NPOI Nitrogen Distribution

By

Wyatt Huling, Amelia Fuller, and Scott Ryan
Team 16

Progress Report

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design I – Fall 2013

Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

Table of Contents

Chapter 1. Introduction

1.1 NPOI Description

The U.S. Naval Observatory (USNO) does research for the Naval Research Laboratory in providing position, navigation and timing for the U.S. Department of Defense. Our sponsor, the Navy Precision Optical Interferometer (NPOI), works under the USNO. The NPOI has its site located just East of Flagstaff, AZ in Anderson Mesa. The research done in this facility involves precise observations of the astronomy needed for navigation use.

On behalf of NPOI, our clients Jim Clark and Steve Winchester have requested an improved nitrogen supply system. This nitrogen supply is used to operate pneumatic actuators at several stations and to purge any humidity or debris from the Siderostat mirrors. It consists of three 300meter arms that have observatory like mirrors along each arm. By utilizing an array, the optical surface being studied is effectively the diameter of the whole facility. Using the mirrors at the ends of the array has an equivalent effect of employing the use of a 600meter diameter solid mirror. These mirrors are used to direct optical light, the visible light spectrum, into a lab facility that further studies the image.

To operate and manage this system of mirrors, each station is equipped with a gaseous nitrogen supply. The gaseous nitrogen is used to accomplish two tasks. The first is to purge the mirrors of any moisture buildup that may ruin the mirrors. Nitrogen is pumped directly onto the mirror surface whenever the array is not in use, which keeps water from accumulating on the very delicate reflective surface. Aside from this, the nitrogen is also employed for a series of pneumatic actuators. Surrounding the very expensive mirrors are housings and flaps for protection. In order to open these flaps to let light through for observation, nitrogen is sent to a pneumatic system that opens the coverings with no vibration due to water in the line or any debris. Pneumatic actuators are also used to operate gate valves that are placed inside the vacuum tubes that direct light into the facility. Gate valves are installed in each arm to prevent the damage from spreading to all of the arms in the array,

On behalf of NPOI, our clients Jim Clark and Steve Winchester have requested an improved Nitrogen Supply system.

1.2 Project Update

From the start of this project our team has made a few design modifications that better fit the needs of our client. A recent visit out to the NPOI site and reviewing our final design submitted from last semester, some changes were made and engineering drawings requested.
This progress report will review these design modifications and review the differences from our previous design. Several Engineering drawings will be implemented in this report to visualize

what our design will consist of and how it will lead to our first prototype. Our first prototype will be tested on a smaller section of the NPOI site. This test section will run along the west arm of the telescope array, a length of ~100 ft. The test section will include one imaging station, astrometric hut, and gate valve station, all of which need a certain supply of nitrogen across each arm.

Chapter 2. Final Design

2.1 Original Concept

To provide nitrogen to each station of the array, 1/2in cleaned and capped copper tubing will be ran along each arm of the array. A tee fitting will be soldered into this supply tubing at each location and off of the branch, brass fittings will be used to convert to 1/4in hose barb. Black UV-resistant 1/4in ID polyvinyl hose will then allow the nitrogen to flow through a ball valve and a regulator for each item. A 5 gallon holding tank will be used prior to the gate valve stations to allow rapid actuation. Rubber-cushioned mounting clamps with stainless steel hardware will attach the tubing to the cable tray.

2.2 Changes to Final Design

After the clients reviewed the project proposal, Jim Clark and Steve Winchester wanted to make small changes to the final design. In addition to the holding tank prior to the gate valves, they would like to add a second tank near the end of each arm (9th imaging station). Since a MATLAB code was created to predict the pressure drop throughout the system, the clients would like to install pressure gauges at several intervals along each arm to verify these calculations. These gauges could also be used when troubleshooting a problem or checking for leaks. The original design included the use of a manifold at line pressure (50-60PSI) feeding a separate regulator for each line at the imaging stations. To simplify the system and lower the cost, a single barb tee will be placed after the ball valve and one side will feed a high pressure (40PSI) regulator for all of the pneumatic actuators while the other side will feed a low pressure (9PSI) regulator for the mirror covers. This change also applies to the single imaging station that will be used in the prototype.

2.3 Final Design Bill of Materials

Item	Quantity	Price	Total Price	McMaster-Carr Part Number

1/2in cleaned and capped copper tubing	4000ft	2.0795 per ft.	8318.00	5174K25
5 gallon tank	6	131.27	787.62	1862K92
1/2in polyvinyl hose	100ft	1.28 per ft.	128.00	5231K84
1/2in copper tee	37	0.86	31.82	5520K71
1/2in male tube to 1/4in female tube reducer	37	1.05	38.85	5520K223
1/4in male tube to 1/4in female NPT	37	3.97	146.89	5520K251
1/4in male NPT to 1/4in hose barb	113	11.87 qty. 10	142.44	5346K14
1/4in barb tee	30	6.34 qty. 2	95.10	91355K47
1/4in ball valve	38	8.27	24.81	47865K21
1/4in polyvinyl hose	100ft	0.76 per ft.	76.00	5231K84
1/2in female tube to 1/2in female NPT	12	1.61	19.32	5520K21
1/2in male NPT to 1/2in hose barb	12	14.25 qty. 5	42.75	5346K25
3/8in male NPT to 1/2in hose barb	12	11.07 qty. 5	33.21	5346K23
1/4-20 SS316 bolt	320	6.40 qty. 25	83.20	93190A542
1/4in SS316 washer	320	8.25 qty. 100	33.00	90107A029
1/4-20 nylon-insert locknut	320	8.24 qty. 50	57.68	90715A125

5/8in Rubber-cushioned clamp	320	10.56 qty. 25	137.28	3225T25
Total			**10195.97**	

Chapter 3. Prototype Design

3.1 Original Design

The NPOI array contains three different stations with different pressure and volume requirements. To create a prototype that can meet the majority of the requirements of the final design, it must provide nitrogen to at least one of each station. For this reason, the prototype will be installed on the west arm and attach to one imaging station, astrometric hut, and gate valve station.

3.2 Changes to Prototype

As was previously stated, the nitrogen distribution system that is currently at NPOI uses a single nitrogen tank at each station. Rather than removing all lines from this current system, the prototype design will simply attach to the current distribution system's infrastructure at each station. Therefore, a single line at each required pressure (9PSI for purges and 40PSI for actuators) is all that is needed for each station. Rather than waiting for the Navy to approve the funds required to purchase the large Dewar tank, the prototype will use a single nitrogen tank that is already on site. At the current time, the clients would also like to install a long coil that will simulate the imaging station in the prototype being at the end of the array. However, this may not be required as pressure gauges can be used to compare the calculated prototype pressure drop to the actual, and accuracy of the calculated final pressure drop can be predicted.

Figure 1- Astrometric hut assembly

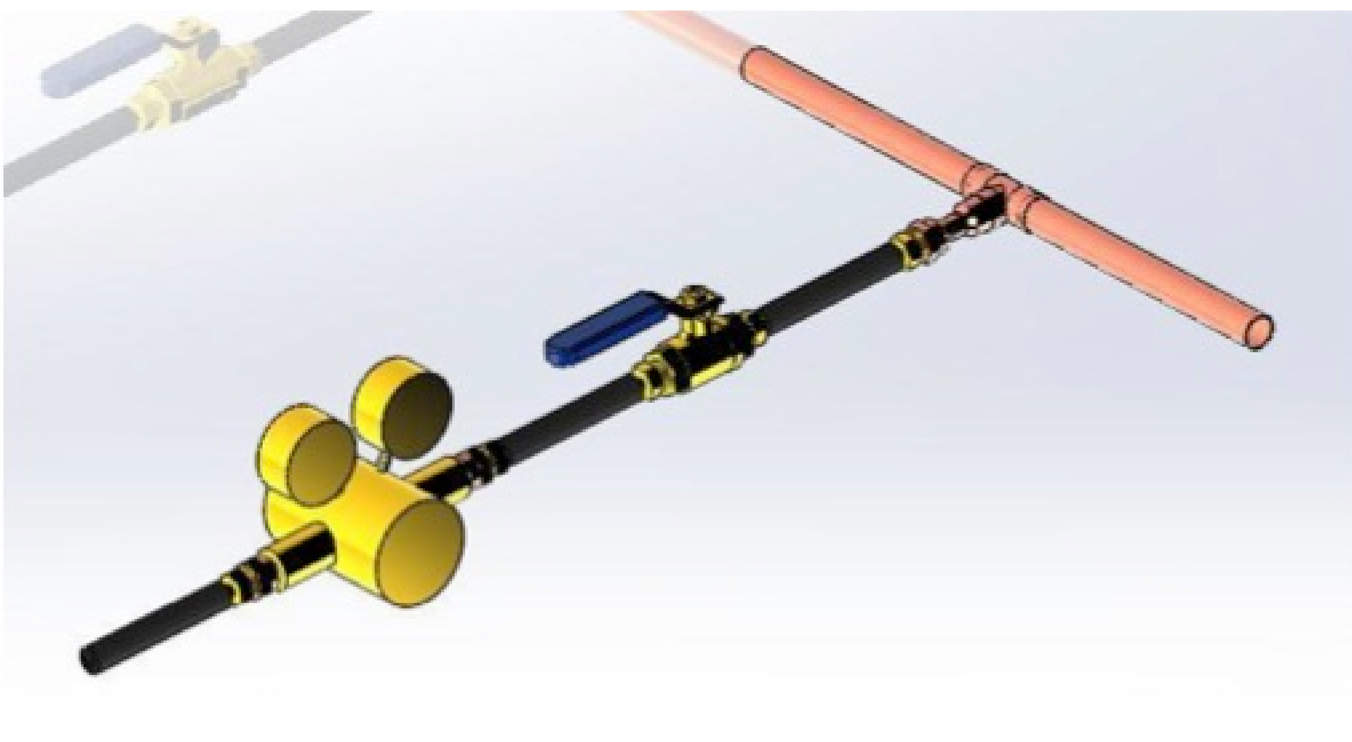


Figure 2- Gate Valve Assembly

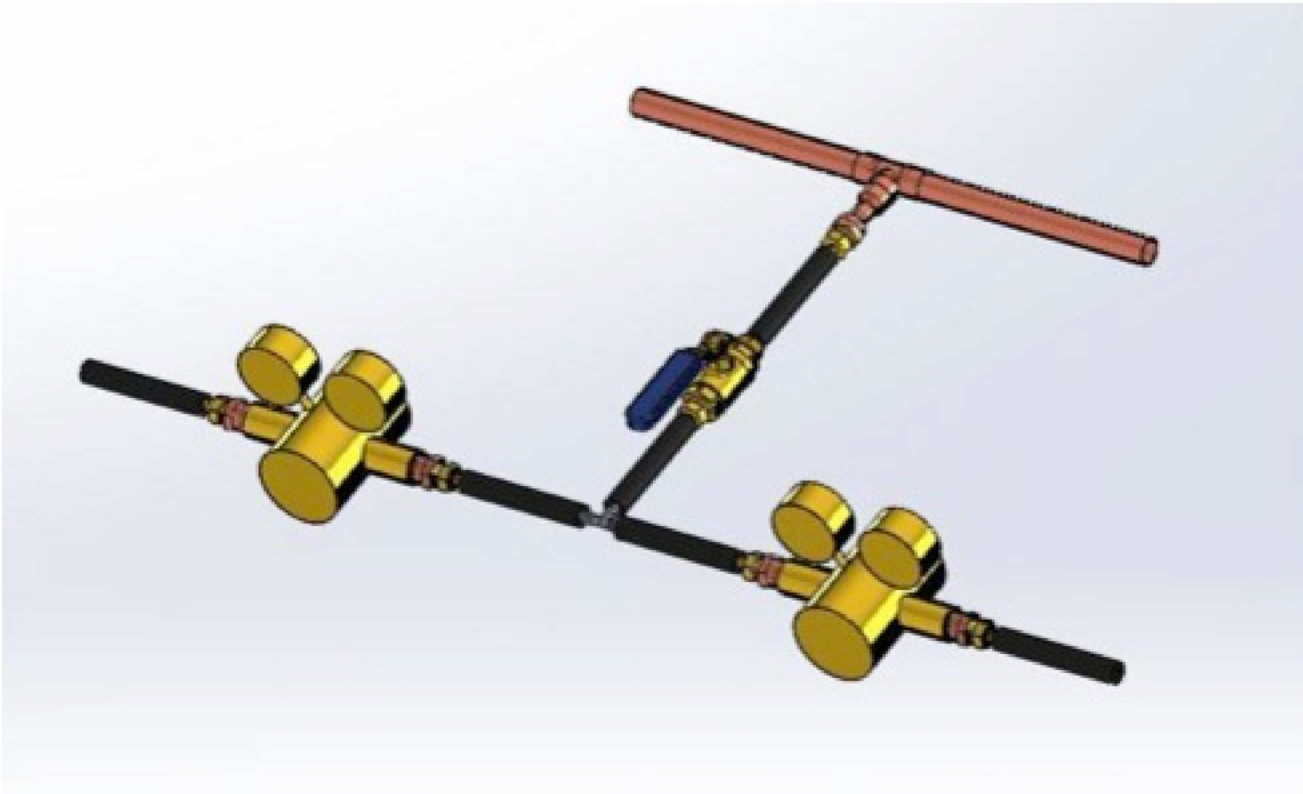


Figure 3- Imaging Station Assembly

3.3 Bill of Materials

Table 1- Prototype Bill of Materials

Item	Quantity	Price	Total Price	McMaster-Carr Part Number
1/2in cleaned and capped copper tubing	100ft	2.0795 per ft.	207.95	5174K25
5 gallon tank	1	N/A		
1/4in polyvinyl hose	25ft	N/A		
1/2in copper tee	4	0.86	3.44	5520K71
1/2in male tube to 1/4in female tube reducer	3	1.05	3.15	5520K223
1/4in male tube to 1/4in	3	3.97	11.91	5520K251

female NPT				
1/4in male NPT to 1/4in hose barb	10	11.87 qty. 10	11.87	5346K14
1/4in barb tee	1	6.34 qty. 2	6.34	91355K47
1/4in ball valve	3	8.27	24.81	47865K21
1/2in polyvinyl hose	25ft	1.28 per ft.	32.00	5231K89
1/2in female tube to 1/2in female NPT	2	1.61	3.22	5520K21
1/2in male NPT to 1/2in hose barb	2	14.25 qty. 5	14.25	5346K25
3/8in male NPT to 1/2in hose barb	2	11.07 qty. 5	11.07	5346K23
1/4-20 SS316 bolt	10	6.40 qty. 25	6.40	93190A542
1/4in SS316 washer	10	8.25 qty. 100	8.25	90107A029
1/4-20 nylon-insert locknut	10	8.24 qty. 50	8.24	90715A125
5/8in Rubber-cushioned clamp	10	10.56 qty. 25	10.56	3225T25
Total			**363.46**	

Chapter 4. Division of Work

4.1 Before Prototype Construction

One of the biggest factors concerning the building of the prototype is when building is allowed to take place. The facility will be in service the entire time building takes place. This means that come night, everything must be functioning. Also, work can only be accomplished with one of the two sponsors present. Not only does the team have to work around its own schedule, but it also has to work around the sponsor's schedule. One team member is responsible for collaborating this schedule. This person will be Amelia Fuller. With the responsibility of making the schedule comes the need to make sure everyone else on the team is informed of this schedule. It will also be her responsibility to make sure that everyone is on the same page with all aspects of the build. Being in charge of communication also makes it Amelia's responsibility to keep the sponsors up to date with the team.

Currently, not all materials for the prototype are on site. A team member will be put in charge of the logistics of the build. This includes knowing when supplies will become available, what supplies are needed and ordering supplies before they are actually needed. Logistics may also include transportation of team members. The prototype site is located several miles outside of Flagstaff and carpooling might be necessary. The person in charge of these logistics is Wyatt Huling.

4.2 During Prototype Construction

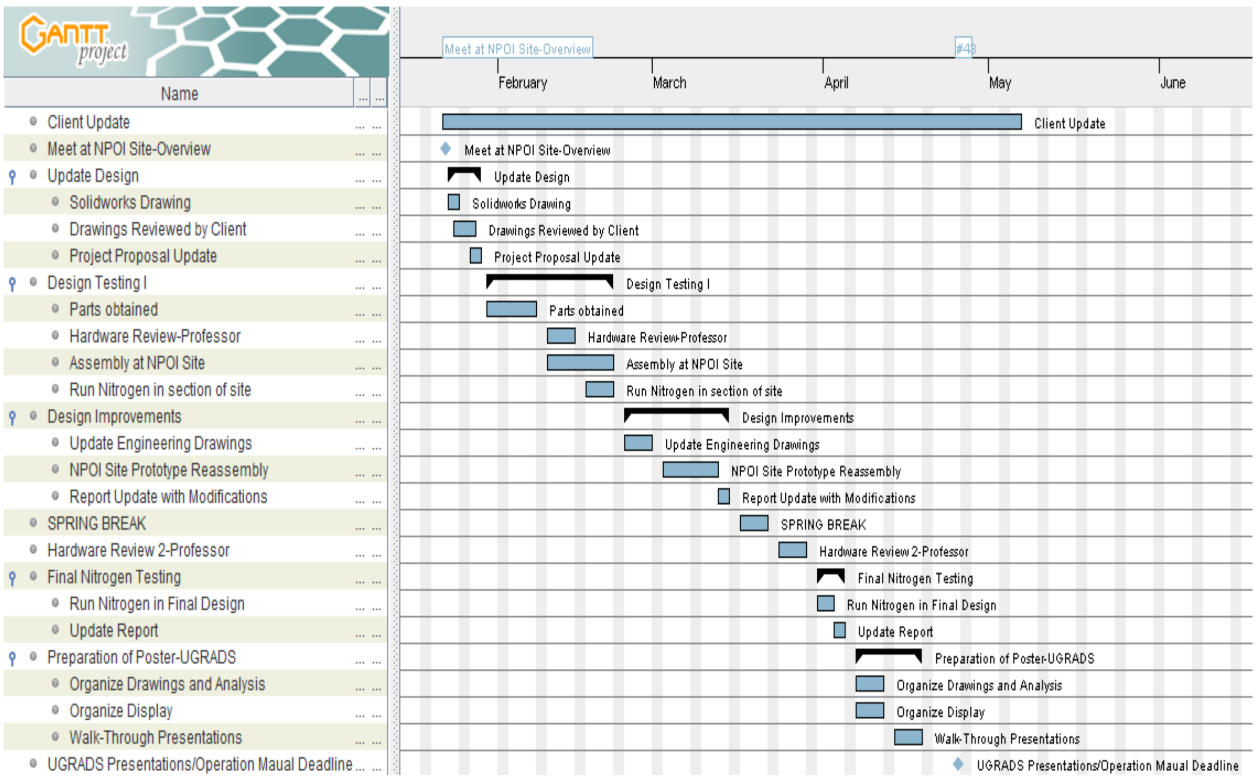
Throughout the whole building process, proper documentation is necessary. Any progress or problems that may arise need to be documented for proper representation at the final UGRAD presentation. Scott Ryan will be in charge of keeping record of all team activities. Once these records are written down, they will be handed over to the website manager, Wyatt Huling. Here the information will be posted to keep others up to date with our process.

In charge of the on-site activities will be Scott Ryan. This job includes the responsibilities of a general project manager. Mainly this consists of job delegation of the actual building process. As the jobs become completed, each team member will be responsible for a component of the system. This includes the general knowledge of the progress and a final check of their designated section. As of right now, Wyatt Huling will be responsible for the soldering and installation of all brass fittings. Scott Ryan has been put in charge of the final installation and securing of the system to cable trays. All accessory devices such as tanks and gauges will be entrusted to Amelia Fuller.

Chapter 5. Conclusion

The process of building the prototype of the nitrogen distribution system at the NPOI has begun. Since initial designs were complete a few changes have been made. The first is the replacement of the manifolds in the imaging stations with a single barbed T-fitting. This is not only easier to install, but it is much cheaper. The second design change was to implement a second reservoir tank on each arm of the final system. This provides a higher factor of safety that is requested for the sake of very expensive equipment. Total cost of the nitrogen system throughout the facility is $10195.97. Installing the prototype will be much cheaper than this. For the purposes of a prototype, only a small section of the telescope will be fitted with the nitrogen system. One astrometric hut, one imaging station and one gate valve will be on the same system with a single nitrogen source, a regular nitrogen tank. A long coil is also a possible addition to the prototype, in order to simulate the entire length of one arm of the telescope. The total cost of building the prototype (not including the coil) is approximately $365.00. In order to build this prototype several jobs had to be delegated among the team members. Amelia Fuller will complete schedule planning and communication. Logistics and transportation, along with the team website, will be head up by Wyatt Huling. Scott Ryan will be in charge of documenting the team's process and delegating task for actual building of the prototype.

Appendix A



GANTT project
Name
Meet at NPOI Site-Overview
#48
February
March
April
May
June
Client Update
Meet at NPOI Site-Overview
Update Design
Solidworks Drawing
Drawings Reviewed by Client
Project Proposal Update
Design Testing I
Parts obtained
Hardware Review-Professor
Assembly at NPOI Site
Run Nitrogen in section of site
Design Improvements
Update Engineering Drawings
NPOI Site Prototype Reassembly
Report Update with Modifications
SPRING BREAK
Hardware Review 2-Professor
Final Nitrogen Testing
Run Nitrogen in Final Design
Update Report
Preparation of Poster-UGRADS
Organize Drawings and Analysis
Organize Display
Walk-Through Presentations
UGRADS Presentations/Operation Maual Deadline