Customer Needs

1.1 Initial Meeting

NASA has partnered with the FAMU-FSU College of Engineering to develop an actively sealed cryogenic coupler to be used for fueling spacecrafts. The team's assigned points of contact at the Marshall Space Flight Center (MSFC) are Marvin W. Barnes (MSFC-ER64) and James C. Buzzell (MSFC-ER14). James Buzzell is the acting point of contact for the team regarding direct project communication and advising.

The initial meeting was held on Friday October 6th, 2023, at 10:00 am EDT on Zoom with the entire team present and our advisor James Buzzell. The team went through a list of questions that were prepared prior to the meeting to gain further understanding of the desired product our sponsor was looking for.

The questions and interpreted needs are placed below in Table 1 to organize the information gathered during the initial meeting. These questions will help the team stay focused on the customers' needs and understand the expectations the sponsors have for the project.

Table 1. *Customer Interview*

Question Asked:	Customer Statement:	Interpreted Need
What are cryogenic couplers used for?	Couplers are used to connect segments that transfer cryogenic fluid.	The coupler seals two connected pipes and functions at cryogenic temperatures.

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What are common causes of leaks and how to prevent them?	Low temperatures affect O-ring seals. Cracks in metal or attachment process may damage the seal.	The coupler withstands the attachment process and seals effectively in low temperatures.
What makes a coupler actively sealed?	The coupler activates the seal upon contact between the two mating halves, like a quick disconnect air fitting.	The coupler activates the sealing mechanism through direct contact of the two halves of the system.
What are the environmental conditions that this system will be used in?	Ambient, spacelike, various states in the US, and Lunar surface.	The coupler system operates in various states: natural environments, in space, and on the lunar surface.
Who will be operating/maintaining this device?	The spacecraft's navigation system and the fuel tank will be able to self-align for attachment. Will not be attached by hand.	The coupler corrects its own alignment, attaches, and detaches on its own.
What can be improved on the current coupler systems?	Cryogenic fuel leak rate.	The leakage rate of the fuel is minimized from the typical rate (10^3 Cf/min).

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What is the expected lifetime for this system?	You can determine the length of the mission, whether that is a few months or a year.	The design operates for an entire mission.
What do you expect from us during this project in terms of communication and updates?	You can decide how often and when to meet. I am open to email communication and virtual meetings.	Questions regarding the design are sent via email, and virtual meetings may be requested if an urgent matter arises.
Is there a recommended material for this application?	Austenitic stainless steels (300 series) are typically used for their cryogenic application.	The chosen materials have high performance at cryogenic temperatures.
Should we be cautious of magnetic interference that is caused by ferromagnetic steels and coldworking?	That hasn't really been a problem for applications that do not use magnets.	Testing for magnetic interference is included if magnets are used in the final design.
Are there constraints for the pipe diameter where the propellant flows?	The outside diameter of the pipe should be 2" or greater. You also shouldn't use a pipe that is unreasonably large in diameter.	The outer diameter of the pipe has a reasonably sized outside diameter that is above the minimum requirement.

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Is improper vehicle alignment something our team should design for?	Don't worry about orienting the vehicle, the astronauts will take care of alignment. However, your design should be able to handle some tolerance.	The design tolerates slight misalignment during connection.
Is lunar regolith a factor to consider for operation of the coupler?	Yes, lander crafts can kick up regolith on the moon and dust on the surface of Mars. Also, spacecraft exhaust particulates.	The coupler is protected from environmental particulate matter and exhaust particulates.
How should the coupler design be structured?	Depot and tanker have two mating coupler halves. No interface in between.	The two mating halves of the coupler, one on the depot fuel station and one on the tanker vessel, are designed with no interface between them.

1.2 Explanation of Results

After interpreting the customer responses, the team derived the necessary elements for the cryogenic coupler project. The primary objective of the coupler project is to extend the lifetime of cryogenic fuel storage with a focus on the leakage rate during fuel transfer. The

customer explained that this design will be implemented in two parts, one for a depot vessel and another for a tanker vessel that will be located on a mobile craft. Due to this, the system will be designed for a 90-day lunar mission and to be used in a multitude of environments. For missions to low-earth orbit or farther beyond, payload is a tremendous consideration as it significantly impacts the cost and thus it is common to use Titanium and aluminum alloys for cryogenic applications. However, due to the cost of those materials and ease of access, stainless steel alloys will be used in the design and testing of this project. A necessary component to this project is that the coupler actively seals upon contact of the two halves. Due to this, it was also outlined by the customer that the craft position and alignment would not be part of our project's scope. When asked about the possibility of lunar regolith interfering with the operation of the coupler, the customer explained that it is possible that the craft may kick up some dirt or dust and this should be accounted for in the design, as well as the possibility of spacecraft exhaust particulates.