FAMU & FSU COLLEGE OF ENGINEERING
Department of Mechanical Engineering

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Preliminary Design Concepts

Mobility Lift for European Insider Applications

Group # 19

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INTRODUCTION

Harmar Mobility currently provides mobility lift solutions for a wide range of vehicles in the United States. However, the majority of vehicles driven in Europe are much smaller and more compact than those in the United States. This prevents the lifts currently offered by Harmar from fitting into European vehicles. Our goal is to provide a solution for the individuals who transport themselves in more compact vehicles and require a mobility lift. The task is to design a lightweight interior lift to compete in the European automobile market.

EXISTING TECHNOLOGY

There are only a handful of companies that currently produce mobility lifts in Europe. Of these, there are even less that have lifts for compact cars. Among those described are the B&S's Samson, AutoAdapt's Carolift 6000, and AutoChair's Olympian. Each of these mobility lifts exhibit a crane-like structure and are operated by an electric motor.

B&S's Samson lift has a lifting capacity of 115 kg, a maximum height of 100 cm and an extension of 65 cm. The height of the lift can be shortened depending upon the size of the cargo area. The lift is operated by an electric motor, and then the rotation of the lift is manual. When not in use, the lift can fold down to increase the available cargo area. Figure A and B depict the B&S Samson.

Figure A: B&S Samson

Figure B: B&S Samson folded position

AutoAdapt's Carolift 6000 is designed for vehicles with a sloping or narrow rear door. It has maximum capacity of 181 kg, minimum height of 87 cm, and maximum arm length of 84 cm. The arm height and length are adjustable. This lift differs from the B&S Samson in that the rotation into the vehicle is powered, not manual. Also, the lift is not capable of lying flat; however, it may be folded to the side to increase cargo capacity. A highlight feature found in smaller models includes a bendable arm as seen in Fig. C & D.

Figure C: AutoAdapt Carolift 6000

Figure D: Bendable Arm found in product line

COMPONENTS

MOTOR AND ELECTRICAL SYSTEM

In order to standardize the manufacturing process and minimize the research and development cost for this project, Harmar Mobility is providing a 50 Volts DC motor. Conveniently, this motor already comes coupled with a gearbox. See table below for additional specification.

Figure E: Driver Motor

	Motor Type	
	KSV 4030	**KSV 4030**
Gear Box	Plastic	Aluminum
Speed (RPM)	15 – 225	15 – 260
Torque (Nm) [Max]	4	5
Starting Torque (NM) [Max]	25	45
Ratio	1:37.5/ 1:75	1:37.5/ 1:75 /1:89
Optional Encoder	No	70 – 100
Optional Self-Locking	No	Yes

CONTROL SYSTEM

Harmar Mobility is also providing the control system and all necessary wiring harnesses. At this point in the design process, no decision has been made on whether not to use a wired or wireless control.

Figure F: Harmar handheld wireless controller

Figure G: Harmar wired control

OVERALL PRODUCT SPECIFICATION

Since this will be a product marketed towards consumers, the final mobility lift that is developed must be tested for safety and reliability. Since safety is a number one factor, our design must include safety switches to shut off power. Our design musts pass a safety factor of 3 set by Harmar, which corresponds to a static load test of 390 pounds. Additionally, the unit must perform 10,000 cycles with a load rate of 130 pounds.

CONSTRAINT

Constraints for our design include: user-friendliness to seniors, light weight, strong, aesthetically pleasing, and compact enough to allow it to fit inside smaller European vehicles. From initial market research, we have selected the Volkswagen Golf, 6th Gen.—the best-selling car of Europe in 2011 as the testing platform for our product.

MATERIALS SELECTION

Accounting for all the constraints above, we must balance between the weight issue and reliability factor. We are planning to use high grade aircraft aluminum or steel tubing for the structure of the mobility lift. Any material chosen must has an excellent in tension and compression strength and high fatigue limit which can endure the long cycle test of 10,000 repetitions and the long life of the product. In addition the material must be able to withstand the cold European weather. Moreover the selected material should have a good machining ability because we have limited resources of machining equipment at the college of engineering machine shop. Also the cost factor will play important role in materials selection.

DESIGN CONCEPT 1

Overview of Design Concept

The motivation behind this design concept comes from a fork lift. In the cargo area of the vehicle a track is installed, this allows for smooth movement of the lift platform in and out of the cargo area. Attached to the track, by way of rollers in a c-channel, are the upright gear tracks. These gear tracks are responsible for keeping the lift platform level while raising and lowering the lift platform. The motor is attached to a strap that goes up over the roller bar, which is fixed between the upright gear tracks, and down to a hook at the base of the lift platform. This allows the employment of a single motor for lifting the platform vertically as well as moving it horizontally; therefore the design is fully automated.

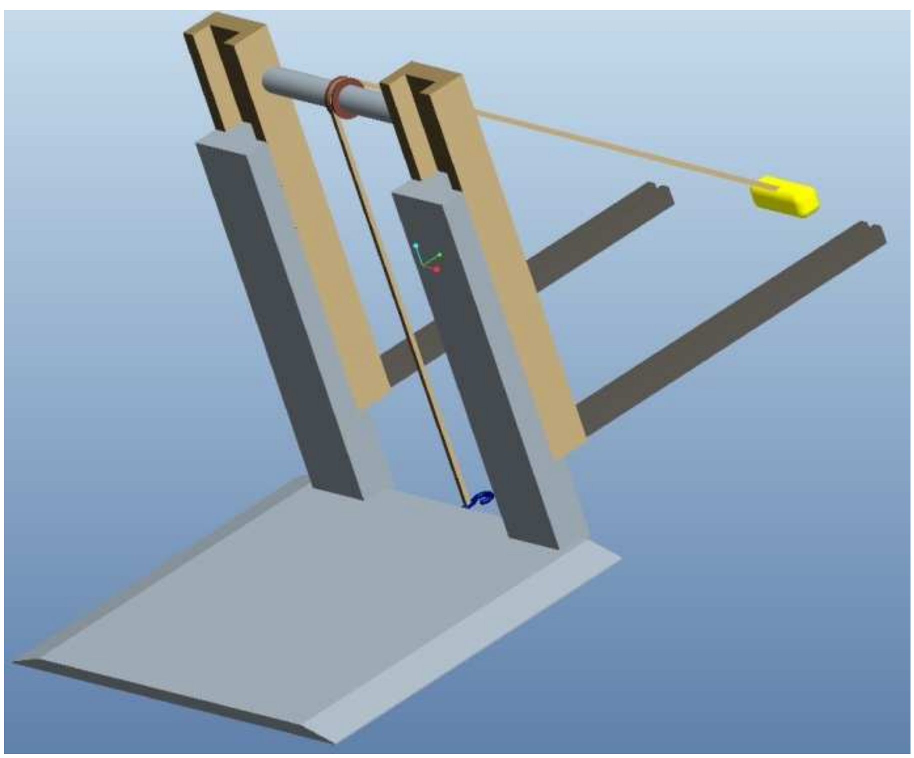

Figure 1-1: Front Angle View

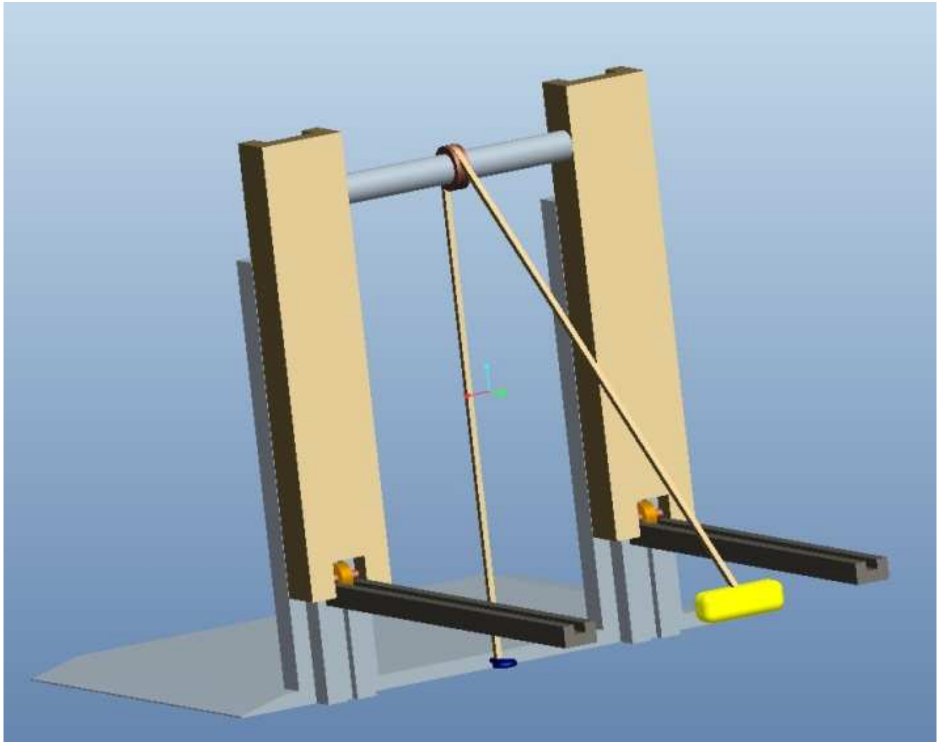

Figure 1-2: Rear Angle View

Components and Function

Affixed to the floor in the cargo area, the track system will be the foundation of the design. The method of affixation has not yet been fully examined; however upon doing some rudimentary calculations for a single fixture, the fixture needs to be able to support a torsion force of approximately 6,230 N-m, or 1,400 lbf-ft. For this design, multiple fixtures will be employed, allowing for overcompensation of forces, as well as the safety of the component. The tracks will have a channel cut into them. This channel is where the roller that is attached to the upright gear track will move horizontally.

The upright gear tracks will have c-channels cut into them, which the lift platform uprights can slide in and out. Although this component has not yet been fully designed, the idea is to have at minimum one set of gears on each side of the channel, which will help to reduce the chance of abrupt sliding and allow for smooth movement vertically of the lift platform. Also, we would like to include some locking mechanism such that once the lift platform is lifted to some height it cannot go back down without unlocking the mechanism. Between the upright gear tracks is the roller bar, and in the middle of the roller bar is a pulley wheel. This pulley wheel allows the strap to be run up over the bar and out past the bumper, so as to not damage the vehicle.

The lift platform consists of 2 components, the uprights and the platform. The platform is the component that the mobility device will be maneuvered onto and will convey the mobility device into the vehicle. In order to allow the mobility device to drive onto it, the platform needs to be thin, yet it must be thick enough to withstand the weight of the mobility device plus a factor of safety of three. An alternative to the solid platform is to have a reinforced grate; this would cut down on the weight of the platform. The uprights will be T shaped and will have gear teeth along the T to mesh with the upright gear tracks, enabling the smooth motion previously described.

A motorized wench and strap runs the entire assembly. The strap remains connected to the base of the lift platform, between the uprights. It is then run up over the pulley and roller bar, and down onto the motorized wench system.

DESIGN CONCEPT 2

Overview of Design Concept

This design concept is a product between classic and modern design. It resembles a typical insider mobility lift that is tailor fit to the European market. Since the 6th Generation Volkswagen Golf will be used as the test base to aid in the development of this product, the mobility lift dimensions are limited to 30 inches in height and 29 inches in width. This concept offers the best versatility and user-friendliness. The design has several advantages at achieving the requirements set by Harmar Mobility. For instance, it is able to fold to save space, can be rotate and swing about its center line, and the boom arm length can be extended and contracted depending on the customers need.

Figure 2-1: Lift assembly and wheelchair

Components and Functions

At the foundation of the mobility lift is its base. It is mounted directly into the customer's vehicle or testing platform. Four gusset plates are welded to the base plate to provide additional strength and assist with the welding process by creating a 90 degree angle. In addition, the user can rotate or swing the device arm from 0 degree to approximately 180 degrees about the upright center line. This design concept provides two folding options—flat at 0 degree and approximately 20 degrees depending on the user's desire. The user can select any folding option by removing the lower pin and inserting it into one of the three pre-drilled holes at the base side.

The arm has a built-in extending and contracting mechanism, which can manually lengthen by an additional 10 inches for easier reach of larger objects. The extending arm is fit nicely into the main arm and secured to the main arm by two screws. The user can extend or contract the arm by placing the two screws at desired locations. The motor is placed inside a secure housing that is mounted directly to the lower arm. The control for this design will be accomplished with by a remote control system provided by Harmar Mobility. There will be precautionary safety switches built-in to limit the travel distance of the cable and hook system. Also, all cables, electrical wires, and pulley can be housed internally inside the arm, with a screw cap to keep it securely away from weather, dirt, and debris.

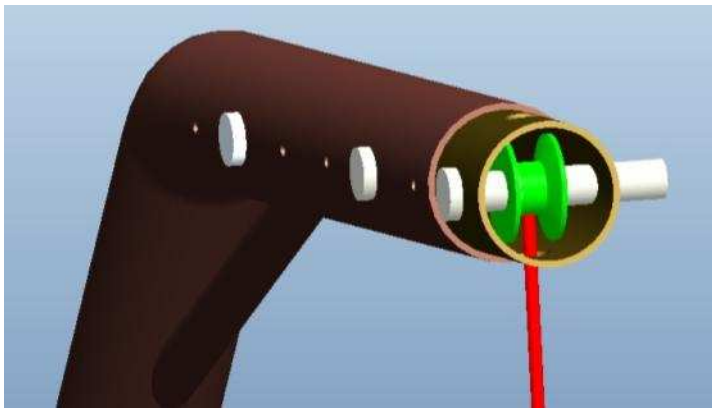

Figure 2-2: Pulley inside housing and extending arm, without cap

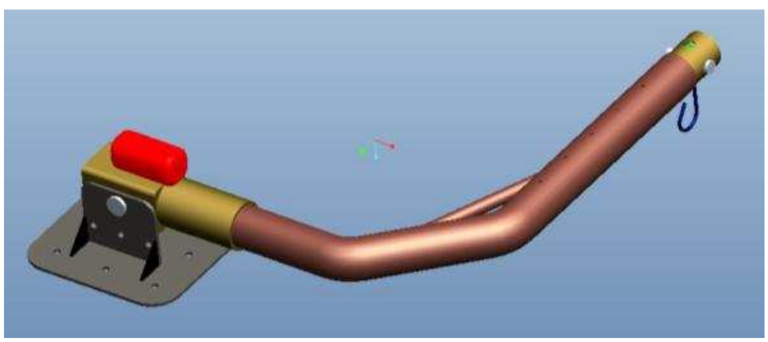

Figure 2-3: Mobility lift at 0° folding position

The round pipe with a correct wall thickness was chosen over a square or t-slotted material for several reasons. One reason being to utilize the round pipe bender available at the College of Engineering machine shop in order to simplify the manufacturing process. Also, it provides a free rotation when pivoted about the center line. In addition, it is more sensible in price when compared to a t-slot structure channel. More likely than not, high grade aircraft aluminum will be used to save weight, but at this design stage no decision has been made.

Since this design is based on a typical mobility lift, it is user friendly to the physical impaired and seniors. Based on initial market analysis, older citizens prefer traditional design with modern accessories. This design concept provides the user- friendliness, ease in manufacturing and cost effectiveness. Also of importance, it satisfies all requirements out forth by Harmar Mobility.

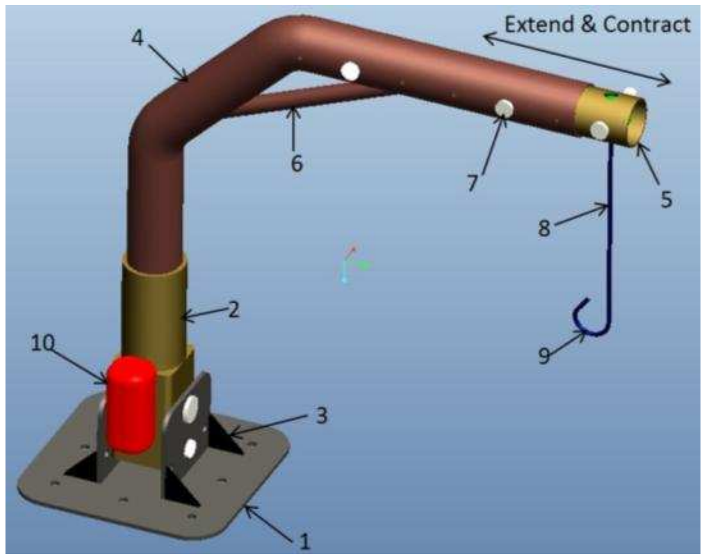

Figure 2-4: Fully labeled assembly view

Bill of Materials		
Number	***Description***	***Qty***
1	Base	1
2	Lower Upright	1
3	Gusset Plate	4
4	Upright Arm	1
5	Extender Arm	1
6	Gusset Bar	1
7	Screw	5
8	Cable	1
9	Hook	1
10	Electric Driver Motor	1

DESIGN CONCEPT 3

Overview of Design Concept

In essence, this project requires the development of a specialized type of crane, or lifting mechanism. To accomplish this, a design featuring multiple advantageous aspects of various crane types was developed. First and foremost, this design concept is based primarily off of an overhead type crane system. This particular type of crane features certain properties that may be more beneficial than other types of traditional mobility lifts in the market today. For example, in industry, overhead cranes are used for their reliability and ability to lift heavy loads [13]. Additionally, this design calls for the implementation of an extending and contracting boom similar to that of a telescoping crane. The relative compactness of a telescoping boom makes them adaptable for many mobile applications [13].

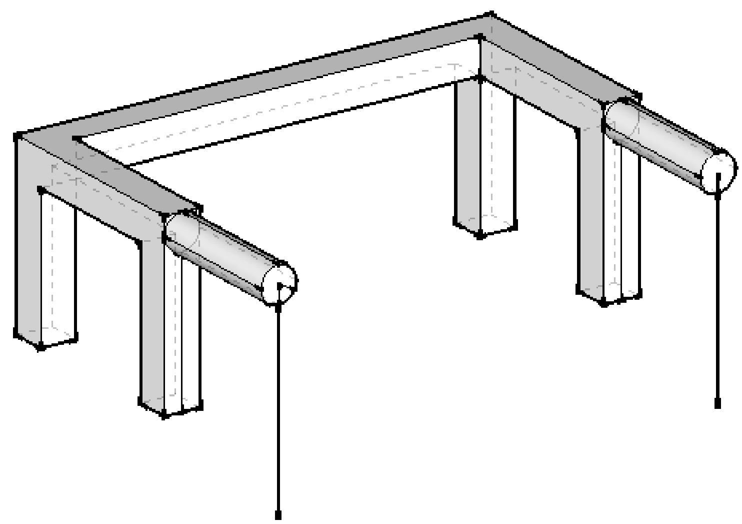

Figure 3-1: Concept 3 Lift Assembly

Components and Functions

For this application, all designs presented are to be based on the Volkswagen Golf VI. At its core, this design features a u-shaped structure. The u-shape allows the apparatus to lift the wheelchair and then secure it within itself. Due to the light weight constraint set for the design, an aluminum alloy will most likely be used such as AL6061. However, if a more economical alternative presents itself, the material selection may be changed. This component will be drawn out from a single tube of material and will, therefore, add to the overall strength of the design. Furthermore, the simplicity in design will not only make it easier to manufacture, but also add to its user-friendliness.

Attached are four legs that will be bolted to the floor of the automobile. Therefore, these legs are to be attached to the floor of the hatchback. The increased number of fixations to ground will ultimately help in distributing the weight of the load to be lifted. Currently, this design calls for the bolting of the legs to the floor of the automobile. This will be accomplished by a total of 16 bolts, 4 per foot. Structural analysis is to be performed to verify the required number of bolts needed for the 390 lb maximum load to be upheld. While a permanent, solid fixture adds to the overall strength of the design, some consumers may shy away from such a tradeoff. Further research into a more compromising alternative is to be explored.

Within the structure, telescoping arms will be housed on each side. These arms will be constrained to only move forward (i.e. out of its housing) and backwards (i.e. into its housing). To achieve this, a bearing slide device will be used. Though not yet decided upon, this design may incorporate any of the following types: linear ball-bearing slides, roller bearing slides, progressive action slide. A sample drawing of a three member ball bearing slider rated at 400 – 600 lbs is shown below. [14]

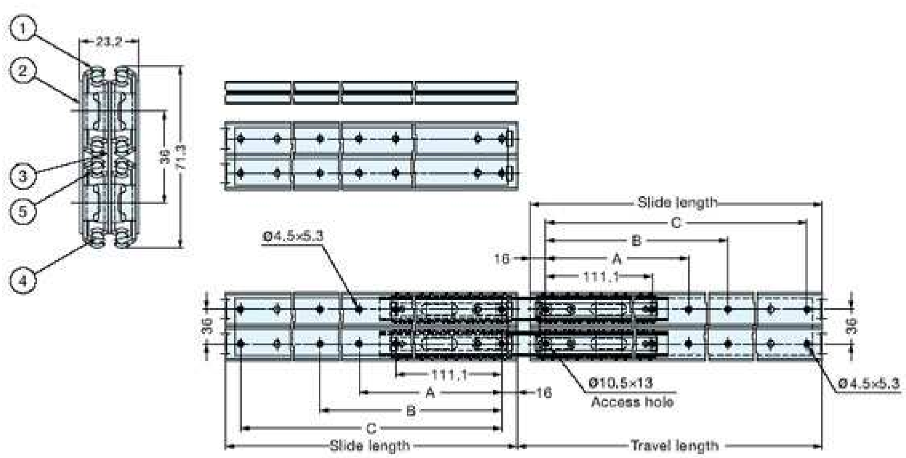

Figure 3-2: Dimensions shown in millimeters.[14]

Within each tracks, a braided cable will run the length of the arm to be connected to the motor. The motor is to be supplied by Harmar Mobility. Therefore, proper attention will be paid to the selection of an in stock motor that will meet the demand of the design. Communication with Harmar personnel and engineers for input and advice on motor selection will be taken. Sample motor data from Harmar is shown in the Appendix. An accompanying strap and various hooks will be supplied to the consumer for attaching to the cables for lifting their load.

Lastly, an electronic mean for operating the lift will be developed in the form of a small hand control. Through discussion, Harmar has expressed their interest in using the new two-button control currently being used for their AL600 model. Harmar currently uses a PC board with a 2-button pendant (hand control) which could be used. The connection is to be wired to ensure possession with lift (i.e. will not get lost).

Overall, the design explained above is a far deviation from what is currently available in the US and Europe. This may be an advantage for Harmar as a means of distinguishing themselves from other competitors. Though different, this design is not without its advantages. Its basis from an overhead type crane directly adds to its ability to lift larger load if needed—also adding to a higher factor of safety for this particular application. Furthermore, the required custom fitting of the design for cars other than the Volkswagen Golf VI may be seen as both an advantage and a disadvantage. This includes the length of the lift to ensure the telescoping boom extends to a length suitable for lifting, as well as the height to ensure the driver's visibility is not impede for operating the vehicle.

Bill of Materials		
Number	***Description***	***Qty***
1	Body (U-shape)	1
2	Leg	4
3	Bolt	16
4	Bearing Slider	2
5	Braided Cable	2
6	Strap	1
7	Hook	2
8	Motor	1
9	Handheld Control	1

CONCLUSION

Based on the design concepts presented above a decision on which selection to continue developing must be made. To accomplish this, a decision matrix (shown below) was employed. Each design was rated from 1 to 3, where 1 is the worst, and 3 is the best. Design 2 has the highest total, making it the current 'best choice'. Below the table are brief explanations of the different selection criteria.

Criteria	Weight	Description
Functionality	20%	"Does this product meet the specifications required by Harmar?" Some of these requirements are that it does not take up much cargo room, is lightweight, and can lift the required 60 kg (times a factor of safety of 3).
Durability	15%	"Does this product stand up to normal or greater use over a term longer than 7 years?" Harmar has a 3 year transferrable warranty on all the mobility lift models, during which the mobility lift should remain in excellent working condition. Doubling the time of warranty as the test period should enable this.
User Friendliness	15%	"Will someone who requires a mobility device be able to operate the product?" This aspect touches on the amount of labor a person must put into making the lift operate. Since the majority of persons using mobility devices are limited in their mobility, the labor involved should be at a minimum.
Manufacturability	10%	"Will the product need many specially made parts, or can it use pre-fabricated parts?" This can also affect the cost of the product.
Appearance	15%	"Is the product aesthetically pleasing?" The sponsor from Harmar stated that they would like the lift to look nice. The reasoning behind it being that in Europe consumers are more inclined to have better appearing components installed on the vehicles.
Cost	25%	"How much will the product cost to manufacture and is it a competitive price?" The sponsor from Harmar made very clear that this is the most important aspect of the design. He also said that a low cost design that doesn't work, is worthless, which is why 'Functionality' is weighted at 20%.

	Weight	Design 1	Design 2	Design 3
Functionality	*0.20*	1	3	2
Durability	*0.15*	2	3	1
User Friendliness	*0.15*	3	2	1
Manufacturability	*0.10*	1	3	2
Appearance	*0.15*	1	3	2
Cost	*0.25*	1	3	2
Total	*1.00*	1.45	2.85	1.70

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VOLKSWAGEN GOLF VI DIMENSIONS