1.4 Target Summary

Targets/Metrics go Beyond Functions

Some important targets for this project beyond the functional decomposition are overall lifespan, cost of manufacturing, and recyclability. Lifespan is an especially important need and is often the limiting factor for current designs. To adequately compete with stemmed versions, the implant should last between 10-20 years with only minimal surgical revisions. This function will not be evaluated due to time limitations. Another function is the cost of manufacturing, which depends on the material composition and overall part density and should be minimized to make the product cheaper and more widely accessible to those in lower-income households. Cradle-to-cradle production is also of importance. Defective parts and those that inevitably fail should be 90% recyclable to allow for cheaper and more sustainable production.

Derivation of Targets/Metrics

The critical components of this project were determined through conversations with our sponsors and stakeholders. From these conversations a general need was determined after which targets and metrics can be assigned to better describe these needs. Preventing premature implant failure is central to the success of this project. To prevent these failures, the design must be improved to resist existing stresses. General implant failure can occur due to shear, torque, or rocking moments meaning that the new design must be superior at resisting these values compared to the original Exactech design. Through conversation with a surgeon who has experience implanting this device, we gathered more information about improvements to ease installation. A general reversible stemless shoulder implant required 1.5-2 hours to implant

successfully. Our hope is that through design implementation and surgical methods this time can be shortened to only an hour.

Critical Targets/Metrics

The critical target and metrics were determined by evaluating the customer needs and which targets and metrics achieve these needs. The critical needs are: Resist Rocking Moments, Resist Torque, Resist Shear Forces, and Increase Lifespan. The corresponding critical targets are:

1. Implant resists rocking moments at least 10% better than Equinox.
2. Implant resists torque at least 10% better than Equinox.
3. Implant resists shear forces at least 10% better than Equinox.
4. The lifespan of the design must last at least 10 years.

The first critical target is the resistance of rocking moments at least 10% better than Equinox, measured in Newton-meters (rotational). The second critical target is the resistance of torque at least 10% better than Equinox measured in Newton-meters (non-rotational). The third critical target is the resistance of shear forces at least 10% better than Equinox measured in Newton/meters^2. The resistance of the forces aims to increase the implant mobility and lifespan by preventing the dislodgement of the implant. It also ensures an increase in the strength of the interface between bone and implant. The last critical target is that the implant remains functional for at least 10 years. This target corresponds to the increase in lifespan of the implant.

Discussion of Measurement

A strain gauge or load cell are tools that will be required to make accurate comparisons. These devices will be used to quantify the difference in stress values that Exactech's Equinox

design can withstand compared to alternative designs. Calipers will be required to record the dislocation distance between the bottom of the implant and the bone surface.

Summary and Catalog

To summarize, the most important targets and metrics are associated with the implant's lifespan. The ability to resist stress, especially the rocking moment, is paramount to the longevity of the implant. These target values, however, are qualitative, not quantitative. The values themselves can only be used in comparison with Exactech's Equinox design due to an inability to replicate bone qualities and metal print titanium employed by Exactech. To test minimal requirements a true comparison can be simulated through FEA (Finite Element Analysis). This will allow for a more comprehensive 1:1 comparison. To test other methods plastic 3D printing and bone simulation material will be used in comparison with a control Equinox model.

Need	Target	Metric
Resist Rocking Moments	10% better than Equinox	Moment
Resist Shear	10% better than Equinox	Stress
Resist Torque	10% better than Equinox	Torque
Easier to Implant	10% better than Equinox	Time, Steps, Physical Exertion