

Wet Sump to Dry Sump Design Project

Engineering Design - ACMA4008

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References:

	Link
Dry Sump Understanding	https://www.drysump.com/index.php/technical-info/technical-explanation-of-a-dry-sump-system
Dry Sump Understanding	https://www.roadandtrack.com/car-culture/videos/a32140/dry-sump-vs-wet-sump/
Dry Sump understanding	https://carsandwrenches.com/wet-sump-vs-dry-sump/
Product Research	https://www.ebay.co.uk/itm/30493306721?chn=ps&norover=1&mkevt=1&mkrid=710-153316-527457-8&mkcid=2&itemid=304933067217&targetid=4584757337645578&device=c&mkttype=&googleloc=&poi=&campaignid=554427144&mkgroupid=1298524317493059&rlsarget=pla-4584757337645578&abcid=9313282&merchantid=87779&msclkid=31b81cc65b35114c98ec7ade1e990c0d
Product Research	https://www.ebay.co.uk/itm/275540982673?chn=ps&norover=1&mkevt=1&mkrid=710-153316-527457-8&mkcid=2&itemid=275540982673&targetid=4584757337645578&device=c&mkttype=&googleloc=&poi=&campaignid=554427144&mkgroupid=1298524317493059&rlsarget=pla-4584757337645578&abcid=9313282&merchantid=87779&msclkid=23529c46e7e817a0ad95fa5ea1af7202
Product Research	https://www.ebay.co.uk/itm/275541051180?chn=ps&norover=1&mkevt=1&mkrid=710-153316-527457-8&mkcid=2&itemid=275541051180&targetid=4584757337645578&device=c&mkttype=&googleloc=&poi=&campaignid=554427144&mkgroupid=1298524317493059&rlsarget=pla-4584757337645578&abcid=9313282&merchantid=87779&msclkid=693f58d371d21573e9923ecb3f0bc137
Product Research	https://www.andersonracingengines.com/duratec-182023l/ford-duratec-20-23-25-l-mountune-dry-sump-kit
Product Research	https://www.ebay.co.uk/itm/275541049443?chn=ps&norover=1&mkevt=1&mkrid=710-153316-527457-8&mkcid=2&itemid=275541049443&targetid=4584757337645578&device=c&mkttype=&googleloc=&poi=&campaignid=554427144&mkgroupid=1298524317493059&rlsarget=pla-4584757337645578&abcid=9313282&merchantid=87779&msclkid=68e7ebbfd60e1b5ecadb8da798d7e995
Product Research	https://www.ebay.co.uk/itm/275541089889?chn=ps&norover=1&mkevt=1&mkrid=710-153316-527457-8&mkcid=2&itemid=275541089889&targetid=4584757337645578&device=c&mkttype=&googleloc=&poi=&campaignid=554427144&mkgroupid=1298524317493059&rlsarget=pla-4584757337645578&abcid=9313282&merchantid=87779&msclkid=26cdcb3103ff1d36a7fcd294439d009
Product Research	https://www.ebay.co.uk/itm/275541088276?chn=ps&norover=1&mkevt=1&mkrid=710-153316-527457-8&mkcid=2&itemid=275541088276&targetid=4584757337645578&device=c&mkttype=&googleloc=&poi=&campaignid=554427144&mkgroupid=1298524317493059&rlsarget=pla-4584757337645578&abcid=9313282&merchantid=87779&msclkid=c4d741d06c9313a45cd527c82b556fa7
Design Understanding	https://www.sciencedirect.com/topics/engineering/quality-function-deployment#:~:text=Product%20planning%20using%20QFD%20gives,target%20values%20to%20be%20achieved.

Introduction

Summary

As a graded assignment for ACMA4008, Engineering Design, this report will detail the design process of redesigning a wet sump into a dry sump. This report will not be covering mechanical properties of the design unless it directly links to the decision-making process of the design because this report is to focus exclusively on the design thought process and the progression towards the final result.

Aims

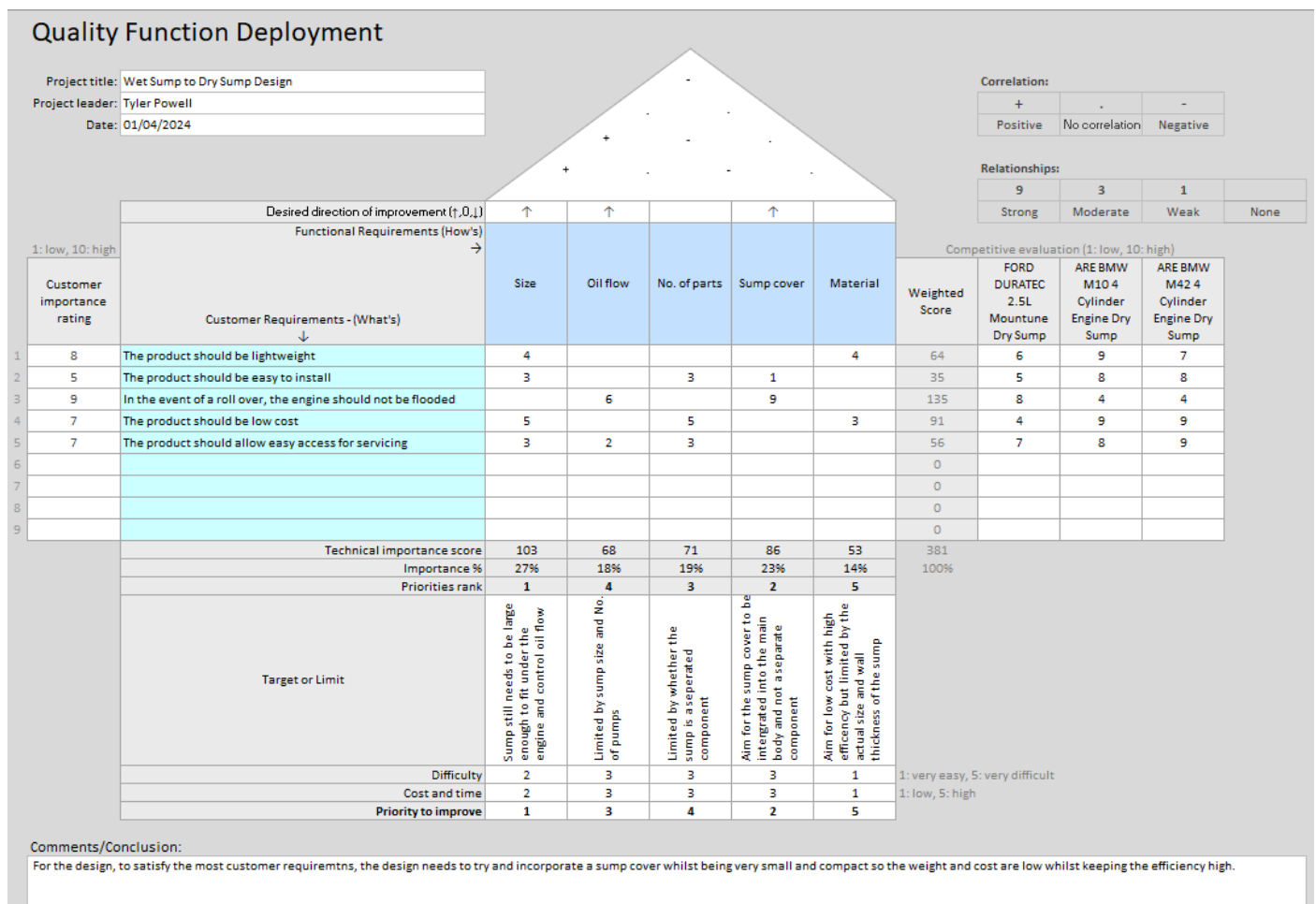
The aim of this report is to demonstrate understanding of the design process and evaluate each design according to various factors such as customer wants and technical needs. Demonstrate each design in a clear way using 2D and 3D CAD tools all in accordance with BS8888. Relate the complexity of the design, the material choice, and the manufacturing process to the volume of required units needed for production.

Design Requirements

Product Research and Understanding

A sump is the cavity under the engine of a car that collects used oil on from the engine. A wet sump system uses the sump as a container for the oil, being drawn directly from here to the engine for lubrication. A dry sump system, however, uses an external tank to store the oil, so the sump merely acts as a way to funnel the oil into the pump to the external tank.

Quality Function Deployment

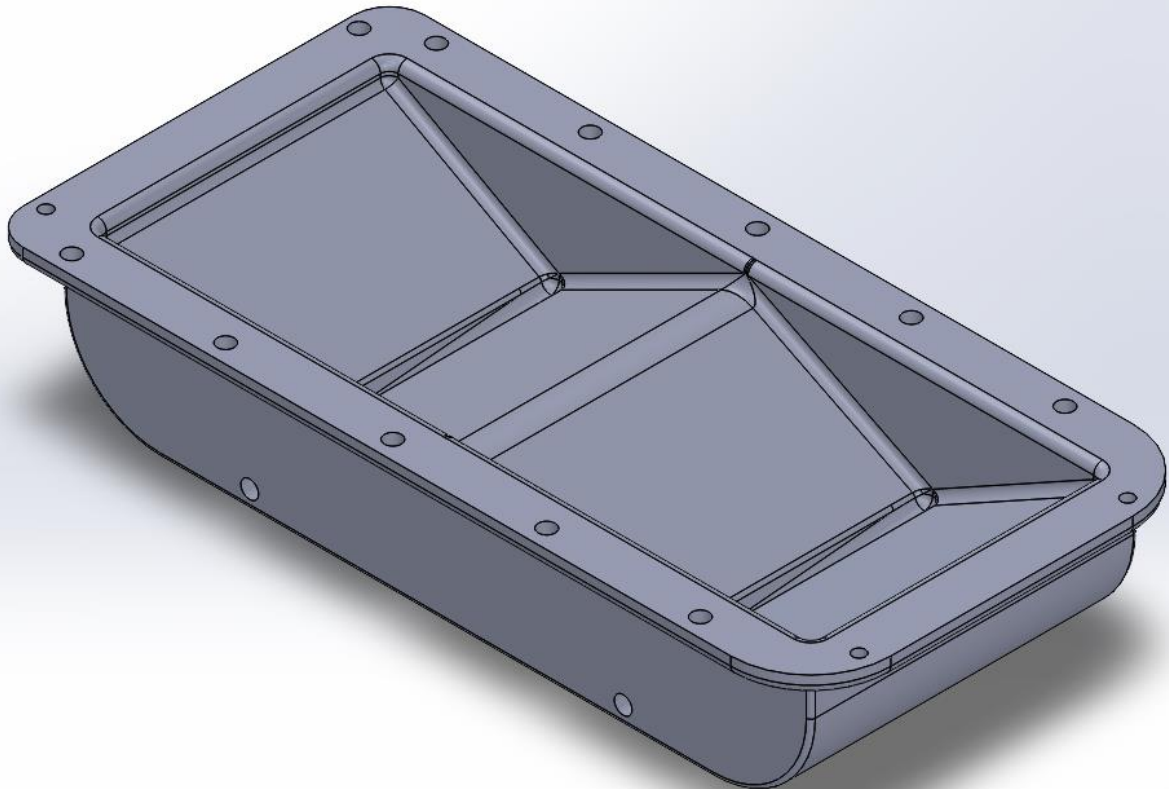


Design Specification

Target	
Small vertical dimension	Limit the size to keep production costs low, promote flowrate efficiency and make the design low weight
Lightweight material	The product should be made from a material with strong physical properties but also be lightweight, such as aluminium
Low material usage	The design should attempt to avoid using unnecessary material and keep only what is structurally required
Include a sump cover or equivalent system	To avoid oil from flooding the engine in the rare event the car topples, there needs to be a system to prevent the flooding
High oil flowrate	The design needs to control the flowrate of the oil to efficiently direct into the collection pump(s), this will also help with preventing the engine from flooding
Fit onto current engine	The redesign needs to still be within the current model's dimensions and have the same screw dimensions
Limit part assembly	Aim to keep the number of components to a minimum without sacrificing serviceability
Limit intricacies in the design	Keep the design simple to keep manufacturing costs low and to allow for easier servicing

Design 1

CAD Design 1



Design Analysis

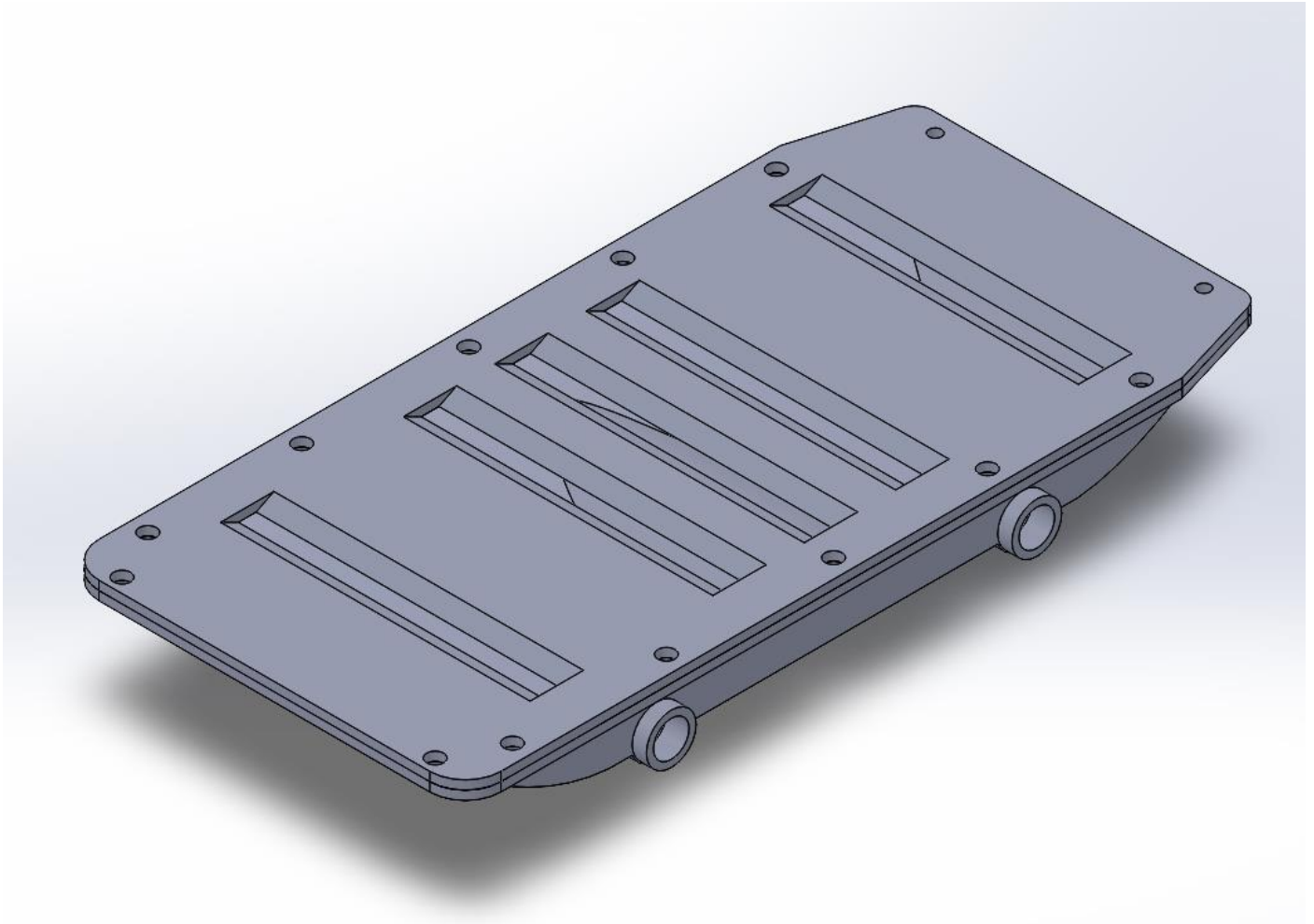
The design is focused on having a high oil flowrate by using a variety of smooth surfaces and ramps to lead into two gutters that will lead the oil directly into the collection pumps. The design should fit onto the current engine perfectly and the design is quite simple and will be made from aluminium, so it should be able to be manufactured without hassle, meaning costs for this design should be low. There are some limitations of this design however, the design is not very efficient on material usage, having a few areas with just very thick areas of material that serve no purpose and the vertical dimensions of the design could be lower. For improvement it would be best to lower the vertical dimension, which may lower flowrate but would lower costs and weight. Also, a key feature missing off the design is a sump cover which is needed to prevent the engine from flooding in the event the car topples. It would also be best to lower material usage and reduce unnecessary material being wasted in the design.

Design in Accordance with Design Specification

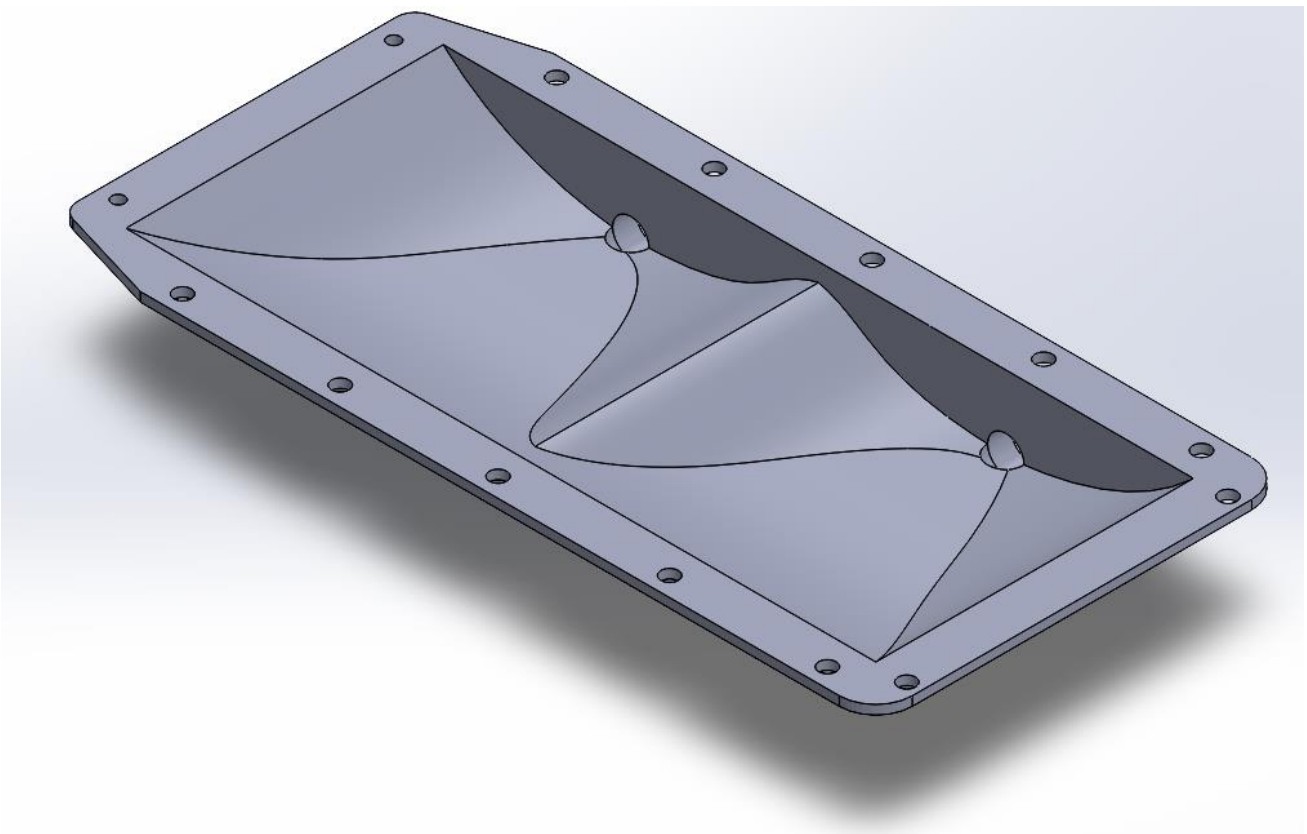
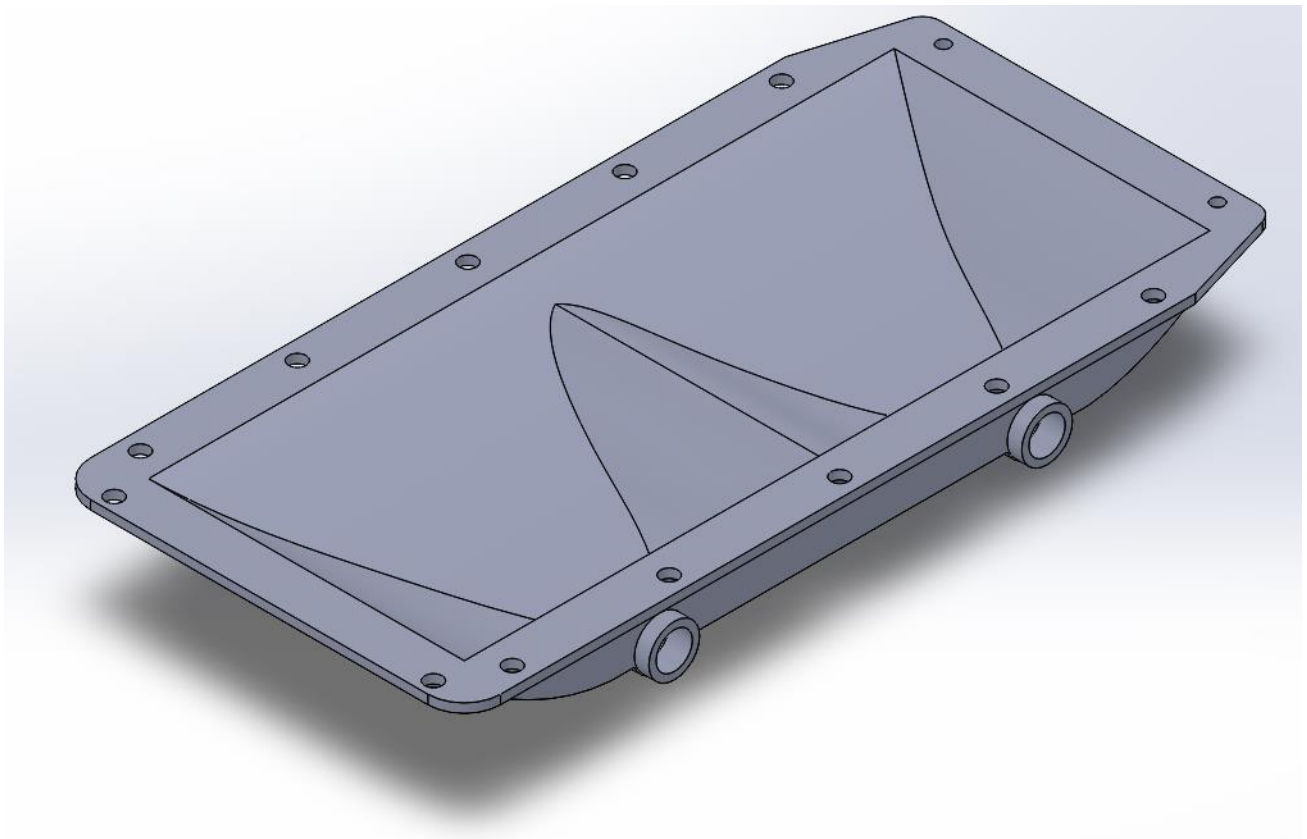
Target	Target met?	Score
Small vertical dimension	NO	1
Lightweight material	YES	10
Low material usage	NO	3
Include a sump cover or equivalent system	NO	0
High oil flowrate	YES	7
Fit onto current engine	YES	10
Limit part assembly	YES	10
Limit intricacies in the design	YES	9
Easy maintenance access	YES	9
	Total	59

Design 2

CAD Design 2



CAD Design 2 without Cover



Design Analysis

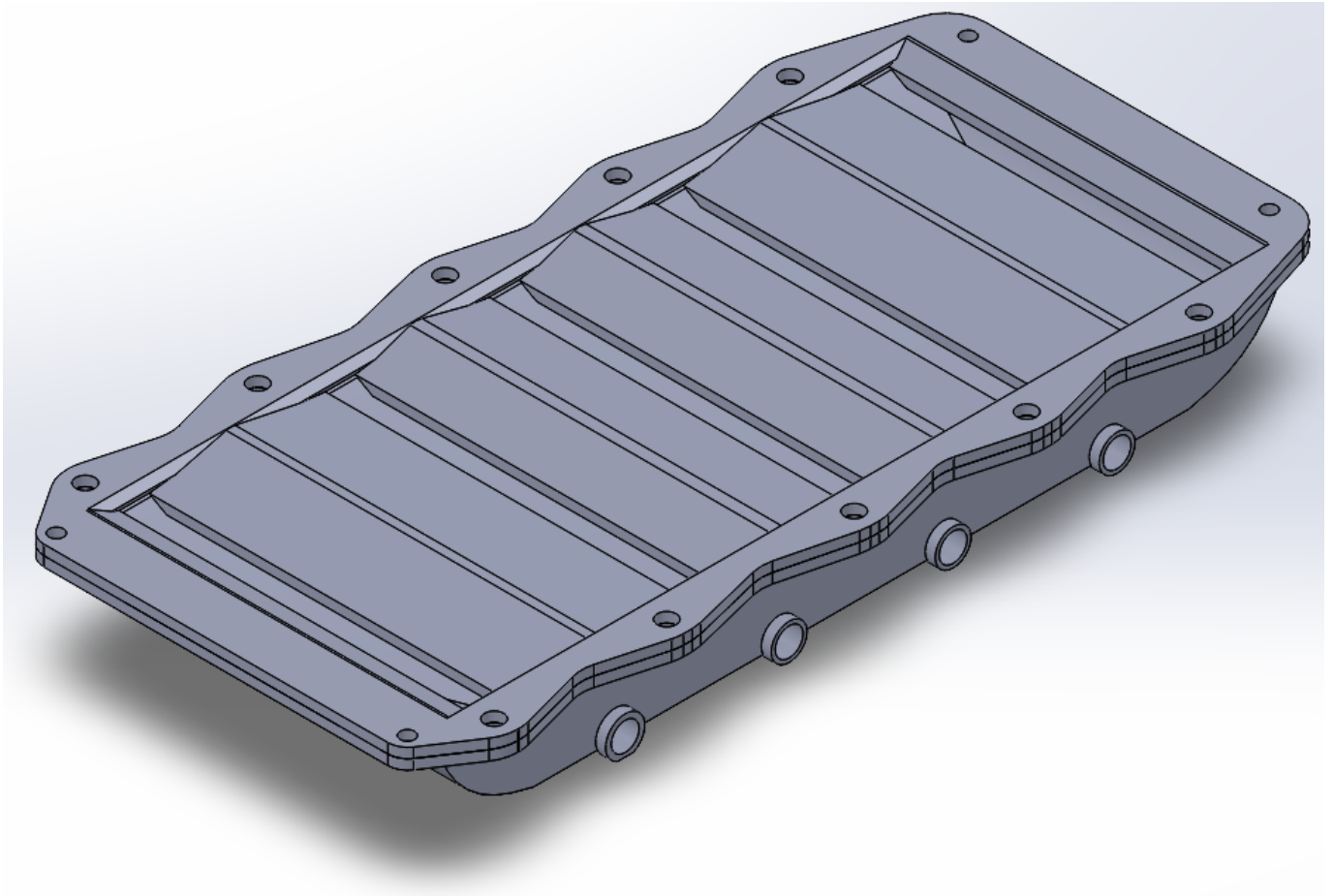
This design focuses on correcting the issues with Design 1. It has much thinner walls and its vertical dimension is much smaller. It also features a cover with baskets on the underside to stop the oil from getting out the grates in the event that the vehicle topples. Every part of the inner basket of the sump is dedicated to directing the oil directly into the scavenge pumps with the curved rounded structure. The design when compared to other models on the market, seem very similar, sharing the overall look and design structure which adds to the success of this design. There are very few improvements that could be made with this design. One such improvement is lowering the number of component pieces, currently the design has 2, the cover and the sump, it may not be possible to successfully combine both into one whole piece and still allow for easy maintenance, but it is worth consideration. Cost wise it shouldn't be expensive to produce with the material being made from aluminium. However, it would likely require varying tools to achieve the shapes in the design which could be costly. For future designs it may be worth considering additional areas for scavenge pumps, increasing from 2 to 4 for max efficiency however that may be overdesigning and needlessly increasing costs it as that is usually only used for high end very competitive vehicles like in 'Formula 1' cars.

Design in Accordance with Design Specification

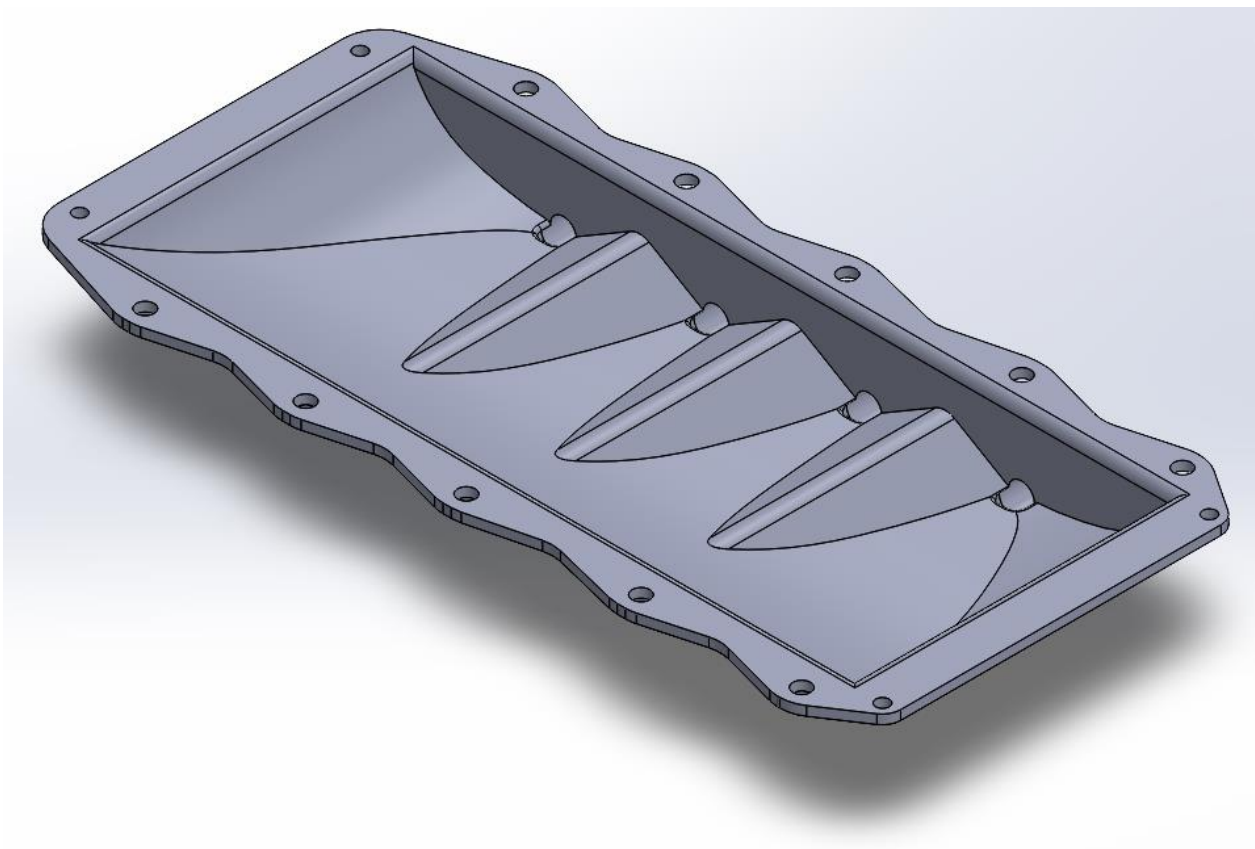
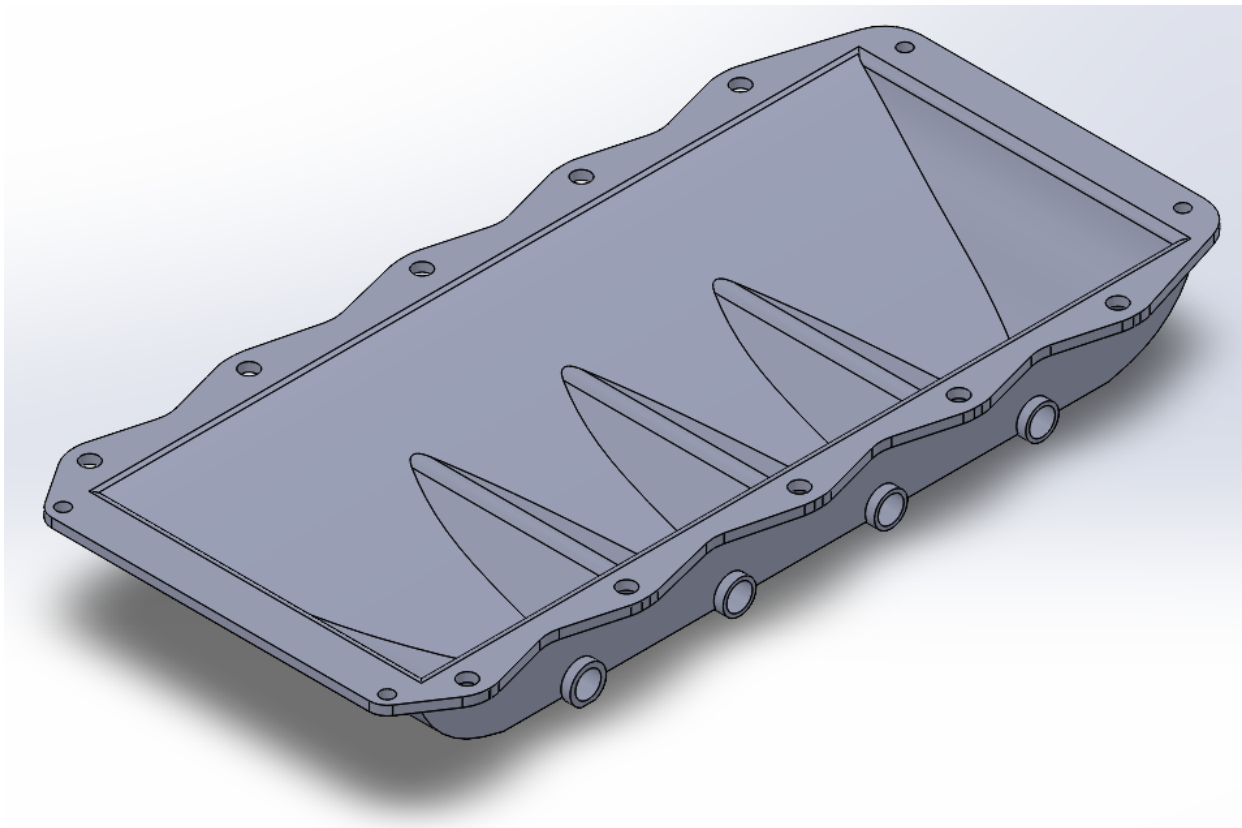
Target	Target met?	Score
Small vertical dimension	YES	9
Lightweight material	YES	10
Low material usage	YES	9
Include a sump cover or equivalent system	YES	9
High oil flowrate	YES	8
Fit onto current engine	YES	10
Limit part assembly	YES	8
Limit intricacies in the design	YES	7
Easy maintenance access	YES	7
	Total	77

Design 3

CAD Design



CAD Design without Cover



Design Analysis

Design 3 aims to improve on Design 2 by leaning more into its positives whilst trying to alleviate some of its minor issues and shortcomings. The main notable change is increasing the number of scavenge pump outlets which should keep the sump as dry as possible. The design also has deeper gutters near the scavenge pumps so there should be less oil in the rest of the sump and make it less likely for oil cavities on the underside of the cover to overfill and flood the engine in the event of a turnover. The other notable improvement is the reduce in wasted material, especially around the connection points. The final major change is the sump cover, it has been completely redesigned and the oil vent system overhauled. It now has much larger slopes to avoid oil collecting on top and not flowing through the vents, so the oil flowrate of on the sump cover has greatly increased. The only noticeable limitation of the redesign sump cover is that if the vehicle would only be toppled at 90 degrees, if there is a substantial amount of oil in the sump, it may flood, but with the four pumps and the increased gutter depths, this should be unlikely to happen.

Design in Accordance with Design Specification

Target	Target met?	Score
Small vertical dimension	YES	9
Lightweight material	YES	10
Low material usage	YES	10
Include a sump cover or equivalent system	YES	10
High oil flowrate	YES	9
Fit onto current engine	YES	10
Limit part assembly	YES	8
Limit intricacies in the design	YES	6
Easy maintenance access	YES	8
	Total	80

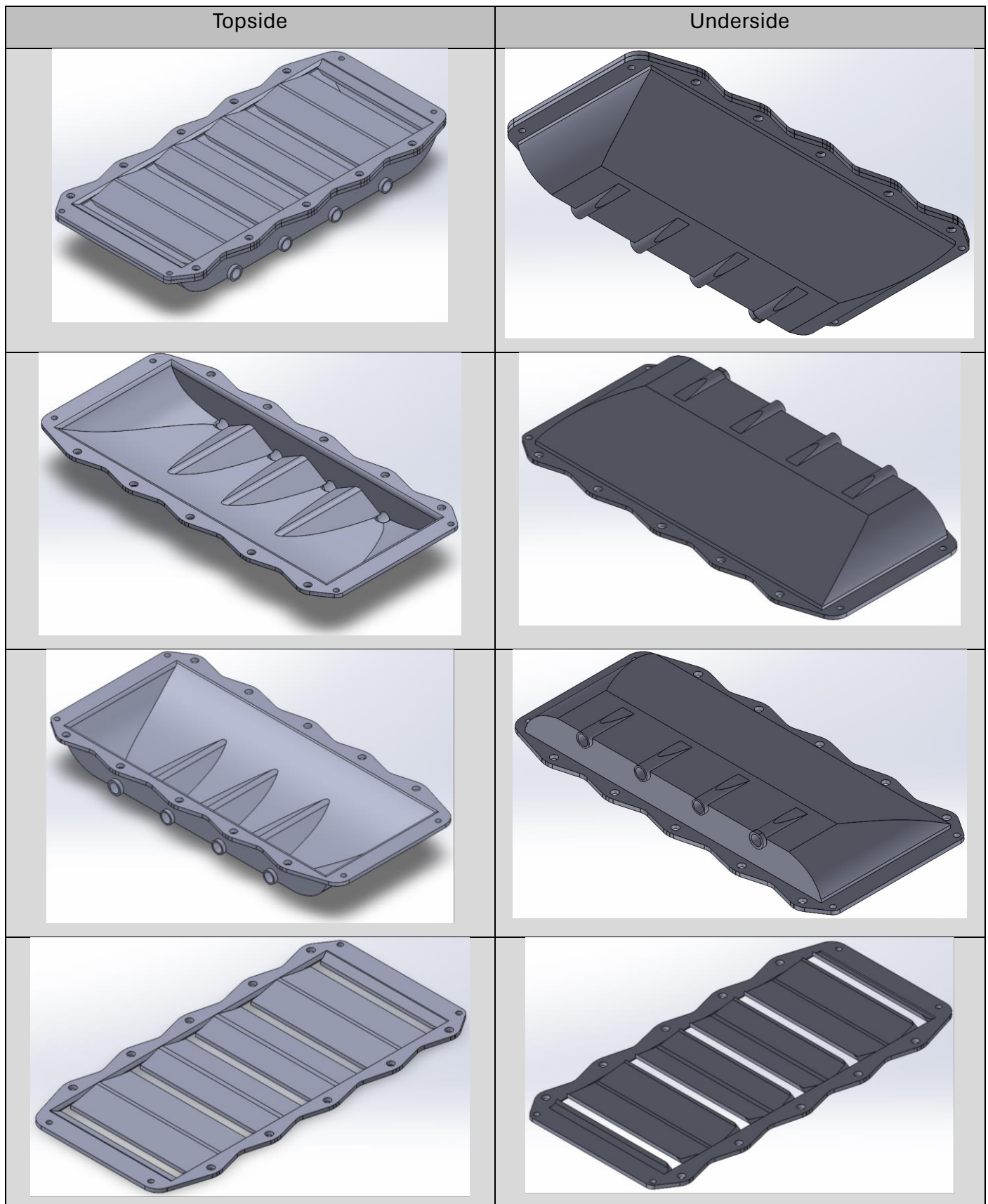
Final Design

Design Comparison

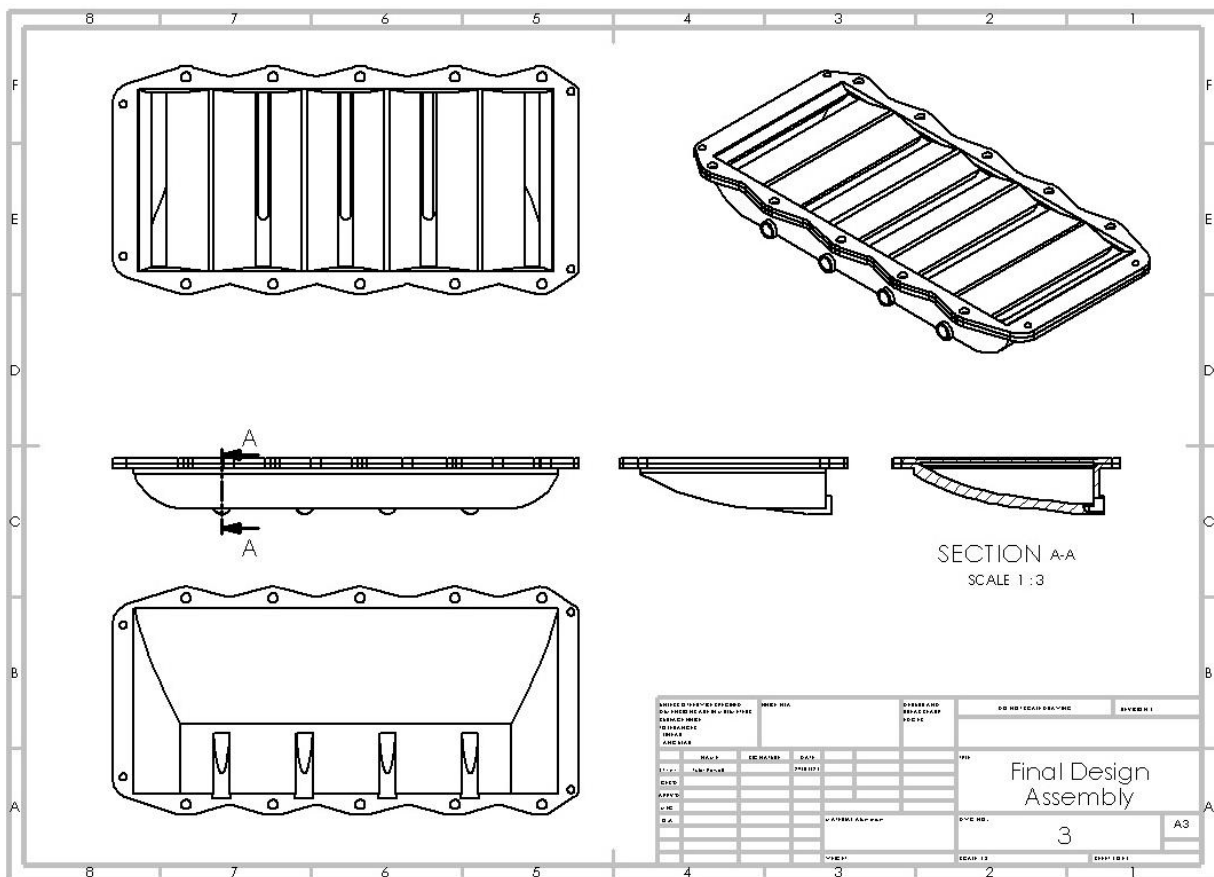
Target	Score		
	Design 1	Design 2	Design 3
Small vertical dimension	1	9	9
Lightweight material	10	10	10
Low material usage	3	9	10
Include a sump cover or equivalent system	0	9	10
High oil flowrate	7	8	9
Fit onto current engine	10	10	10
Limit part assembly	10	8	8
Limit intricacies in the design	9	7	6
Easy maintenance access	9	7	8
Total	59	77	80

Based off the total scores of each design, Design 3 is the most suitable for the customer and will be selected as the final design.

Final Design CAD Images



[illegible]



Evaluation

To best know if this design is truly optimal and best for the customer needs it would have to undergo some tests. The following showcases tests and evaluations and what their results would yield.

Test/Evaluation	Reasoning
Hot oil flow test	To properly determine the speed at which the oil is flowing and to detect whether the temperature of the oil will have any negative effects on the structure or flow of the oil. This should also allow for the visualisation of where the oil congregates and flows most which could be useful information for future designs.
Cold oil flow test	
Vehicle topple test	This will determine whether the sump can successfully prevent engine flooding when toppled with varying amounts of oil.
Screw hole wear test	This will test how many times the screw holes can be screwed/unscrewed before causing issues. This can help to understand how often it can be serviced and removed without needing repair/replacement.
Scavenge pump test	This will help to understand if the additional pumps are necessary and are actually getting used. If the results show that they are not getting used as much, it would be best to use 'Design 2' instead but with the improved cover of 'Design 3' for lower costs. A consideration for later in the design process.
Leak test	To test if oil will leak from near any of the connection points either around the points connecting to the engine, between the sump and the cover or around the scavenge pump connectors.
Vibration test	The sump will be attached to the engine which will be producing a large amount of force and residual force will be applied to nearby components such as the sump so it will need to be able to withstand these forces without compromising.

The selected material for the final design will be aluminium as it best suits the customer needs of allowing the dry sump solution to be lightweight whilst still maintaining strong mechanical properties.

Manufacturing

For an intricate design such as this it would require multiple processes to produce. For cost efficiency it would be recommended to use sheet metal bending and cutting techniques to achieve the base shape of the sump. Then using various cutting machinery or tools for cost efficiency to craft additional metal pieces for welding onto the main structure. If manufactured using welding, various weld strength tests will need to be conducted for structure integrity and safety.

Appendix