**P21900: Pump Report**

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Given the current project timeline, risk assessment, and team resources, the hardware subteam with the assistance of Dr. Stiehl has determined two potential paths forward for the remainder of the P21900 project. These paths are outlined below.

An important factor that drives this dilemma is the current pump market. Market analysis done during the scope of this project shows that pumps largely exist in two distinct market categories: “industry pumps” and “aquarium pumps” for the purposes of this document.

**Table 1 – Current Pump Market**

|  |  |  |
| --- | --- | --- |
|  | **Industry Pumps** | **Aquarium Pumps** |
| Target audience | STEM industries | Hobbyists and DIYers |
| Documentation | Clear engineering and technical documentation | Some or minimal documentation |
| Pump control | Dedicated control system (included in the pumping system or as an addition to the system) | Can be integrated with a user’s control system; may be purchased with a control system included |
| Manufacturer | Well-known industry suppliers | Various, may not have tight manufacturing tolerances |
| Price Range | $200+ | $10-30 |

The requirements of this project fall into the “no man’s land” of the existing pump market; pumps that allow user-integration of control systems while maintaining reliability and meeting engineering standards are niche need.

**01 – Manual Pump Flow Variation**

This option is the continuation of the team’s plan prior to the Phase VI Review, and is built upon the customer requirements originally determined in Phase I. The hardware team is more confident in this option resulting in a completed, final product due to the factors outlined below.

**01.A. – Pump**

The team has already specified and found a pump that would be appropriate for this project based on modeling of heat transfer and pressure throughout the system. Additional information about this pump can be found in Appendix A. Benefits of this pump are as follows:

* There is a dial on the pump that would allow the user to manually change the flow rate as necessary if there was concern about rodent body temperature. Alarms could be integrated into the software system and a suggested pump rate could be prompted by the software system.
* The pump is sold by Grainger, a company that has a local Rochester location and is an approved vendor for purchasing. The pump should arrive within a day of the approval of Multidisciplinary Senior Design (MSD) Purchasing Office.
* The pump is sold from a well-respected industry supplier and has appropriate specifications and documentation to support its purchase and integration into our system. Information such as minimum and maximum flow rates, pump head, maximum pressure, tolerances, and temperature compatibility are readily available.
* Pump tubing is included in the purchase.
* Replacement pump parts are easily available for down-the-line.

Downsides to this pump:

* The pump is around $290. The MSD team would be able to contribute $150 from the team’s budget to cover this pump cost. The remainder of the purchase would have to be covered by the customer.
* High cost would use the remainder of the team’s available budget.
* Requires manual control of flowrate.

**01.B. – System Integration**

In this system model, there are two entirely separate subsystems: hardware and software. The benefit of this separation is that is streamlines the build and testing process, specifically with the members of our overall team in two (soon to be three) different physical locations. Troubleshooting is simpler with a singular system component.

**02 – Closed Loop Pump Flow Variation**

This option is based on the customer’s support of a closed-loop system during the Phase VI Review. The hardware team anticipates that this option will result in a functional prototype and for another MSD team to see this project to completion.

**02.A. – Pump**

As discussed previously, specifying a pump for this option will be more difficult due to documentation. The team has found pump options through preliminary searches but would need to update the system model to confirm their viability. Benefits of a similar pump are as follows:

* Integration with the software system would allow dynamic, closed-loop control.
* Pumps of this sort are generally available for purchase on various sites. It is anticipated that an appropriate pump could be found for purchase from an approved vendor.
* Low entry cost would allow for multiple pumps to be purchased for concurrent prototyping between both subteams.

Downsides to this pump:

* Incomplete documentation may lead to unexpected pump behavior or failure.
* Manufacturing tolerances may mean that the two pumps may not be totally interchangeable.
* Pump still needs to be selected.
* Unknown lead time on purchase.
* A higher-end pump will likely need to be purchased in the future for long-term use.

**02.B. – System Integration**

In this system model, both subsystems are interconnected. The long-term result is certainly a more integrated product, but likely will require a second iteration of MSD to achieve a finished product. The increased complexity of the system will increase the complexity of build, testing, and prototyping, specifically due to the international nature of our team. Subteams will be dependent on each other for moving forward, which increases risk. These factors, among others, contribute to the hardware team’s assessment that the end result of this option will likely be a functional prototype.