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1.0 Introduction

Senior design project serves as an important aspect of four-year programs in engineering and technology providing capstone experience to students (1-4). An open-ended engineering design and product development problem with constraints provide sufficient challenges to students in developing skills in all aspects of engineering, including project management. In this regard, projects sponsored by industries are a boon to students and colleges. Often, industries support their projects with funding, materials including access to their experts (5-7). Now, it is up to students and project advisor(s), prudently use this opportunity, to deliver a successful project. This can be achieved with hard work and dedication by project teams. Several documented research shows that friendly rivalry among competing teams produce better results and outputs (8,9). In this paper, one such project is attempted and completed successfully to the fullest satisfaction of the sponsoring industry.

2.0 Background

The University of Texas Rio Grande Valley (UTRGV) is a minority serving institution situated in developing region of the Texas state, where recently, there has been a steady expansion of advanced manufacturing industries, including innovative aerospace companies like the Space X. These industries look for engineering and technology students who are creative thinkers and capable of addressing complex engineering problems. These industries regularly offer internships to engineering students and often hire them as regular employees. In Spring 2021, a local aerospace company approached the College of Engineering and Computer Science (CECS) at UTRGV with an interesting project. The company regularly tests its rockets at the nearby Boca Chica facility in Brownsville, Texas. Local weather plays an important role in successful launch and testing of rockets. The company needs to use weather balloons before launch of rockets to assess local atmospheric conditions, such as, wind speed, temperature, and humidity in various altitudes. The weather balloon filled with helium, is attached with an electronic device, radiosonde, and tested before the release. The electronic device captures and sends back weather data to the receiving station. This task of preparation and launch of weather balloon takes two hours per launch for two employees. The company thought that this presents an opportunity to fully or partially automate this process to save human-power for other tasks. Also, the weather balloon launch automation will greatly help the facilities in remote locations. The purpose of this project is to automate weather balloon launch process fully or partially.

The CECS supports a signature program, Engineering Technology (ET), at the YYY campus. The ET program is an ideal candidate for this project since the program concentrates on mechatronics and automation. Also, ET program offers students with hands on engineering curriculum with exposure to designing, building, and testing of current technologies. Hence, this project was undertaken by the ET program to challenge its students as a part of their required senior design project experience.

3.0 Student Senior Design Project Experience

The project sponsor, suggested student teams to work separately on the project, so that the best of student output often comes out with a friendly competition. Hence, two student teams were assigned with the same sponsored project to come out with innovative solutions. The industry allotted a budget of $3000/- to come out with successful proof of concepts. The project consists of designing and building a semi-automatic weather balloon launching system with minimum human intervention. The competing teams did extensive research on existing technology and constraints in arriving at feasible solutions. One of the design goals is to develop this automated system with flexibility in site selection and launch schedule. The intended design must include inflating balloon with helium that has a lifting capacity of around two pounds. The payload is a radiosonde- an electronic device that captures and transmits to the control base, weather-related details such as humidity, temperature, pressure, and wind speed at different altitudes of the atmosphere. This weather data is used to determine flight conditions of rockets that are launched. Hence, this data plays a paramount importance in launching of rockets with valuable payloads. Typically, it takes two persons several man-hours to assemble and launch these weather balloons. The design and development of automated weather balloon launching system by the two competing teams are presented in the following sections.

3.1 Project Background

The objective of this project is to automate the launching of a weather balloon. This weather balloon serves as a data capturing device that gives feedback on different weather statistics. The current manual process that is being followed to launch this balloon is as follows:

1. Inflation: The balloon is manually inflated by using a helium tank that is opened by hand and a hose that is also inserted into the balloon by hand. Once the balloon is inflated to be able to lift a 2-pound weight that is attached to it, then the flow of helium is stopped.
2. Attachment of weather reading device: After the balloon is inflated to the desired volume, a radiosonde (which is a weather capturing device) is attached via zip tie to the base of the balloon.
3. Release of the balloon: The balloon is then released into the atmosphere and the process starts over from the beginning.

3.2 Project Constraints:

The constraints prescribed by the sponsor team as follows:

1. *Basic dimensioning:* The Sponsor team plans to implement auto-balloon system within a standard storage container for easy transportation to any region it may be needed.
2. *Budget:* A budget of $ 3,000 for the project teams to build a functioning prototype.
3. *Timeline:* The project consisted of three separate phases with progress reports.
   The project began in spring term, with each phase stablish as follows:
   - First Phase: 2 months
   - Second Phase: 1 month
   - Third Phase: 2 months

3.3 Team 1 Project Design and Development

3.3.1 Concept Generation:

The Team1 did an extensive literature survey and gathered technical information to conceptualize design ideas for the project (10-11). The initial concept idea and its improvement is shown below in Figure 1.

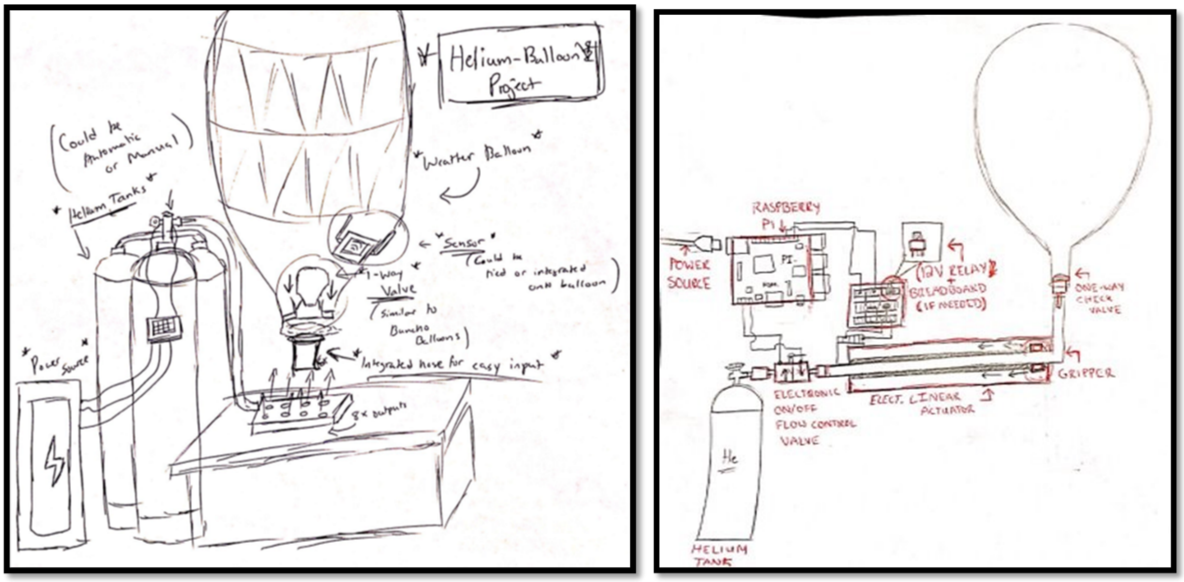

Figure 1. Initial project concept and improvement – Team1

The first hand-sketch shows the initial idea, and the adjacent sketch shows a concept with improvement suggested by the sponsor organization engineers and the faculty advisors. The improved concept includes the use of a raspberry pi to control the circuit system through a breadboard, and a linear actuator for detachment of the hose from the weather balloon. Several trials were conducted before finalizing a concept for the prototype. The final conceptual design is shown in the Figure 2. This design provided the team with enough information to build a housing for the system.

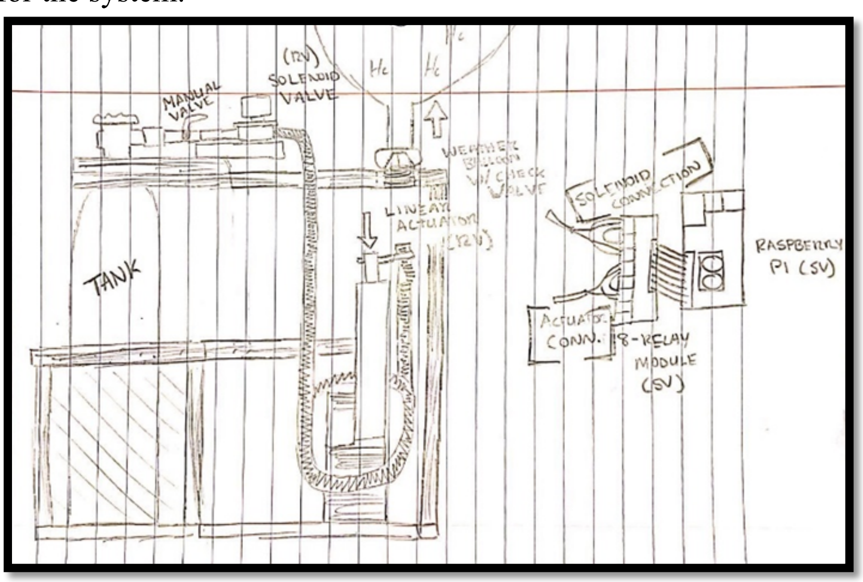

Figure 2. Final Conceptual Design – Team1

The breadboard idea was scrapped in favor of an 8-port relay module for the circuitry, and instead of using a gripper arm to remove the balloon from the hose, the team implemented a simple opening onto the top of the system large enough to comfortably connect a weather balloon to the actuator. This opening is designed to hold the balloon in place while the actuator removes the hose from the balloon for instant rise.

3.3.2 Final Prototype

Additional improvements were made in the design when constructing a housing for the auto balloon system. A plastic container was fabricated to hold all the electronic components and allows for easy removal for ease of repair and maintenance. Power strips were included in the design to accommodate all the power cords (12-14).

Multiple helium gas tanks were connected in series to provide uniform pressure to the system. However, adding more tanks makes the system less portable and more expensive. Pressure sensor and flow control valve are connected to the cylinder for metered supply of helium to the balloons. The flow control valve is automated to open and close for inflating the balloon to sufficient pressure. The second part of the assembly comes with the linear actuator and gripper. This assembly is the one that grabs the balloon and attaches it to the hose. The initial process is that the gripper closes and grabs a balloon from a spring-fed mechanism to allow the repeatable grabbing of balloons. After the gripper closes, the linear actuator is activated and attaches the balloon securely to the nozzle. Once the balloon is filled up, the actuator activates once more in the reverse direction and the gripper opens back up to allow the release of the balloon into atmosphere. All these mechanisms are wired through a relay switch that is controlled by Raspberry Pi. Figure 3 shows the prototype of auto balloon launching system developed by the Team1.

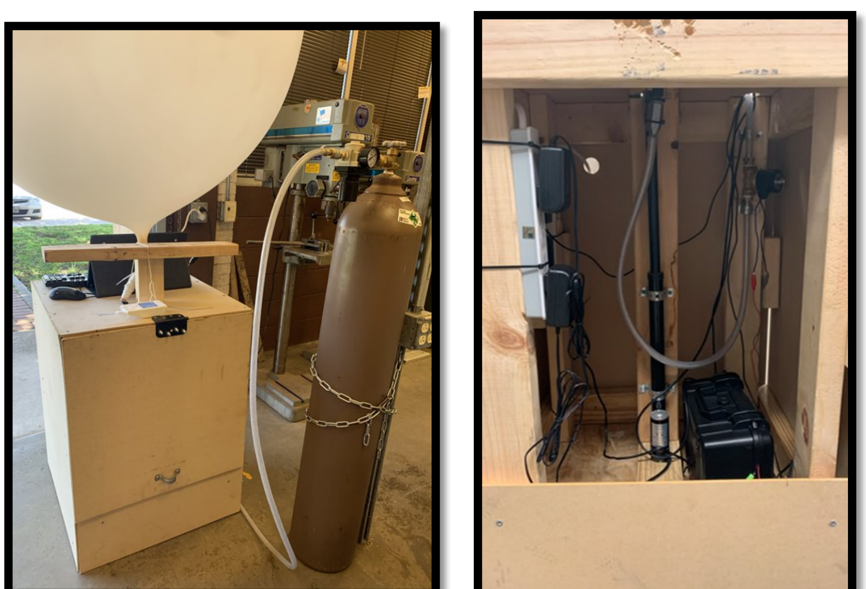

Figure 3. Prototype of auto balloon launching system

Since this project prototype will most likely serve as the basis for a more refined version in the future, the housing was constructed entirely of wood to keep budget costs down, a door was added to the front of the housing for access to all the internals and power cords. The black pelican case in the second image keeps the circuits from being exposed to any of the elements.

3.3.3 Automation and Control

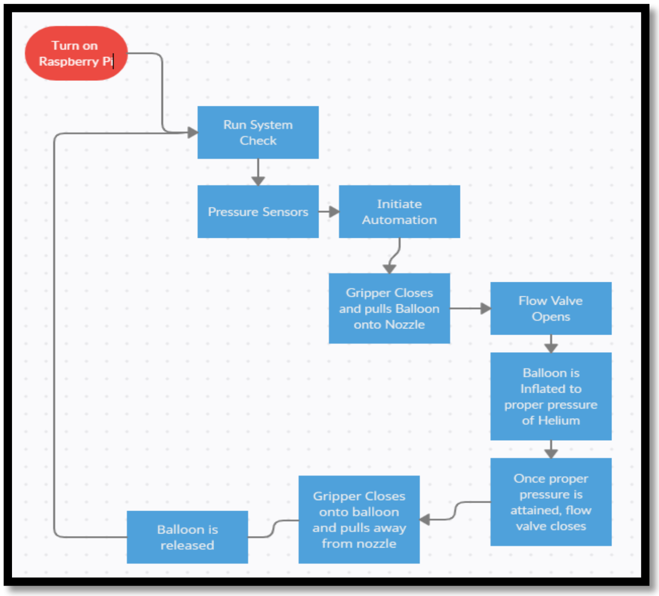

Figure 4. Automation and Control Flow Diagram

The Figure 4 shows the block diagram depicting the sequence of automation process and control. The control program starts off by running a system check to ensure that all sensors are active. The main systems - electronics, program, and balloon seal (via check valve) was tested and verified for flawless operation. The code was kept relatively simple since the team was not familiar with operation of python coding language before undertaking this project. The check valve was tested for the operating pressure of 30 psi using regulator control. The auto balloon launching system was tested and found to operate reliably in the lab and outdoor settings.

3.4 Balloon launching system design and development by Team2

3.4.1 Background Research

The Team2 learned intricacies of the project from literature survey (15-19). Foote et al (15) discuss control aspect of an *Automated Weather Balloon Radiosonde Launcher system,* which was not fully automated. This project used a switch sensor attached to the radiosonde, when the radiosonde raised a certain distance, the switch would get unplugged, and the filling process would stop giving the needed volume for the weather balloon. The team2 did several experiments to find the volume needed for the balloon to be fully filled (65ft^3) at the pressure of 60psi. Wei and Jiangping (16) used a carrousel preloaded with balloons for their automated launching system. The balloons were already assembled with radiosondes. The system used a rotating carrousel that would line up nozzle to inflate the balloon. Once balloon connected to a nozzle, a timer was used to fill balloon with the correct volume and pressure.

3.4.1 Product Design

3.4.1.1 Design Alternative 1

Team2 based its first concept based on a model provided by the sponsor organization. This model used a weight system to turn ON and OFF helium supply in filling the balloon. When the balloon picks up the weight, the mechanical button is released by the device and the flow of helium is stopped by a sealer. After releasing balloon, the handle is manually reset. To make the system more automatic it is decided to add one actuator that would reset the lever, and a push button that would give the signal to the Raspberry Pi to close the ball valve which would stop the flow of helium (Figure 5). The flow chart is shown in Figure 6.

Figure 5. Concept Design

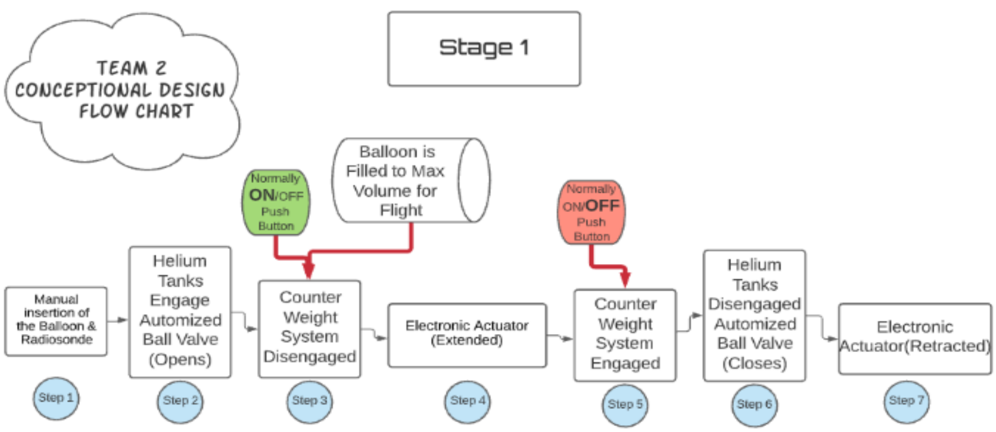

Figure 6. Design 1 Flow chart.

3.4.1.2 Design Alternative 2

The second design is based on a timer, 3D printed parts, and a moving table. The main purpose of this design was to integrate a sealing and releasing process that was not included in the first design. This design kept the balloon without movement when inflated. This design includes 3D printed ball valve controlled by a timer for sealing and a quick connect/disconnect mechanism. This conceptual design includes a Pi that would start the process of the actuator to push a small table upwards for five seconds. After it was completed, the tension created on two cables was released and allowed to connect a quick connector. The ball valve would then open and allow for a flow of helium, and it would stay open for one minute and thirty second for the balloon to be filled. Once the timer was completed the actuator would pull the table downwards to create tension once again and releasing the quick connect, allowing for the balloon to fly. This model is shown in Figure 7.

Figure 7. Concept Design 2

3.4.1.3 Final Design Alternative

The final design of Team2 models the conceptual design alternative 2. The design uses an actuator that pulls cables directly to create and release tension that provides up and down movement to a quick connect. The frame was switched from wood to aluminum. Another difference is an addition of a flow meter to calculate the amount of helium needed to fill the balloon. The process flow chart is shown in the Figure 8.

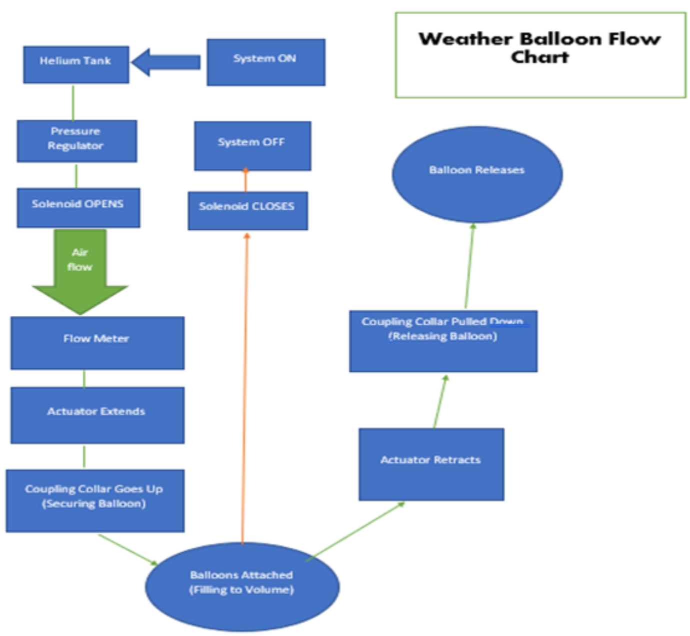

Figure 8. Final Design Flow Chart

The actuator is located on the center section with the quick connector. The Figure 9 shows the connection of cables with the actuator. The Figure 10 shows cables connected to the quick release mechanism, which has a nut that is press fitted to the quick connect. The nut along with two screws hold cables with rest of the system.

Figure 9. Mechanical Cables with Actuator

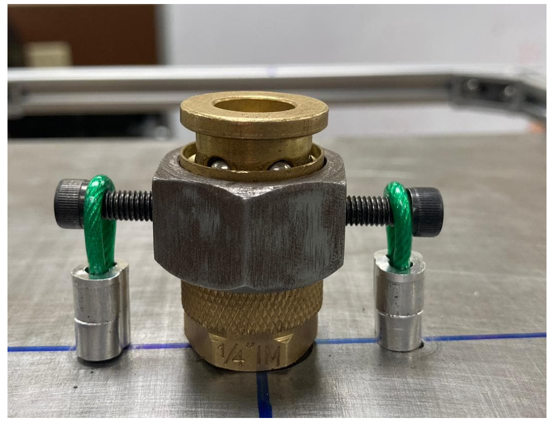

Figure 10. Cables with Quick connector

3.4.2 Automation:

A weather balloon calculator is used to find volume of the balloon required to lift the needed weight. A Raspberry Pi with electrical connections and control program is used in the automation. The final prototype is shown in the Figure 11. This prototype was used to successfully demonstrate the process of automated launching of weather balloon on a portable platform.

Figure 11. Final Prototype and Testing – Team2

3.5 Project Outcomes and Benefits through competition

It has been seen in real life that friendly competition in engineering projects produce better outcomes through new scientific discovery and innovations. This concept is used to produce better outcome to satisfy the need of the company that sponsored this project. The outcome of the completion is that both teams could produce functioning prototypes that are satisfactory to the sponsoring industry. However, comparing two prototypes by Team1 and Team2, the latter has a better design and ready to be deployed by the industry. The student teams' participation and success in this modern aerospace industry sponsored competition received much attention by university and local news agencies. Articles appeared in news releases and newsletters at the university, and college level. Moreover, senior design students are interested in similar project and its success. The course advisors use this project as an example of a thorough senior design experience, with all the hindrances and occasional setbacks typical of industry projects. However, competition-based projects demand additional motivation and perseverance from the student teams.

4.0 Lessons Learned

The lessons learned can be categorized into two focus points. The first of the lessons learned are related to the administration and organization of student teams in the period of COVID-19 pandemic, where the class meetings are done through online. Especially, during this time it was a challenge to coordinate advisor time with team members' availability. Secondly, the open-ended nature of the project required for the students to test their knowledge in mechanical product design and automation systems that they are not very familiar during the past semesters. The experiences gained on capstone competition teams are very rewarding for the students involved. A few curricular changes can be made to include the needed skills in mechanical system design and automation. This will greatly enhance the project administration and efficacy.

5.0 Conclusion

The outcomes of the projects were evaluated and assessed by a rubric-instrument developed to meet the ABET-TAC (Accreditation Board of Engineering and Technology- Technology Accreditation Commission) accreditation requirement. Student survey instrument was used to capture collaboration and engagement of students for the successful completion of their projects. Student teams collaborated effectively and shared information freely even though they were in competition. The main motivation came from the fact that there are no losing team. Only winning criteria is a successful demonstration of the prototype that meets the project goal. Student teams have shown matured skills in the pedagogical aspects of the Engineering Technology curriculum in project management, systems engineering, product, and process development. The successful completion of prototypes by the two competing teams have proved that the seamless integration of industry sponsored projects has the potential to enhance their marketability.

References

1. Robert H. Klenke, “A UAV-Based Computer Engineering Capstone Senior Design” Project Proceedings of the 2005 IEEE International Conference on Microelectronic Systems Education (MSE’05).
2. Teodora Rutar Brandon Shuman, “A Modular Project Management Approach to Undergraduate Senior Design Projects” American Society for Engineering Education, 2011.
3. Gregory Watkins, “Group Selection Techniques for a Mechanical Engineering Senior Design Project Course” American Society for Engineering Education, 2008.
4. Bryan S. Goda, Andre H. Sayles, and Daniel C. Gray, “One Approach to Multidisciplinary Senior Design Projects” FIE '96 Proceedings, IEEE.
5. Betsy Aller, Alamgir Choudhury, James Kamman, et al, “Industry-sponsored Design Competition: Opportunities and Challenges for a Capstone Senior Design Project”, American Society for Engineering Education, 2006.
6. Todd Kaiser, “Robosub: “A Contest-based Multidisciplinary Senior Design Capstone Project” ASEE’s Annual Conference and Exposition, New Orleans, LA, June 26-29, 20216.
7. Robert J. Fornaro Margaret R. Heil Alan L. Tharp, “What Clients Want – What Students Do: Reflections on Ten Years of Sponsored Senior Design Projects” Proceedings of the 19th Conference on Software Engineering Education & Training (CSEET’06).
8. Mark J. Paulik, and Mohan Krishnan “A Competition-Motivated Capstone Design Course: The Result of a Fifteen-Year Evolution”. IEEE TRANSACTIONS ON EDUCATION, VOL. 44, NO. 1, FEBRUARY 2001.
9. Dean Kim, Martin Morris Richard Deller A SUCCESS STORY: THE SAE BAJA CAR AS A CAPSTONE SENIOR DESIGN PROJECT American Society for Engineering Education, 2007.
10. Skiwithpete, director. *Raspberry Pi: 8 Channel Relay Step-by-Step with Software Examples for Automation*. YouTube, 24 May 2014, www.youtube.com/watch?v=oaf_zQcrg7g..
11. 17:04, Jacobus 7-22-2018 at, et al. “Raspberry Pi: Control Relay Switch via GPIO.” *Raspberry Pi Tutorials*, www.tutorials-raspberrypi.com/raspberry-pi-control-relay-switch-via-gpio/.
12. MikeWi lliamson. “Controlling a 12V Solenoid with a Raspberry Pi.” *Welcome to the Information Age. It's Your Data – What Do You Want to Do with It?”* 26 Jan. 2020, dikuw.wordpress.com/2019/10/20/controlling-a-12v-solenoid-with-a-raspberry-pi/.
13. Joker56. *“Control Solenoid Using Raspberry Pi”* - Raspberry Pi Forums, 13 Oct. 2017, www.raspberrypi.org/forums/viewtopic.php?t=212686.
14. Daveh, Auhtor. *“Drop pi – Wter Droplet Photography with Raspberry Pi.”* - www.DaveHunt.ie, 29 Aug. 2015, www.davidhunt.ie/water-droplet-photography-with-raspberry-pi/.
15. J.P. Foote, J. T. Lineberry, and B. R. Thompson, “Automated Weather Balloon Radiosonde Launcher Development” https://www.arm.gov/publications/proceedings/conf08/extended_abs/foote_jp.pdf
16. LI Wei, Haung Jiangping, “Study and Development on Fully Automated Sounding System” https://library.wmo.int/pmb_ged/iom_109_en/Session5/O5_09_Li_Autosonde_study_in_China.pdf
17. Flinn Scientific Physical Science Fax! “Flame- Retardant Balloon” https://www.flinnsci.com/api/library/Download/8c21e94f13bb429c90501abbe58400c5
18. *Actuated Ball Valves vs. Solenoid Valves*. Comparing ball valves vs. solenoid valves for various applications. (n.d.). https://plastomatic.com/ball-vs-solenoid.html.
19. Engineering, O. (2020, October 14). *Flow meters*. https://www.omega.com/en-us/. https://www.omega.com/en-us/resources/flow-meters.