Design Engineering 1

Small Sports Car – Space Challenge

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1.0 Abstract

This report will cover the challenges faced when designing for people, specifically where space is a constraint. The main objective is to design a sports car that satisfies the following requirements.

- must fit into the Japanese K class of vehicles
- must seat two people (97.5 percentile UK males / 2.5 percentile females)
- carry a small amount of luggage
- be powered by an internal combustion engine
- maximum dimensions of: length 3.3m, width 1.5m and height 1.2m
- maximum speed you require is approximately 100 mph on a flat road, and at this speed the motor needs to be producing its maximum power output

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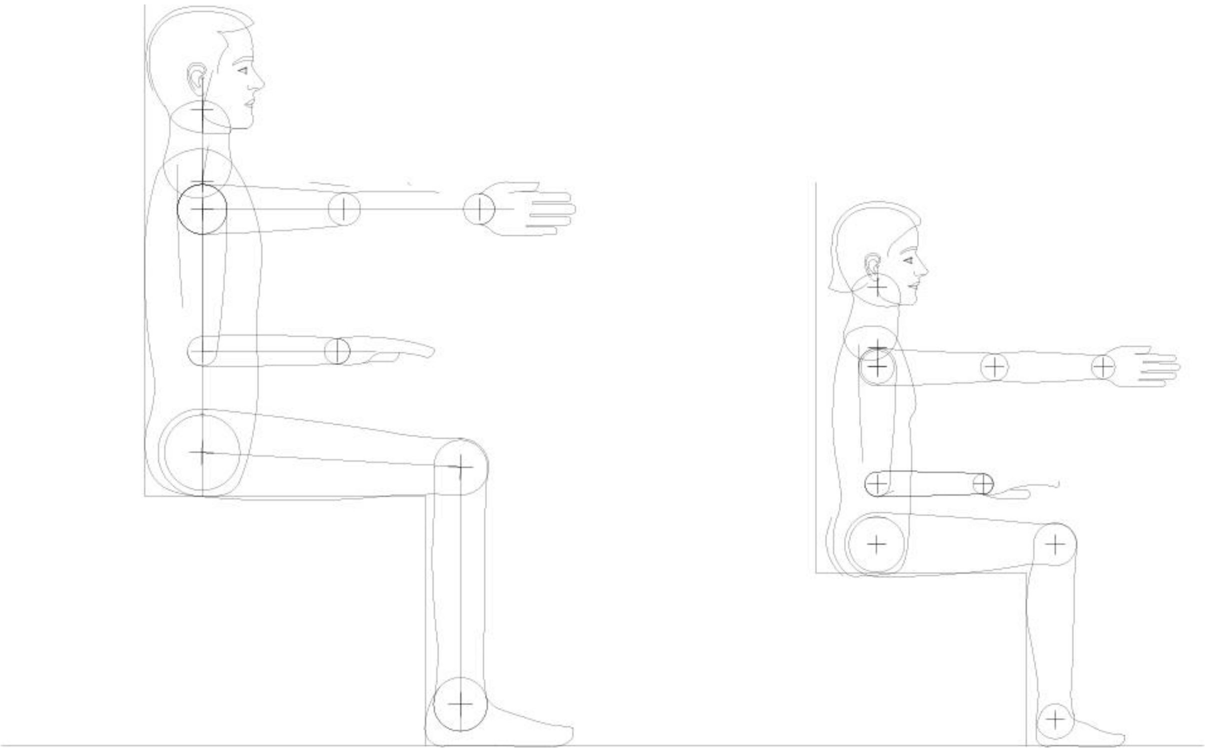
3.0 Introduction

To design a car under these constraints, I must firstly define and understand what those constraints are, and how they will affect the design. I need to do the relevant research to have adequate information to understand as accurately as possible what volumes of space will adequately fit two humans in the vehicle, wasting as little space as possible. Calculations will be made, to best determine the optimal engine specifications.

4.0 Anthropometrics

Not having done any vast statistical gathering, I used already available anthropometric data, table 1 in the appendices (1). I was able to build a model of a 97.5 percentile male and a 2.5 percentile females. Given that the statistical data isn't 100% accurate/ complete/ up to date, the design choices based on this data will also be inaccurate. However the data is sufficient enough to design a car that will accommodate approximately 95.44% of the population. Populations in the outer margins will either not fit to design, or fit with discomfort.

What is important to understand is what dimensions are most relevant. I need to understand how far someone needs to reach the gear stick for example, but allow enough tolerance so that if a person has short or long arms, there is no discomfort in reaching for it. The same applies for almost anything you would need to do in a car.



From left to right 97.5 percentile male, 2.5 percentile female

5.0 Specifications

I have thought up some design features that might help maximise the use of space, whilst allowing for space for: storage, the engine, the transmission, the suspensions, the fuel tank and also ground clearance.

Horizontally mounted straight cylinder engine- space saving engine configuration

Front wheel drive- remove the need for a prop shaft – less room to recline but more to stretch out – leaves space behind seat for fuel and luggage

Lowered suspension– to reduce overall height; however a lower roof means that to fit in 97.5 percentile males, the seats must recline.

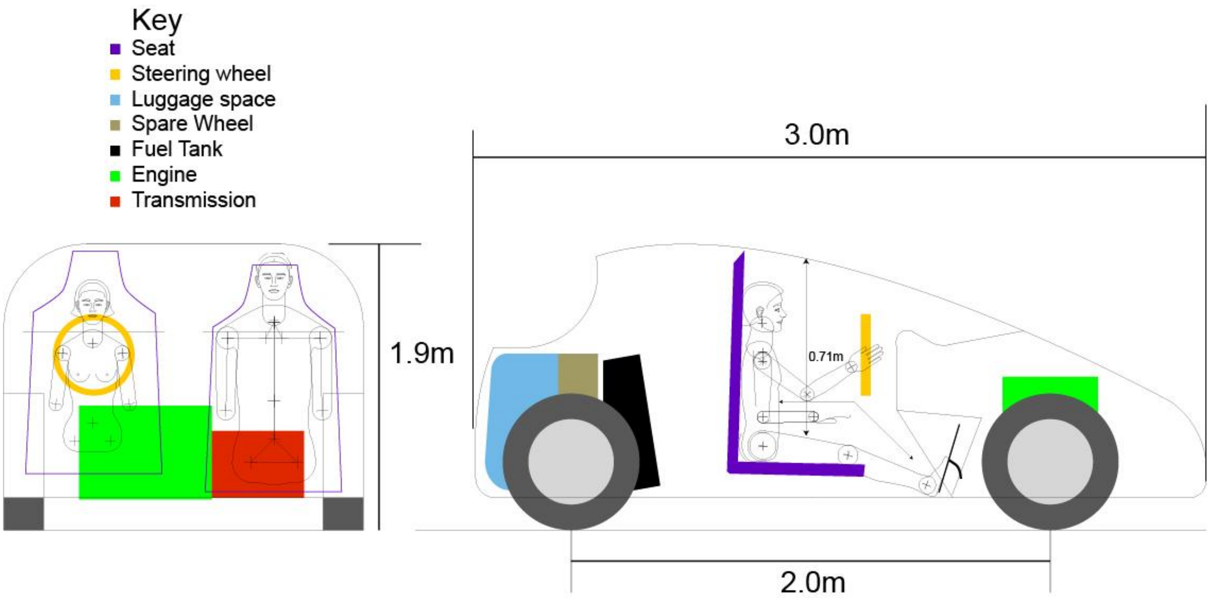
Adjustable seats and steering column - to allow people with longer or shorter legs to reach the controls.

Sensitive foot pedals- to compensate for shorter leg travel

Wide door- for a more horizontal entrance. Having a low roof will make it uncomfortable to keep bending over to enter the car, so a longer door will make it easier to put your legs in first.

There’s almost an infinite amount of configurations possible, even under these design constraints. In reality a car manufacturer would be limited by time, resources, available technology, and money. So these specifications that I’ve laid out are hypothetically based on what’s been done already, and what most trends with K Sports cars.

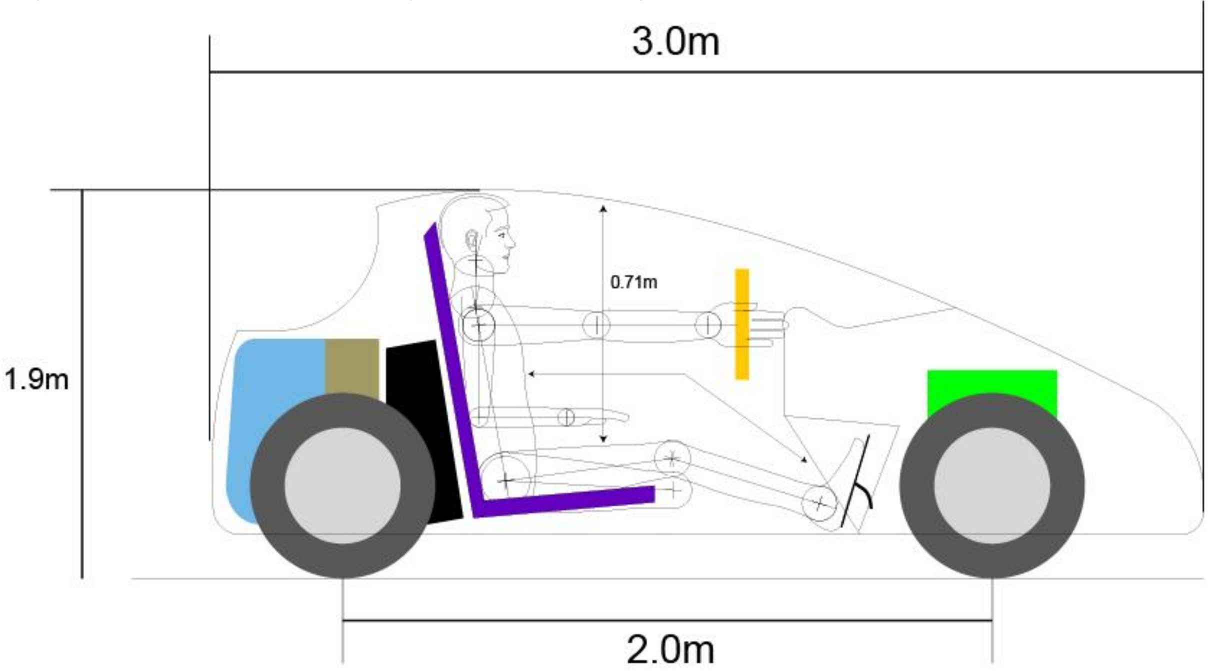
6.0 Layouts



Front view on the left side view on the right

This diagram above shows how a 2.5 percentile female can fit inside the vehicle, can reach the controls and sea over the steering wheel. Notice that the seat is adjusted closer to the steering wheel and is in an upright position.

The diagram below show how a 97.5 percentile male can fit inside the vehicle. Notice that the seat is fully reclined and moved all the way back. The steering wheel is also raised.



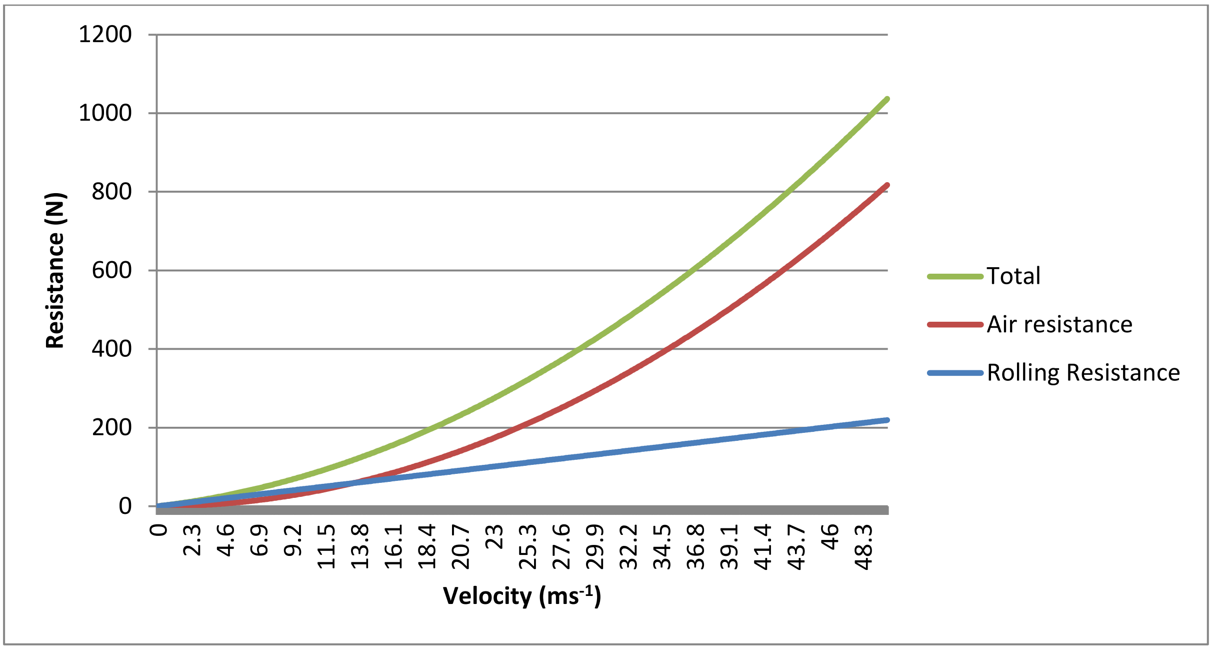
7.0 Calculations

Without taking into consideration the mass of vehicle (with/ without passengers of luggage), transmission efficiency, fuel efficiency, etc. an estimation of the power required to overcome rolling resistance, air resistance, to accelerate the car to 100 mph (44.704ms^{-1}) can be made using this formula.

Total Resistance (N) = $\left(\frac{1}{2}\rho \cdot C_d \cdot A \cdot V^2\right) + (RR \cdot V)$

$\rho = 1.293 kg^{-3}$
C_d= 0.32 (assumption based on Suzuki Swift (2))
A= 1.58m^2
V^{2}=velocity squared

$(RR \cdot V)$ can be substituted for N $= 4.38409 \cdot V$,an assumption can be made that the rolling resistance is equal to that of the air resistance when the vehicles velocity is at 30mph (13.4112ms$^{-1)}$.



At 100 mph (44.704ms^{-1}) the total resistive force is 849.2789 Newtons.

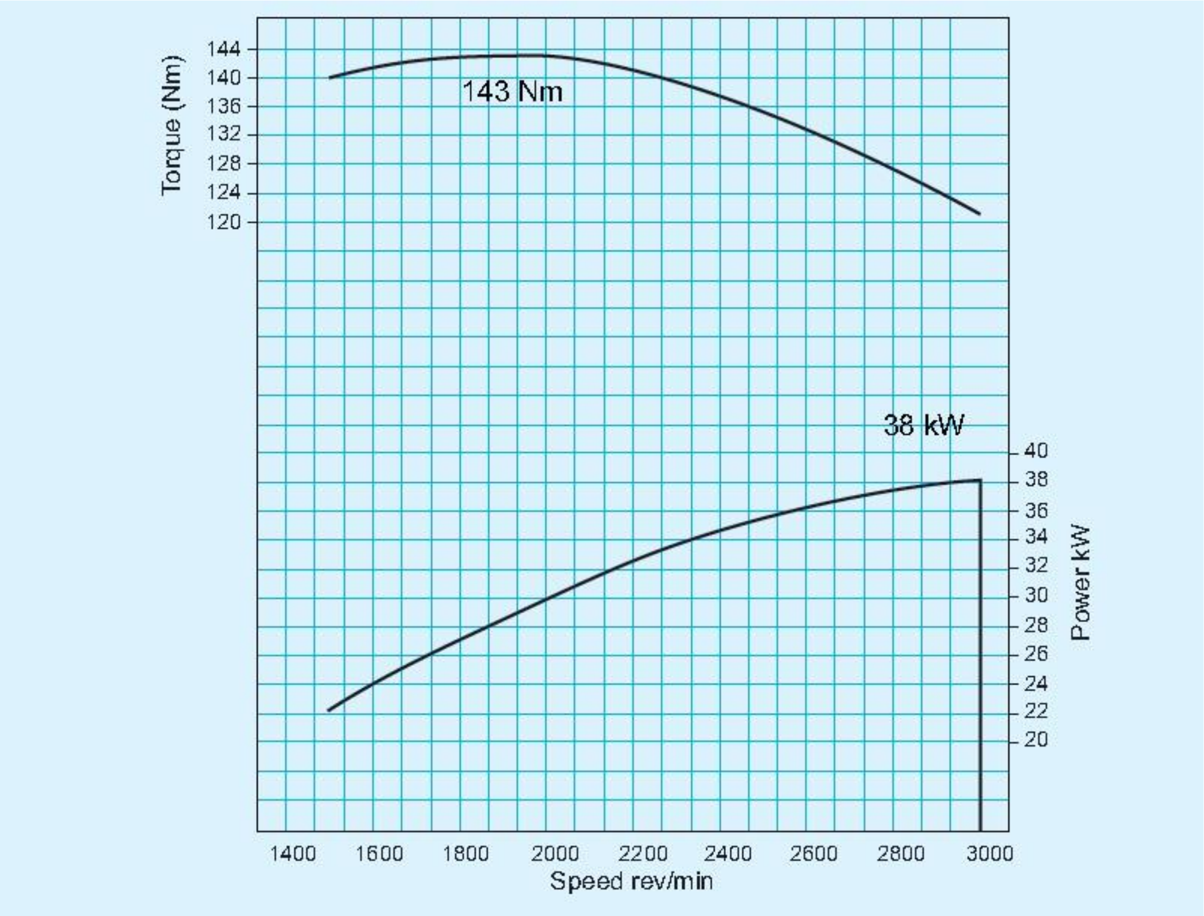
Using the formula:

Power = Force x Velocity

849.2789 x 44.704ms^{-1} = 37.97 kW

This is requirement well below the K car regulations (3) *table 2 appendix*, any extra power would go towards carrying passengers and luggage.

I did some research online and found a suitable engine. Perking 404D-22 Industrial Engine 38 kW / 51 bhp @ 3000 rpm (4) meets the power requirements.



Peak Torque @ 1800rpm

Torque drops as the engines speed increases, meaning that increments of higher gear ratio need to be employed to improve acceleration.

To determine the top speed of the vehicle with this engine, a 1:1 end gear and a tyre size of 165/65 R 14 78h (5), this formula will produce the results.

$\text{Speed} = \frac{\text{Tyre Radius} \cdot \text{RPM}}{168 \cdot \text{Gear Ratio}}$ (this equation uses imperial units, hence the 168 constant)

$\frac{11.2'' \cdot 3000\text{rpm}}{168 \cdot 1} = 200mph$ higher gear ratios will decrease the top speed, but improve acceleration, though that cannot be proven with this formula alone.

8.0 Conclusion

This brief report outlines the essentials for designing a car. Also how human variables can affect design and how optimisations can be made through calculations.

To take this design further I would need to produce a 3-dimension model, and work with more specific parts. Only then will I be able to determine, far more accurately how much space I can actually save. Also, I would need to generate 3-dimensional models of humans, spanning all the standard deviations of the population. Then I could calculate precisely where to put controls, and how big or small I need to make parts of the vehicle.

9.0 References

1. **Pheasant, Stephen.** *Anthropometrics an introduction.* s.l. : BSI Education, 1990.
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3. Kei car. *http://en.wikipedia.org/wiki/Kei_car.* [Online]
4. Suzuki Cappuccino 1989. *http://www.carfolio.com/specifications/models/car/?car=17743.* [Online]
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10.0 Appendices

Anthropometric estimates for British adults (19 to 65 years)

Table 1

Dimension s	**Man (Percentiles)**				**Women (Percentiles)**			
	5%	50%	95%	SD	5%	50%	95%	SD
Weight	55	75	95	12	45	63	81	11
1- Stature	1625	1740	1855	70	1510	1610	1710	62
2-Eye Height	1515	1630	1745	69	1405	1505	1605	21
3-Shoulder Height	1315	1425	1535	66	1215	1310	1405	58
4-Elbow Height	1005	1090	1175	52	930	1005	1080	46
5-Hip Height	840	920	1000	52	740	810	880	43
6-Knuckle Height	690	755	820	41	660	720	780	36
7-Fingertip Height	590	655	720	38	560	625	690	38
8-Sitting Height	850	910	970	36	790	850	910	35
9-Sitting Eye Height	730	790	850	35	685	740	795	33
10-Sitting Shoulder Height	540	595	650	32	505	555	605	31
11-Sitting Elbow Height	195	245	295	21	185	235	285	29
12-Thigh Thickness	135	160	185	15	125	155	185	17
13-Buttock-Knee Length	545	595	645	31	520	570	620	30
14-Buttock-popliteal Length	440	495	550	32	435	480	530	30
15-Knee Height	495	545	595	32	455	500	545	27
16-Popliteal Height	390	440	410	29	355	400	495	27
17-Shoulder Breadth (Bideltoid)	420	465	510	28	355	395	435	24
18-Biacromial Breadth	365	400	435	20	325	355	385	18
19-Elbow-elbow breadth	370	450	530	49	320	385	450	41
20-Hip breadth	310	360	410	29	305	370	435	38
21-Chest (bust) depth	215	250	285	22	205	250	295	27
22-Abdominal depth	220	270	320	32	205	255	305	30
23-Shoulder-fingertip length	720	780	840	36	650	705	760	32
24-Shoulder-elbow length	330	365	400	20	300	330	360	17
25-Elbow-fingertip length	440	475	510	21	440	430	460	19
26-Span	1655	1790	1925	83	1490	1605	1720	71
27-Elbow span	870	945	1020	47	780	850	920	43
28-Standing overhead reach	2040	2170	2300	79	1895	201	2125	70
29-Sitting overhead reach	1255	1355	1455	61	1150	1255	1340	58
30-Forward reach	835	890	945	33	760	810	860	30

Table 2

Date	Maximum length	Maximum width	Maximum height	Maximum displacement		Maximum power
				four-stroke	**two-stroke**	
8 July 1949	2.8 m (9.2 ft)	1 m (3.3 ft)	2 m (6.6 ft)	150 cc	100 cc	n/a
26 July 1950	3 m (9.8 ft)	1.3 m (4.3 ft)		300 cc	200 cc	
16 August 1951				360 cc	240 cc	
4 April 1955				360 cc		
1 January 1976	3.2 m (10.5 ft)	1.4 m (4.6 ft)		550 cc		
March, 1990	3.3 m (10.8 ft)			660 cc		47 kW (64 PS; 63 hp)
1 October 1998	3.4 m (11.2 ft)	1.48 m (4.9 ft)				