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HANDOUT 7

Chassis Components & Construction

Excellent work and description — I'm still concerned about the roll bar — the sooner we can get some mock ups — maybe out of some copper tube? — and try some mirror-head-helmet combinations — the sooner a final design can be done — I assume an accurate drawing of the canopy is available —

Also — the structural report regarding the roll bar will probably not be acceptable due to the high (miscalculated) stresses — these designs have a shallower rear support and so will have less stress in the hoop from a horizontal load — we'll probably need to recalculate it for Sunrayce —

Do we have a back-up plan if they insist on forward supports?

P. Stern 3/24/99

Ryan Gaida
ME 5190
March 22, 1999

Design

During this past quarter I spent time working on all the mechanical systems, but spent a great deal of it working on the chassis construction and design. The chassis was designed around the electrical components, roll-bar attachment points, suspension hard-points, brake pedal, lift mechanism, and shell support. The different aspects I worked on this past quarter were the chassis panels, roll bar, driver constraints, and wheel turning disk. Also included in the design was to have the center of gravity located properly. Currently the weight distribution is 55% of the weight on the front wheels and 45% of the weight on the rear wheels. This proper CG location can always be obtained by moving different components of the car to incorporate different driver's mass and different batteries including NiMH. A list of all the components in and on the car is located in Appendix A along with a CG analysis.

The chassis design was completed December 14, the panels ~~where~~ WERE cut December 22, 1998. The panel construction started December 27 with sanding and cleaning and finished March 20, 1999 with a fully assembled chassis. The reason for the three-month build time was that each lay-up took a weekend to do and there were a total of 10 lay-ups done on the car.

The roll-bar is still being designed but has been minimized to a couple of designs, which consist of a roll-bar similar to the one used in the 98' World Solar Rallaye in Japan. The other design is a single hoop attached to the bottom of the chassis made of either steel or aluminum. Lance Molby is currently optimizing the design of both roll bars using Pro/Mechanica to fit it inside the canopy area and to withstand the 3g force required by sunrayce rules. The two options being considered are shown in Appendix B.

The driver constraint brackets are also designed and will be built the week of March 21. The design is the same as the previous cars. Pictures of the brackets are also shown in Appendix B. Note that they will be bent at a 90-degree angle and fitted around the waist position of the person in the chassis.

The last aspect of the chassis that I have been exploring this past quarter is the turning disk. Although the designs are not finalized, many ideas have been passed around and will be placed on pro/engineer over the next few weeks. A basic description of the design is to have two sheet of carbon fiber sandwich the bottom chassis panel around the wheel. It will be held together with either a spring or a bolt with a spacer between the carbon fiber sheets allowing the sheets to slide freely on the fiberglass panels.

Additionally I included a condensed step by step process on the following pages describing the construction of the chassis panels for future teams reference.

Chassis Construction

The chassis is the backbone of the solar car and was designed to be stiff with a safety factor of 40. My first suggestion for designing the solar car chassis is to have the battery decision nailed down early in the design process, so that the chassis doesn't have to be built around three different sizes of batteries. Another suggestion would be to make the car thicker and work to reduce weight. Many of the components can be reduced in size and strength, plus less fiberglass panels would be needed for the chassis, meaning a lot of weight can be reduced from the design. Also note that the aerodynamics of the body does not change much if the car is thicker and is less important then the overall weight of the car. Lastly, make sure the shock and lower a-arm have a bulkhead positioned close to where they will be mounted as it will make the front suspension design easier to design.

The chassis construction began with Laser Machining cutting the chassis panels. The cutting process took about eight hours to finish with help from two solar car members placing and removing panels from beneath the laser. The files laser machining used to cut the panels were AutoCAD files that were converted from Pro-E at a 1:1 scale (*.dfx files).

After the laser cutting of the panels, a black carbon deposit was left on the nomex core. The carbon deposit was cleaned with wire brushes and a tooth brush with isopropyl alcohol on it. The cleaning process took a full weekend to finish. After cleaning, each panel was sanded a half-inch up along the edges where the glue would be placed. 100 grit sandpaper was used and the surface was roughed until a white finish was observed. The sanded area and the edges where again cleaned with isopropyl alcohol to remove all fiberglass dust from the surface.

The gluing process used 3M structural adhesive EC-2615 with a strength of 9000-psi. The panels were glued in small sections starting with the upright panels. After they were cured the top and bottom panels where glued onto the upright section and were weighted down with batteries. Make sure the surface the chassis is being assembled on is perfectly flat, this flatness will determine the accuracy of the finished chassis. When gluing the panels together the glue must be packed into the edge of the panel and worked into the nomex core to remove all air bubbles. Any air bubble in the glue will weaken the seam. A lot of extra glue should then be placed on the edge of the panels, so when the panels are assembled most of the glue will pushed out of the seam. Then use a tongue depressor laid flat against the surface of the panel to create a ¼" fillet with the excess material that was pushed out of the seam. The glue takes two days to cure-to-the-touch and seven days to set up completely.

The final stage of building the chassis is the reinforcing tape that goes over the glued sections. There was a lot of discussion with the '99 car if this tape was really needed. To answer this question some tests were done on the panels with no tape, one layer of tape and two layers of tape. The test were performed on a "T" seam and had the seam in bending. The results showed that the seam strength was 4750-psi with one layer of tape and was the same with two layer of tape. The strength without tape was 2500-psi. So the conclusion that the team came to the added strength of one layer of tape was worth the maximum of 4 extra pounds but two layers of tape was not needed. The tape also serves the purpose to protect the seam from being scratched or damaged which would weaken them especially in the battery compartments.

The tape used was 4" wide, 4-oz. Fiberglass cloth supplied by Express Composites. The resin used was Epon 828 with Epicure as the catalysis. The mixing ratio was 1 part 828 with 0.4 part Epicure. In 1997 the catalysis used was Jeffamine mixed with the same ratio. I noticed no difference in the final results between the two catalysis. All the taped area on the chassis panels were again sanded with 100 grit sandpaper and cleaned with isopropyl alcohol. The tape and resin mixture was then laid on the sanded areas and then vacuumed bagged to remove all excess resin and air pockets in the fabric. The vacuum bag consisted of a peel ply positioned against the tape and a breather on top of that. The vacuum bag was left on for two days to allow the resin to fully cure.

Appendix A

Weight Break Down & CG Analysis

Note: X = Front to Back from foot bulkhead
Y = Left to Right from center line of car
Z = Top and Bottom from top of bottom panel

SYSTEM	PART	WEIGHT	X	Y	Z	MX	MY	MZ
Mechanical								
	FS Lower A-arm	1.3	-3			-3.9	0	0
	FS Lower A-arm	1.3	-3			-3.9	0	0
	FS Upper A-arm	0.75	-3			-2.25	0	0
	FS Upper A-arm	0.75	-3			-2.25	0	0
	FS Hub	2	-2.2			-4.4	0	0
	FS Hub	2	-2.2			-4.4	0	0
	FS Upright	2.5	-2.2			-5.5	0	0
	FS Upright	2.5	-2.2			-5.5	0	0
	FS Shock	1.3	-2.2			-2.86	0	0
	FS Shock	1.3	-2.2			-2.86	0	0
	FS Brakets	3	-9			-27	0	0
	FS Brakets	3	-9			-27	0	0
	FS Wheel	5.6	-2.2			-12.32	0	0
	FS Wheel	5.6	-2.2			-12.32	0	0
	FS Caliper	1	-1.2			-1.2	0	0
	FS Caliper	1	-3.2			-3.2	0	0
	FS Caliper	1	-1.2			-1.2	0	0
	FS Caliper	1	-3.2			-3.2	0	0
	Chassis	57	45			2565	0	0
	Roll Bar	4	77			308	0	0
	200 Grommets	1	0	0	0	0	0	0
	Pulley	0.2	0			0	0	0
	Pulley	0.2	0			0	0	0
	Pulley	0.2	73.5			14.7	0	0
	Pulley	0.2	73.5			14.7	0	0
	Center Pulley	0.34	2			0.68	0	0
	Handle	0.5	50			25	0	0
	Handle	0.5	50			25	0	0
	Rack & Pinion	1.3	2			2.6	0	0
	Steering Rods	1	1			1	0	0
	Master Cylinder	1	6			6	0	0
	Master Cylinder	1	6			6	0	0
	Brake Bracket	1	6			6	0	0
	Gas Pedal	1	6			6	0	0
	RS Lower A-arm	0.75	85			63.75	0	0
	RS Lower A-arm	0.75	85			63.75	0	0
	RS Upper A-arm	0.75	85			63.75	0	0
	RS Upper A-arm	0.75	85			63.75	0	0
	RS Upright	2.3	89			204.7	0	0
	RS Upright	2.3	89			204.7	0	0
	Shock	2	89			178	0	0
	Shock	2	89			178	0	0
	RS Wheel	5.6	89			498.4	0	0
	RS Wheel	5.6	89			498.4	0	0
	RS Hub	2	89			178	0	0
	RS Brackets	2	83			166	0	0
	RS Brackets	2	83			166	0	0
	Lift Arm	1.5	91			136.5	0	0
	Gas Spring	1	91			91	0	0
	Front Latch	0.3	20			6	0	0
	Rear Latch	0.3	90			27	0	0
	Hinge	0.3	20			6	0	0
	Hinge	0.3	50			15	0	0
	Hinge	0.3	80			24	0	0
	Turning Disk	1	1			1	0	0
	Turning Disk	1	1			1	0	0
						0	0	0
						0	0	0
						0	0	0
Weight ME	142.14					0	0	0

Electrical					0	0	0
					0	0	0
VIA	2.175	65			141.375	0	0
Breeze Com	0.8851	65			57.5315	0	0
Battery Switch	1.22	65			79.3	0	0
Arrary Switch	0.9	65			58.5	0	0
Motor Switch	1.22	65			79.3	0	0
Display Box	0.37	38			14.06	0	0
Switch Box	0.15	38			5.7	0	0
Switch Box	0.15	38			5.7	0	0
Barrier Strip Box	1.34	65			87.1	0	0
Cruise Control Box	0.15	65			9.75	0	0
Light Box	0.21	65			13.65	0	0
Horn Box	0.265	65			17.225	0	0
Speedo Box	0.245	65			15.925	0	0
T/S Box	0.245	65			15.925	0	0
Back Display Box	0.3	65			19.5	0	0
Motor Controller	10.66	85			906.1	0	0
Motor Controller	0				0	0	0
Motor	35	89			3115	0	0
Spacer Motor	2.45	89			218.05	0	0
Battery	36.134	-3.75			-135.5025	0	0
Battery	36.134	-14			-505.876	0	0
Battery	36.134	-14			-505.876	0	0
Battery	36.134	22			794.948	0	0
Battery	36.134	30			1084.02	0	0
Battery	36.134	38			1373.092	0	0
Battery	36.134	46			1662.164	0	0
Battery	36.134	22			794.948	0	0
Battery	36.134	30			1084.02	0	0
Secondary Battery	3.6	93			334.8	0	0
DC to DC Converter	0.29	93			26.97	0	0
Fan	0.51	80			40.8	0	0
Fan	0.51	80			40.8	0	0
Fan	0.51	-20			-10.2	0	0
Fan	0.51	-20			-10.2	0	0
Radio	0.5	70			35	0	0
Handle Box	0.4	50			20	0	0
Handle Box	0.4	50			20	0	0
Wire	4	0	0	0	0	0	0
Horn	0.6				0	0	0
Amp Hour Meter	0.47				0	0	0
					0	0	0
Weight EE	395.4411				0	0	0
					0	0	0
Aero					0	0	0
Body	63.8	75	0	6	4785	0	382.8
Fairings	0.9	1			0.9	0	0
Fairings	0.9	1			0.9	0	0
Fairings	0.9	90			81	0	0
Fairings	0.9	90			81	0	0
Canopy	4	73	0	16	292	0	64
Venting	0.3	60	-20	1	18	-6	0.3
Venting	0.3	60	-20	1	18	-6	0.3
Venting	0.3	60	20	1	18	6	0.3
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
Weight AERO	72.3				0	0	0

							0	0	0
Array							0	0	0
	Array		35	60	0	11.5	2100	0	402.5
	Array Wire Box		1	105	-15	10	105	-15	10
	Power Tracker		1.2	48	-13	1.5	57.6	-15.6	1.8
	Power Tracker		1.2	54	-13	1.5	64.8	-15.6	1.8
	Power Tracker		1.2	60	-13	1.5	72	-15.6	1.8
	Power Tracker		1.2	66	-13	1.5	79.2	-15.6	1.8
	Power Tracker		1.2	72	-13	1.5	86.4	-15.6	1.8
							0	0	0
							0	0	0
							0	0	0
							0	0	0
							0	0	0
							0	0	0
							0	0	0
							0	0	0
Weight ARRAY		42					0	0	0
							0	0	0
PR							0	0	0
	Stickers		1	0	0	0	0	0	0
							0	0	0
							0	0	0
Weight PR		1					0	0	0
							0	0	0
							0	0	0
	DRIVER		176	42	0	4	7392	0	704
							0	0	0
							0	0	0
							0	0	0

Total	WEIGHT	MX	MY	MZ
	828.8811	31945.519	-99	1573.2

CG LOCATI	38.54053253	-0.11943812	1.897980301

CG BREAK-DOWN

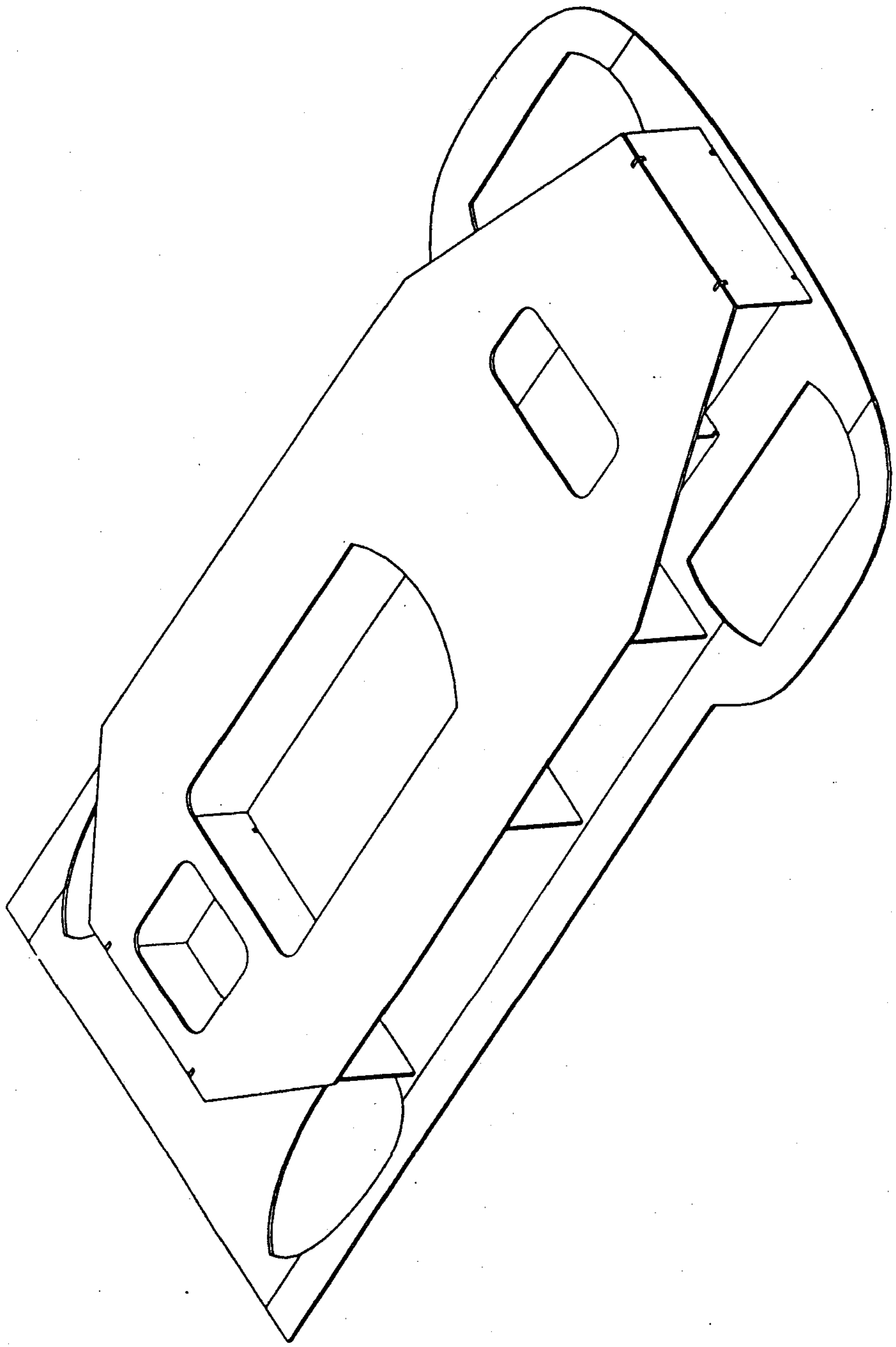
	NiMH Battery Layout			Lead Acid Layout		
	Weight	Position	Moment	Weight	Position	Moment
Driver	160	42	6720	160	42	6720
Battery	20	-1.375	-27.5	36	-4	-144
Battery	20	-4.125	-82.5	36	-13	-468
Battery	20	-6.875	-137.5	36	-13	-468
Battery	20	-9.625	-192.5	36	21	756
Battery	20	-12.375	-247.5	36	21	756
Battery	20	-15.125	-302.5	36	29	1044
Battery	20	19.125	382.5	36	29	1044
Battery	20	16.375	327.5	36	37	1332
Battery				36	45	1620
Power Trackers	6	30	180	6	58	348
Electrical Boxes	6	60	360	6	60	360
Shell w/Array	100	73	7300	100	73	7300
Motor	35	87	3045	35	87	3045
Motor Controller	10	82	820	10	82	820
Driver Balast	16	42	672	16	42	672
Chassis	55	43	2365	55	43	2365
Secondary Battery	5	16	80	5	91	455
Brake	4	6	24	4	6	24
Steering	6	30	180	6	30	180
Front Suspension	44	-2	-88	44	-2	-88
Rear Suspension	36	89	3204	36	89	3204

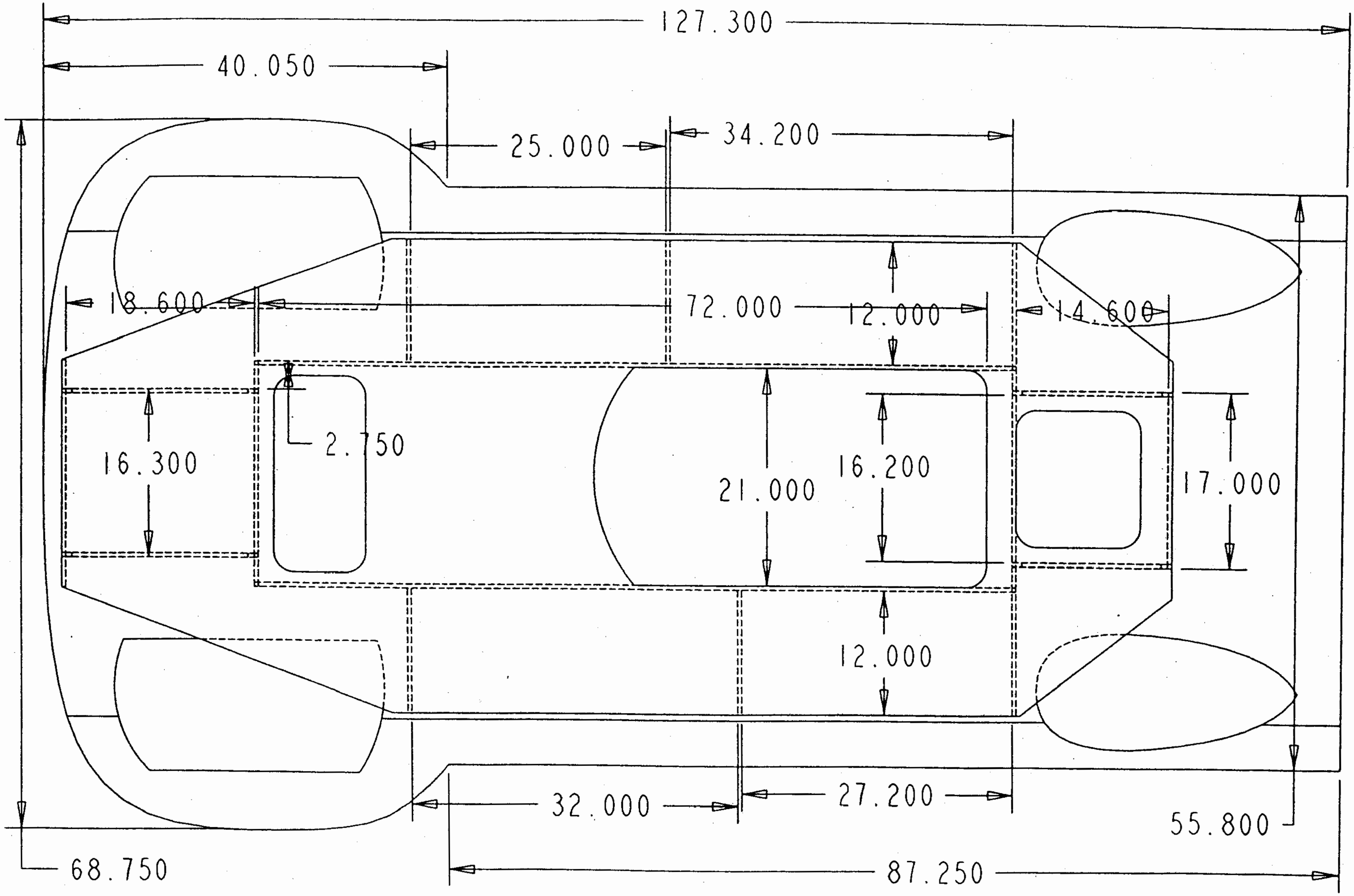
Total Vehicle Weight **667** **CG Dist. 36.85457** **832** **CG Dist. 37.11178**

56.34% on Front Wheels **56.05% on Front Wheels**

Note: CG is measured from the bulkhead at the drivers feet.

Appendix B





PROPRIETARY INFORMATION
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All dimensions in inches unless otherwise stated

Title: Chassis Panels Top View		
Aurora 4	Designed for: Sunrayce 99	
	UNIVERSITY OF M Solar Vehicle I	
Scale	Date:	Drawn by: RMG

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