Composite Lotus Elise Chassis Development

Mike Pilbeam

21st April 2016

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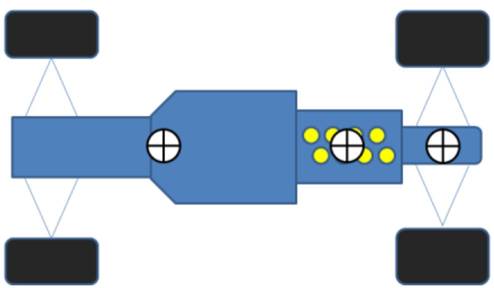
Racecar Design

- Pilbeam has designed and built cars for F1, Le Mans and Hillclimbing over many years.
- Constantly seeking new methods to take the guesswork out of the process.

Layout

- Key Factors:
  - Weight distribution
  - CofG height
  - Moments of Inertia
- Sometimes these are missed.



MP 98 Sports car Weight Distribution
Use this sheet for reporting weights calculations & estimating center of gravity.

26-Jan-10

Input only items in blue

Moments & cg are calculated

	Weight Kg	Loc Mtrs	Moment Kg-M
CHASSIS	**75.0**		**137**
Monococque	50	1.8	90
Fuel tank	5	2.5	13
Fuel system	3	3.0	9
Pedals	4	1.0	4
F Lights	5	0.5	3
R Lights	1	4.0	4
Loom	5	2.0	10
Data	2	2.5	5
			0
			0
			0
ENGINE	**154.0**		**452**
Engine	90	2.8	252
Air Induction	3	2.8	8
Cooling	6	2.0	12
Exhaust	6	2.0	12
Gearbox	42	3.5	147
Bell hsg	0	3.0	0
Oil tank	3	3.0	9
Starter	4	3.0	12
			0

	Weight Kg	Loc Mtrs	Moment Kg-M
BODYWORK	**62.0**		137
Splitter	10	0.5	5
Nose	8	1.0	8
cockpit	8	1.5	12
engine cover	8	3.0	24
front floor	10	2.0	20
side pods	6	2.3	14
diffuser	6	3.5	21
Rear wing	6	4.2	25
Rear wing Mtg	2	4.2	8

	Weight Kg	Loc Mtrs	Moment Kg-M
Suspension	**72.0**		162
Front wheels	20	1.0	20
Front brakes	10	1.0	10
F wishbones	4	1.0	4
F dampers	2	1.0	2
Rear wheels	20	3.5	70
Rear brakes	10	3.5	35
R wishbones	4	3.5	14
R damoers	2	3.5	7

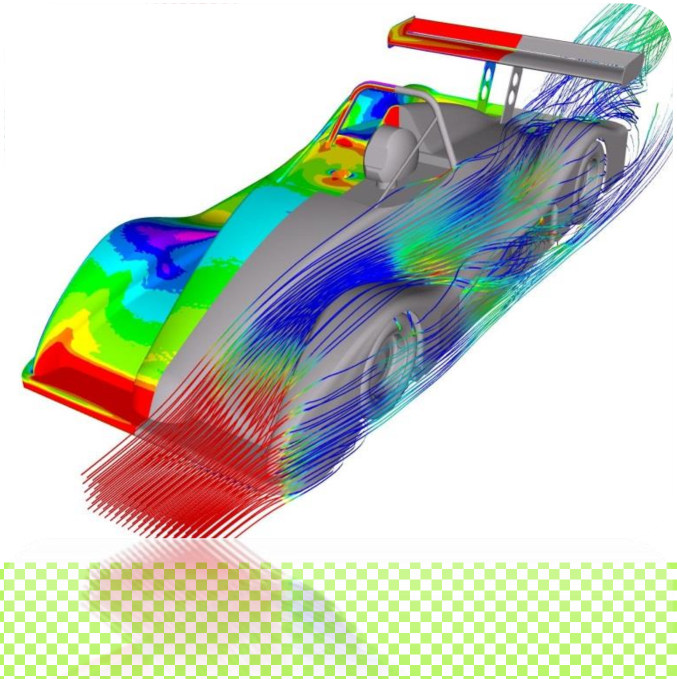
(% We Allowance)	10			enter %
Empty Weight Allowance	29.1	2.5	73	don't enter these
TOTAL WEIGHT EMP	**392.1**	**2.0**	799	Calculated Empty Weight constant "a".
LOAD	**257.9**			
Driver	80.0	2.0	160	
Fuel	60.0	2.5	150	
Oil	6	3.0	18	
Passengers	0	2.0	0	
Luggage	0	2.0	0	
GROSS WEIGHT	**650.0**	**1.7**	1127	

Possible Loading Conditions

Driver+Pass+lug, No Fuel	472.1	2.1	977
Driver+Pass,No lug,No Fue	472.1	2.1	977
Driver only, No Fuel	472.1	2.1	977
Driver only, Full Fuel	532.1	2.1	1127

Aero

- Aerodynamics is a critical area for all motorsport disciplines.
- A significant amount of testing and study is required to make the most of a car.



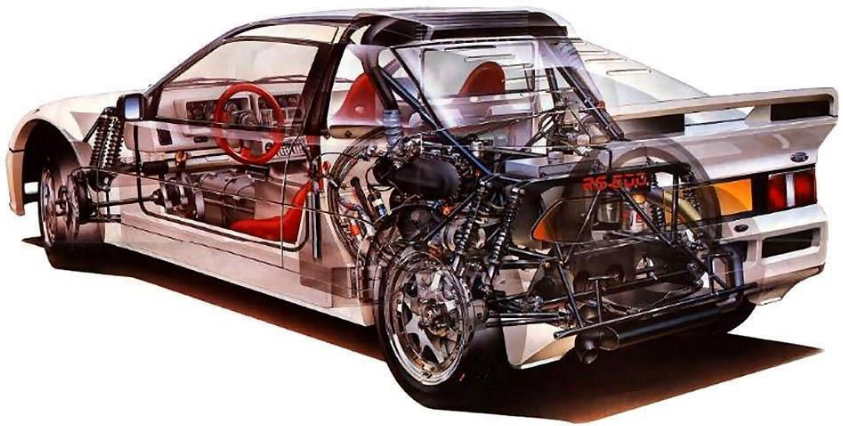
Suspension

- Needs to be a balance of high grip over bumpy surfaces, while giving a stable platform for the Aero.
  - Le Mans – smooth surface, aero priority
  - Rally – bumpy surface, grip priority
  - Hillclimb – balance of both

	TYRE FORCES	**MP101**				**DRY**	100 MPH		20 09 2012			
	Weight including driver	kg				390.0						
	310+80			**front**				**rear**				
			outside		inside		outside		inside		0.0	
1	Total weight -kg	kg		144				246		37.0	246	rear weight
2	Wt per corner	kg	72		72		123		123	63.0		
3	Unsprung wt	kg	18		18		22		22		Aero figures from track test	
4	Sprung wt per corner	kg	54		54		101		101	134	Mech drag @ 100 m/h	
	Download at 100mph	kg	(144)	170	(180)	460	(221)	290	"(380)	1610	Aero drag @ 100 m/h	
5	Track	mm		1392	max			1372	max	**3873**	Drag at max speed	
6	Wheelbase	mm				2298				5872	Traction force @100 m/h	
7	C.G. Height	mm				270				**3889**	Traction at max speed	
8	Tyre dia	mm		530				600		31	M/S at 1000 r/m wheelspeed	
9	Tyre grip coeff.					**1.6**				113	Km/H at 1000 r/m wheelspeed	
10	Total load transfer	kg				158						
11	Load transfer/wheel	kg		103				56				
12	Vertical tyre force	N	2558		531		3177		2083			
13	Lateral tyre force	N	4093		850		5084		3332	13359	TOTAL	
14	Torque through diff	N-M						525		37.0	% Lat Front	
14A	Lateral G	%g				**3.50**						
15	**Acceleration**											
16	load transfer	N				557						
17	Vertical tyre force		1262		1262		2903		2903			
18	Traction force	N	0		0		4644		4644	350	HP	
19	Traction torq	N-M	0		0		**1393**		**1393**	398	HP required for wheelspin at 1000r/m	
20	Acceleration	%g				**2.43**				99	Km/H for wheelspin at 350 HP	
21	**Braking**										111	Rear Downforce at Wheelspin speed-kg
22	load transfer	N				1566				108.0	%g	Max Accel at 100 m/h
23	Vertical tyre force	N	2324		2324		1841		1841	**151.0**		Max speed -M/h
24	Braking force	N	3718		3718		2946		2946	243.1	km/h	
25	Braking torq	N-M	985	53	985		884	47	884			
26	Braking	%g		%		**3.49**		%				
27	Static ride height			72				60				
28	Ceiling speed					92						

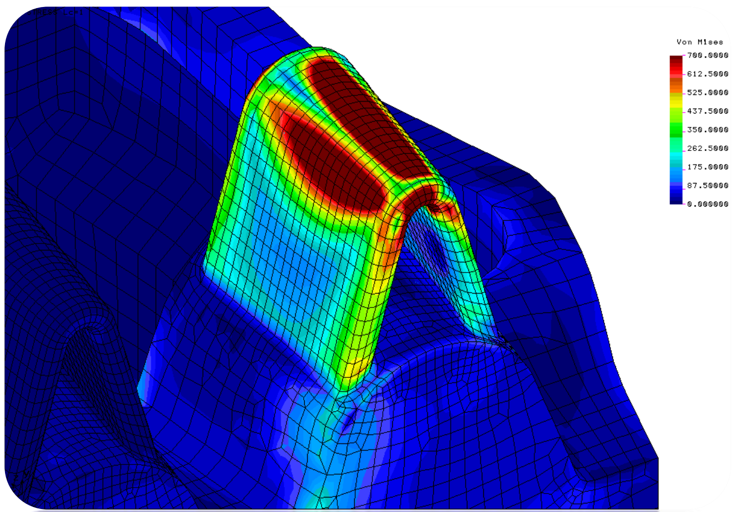
Weight

- Always at a minimum, regardless of regulations.
- Ballast can be added to meet minimum weight, giving low CofG height.
- Chassis design can offer a large weight saving.



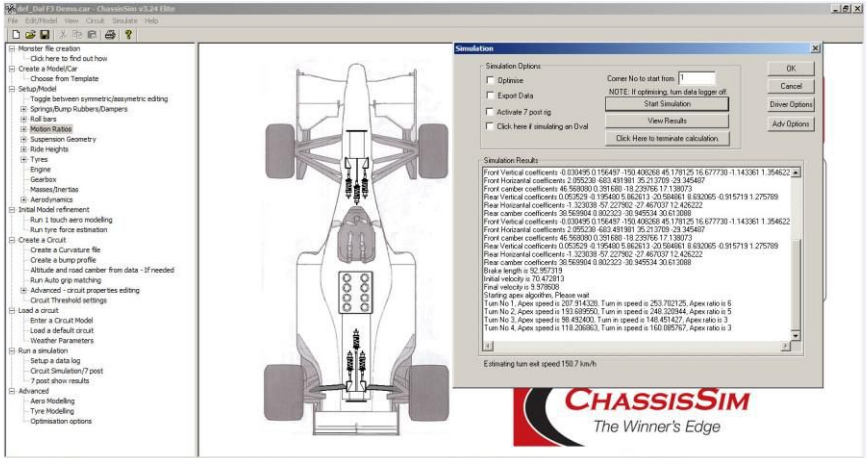
Chassis

- A strong stiff chassis is a vital platform to mount the preceding items onto.
- Uncontrolled flexibility introduces poor responses to driver input:
  - The driver cannot be sure of the response to his controls and incidents will occur.
  - The driver will lose confidence and never be able to push the car to its limit to maximise performance.



Simulation

- Computing power can be used to develop the following areas:
  - Aero studies in CFD codes.
  - FEA to improve suspension and chassis stiffness.
  - Lap simulation to locate the ideal balance and combination of aero, suspension etc.



- Optimisation techniques will deliver these answers in the shortest timescale possible.

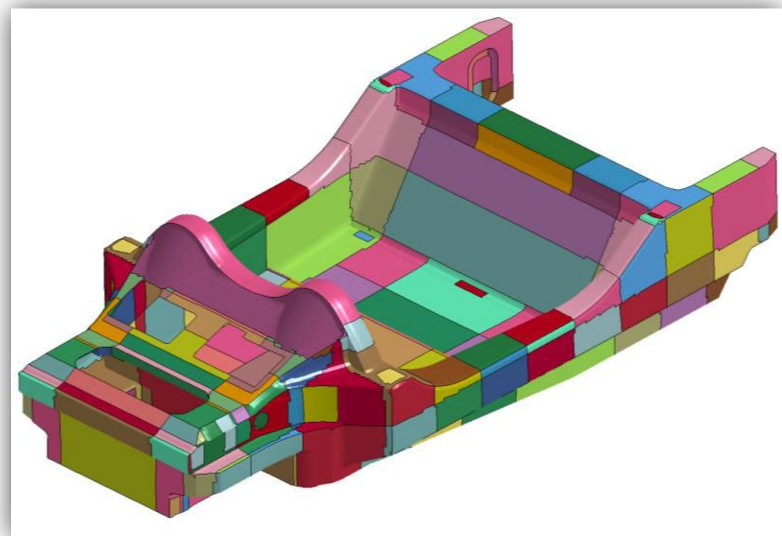
Composite Lotus Elise Chassis Development

Tristan King

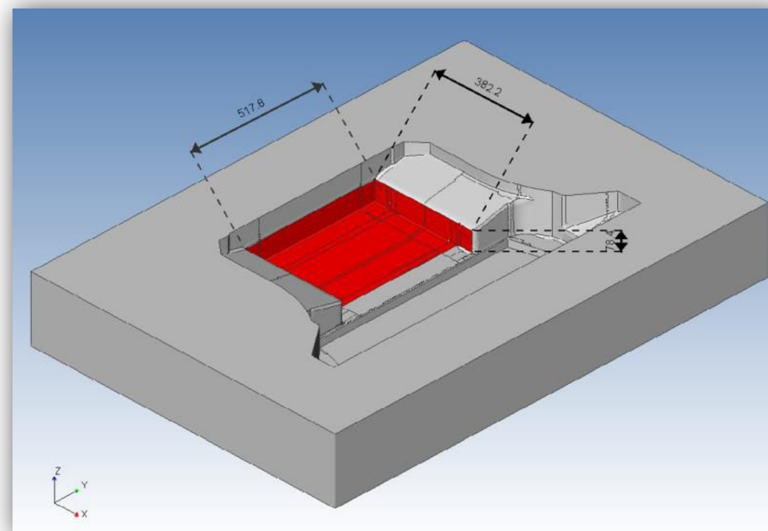
21st April 2016

Elise Chassis Application

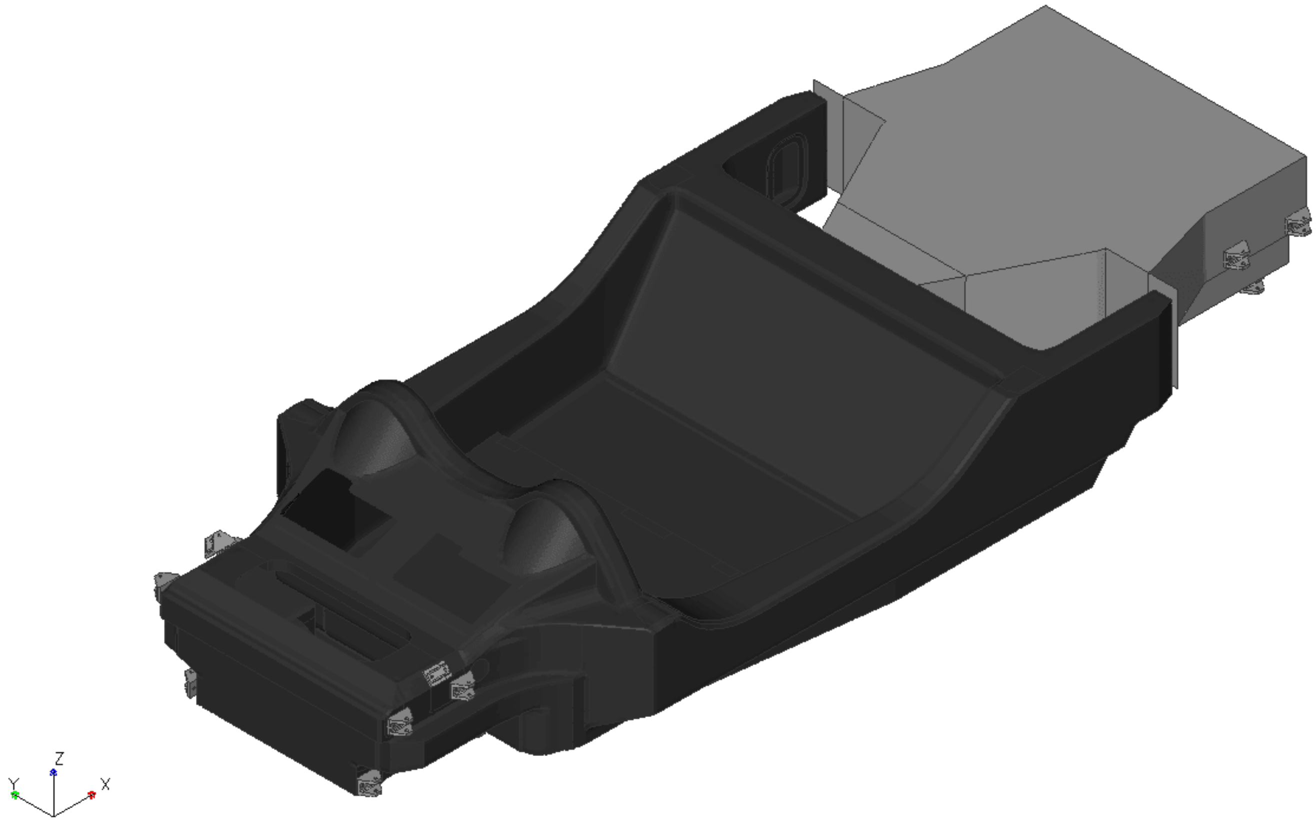
Optimisation Summary



Laminate Reporting



Pilbeam Chassis Design



Genesis Optimisation Model

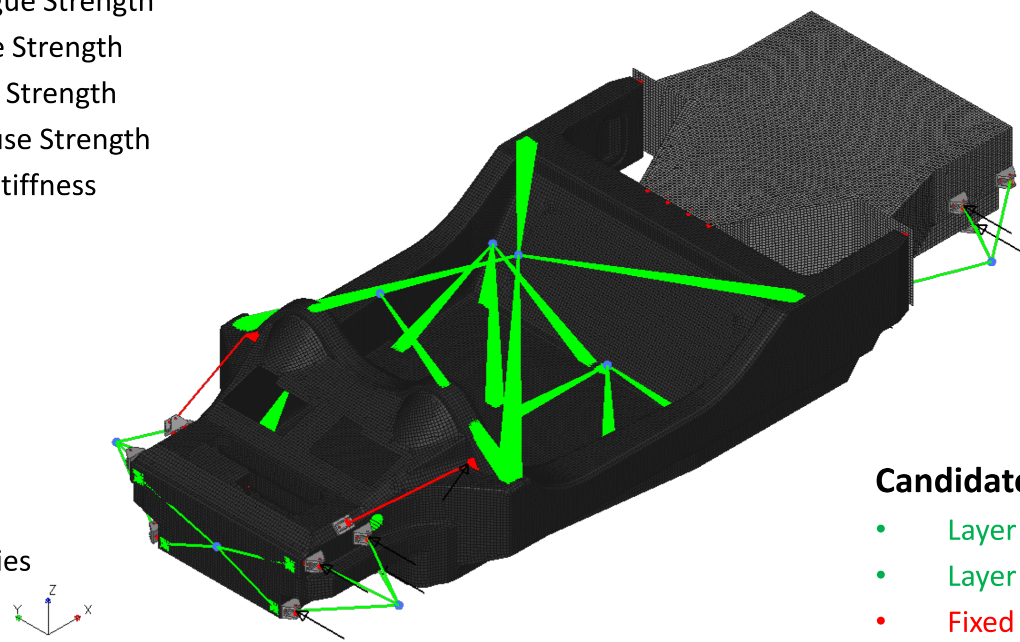
Pilbeam
RACING DESIGNS

Load cases

- Cornering – Fatigue Strength
- Braking – Fatigue Strength
- Crash – Ultimate Strength
- Kerb strike – Abuse Strength
- Static Torsion – Stiffness

Optimisation Control

- Laminate symmetry
- Min and Max thickness
- Mass target



Major Masses

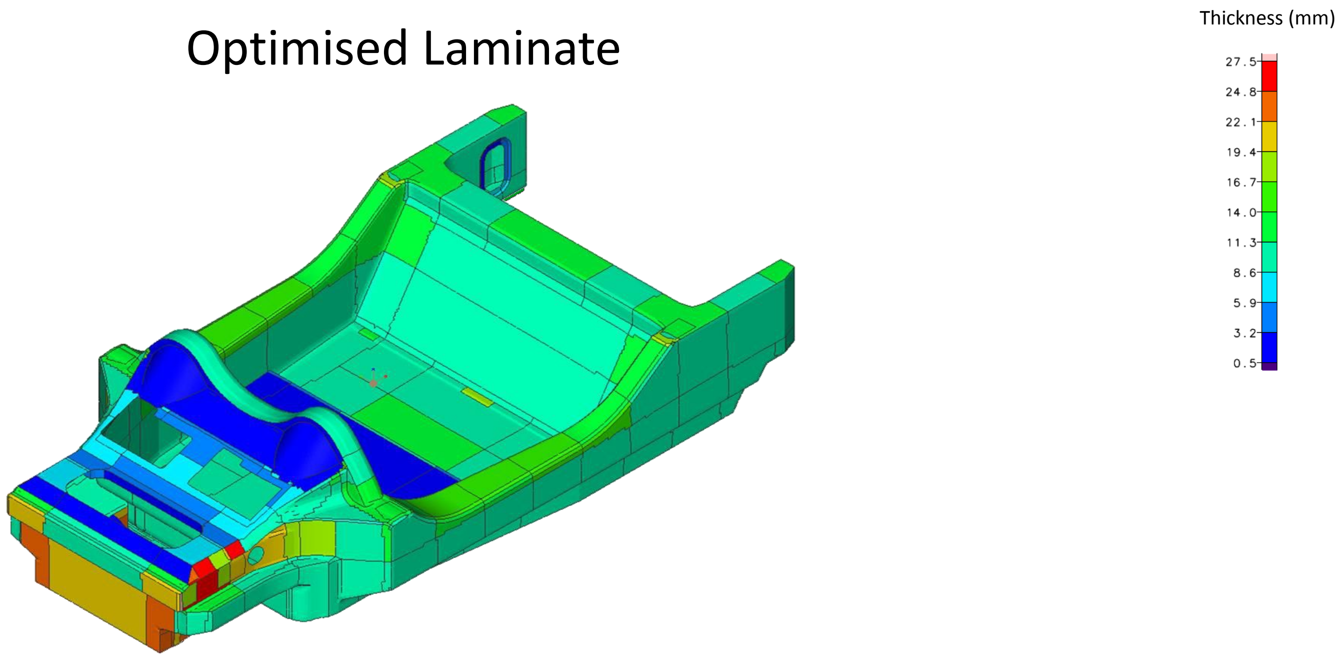
- Power train
- Wheel assemblies
- Roll cage
- Seats
- Wiring

Candidate layup info

- Layer 1 - Carbon Cloth 0°
- Layer 2 - Carbon Cloth 45°
- Fixed Layer – Honeycomb Core / Inserts
- Layer 3 - Carbon Cloth 45°
- Layer 4 - Carbon Cloth 0°

The Laminate

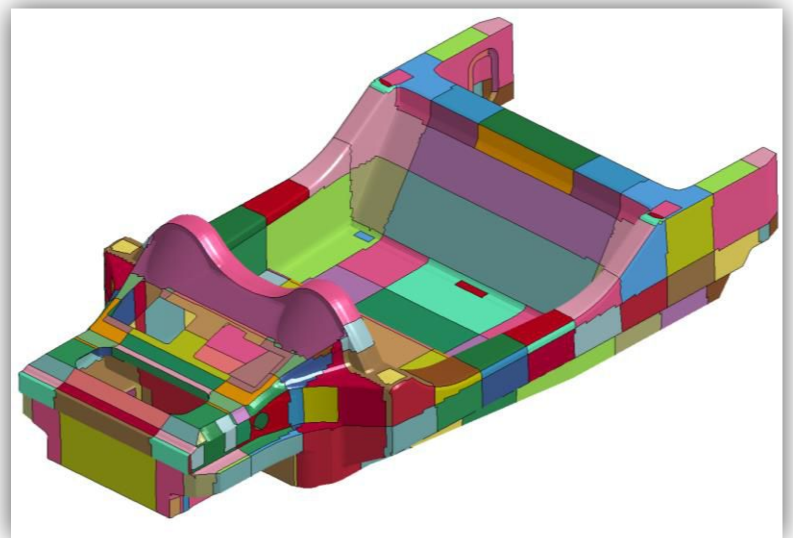
Optimised Laminate



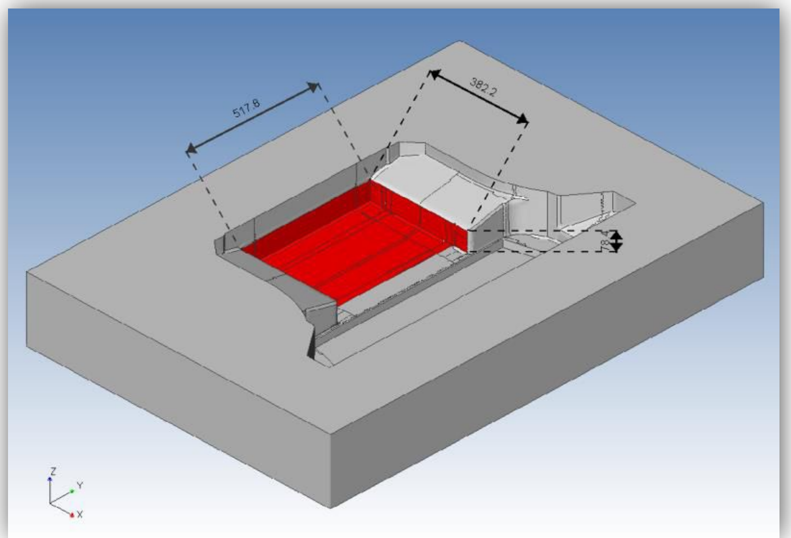
The optimised laminate has been developed to achieve a manufacturable layup with a mass of 40.3kg which meets all strength and stiffness targets for the given load cases.

Elise Chassis Application

Optimisation Summary

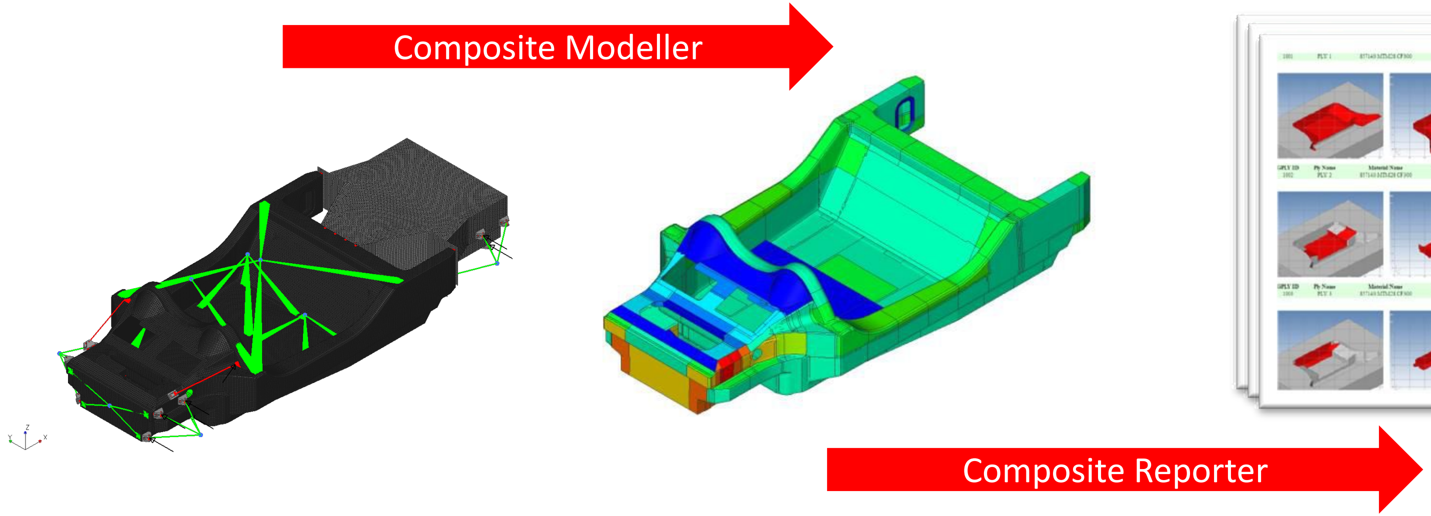


Laminate Reporting



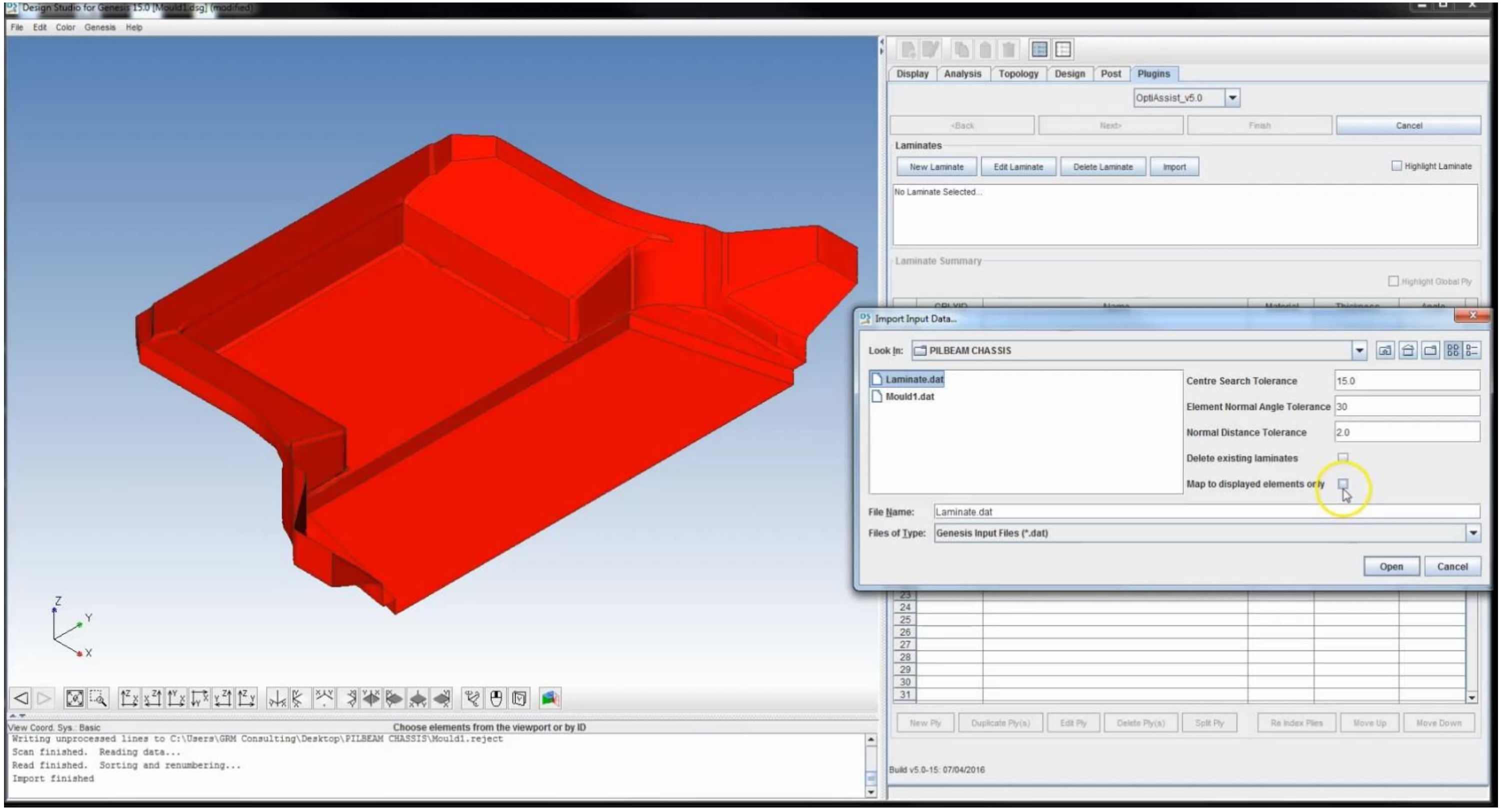
Developing the Ply book Data

- OptiAssist is an analysis and optimisation environment tailored to the composite engineer's requirements.



- We use the composite reporter to efficiently communicate our laminate design to the composite lay up technician. This ensures the design is manufactured accurately which will result in a design meeting the desired targets.

Composite Reporter Demo



OptiAssist Ply book

Overall Laminate Summary

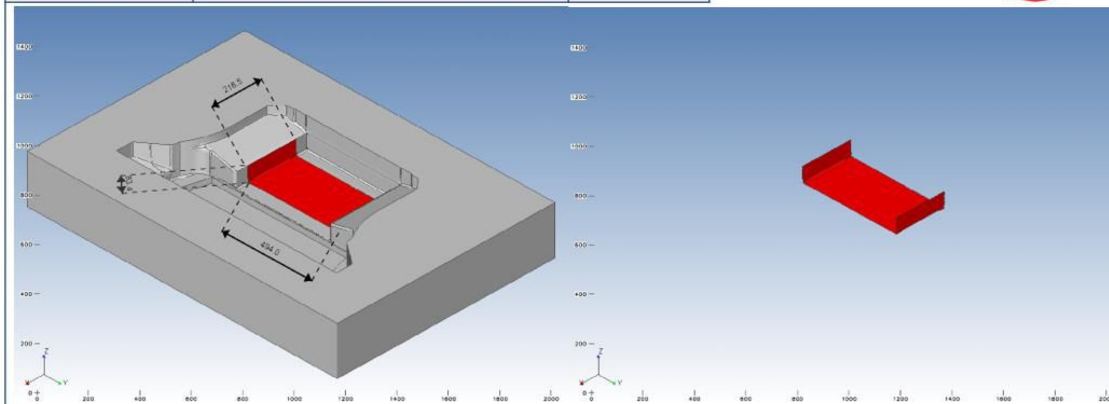
Part Number: Lower Toe-Box Laminate

Ply ID	Name	Material	Orientation	Thickness
1001	Outer Ply	3:MTM28 CF300	0.0	0.231
1002	Front Lower	3:MTM28 CF300	0.0	0.231
1003	Left Longitudinal	3:MTM28 CF300	45.0	0.231
1004	Right Longitudinal	3:MTM28 CF300	45.0	0.231
1005	Lower Floor 1	3:MTM28 CF300	45.0	0.231
1006	Lower Floor 2	3:MTM28 CF300	0.0	0.231
1007	Honeycomb Core	4:HONEYCOMB-5052-CORE	0.0	10
1008	Aluminium Inserts	2:ALUMINIUM	0.0	10

Colour	Material
Red	3:MTM28 CF300
Blue	4:HONEYCOMB-5052-CORE
Salmon	2:ALUMINIUM

OptiAssist Ply book

1006	Lower Floor 2	0.0



Notes: Lower Floor 2 – Ply 6 – Lower Toe-Box Laminate	Material:	MTM28 CF300
	Thickness:	0.231

Conclusion

- GRM's OptiAssist plugin has been utilised to both setup the optimisation and communicate this optimised design to Pilbeam Racing designs.

- The composite reporter is vital to ensure the composite laminate designs we produce in the software are properly implemented in production.

- As a result of using our latest OptiAssist plugin we have efficiently designed a lightweight chassis laminate and we were able to suggest geometry changes based on baseline analysis results.

- Thanks for listening.