenarios where the team and the client could not go into the NPOI station to use the purchased materials as well as the machinery needed to make the actual objects required for the NPOI project. Therefore, the team is seeking new improvements.

1. With the current event, the team needs to find an alternative plan for the project to work. Without the actual objects, the team needs to do different ways to display the actual objects for this project.

2. A more detailed CAD is always important in this project. The team needs to do more analysis to make sure the model would work in the real world.

1.4 Action Items

From the listed items from room for improvement above, the team makes an action plan so all the team members can try to work with and improve themselves for the future.

1. For the unwanted event, the team noticed that they could no longer use the purchased materials as they were denied permission to enter NPOI station. Therefore, the team came up with the plan to meet up with the client and professor to discuss further about this matter. After the discussion, the team now changes the plan to make model scale objects of front and back seal plates, snoot adjustment and light covers. The team must also display how the objects would perform on a 3-D printing FDL tanks.
2. Since the team could no longer build real objects from metals, the scale model needs to show that they work properly as they would in the real world. Therefore, the team needs to improve the current CAD designs to achieve that purpose.

1.5 Remaining Design Efforts

The team already completed most of the base objects for the project, there are some small adjustments to the design before a scale model could be built.

1. More analysis of the designs such as weight distribution and weight lighting must be done to prove that the objects are working properly under vacuum condition and standby.
2. The Christmas trees are newly added to the team package. The team now needs to connect the Christmas trees with the snoot adjustments.
3. The light covers are essential for the clients' requirements. The team still needs to figure out how to work it perfectly for the final design.

2 Gantt Chart

The Gantt chart, included in Appendix A, will the schedule that the team adheres to for the following semester. Each goal is listed along with its timeline. The big sections of the chart are the progress milestones, and the final presentation. Within each of those sections are the smaller goals required. Our client has made it clear that he would like regular meetings, which is also included in the chart.

3 Purchasing Plan

Purchasing for the NPOI Capstone has been ordered through procurement on site. The team determined the parts needed, determined raw material needs, and ordered necessary materials through the Site Steward. The suppliers used for the project are McMaster Carr and Interstate Plastics, primarily McMaster Carr. A total of $9500 was the team's budget, the total spent is $7089.58.

3.1 Overall BOM & Cost

The total Bill of Materials (BOM) has been broken down and only purchased goods are shown in Table 1. The goal for this project was to use as many off-the-shelf parts as possible, to reduce the machining time. Only critical custom parts such as seal plates, snoot plates, and snoot fixture/adjuster will be custom machined. The other components within the assembly will be off-the-shelf for ease of assembly and reproduction.

Table 1: Purchased Parts and Machining Plan

Part Name	Assembly Part Name	Supplier	Lead Time	Status	Ind. Cost($)	Assembly Sub-Section	Quantity	Total Cost ($)	Needs Machining	Machining Complete	Machining Loaction
22" x 2" 6061-T6 Plates	Rear Seal Plate	Industrial Metal Supply	N/A	On-Site	Gifetd	Rear Seal Plate	6	0	YES	NO	NOFS
Handles	Handle	McMaster Carr	N/A	On-Site	Gifted	Rear Seal Plate	12	0	NO	N/A	N/A
Polycarbonate Rod	Polycarbonate Window	Interstate Plastics	N/A	On-Site	170.7	Rear Seal Plate	1	170.7	YES	NO	NPOI
Blank Disk Material (alum)	Blanking Plate	McMaster Carr	N/A	On-Site	6.89	Rear Seal Plate	8	55.12	YES	NO	NPOI
QF Adapter Material (alum)	QF50 to 6bolt Adapter	McMaster Carr	N/A	On-Site	53.46	Rear Seal Plate	1	53.46	YES	NO	NPOI
8-32 Screws (SS) (100 pk)	Window Screws	McMaster Carr	N/A	On-Site	15.37	Rear Seal Plate	2	30.74	NO	N/A	N/A
1/4-20 Screws (SS) (50 pk)	Handle Screws	McMaster Carr	N/A	On-Site	34.74	Rear Seal Plate	1	34.74	NO	N/A	N/A
#8 Screw Washers (SS) (100 pk)	Window Washers	McMaster Carr	N/A	On-Site	4.11	Rear Seal Plate	2	8.22	NO	N/A	N/A
Viton O-ring #225 (10 pk)	Window/Blank O-Ring	McMaster Carr	N/A	On-Site	10.44	Rear Seal Plate	3	31.32	NO	N/A	N/A
End Mill (1" diameter, HSS)	N/A	McMaster Carr	N/A	On-Site	73.7	All Machining	2	147.4	NO	N/A	N/A
22" x 2" 6061-T6 Plates	Front Seal Plate	Industrial Metal Supply	N/A	On-Site	Gifted	Front Seal Plate	6	0	YES	NO	NOFS
Handles	Handle Screws	McMaster Carr	N/A	On-Site	Gifted	Front Seal Plate	12	0	NO	N/A	N/A
10" x 12" Rod (alum)	Snoot Plate	McMaster Carr	N/A	On-Site	698.52	Front Seal Plate	2	1397.04	YES	NO	NOFS
2.5" X 2FT ROD (alum)	Window Hat	McMaster Carr	N/A	On-Site	103.72	Front Seal Plate	1	103.72	YES	NO	NPOI
1/4" Screw SAE Washer (50 pk)	Snoot Plate Washers	McMaster Carr	N/A	On-Site	8.52	Front Seal Plate	2	17.04	NO	N/A	N/A
1/4-20x2.75" SS Screw (5 pk)	Snoot Plate Screws	McMaster Carr	N/A	On-Site	5.44	Front Seal Plate	24	130.56	NO	N/A	N/A
O-Ring #377 Viton (2 pk)	Snoot Plate O-Ring	McMaster Carr	N/A	On-Site	23.51	Front Seal Plate	6	141.06	NO	N/A	N/A
8-32x0.5" SS Screw (100 pk)	Window Hat Screws	McMaster Carr	N/A	On-Site	11.43	Front Seal Plate	2	22.86	NO	N/A	N/A
O-Ring #365 Viton (2 pk)	Snoot Plate O-Ring	McMaster Carr	N/A	On-Site	15.16	Front Seal Plate	6	90.96	NO	N/A	N/A
1/4-20x2" SS Screw (5 pk)	Snoot Plate Screws	McMaster Carr	N/A	On-Site	4.3	Front Seal Plate	24	103.2	NO	N/A	N/A
2" QF50 Butt Weld Connector	QF50 Weld Adapter	McMaster Carr	N/A	On-Site	43.3	Front Seal Plate	6	259.8	NO	N/A	N/A
2" Ring for QF50	O-Ring for QF50	McMaster Carr	N/A	On-Site	19.55	Snoot Fixture/Adjuster	45	879.75	NO	N/A	N/A
2" QF50 Clamp w/wingnut	QF50 Clamp	McMaster Carr	N/A	On-Site	22.33	Snoot Fixture/Adjuster	45	1004.85	NO	N/A	N/A
2" OD 1215 Steel Collar Clamp	Snoot Clamp	McMaster Carr	N/A	On-Site	25.78	Snoot Fixture/Adjuster	28	721.84	NO	N/A	N/A
12" QF50 Bellow	Stellar Bellow	McMaster Carr	N/A	On-Site	269.02	Snoot Fixture/Adjuster	4	1076.08	NO	N/A	N/A
12.5" QF50 Straight Pipe	Stellar Pipe	McMaster Carr	N/A	On-Site	114.78	Snoot Fixture/Adjuster	4	459.12	NO	N/A	N/A
QF50 2" Tube Socket Connect	Copper Pipe Adapter	McMaster Carr	N/A	On-Site	25	Snoot Fixture/Adjuster	6	150	NO	N/A	N/A
Christmas Tree Weldment	Christmas Tree Stand	NPOI	N/A	On-Site	Gifted	Snoot Fixture/Adjuster	6	0	YES	NO	NPOI
12" X 1" 6061-T6 Alum Plate	Snoot Fixture/Adjuster Plate	NPOI	N/A	On-Site	Gifted	Snoot Fixture/Adjuster	6	0	YES	NO	NPOI

The NPOI team has had various parts donated from the NPOI surplus collection, these parts include 22"x2" Plate, Handles, Christmas Tree Weldment, and 12"x1" Aluminum Plate. This material has been stored at NPOI for use on various projects as needed, the material was classified as NPOI Capstone material. Shown in figure 1 is the Christmas tree which was gifted to the team, this will require planning for use in the system.

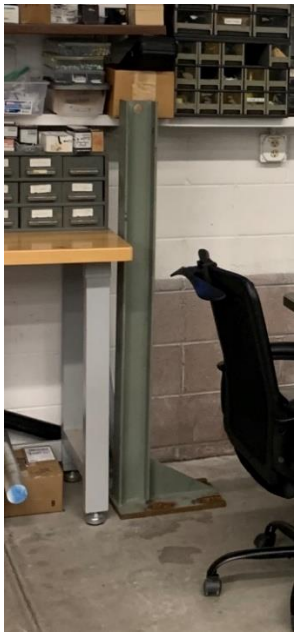

Figure 1: Christmas Tree (faded green part)

This specific part will be used in the snoot fixture/adjuster sub-assembly, the following are action items to finalize the design using this part.

1. **Identify floor anchors to be used on mounting the assembly to the concrete floor.**
2. **Specify how the Aluminum plate will be attached to this steel I-Beam.**
3. **Finalize the height dimension of the part in the total assembly.**

All parts delivered to the NPOI site have been inventoried for order accuracy and assurance all parts are received. Bradley Kingsley completed the inventory over winter break, organizing the parts according to their specified sub-assembly. The organized inventory is shown in figure 2.

Figure 2: Organized Inventory

The bottom two boxes shown are the snoot fixture/adjuster parts, the two top boxes are the front seal

plate parts, and the small box on the right is the rear seal plate components. Each subassembly parts was placed in a respective box and labeled on the top of the box. Action items for the received components is shown below.

1. **Sperate sub-assembly parts by assigned FDL location.**
2. **Identify components needing ultra-sonic cleaning for vacuum application.**
3. **Ultra-sonic clean parts and store in clean bags.**

The NPOI capstone team has reached a "purchase closure" due to current NPOI funding stream. No further purchases can be made for the capstone project. All components needed for completion have been purchased and stored on-site.

3.2 Part and Vendor Selection

The parts ordered within this capstone project were ordered through McMaster Carr and Interstate Plastics. The gifted materials were from the site originally or ordered before beginning of capstone from Industrial Metal Supply (IMS). Specifically, the seal plate material was ordered from Industrial Metal Supply. Raw material was selected from IMS for the need of a material property sheet, which the material included per NPOI staff.

The predominate quantity of parts were ordered from McMaster Carr, with exception of the window raw plastic material. The polycarbonate material was ordered from Interstate Plastics due to the cost and lead time when placing the order. Interstate plastics quoted the material 20% below other competitors, as well as shipping the product within 3 days of ordering. The predominate materials were ordered through McMaster Carr due to quick shipping, formal invoices, and ease of procurement. McMaster Carr was able to deliver all orders within 4 days of placing the order, this was essential for the time scale which the team had availability to order parts. The team had to have all orders delivered by a specified date due to the funding stream style at NPOI. The formal invoices emailed by McMaster Carr were beneficial to the team to keep orders tracked and ensure parts were not ordered incorrectly. The invoice type using part numbers, cost, and a photo allowed the team to easily identify parts in the orders. Due to the procurement type while ordering parts for NPOI capstone, the use of McMaster Carr ensured easy ordering due to the organization having a business account and tax-exemption. This allowed the team to order quickly through the business office and save some of the budget for later costs due to the tax exemption. McMaster Carr was critical in ensuring part delivery within the required time scale for ordering and assured the team would receive all orders before the close of the team ordering window.

4 Manufacturing Plan

4.1 Part Manufacturer Location and Personnel

The NPOI capstone team has a total of 9 individual parts to get manufactured, including parts that are beyond the NPOI machine capability. The options for machining the required parts are Team machining at NPOI or the Naval Observatory Flagstaff Station (NOFS) machinist. The NPOI site has a Bridgeport manual knee mill and Monarch manual lathe for use, the NOFS site has various manual machines and a larger CNC mill which can handle the seal plate raw material. Shown in Table 2 is the manufacturing plan for each part with estimated machining time and hard due dates.

Table 2: Manufacturing Plan & Schedule`

Part Name	Material:	Loaction of Machining	Status	Machining Time:	Due Date:
Rear Seal Plate	6061-T6 Aluminum	NOFS (Ryan)	Material +Drawing Received	3 weeks	2/6/2023
Front Seal Plate	6061-T6 Aluminum	NOFS (Ryan)	Material Received	3 weeks	3/1/2023
Polycarbonate Windows	Polycarbonate	NPOI (Bradley)	Material +Drawing Received	2 days	2/6/2023
Blanking Plate	6061-T6 Aluminum	NPOI (Bradley)	Material +Drawing Received	1 day	2/6/2023
QF50 Adapter	6061-T6 Aluminum	NPOI (Bradley)	Material +Drawing Received	2 days	2/6/2023
Snoot Plates	6061-T6 Aluminum	NPOI (Bradley)	Material Received	1 weeks	3/1/2023
Window Hat	6061-T6 Aluminum	NPOI (Bradley)	Material Received	2 days	3/1/2023
Snoot Fixture/Adjuster	6061-T6 Aluminum	NPOI (Bradley)	Material Received	2 weeks	3/15/2023
Christmas Tree Weldment	Mild Steel	NPOI (Bradley)	Material Received	1 day	3/15/2023

The NOFS location is occupied by a professional machinist, Ryan, who was hired to be the machinist on NOFS site. The client, Jim Clark, has agreed to let the team talk with Ryan about having the seal plates machined by Ryan. A meeting with the machinist will be scheduled to discuss the part drawings and approve understanding for machining. Only the Seal Plates (front & rear) will be machined at NOFS. The remainder of the custom machined parts will be machined at the NPOI site by Jim Clark and Bradley Kingsley leading the task. Dustin Haines and Trung Son Nguyen will be trained on the NPOI machines, if approval of proficiency is given, the individuals will be given machine time to produce parts with direct supervision.

4.2 Overall Manufacturer Action Items

The team has accumulated many parts and raw material sections for use in the overall design of the FDL design. Due to the specific nature of the raw material delivered to site, a few action items will need to be addressed within the next two weeks. The items which need addressing are the seal plate material and the polycarbonate material. Figures 3 & 4 show the material and will have listed action items below.

Figure 3: Seal Plate Raw Material

Seal plate action items…

1. **6 Pieces in 22” diameter circles and 6 in 22”x22” squares, determine if the CNC mill can remove excess on square or if laser cutting is required for the circular shape.**
2. **Determine the parallelism between surfaces of the material, this will be used to verify our design can be machined without thinning the part beyond the current design.**
3. **Identify uses of excess material of the 22” laser cut rounds.**

Figure 4: Polycarbonate Rod Raw Stock

Polycarbonate Window action Items…

1. **After sectioning off a 0.490” thick section, how to vapor smooth or buff the surface for a transparent part that can be seen through with ease.**
2. **Determine the speed and feed rate for turning polycarbonate and achieving seal surface finishes.**
3. **Custom Grind a groove tool from High-Speed Steel Stock to machine the O-Ring groove.**

The action items shown below figure 3 & 4 are those which need to be addressed before machining in order to assure the parts can be made properly, and will be made to a certain quality standard proposed by Bradley Kingsley. The quality standard is considered to be meet for each part if the following are ALL adhered to…

1. All dimensions are within tolerance given on manufacturing drawing. Verified by Inspection.
2. No sharp edges or burrs on the parts.
3. No scuffs or dents on final product. Even on non-critical faces, part must be as designed with no variations due to error.
4. ALL O-Ring Grooves allow sealing to a moderate vacuum (~10 mTorr).
5. All grease and oils removed from parts before approved to be placed in FDL room.

The above requirements ensure the produced parts are up to standard with other components on the current NPOI system and ensure that capstone designs show high quality engineering & manufacturing practices which representing Northern Arizona University and The Navy Research Laboratory.

5 CONCLUSIONS

The plan for the rest of the semester has been set, with respect to the project management standpoint. The successes of the first semester were reflected upon and improvements and plans were made to remedy some past shortcomings. A Gantt Chart was made to organize the schedule and to make sure we stay on track for all the deliverables throughout this semester. In depth purchasing and manufacturing plans were made. The purchasing plan includes important information as to whether each part will be bought or made, along with the cast and vendor/manufacturer. The manufacturing plan includes who, when, and where each part will be made. This also acts as a starting point for the next few months as we strive to meet the criteria of the client and finish our project.

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7 APPENDICES

7.1 Appendix A: Gantt Chart