Customer Definition and Needs Identification Process

Team 517's sponsors at MSFC act as the primary customers for this project. Their goals for this project serve as the foundation for its future development, and so gaining a detailed understanding of their vision will be critical for this project's success.

Meetings with the sponsors have taken place weekly since establishing contact between parties. Throughout these meetings, customer needs have been identified through both general discussion and directed questions. These responses, their answers, and interpreted meanings are listed in the table below.

Table 1: *Questions, Customer Statements, and Interpreted Needs*

Question	Customer Statement	Interpreted Need
Walk us through a typical testing setup using this product.	Testing is conducted within a vacuum chamber to eliminate influences from the atmosphere. The thrust stand will be mounted within this chamber and features a thrust sensor to gauge the force produced by the thruster.	The thrust stand and its components withstand vacuum like conditions A sensor is present to gauge the force produced by the thruster
What improvements can be made over current designs?	1. The thrust stand is too heavy to move with one person 2. The ease of connection is limited- fluid/electrical lines, and force sensors 3. Thrust measurement could be more accurate 4. The stand material (aluminum) is not compatible with the propellant with leaks	1. The thrust stand is maneuverable enough for 1 person to handle. 2. Lines and connections are easily accessible. 3. Thrust measurement method provides accurate measurements. 4. The thrust stand's composition and functionality will not deteriorate or be affected by propellant leaks.

	5. The field of view is limited, and the stand cannot be seen from outside the vacuum chamber	5. The thruster and all critical components are visible from viewports outside of the vacuum chamber.
What aspects of current products are you looking to retain?	Currently, the thruster is mounted vertically which makes calibration much easier. 1/8” tubing is very nice for dealing with fluid input since it can fit into smaller spaces and induces less torque on the thrust stand. Similarly, VCR fittings are great for leak-free operation.	The thruster is tested in a vertical orientation with ignition facing downward. Fluid lines are optimally sized, designed compactly, and cause minimal amounts of torque on the thrust stand. Fluid lines and fittings are leak free.
What type of calibration needs to be done for the thrust stand?	External forces are always going to be present in a setup like this. To account for this, the thrust sensor will need to be remotely calibrated from outside the vacuum chamber.	The thrust sensor and other relevant systems are remotely calibrated.
What types of measurements will need to be taken?	The thrust is the required measurement, the plume temperature and the pressure would be nice	A system of measurement is available to record thrust exerted, plume temperature, and pressure in relevant locations.
Are there any size constraints for this thrust stand?	The thrust stand must fit within the vacuum chamber. It must fit within these volume parameters: 12in long x 18in wide x 12in high	The thrust stand fits in a 12”L x 18”W x 12”H volume inside the vacuum chamber.
What is the maximum temperature of the plume?	The steady state (maximum) plume temp is 1600 °C.	The plume temperature sensor accurately measures up to 1600 °C. All materials and components subject to this temperature do not experience plastic deformation as a result.
What is the strength of the vacuum in the chamber?	At maximum, the pressure is 1e-6 Torr, and normally is 1e-3 Torr.	The stand and its components, including sensors, can withstand a maximum of 1e-6

		vacuum pressure without outgassing.
What kind of thrusters will this thrust stand need to accommodate?	This stand needs to accommodate our 0.1N class of thruster with the potential to accommodate our 5N class of thruster down the line.	The thrust stand is designed to hold a 0.1N thruster and potentially scalable up to NASA-MSFC's 5N class thruster.
What kind of deliverables is NASA expecting for this project?	We are looking for this thruster to be reproducible by other universities. So, besides the thrust stand itself, we need a design book/user guide for the stand which includes an uncertainty analysis documenting all sources of potential error.	The thrust stand design is made of materials and parts that can be created with resources and shops that other universities will have access to.
What kind of software is used to obtain data from the thrust stand?	For our current setup, our team uses LabVIEW to view thrust, temperature, and volumetric flow rate data. We also have experience with Arduino and are comfortable using it for the project.	The thrust stand interfaces with an Arduino microcontroller and is compatible with LabVIEW for future use.
Are there any other conditions within the current setup that would need to be accounted for?	For all the sensors, we have a terminal block that your thrust stand will have to interface with.	All sensors and wiring will terminate at the terminal block for ease of connection and portability.

Explanation of Results

As discussed earlier, the customer needs were identified during a series of meetings with Team 517's sponsors at MSFC. During the first meeting, the sponsors laid the groundwork for the main goals of this project, discussing key goals, deliverables, and the integration with their current setup. In conjunction, Team 517 had discussions about both potential improvements and what kinds of data the thrust stand would need to produce. In the second meeting, the team gathered more information on crucial instrumentation, further discussed potential improvements,

and attained a deeper understanding of where accuracy improvements need to be made. The sponsors were gracious enough to answer our questions, show a video of thrust stand operation, and demonstrate how they obtain data.

Researchers at MSFC are looking for a thrust stand capable of accurately measuring the thrust from a 0.1N class of green propellant thruster. The stand and its components will be placed within a vacuum chamber and need to withstand conditions down to 1e-6 torr. Due to these low pressures, the thrust sensor will also need to be remotely calibrated from outside the chamber. In comparison to previous models, NASA is looking to decrease weight, improve thruster visibility, and switch to a more suitable material for the stand. Beyond producing a thrust measurement, the stand will also feature sensors for tracking the plume temperature and potentially pressure ports as well.

In conjunction with its core functionalities, the researchers are also looking to develop a reproducibility package. This entails producing a design book and user guide so other universities can manufacture the thrust stand in their own facilities. Alongside this, an uncertainty analysis for the entire stand will be prepared and presented in this user guide.