WEC 2020

Chassis Design Specification

V11

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Version	Initials	Update	Date
V00	MT	Initial draft	16.08.2019
V01	MT	Update for project start, no ERS, electrical actuation	26.09.2019
V02	MT	Multiple updates	11.11.2019
V03	MT	Prelim cooling data added. Suspension targets updated	20.11.2019
V04	MT	Multiple updates	06.12.2019
V05	MT	Updated for AER P60C engine and Xtrac transverse gearbox	13.01.2020
V06	MT	Multiple updates	24.01.2020
V07	MT	Suspension, cooling and other updates	19.02.2020
V08	MT	Updated for Pipo V8 Engine, plus multiple other updates	01.04.2020
V09	MT	Safety factors, suspension, brakes, pedals, cooling, ballast	17.04.2020
V10	MT	Updated for new mass and power, plus multiple other updates	03.06.2020
V11	MT	Multiple updates	26.10.2020

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General Considerations

This specification is to suit the 2020 FIA/ACO Le Mans Prototype Hypercar Technical and Sporting Regulations.
This is a working document, values are preliminary and specifications will be updated as the design progresses. All provisional values and information pending marked in red. Updates for each version are marked in magenta.
This document should be read in conjunction with the relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical and Sporting Regulations and their Appendices.

Design Philosophy

- Design is simple, light, elegant and effective.
- Standard parts used where possible.
- Consideration made for cost of components.
- Structural bolted junctions incorporate studs where possible.
- Standard bolts and nuts used where possible.
- Rotary drive connections use standard splines.
- All structural shear connections are double shear where possible.
- Consideration made for serviceability and exchange of components during a race.
- Mass tracker to be maintained throughout the design process.

Key Car Parameters

- Aerodynamic performance
  - ClA max: 4.10 m^2,
  - ClA min: 3.92 m^2
  - CdA max: 1.04 m^2
  - CdA min: 0.98 m^2
- Aero balance target range 43 - 46 % front.
- Aerodynamic safety criteria in accordance with regulation requirements.
- Maximum engine power at driveshafts 500 kW +/- 20 kW for BoP.
- Maximum overall length 5000 mm.
- Maximum bodywork width 2000 mm.
- Maximum height above reference plane 1150 mm.
- Minimum bodywork frontal area 1.6 m^2
- Total fuel cell capacity, including all internals and foam 127 litres.
- Regulation mass target, including ballast, but excluding driver, trim ballast and fuel 1030 kg.
- Mass target, no ballast, no air conditioning 1000 kg.
- Weight distribution target range including driver, trim ballast and fuel 45 – 47 % front.
- Ballast provision excluding BoP ballast and with no air conditioning 35 kg minimum, including 5 kg trim ballast.
- BoP ballast provision 50 kg.
- Ballast positioned to achieve required weight distribution, low CG height and low polar moment.
- Dry car CG height 240 mm, including ballast, but excluding driver, and fuel.
- Wheelbase 3140.0 mm.
- Front axle position X = 0.0 mm.
- Low placement of all components where possible to allow low CG height.
- All electronics positioned to allow accessibility and cooled if necessary.
- ERS is not included.

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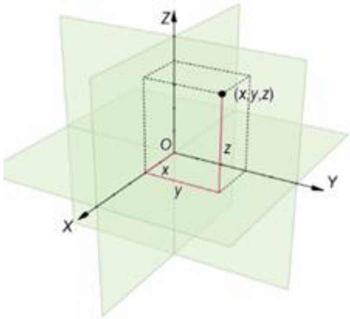
General Information

Design Methodology:

Coordinate system
X = 0.0 at the front wheel centreline, positive rearwards.
Y = 0.0 on the car centreline, positive to right.
Z = 0.0 on the reference plane (skid block top surface).



- The left-hand side of the car will be modelled unless parts are non-symmetrical.
- When parts are symmetrical the left-hand version only will be drawn.

Part Design:

Metallic parts designed in accordance with the Standard Metallic Materials list.
Heat treatments specified according to the Heat Treatment Specification list.
Surface treatments chosen from the Surface Treatment Specification list.
Composite parts designed in accordance with the Standard Composite Materials, Cure Cycles and Bonding specifications.
Cost effective design employed.
Account to be taken of fillet radii specification and surface finish requirement on machining time and cost.

Bolts and Fasteners:

Structural mountings to use studs where possible and incorporate shear locations where necessary.
Studs for structural mountings to have Imperial rolled threads for the nut attachment.
Stud material 17-4PH H900.
Bolted shear connections to use standard Imperial NAS aircraft type bolts where possible.
Non-structural and non-shear connections to use metric Unbrako cap-head, countersunk or button-head bolts.
Knuts to be used for standard fixings.
Imperial Knuts to be used for all structural attachments 1/4” and above.
Knuts with integral washers to be used wherever possible.
Separate washers to be fitted under bolt heads and nuts for attachments to aluminium parts.

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Loctite Specifications:

The following Loctite grades should be specified according to the application.

Loctite 222 – Low Strength
- Vibration resistance of small fixings that need to be easily removed

Loctite 243 – Medium Strength
- Retention of safety critical fixings that still require removal

Loctite 270 – High Strength
- Permanent retention of parts such as studs
- Heat required for removal

Loctite 648 – High Strength
- Permanent retention of parts
- Generally used for plain shaft fits rather than threaded fasteners
- Heat required for removal

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Safety Critical Components

The components and associated parts listed below are considered to be ‘Class A’ and require sign-off according to the requirements shown prior to car running:

Component	FEA	Physical Test
Monocoque	Yes	Yes
Inboard suspension	Yes	No
Outboard suspension	Yes	No
Steering rack assembly	Yes	No
Steering column assembly	Yes	Yes
Brake pedal assembly	Yes	No
Throttle pedal assembly	Yes	No
Rear wing & mounting assembly	Yes	Yes

Details of physical test requirements can be found in Appendix 3.

Load Cases:

Load case assumptions:

Base car mass	1030 kg
Driver mass	80 kg
BoP ballast	50 kg
Race consumables	5 kg
Minimum car mass, including driver	1115 kg
Maximum car mass, including driver	1165 kg
Maximum on track fuel mass	80 kg
Fuel mass for impact calculation	95 kg
Front mass balance range	44.5 – 47.5 %
Front roll balance range	50 - 65 %
Front brake balance range	55 - 65 %
Front aero balance range	42 - 47 %

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Suspension load case conditions:

	Acceleration	Speed, kph	Mass, kg
Brake	4.0 g	320	1165
Bump	5.0 g	320	1245
Brake + bump	3.0 g + 4.0 g	250	1245
Lateral	3.0 g	320	1245
Lateral + bump	2.5 g + 4.0 g	200	1245
Brake + lateral	3.0 g + 2.5 g	320	1245
Reverse brake + bump	2.5 g + 5.0 g	0	1245
Acceleration	1.6 g	150	1245
Acceleration + bump	3.5 g + 5.0 g	150	1245

Bump condition to be considered for each axle and for single wheel.

Lateral impact load at contact patch, for upright only: 60 kN

Safety Factors:

The following minimum safety factors are to be applied based on the design loadcases and material yield stress where appropriate:

Inboard suspension, excluding springs	Sf = 1.25
Outboard suspension, except trackrod and toelink	Sf = 1.6
Outboard suspension buckling, except trackrod and toelink	Sf = 1.6
Trackrod, steering rack and toelink	Sf > 4.0
Outboard suspension mounting lugs	Sf = 1.6
Suspension wishbone, trackrod and toelink mounting bolts	Sf > 2.5
Monocoque and gearbox outboard suspension mounting points	Sf > 2.5
Gearbox inboard suspension mounting points	Sf = 1.6
Tether attachments to monocoque and gearbox	Sf > 1.25
Monocoque engine mounts	Sf = 2.0
Steering column	Sf = 2.0
Brake pedal assembly	Sf = 2.0

Rig Testing:

Safety critical parts are to be proof and/or fatigue tested prior to car running. See Appendix 3.

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Part Lifing:

Minimum part life 6000 km (Full Le Mans race distance, plus practice and qualifying)
All safety and/or reliability critical parts and assemblies to have a specified part life.
All lifed parts to be serial number marked for mileage tracking.

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Performance Sensitivities

Factor	Lap-time, s	Quantity
Mass	0.40	10 kg @ Le Mans
Downforce	1.52	10 % @ Le Mans
Drag	1.96	10 % @ Le Mans
Power	0.77	10 kW @ Le Mans
Grip	6.1	10 % @ Le Mans

Aerodynamic Design

As well as meeting the aerodynamic performance targets, account to also be taken of the following:

- Minimise sensitivity to yaw, steer and roll to give an easy to drive car
- Low sensitivity in traffic for aero performance, brake and engine cooling
- Ease of component manufacture.
- Ability to split bodywork panels to allow quick replacement in case of accident.
- Design to be such that accidental damage due to contact with other cars, kerbs etc is avoided as far as possible e.g. forward corners of car high enough to avoid damage on kerbs, no small winglets that can easily be damaged etc.
- Consideration for driver entry and exit.
- Consideration for screen shape to aid wiper effectiveness.
- Maximise area available for headlights.
- Rim heating/cooling options.
- Brake cooling targets defined in Brake System section.
- Driver cooling inlet options:
  - Main inlet through nose and FIAS
  - Additional inlet(s) on forward roof to allow direct cooling flow to sensor

Bodywork Tolerances

Bodywork surfaces to be within the FIA regulation legality limits by minimum the amounts shown in the table below:

Car area	Inside FIA limit, mm	Notes
Front overhang	8.0	
Overall length	10.0	
Floor width	3.0	Per side
Bodywork width	5.0	Per side

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Key Dimensions

Coordinate system
X = 0.0 at front wheel centreline, positive rearwards.
Y = 0.0 on car centreline, positive to right.
Z = 0.0 at chassis chassis bottom surface on reference plane, positive upwards.

Front axle centreline	X = 0.00 mm
Rear axle centreline	X = 3140 mm
Monocoque front bulkhead	X = -300.0 mm
Vertical front face of rear roll structure (Xref)	X = 1600 mm
Monocoque rear bulkhead	X = 2000 mm
Engine front mounting face	X = 2002.5 mm
Engine mounting length	532.0 mm
Engine rear mounting face	X = 2534.5 mm
Gearbox length from front face to diff centreline	287.5 mm
Diff centreline	X = 3110.0 mm
Pedal pad face design position	X = 85.0 mm
Bottom surface of monocoque	Z = 5.0 mm
Skid block lower surface	Z = -20/-25 mm
Bottom of crankcase	Z = 5.0 mm
Crankshaft centreline	Z = 101.0 mm
Diff centreline	Z = 259.0 mm
Headlight beam centre height min	Z = 400 mm
Steering wheel top height min	Z = 650 mm
Steering wheel centre height	Z = 525 +/- 25 mm
Estimated fuel volume per stint (12 laps)	107 litres
Total fuel cell volume, including internals + margin	127 litres
Regulation min mass - no diver, no fuel	1030 kg
Dry car mass target - no driver, no ballast, no fuel	1000 kg
Weight distribution - no driver, no ballast, no fuel	44.5 %
Minimum ballast mass, including trim ballast	35 kg
BoP ballast mas (added to 1100 kg min)	50 kg
Fluid mass, excluding fuel	TBA kg
CG height - no driver, no fuel	Z = 240 mm
Minimum frontal area - @ FRH & RRH = 50mm	>1.6 m^2

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1. MONOCOQUE

Carbon composite construction incorporating driver safety cell and fuel cell compartment.
Design to be simple, robust and to suit manufacturing requirements.
Minimise mass below Z = 370.0 mm to achieve CG height requirement.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 13: Cockpit and Survival Cell
Article 15: Safety Structures
Appendix 3: Cockpit and Survival Cell - weight and CoG measurement conditions

1.1 Weight

Minimum weight: 90 kg (including Zylon panels and 5 kg ballast)
Minimum CoG Height: Z = 370.0 mm
Both above considering the weight perimeter defined in Appendix 3 of the Technical Regulations. Zylon panels included.

1.2 Stiffness

Target minimum torsional stiffness: 60000 Nm/deg
Front axle centreline to rear bulkhead with rigid front suspension fitted.

Attention to local installation stiffness for all suspension and engine mountings.

1.3 Survival Cell

The survival cell must comply with the relevant sections of Article 13 of the Technical Regulations.

The survival cell must comply with Article 15.2 of the Technical Regulations and be capable of passing the static load tests detailed in Article 2.1 of the Appendix relating to Article 15.2.4 of the Technical Regulations.

Minimum safety factor Sf = 1.5

Additional supplementary panels are required in accordance with Article 15.2.2 and 15.2.3 of the Technical Regulations

1.4 Roll Structures

The front and rear roll structures must comply with Article 15.1 of the Technical Regulations and be capable of passing the static load tests detailed in Article 2.3 of the Appendix relating to Article 15.1.3 of the Technical Regulations.
Lifting points incorporated in accordance with Article 14.13 of the Technical Regulations.

1.5 Equipment

Fittings for equipment fitted in the monocoque to withstand 25 g load in any direction.

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1.6 Fuel Hatch

Fuel cell fitting through hatch in internal bulkhead of monocoque.

1.7 Engine Oil Tank Provision

Recess in rear bulkhead to suit engine oil tank.
Minimum clearance between monocoque surface and oil tank 5.0 mm to allow for insulation if necessary.
Fuel cell fittings to be recessed to avoid possible contact with oil tank.

1.8 Engine Mounts

Engine mounting to chassis to suit Pipo installation.
Mounting via studs and threaded sleeves in monocoque.
Middle studs transfer shear load only.
Metric threads in monocoque.
Imperial threads and 12 point K-nuts on engine side.
Stud material 17-4PH H900.

Design load cases see separate detail document.
Minimum safety factor: Sf = 2.0

1.9 Pedal Mounts

Pedal mounting to allow alternative pedal positions.
Fixing via countersunk screws.

Longitudinal hole pitch: 25.0 mm (half pedal bracket hole pitch)

1.10 Seat Area

Laminate thickness below seat: 5.0 mm

1.11 Materials

General laminate to use 630 gsm T700 based material.
Structural inserts to be in Al 7075, non-structural in carbon.

1.12 Machining Details

Threaded holes to be metric.

1.13 Towing Eye

Towing eye in compliance with Article 14.12 of the Technical Regulations.
Attached to FIAS.

Design loadcase: 16.5 kN
Minimum safety factor: Sf = 1.2

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1.13 Skid Block Attachment

Skid block and forward floor attached to monocoque via mechanism to achieve defined vertical compliance.

1.14 Ballast Provision

See Appendix 1.

Design loadcase horizontal:	25 g
Design loadcase vertical:	5 g
Safety factor:	2.0

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	Edit Value
Front Toe Angle {SAE} (deg)	-0.0127
Front Camber Angle (deg)	-2.0001
Rear Toe Angle {SAE} (deg)	-0.0257
Rear Camber Angle (deg)	-0.9490

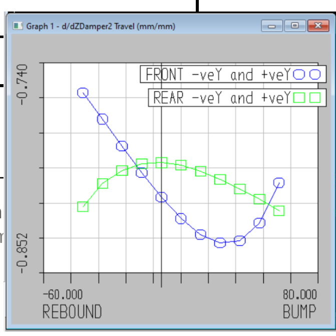
2. FRONT SUSPENSION

Double wishbone concept with pushrod operated inboard spring/damper system.
Coil springs, linear lateral dampers, linear central damper and anti-roll bar.
Fabricated steel wishbones, pushrod and trackrod.
Wishbone fairings have maximum aspect ratio 3:1
Ability to change complete corner in event of accident with minimum number of fasteners to remove and minimum number of tools required.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 10: Suspension and Steering Systems

2.1 Kinematic Targets

Front axle centreline	X = 0.0 mm
Design static ride height	76.0 mm
Minimum static ride height	45.0 mm
Maximum static ride height	85.0 mm
Maximum dynamic ride height	110.0 mm (regulation)
Tyre static loaded radius	346 mm
Max single wheel bump travel	50.0 mm
Max heave bump travel	40.0 mm
Max wheel droop travel	30.0 mm
Design camber	-2.0 deg
Static camber range	-0.5 to -3.5 deg
Camber adjustment increment	0.25 deg
Camber change per 10mm wheel bump	0.20 deg
Design toe	0.0 deg
Total toe adjustment range	+/-6.0 mm on rim
Toe adjustment increment	+/-1.0 mm on rim
Toe change with bump	Minimise
Design track legality	-4.0 mm total @ max camber
Castor angle	5.8 deg
Castor trail	26.3 mm
Kingpin angle	14.2 deg
Scrub radius	59.7 mm
Roll centre height to ground @ static RH	56.0 mm
Roll centre height variation relative to chassis	Minimise
Anti-dive	75 %
Ackerman	TBA %
Lateral damper motion ratio	0.8



Central damper motion ratio	1.2
Anti-roll bar motion ratio	8.99 deg/deg body roll

2.2 Stiffness Targets

Vertical on rigid central element	7600 N/mm
Vertical on rigid lateral damper	3800 N/mm
Camber under lateral load	55 kN/deg
Toe under longitudinal load	65 kN/deg
Toe under lateral load	55 kN/deg

2.3 Adjustment

Ride height via shims under pushrod inboard fitting.
Camber via shims under bracket on upright.
Zero degrees camber is required for transport only.
Toe via shims under rack mounted clevis.
Spring rate via alternative coil springs on central and lateral dampers.
Dynamic ride height via coil spring, Belleville washers, bump rubbers and packers on central damper.
Track width via spacers under inboard wishbone mounting brackets.
Anti-dive and roll-centre height via alternative spacers in FLWB brackets: +/- 5.0mm front and rear.

2.4 Steering Lock Clearance

All structural components, brake ducts and fairings to have 3.0 mm minimum clearance throughout the entire suspension travel and steering lock range.

2.5 Bodywork Clearance

Minimum bodywork clearance 10 mm in the following conditions:

	Travel	Camber	Steer
Design static RH	0	-0.5/-3.5	+/- 22.0
Full bump - from design static RH	50	-0.5/-3.5	+/- 14.5
Full droop - from max static RH	-30	-0.5/-3.5	+/- 22.0

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2.6 Front Upright

Aluminium Pankl P300 (Al 7075).
Shot peened.
Design consideration for brake cooling.
Pushrod mounted on upright.
Structural integrity proven by FE analysis.
No failure at 60kN lateral impact load at contact patch.

Sensor requirements:
Twin wheel speed sensors.
Infra-red brake temperature sensor.
Accelerometer for testing.
Brake duct Kiel probe sensor for testing.
See electrical system documents for all details.

2.7 Front Hub

Steel Pankl P105.
Shot peened.
To suit AP spline drive disc bell.
M58 x 3.0 wheel nut thread.
Wheel nut thread LH on LH part and RH on RH part.
Hub nut thread LH on LH part and RH on RH part.
Wheel drive pegs located in rim.
Drive peg number 6.
Structural integrity proven by FE analysis.
Outboard hub geometry identical to rear hub.

2.8 Front Wheel Bearings

Outer bearing size: 130 x 95 x 18
Inner bearing size: 130 x 95 x 18
Cerobear supply.

2.9 Front Disc Bell

Titanium Ti-6Al-4V solution treated and aged.
Shot peened.
Spline drive to hub.
Spline drive to brake disc.
Structural integrity proven by FE analysis.
AP Racing design and supply.

2.10 Camber Bracket

Steel Pankl P100 (4340)
Shot peened.
Black oxide surface treatment for corrosion resistance.
Mounting for both FTWB and trackrod.
Steering arm length 128.5 mm.
Mounted to upright using shims to allow camber adjustment.

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2.11 Front Top Wishbone (FTWB)

Steel 15CDV6 fabricated construction.
Inboard spherical bearings.
Outboard eyelet with spherical bearing to mount in camber plate clevis.
Structural integrity proven by FE analysis.
Carbon fibre composite fairing in accordance with Article 10.3.1 of the Technical Regulations
Tether routing along forward leg.

2.12 Front Lower Wishbone (FLWB)

Steel 15CDV6 fabricated construction.
Inboard spherical bearings.
Outboard eyelet with spherical bearing to mount in upright clevis.
Structural integrity proven by FE analysis.
Carbon fibre composite fairing in accordance with Article 10.3.1 of the Technical Regulations.
Tether routing along forward leg.
Provision for vertical adjustment of inboard mountings by +/- 5.0 mm

2.13 Trackrod

Steel 15CDV6 fabricated construction.
Outboard and inboard eyelets with spherical bearings.
Non-adjustable.
Structural integrity proven by FE analysis.
Carbon fibre composite fairing in accordance with Article 10.3.1 of the Technical Regulations.
Minimum safety factor 4, but consideration for maximum permissible steering rack load to minimise possibility of rack damage in an accident.

2.14 Front Pushrod

Steel 15CDV6 fabricated construction.
Ride height adjustment via shims under inboard end fitting.
Load cell on outboard end fitting.
Spherical bearings inboard and outboard.
Structural integrity proven by FE analysis.
Carbon fibre composite fairing in accordance with Article 10.3.1 of the Technical Regulations.

2.15 Tethers

Each corner fitted with two tethers compliant with Article 14.9 of the Technical Regulations.
Minimum inside diameter of tether end fitting 15 mm.
Minimum strength of tether attachment 80 kN within a 45 deg included angle cone.
Attachments separated by at least 100 mm on the monocoque
Attachments separated by at least 90 deg radially and 100 mm on the upright assembly.
Attachment to suspension bracket to allow ease of suspension change.
Tether routing as above.
Cortex supply.

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2.16 Front Rocker

Titanium Ti-6Al-4V solution treated and aged.
Shot peened.
Pivot bearings standard aircraft control type full complement ball.
Structural integrity proven by FE analysis.

2.17 Front Lateral Springs

Steel coil springs.
Eibach or H&R manufacture.
Nominal inner diameter 2.0”.

Static set-up mass of car supported by lateral springs.
All springs to have same length under set-up conditions – changing spring rate does not affect ride height.
Above may be achieved using individual spacers with each spring.
Standard catalogue springs for initial testing.

Assumptions for design:
Car set-up mass: 1115 kg
Weight distribution: 46 % front
Unsprung mass: 42.5 kg per corner

Design rate range (N/mm @ wheel): TBA

Initial range (N/mm @ wheel): TBA

2.18 Front Lateral Dampers

Linear through rod design.
4 way adjustable.
Main bore diameter 34.925 mm.
Shaft dia 12.7 mm (0.50”)
Stroke 65.2 mm.
Design to accept coil spring and bump rubbers.
Spring seat position adjustable via spacers.
Stroke measurement via linear potentiometer.
Standard spherical bearings on outboard ends.
Plain bearings on inboard end to suit common central mount.
Damper provides bump and droop stop.
Penske design and supply.

2.19 Front Central Damper

Transverse installation operated directly by rockers.
Linear through rod design.
4 way adjustable
Main bore diameter 34.925 mm.
Shaft dia 15.875 (0.625”)
Stroke 86.9 mm
Design to accept coil spring, bump rubbers and Belleville washers.
Standard spherical bearings both ends.
Penske design and supply.

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2.20 Front Central Coil Springs

Steel coil springs.
Eibach or H&R manufacture.
Nominal inner diameter 2.0”.
Spring engages from static ride height condition only.
Standard catalogue springs for initial testing.

Initial range (N/mm @ axle): TBA

2.21 Front Anti-Roll Bar

U bar with blades and drop-links to rockers.
Blades rotate through 90 degrees to allow rate adjustment during pitstop.
Ability for mechanic to adjust rate remotely during pitstop in <5 seconds.
Fatigue test 1st off parts TBA.
Max weight 6.0 kg

Design rate range (Nm/deg body roll @ wheel): 990 – 3300
Rate steps: TBA

Splined torsion bars in steel P105
Shot peened
Removable via access hole in side of monocoque
Torsion bar design rate range (Nm/deg body roll @ wheel): TBA
Minimise number of parts to achieve overall rate range

ARB blades in steel P105
Shot peened
Blade design rate range: TBA
Minimise number of parts to achieve overall rate range

2.22 Front Rim

Rim dimensions in compliance with Article 12.5 of the Technical Regulations and in accordance with ETRTO 12.5 J 18 requirements.
Suits Michelin tyre 29/71-18.
Design to be checked by Michelin prior to manufacture.
Design includes provision for TPMS.
OZ design and manufacture.

Material:	Mg AZ80
Target mass:	8.75 kg

2.23 Wheel Nut Retention System

Sprung loaded pawl system operated directly by wheel nut gun.
Design common front and rear.
Pankl design and supply.

2.24 Wheel Nut

Pankl design and supply.
Steel Pankl P105.

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PODIUM
ADVANCED TECHNOLOGIES

	Edit Value
Front Toe Angle {SAE} (deg)	-0.0127
Front Camber Angle (deg)	-2.0001
Rear Toe Angle {SAE} (deg)	-0.0257
Rear Camber Angle (deg)	-0.9490

3. REAR SUSPENSION

Double wishbone concept with pushrod operated inboard spring/damper system.
Coil springs, linear lateral dampers, linear central damper and anti-roll bar.
Fabricated steel wishbones, pushrod and toe-link.
Wishbone fairings have maximum aspect ratio 3:1
Ability to change complete corner in event of accident with minimum number of fasteners to remove and minimum number of tools required.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 10: Suspension and Steering Systems

3.1 Kinematic Targets

Rear axle centreline	X = 3140 mm
Design static ride height	96.0 mm
Minimum static ride height	45.0 mm
Maximum static ride height	100.0 mm (regulation)
Maximum dynamic ride height	110.0 mm (regulation)
Tyre static loaded radius	346.0 mm
Max single wheel bump travel	65.0 mm
Max heave bump travel	55.0 mm
Max wheel droop travel	35.0 mm
Design camber	-1.0 deg
Static camber range	0.0 to -3.0 deg
Camber adjustment increment	0.25 deg
Camber change per 10mm wheel bump	0.26 deg
Design toe	0.0 deg
Total toe adjustment range	+/-6.0 mm on rim
Toe adjustment increment	+/-1.0 mm on rim
Toe change with bump	Minimise
Design track legality	-4.0 mm total @ max camber
Roll centre height to ground @ static RH	102.0 mm
Roll centre height variation relative to chassis	Minimise
Anti-lift	40 %
Anti-squat	16 %
Lateral damper motion ratio	0.8
Central damper motion ratio	0.9
Anti-roll bar motion ratio	6.07 deg/deg body roll

Bump Travel (mm)	Roll Centre Height {to Body} (mm)	Roll Centre Height {to Grnd} (mm)
60.00	89.7770	29.7770
50.00	91.7155	41.7155
40.00	93.7130	53.7130
30.00	95.7682	65.7682
20.00	97.8797	77.8797
10.00	100.0462	90.0462
0.00	102.2668	102.2668
-10.00	104.5406	114.5406
-20.00	106.8670	126.8670
-30.00	109.2455	139.2455
-40.00	111.6760	151.6760

3.2 Stiffness Targets

Vertical on rigid central element	5000 N/mm
Vertical on rigid lateral damper	2500 N/mm
Camber under lateral load	70.0 kN/deg
Toe under longitudinal load	70.0 kN/deg
Toe under lateral load	110.0 kN/deg

3.3 Adjustment

Ride height via shims under pushrod inboard fitting.
Camber via shims under bracket on upright.
Toe via shims under toe-link bracket on upright.
Spring rate via alternative coil springs.
Dynamic ride height via coil spring, Belleville washers, bump rubbers and packers on central damper.
Track width via spacers under inboard wishbone mounting brackets.
Anti-lift, anti-squat and roll-centre height via alternative RTWB and RLWB forward bracket positions on bellhousing.

3.4 Bodywork Clearance

Minimum bodywork clearance 10 mm in the following conditions:

	Travel	Camber	Toe
Design static RH	0	0.0/-3.0	+/- 3.0
Full bump - from design static RH	65	0.0/-3.0	+/- 3.0
Full droop - from max static RH	-35	0.0/-3.0	+/- 3.0

3.5 Rear Upright

Aluminium Pankl P300 (Al 7075).
Shot peened.
Design consideration for brake cooling.
Pushrod mounted on upright.
Structural integrity proven by FE analysis.

Sensor requirements:
Twin wheel speed sensors.
Infra-red brake temperature sensor.
Accelerometer for testing.
Brake duct Kiel probe sensor for testing.
See electrical system documents for all details.

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3.6 Rear Hub

Steel Pankl P105 with case hardened CV joint tracks.
Shot peened.
To suit AP spline drive disc bell.
M58 x 3.0 wheel nut thread.
Wheel nut thread LH on LH part and RH on RH part.
Hub nut thread LH on LH part and RH on RH part.
Wheel drive pegs located in rim.
Drive peg number 6.
Structural integrity proven by FE analysis.
Outboard hub geometry identical to front hub.

3.7 Rear Wheel Bearings

Outer bearing size: 130 x 95 x 18
Inner bearing size: 130 x 95 x 18
Cerobear supply.

3.8 Rear Disc Bell

Titanium Ti-6Al-4V solution treated and aged.
Shot peened.
Spline drive to hub.
Spline drive to brake disc.
Structural integrity proven by FE analysis.
AP Racing design and supply.

3.9 Rear Top Wishbone (RTWB)

Steel 15CDV6 fabricated construction.
Inboard spherical bearings.
Outboard eyelet with spherical bearing.
Structural integrity proven by FE analysis.
Carbon fibre composite fairing on trailing edge only for protection of tether and loom.

3.10 Rear Lower Wishbone (RLWB)

Steel 15CDV6 fabricated construction.of tether
Inboard spherical bearings.
Outboard eyelet with spherical bearing to mount in upright clevis.
Structural integrity proven by FE analysis.
Carbon fibre composite fairing on trailing edge only for protection of tether and brakes line.

3.11 Toe-link

Steel 15CDV6 fabricated construction.
Inboard and outboard eyelets with spherical bearings.
Toe adjustment via shims under toe-link bracket on upright.
Structural integrity proven by FE analysis.
No fairing.

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3.12 Rear Pushrod

Steel 15CDV6 fabricated construction.
Ride height adjustment via shims under inboard end fitting.
Load cell on inboard or outboard end fitting TBA.
Spherical bearings inboard and outboard.
Structural integrity proven by FE analysis.
No fairing.

3.13 Tethers

Each corner fitted with two tethers compliant with Article 14.9 of the Technical Regulations.
Minimum inside diameter of tether end fitting 15 mm.
Minimum strength of tether attachment 80 kN within a 45 deg included angle cone.
Attachments separated by at least 100 mm on the gearbox maincase.
Attachments separated by at least 90 deg radially and 100 mm on the upright assembly.
Tether routing to suit Xtrac inboard mounting points.
Cortex supply.

3.14 Rear Rocker

Aluminium 7075.
Shot peened.
Pivot bearings standard aircraft control type full complement ball.
Single shear pivot pin into gearbox maincase.
Anchor nuts fitted for ease of assembly TBA.
Structural integrity proven by FE analysis.

3.15 Rear Lateral Springs

Steel coil springs.
Eibach or H&R manufacture.
Nominal inner diameter 2.0".

Static set-up mass of car supported by lateral springs.
All springs to have same length under set-up conditions – changing spring rate does not affect ride height.
Above may be achieved using individual spacers with each spring.
Standard catalogue springs for initial testing TBA.

Assumptions for design:
Car set-up mass: 1115 kg
Weight distribution: 45.5 % front
Unsprung mass: 50 kg per corner

Design rate range (N/mm @ wheel): TBA

Initial manufactured range (N/mm @ wheel): TBA

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3.16 Rear Lateral Dampers

Linear through rod design.
4 way adjustable.
Main bore diameter 34.925 mm.
Shaft dia 12.7 mm (0.50")
Stroke 74.0 mm.
Design to accept coil spring and bump rubbers.
Spring seat position adjustable via spacers.
Similar design to front damper to allow common use of components.
Stroke measurement via linear potentiometer.
Standard spherical bearings both ends.
Damper provides bump and droop stop.
Penske design and supply.

3.17 Rear Central Damper

Longitudinal installation operated by T bar.
Linear through rod design.
4 way adjustable.
Main bore diameter 34.925 mm.
Shaft dia 15.875 mm (0.625")
Stroke 82.4 mm.
Design to accept coil spring, bump rubbers and Belleville washers.
Similar design to front damper to allow common use of components.
Travel adjustable with split and solid packers.
Standard spherical bearings both ends.
Penske design and supply.

3.18 Rear Central Coil Springs

Steel coil springs.
Eibach or H&R manufacture.
Nominal inner diameter 2.0".
Spring engages from static ride height condition only.
Standard catalogue springs for initial testing TBA.

Initial range (N/mm @ axle): TBA

3.19 Rear Anti-Roll Bar

T-bar with drop links to rockers.
Alternative positions on T-bar allowing +/- TBA% rate change
ARB torsion bars in steel P105
Shot peened.
Fatigue test 1st off parts TBA.

Design rate range (Nm/deg body roll @ wheel): 630 – 2100

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3.20 Rear Rim

Rim dimensions in compliance with Article 12.5 of the Technical Regulations and in accordance with ETRTO 14.0 J 18 requirements.
Suits Michelin tyre 34/71-18
Design to be checked by Michelin prior to manufacture.
Design includes provision for TPMS.
OZ design and manufacture.

Material:	Mg AZ80
Target mass:	9.25 kg

3.21 Wheel Nut Retention System

Sprung loaded pawl system operated directly by wheel nut gun.
Design common front and rear.
Pankl design and supply.

3.22 Wheel Nut

Pankl design and supply.
Steel Pankl P105.

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4. STEERING SYSTEM

Electrically assisted rack and pinion.
Column incorporating single universal joint and energy absorbing section.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 10.4: Steering
Article 13.4: Position of the steering wheel

4.1 Geometry

Steering wheel to road wheel ratio	12.5 straight ahead
Steering arm length	128.5 mm
Rack ratio	Approx 68.30 mm/rev
Wheel steer angle	22.0 deg toe out, 22.0 deg toe in
Rack travel	44.0 mm

4.2 Rack and Pinion

KYB design and supply rack and pinion with integrated electric motor.
Max assistance 95 Nm
Rack travel designed for 44.0 mm max but with stops to allow reduction.
Rack to trackrod joint via clevis on rack and spherical bearing in trackrod.
Mass approx. 7500 g

4.3 Rack Housing

KYB design to bespoke installation dimensions.
Integral mounting points.
4 off mountings to accept 5/16-24 UNF NAS bolts.
Mounting to monocoque via adaptor brackets each side.

4.4 Rack Loads and Safety Factors

Max input torque	50 Nm
Rack axial load capacity	20 kN

4.5 Position Sensing

Position sensing by rotary potentiometer with drive from pinion.
Incorporated into standard KYB design.

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4.6 Steering Column

Crash element incorporated into upper column.
Peak Technology design and supply upper column.
Carbon upper column with metallic bonded end fittings.
Column support via torque sensor housing.
Krontec quick release and electrical connector.
The steering column capable of passing the impact test detailed in Article 2.4 of the Appendix relating to Article 10.4.3 of the Technical Regulations.
Fatigue and ultimate load test required on 1st off upper column part.
Proof test required on all upper column parts prior to car running.
Structural integrity of forward column section proven by FE analysis.
Minimum life 6000 km.

4.7 Forward Colum

Single Hook type joint.
Column joint arranged to give max on-centre steering ratio (slowest).
Proprietary cross-piece with needle roller bearings.
Splined upper and lower fork to suit torque sensor and steering rack spline.
Titanium Ti-6Al-4V solution treated and aged.
Shot peened.

4.8 Torque Sensor

KYB supply.
Integrated into steering column assembly.
Mounted to chassis as forward column support.

Max axial load without influencing calibration:	2.0 kN
Max axial load without structural failure:	5.0 kN

4.9 Stiffness

Minimum complete column stiffness:	6.0 Nm/deg

4.10 Column Load and Safety Factors

Design column torque:	50 Nm
Minimum safety factor:	Sf = 2.0 for metallic parts
	Sf = 3.0 for composite parts
Fatigue test:	10^5 cycles @ +/-100 Nm
Maximum load test:	>150 Nm

4.11 Steering Wheel

Development of Podium Engineering SCG 004C part.
Incorporates gearshift and clutch paddles.
Standard display fitted.
Button and switch details as defined in separate document.
Final height to be defined during driver fit.
Longitudinal position to be adjustable via spacers.
Maximum spacer 50 mm.

Top of steering wheel to be at min: Z = 650.0 mm (regulation)

Steering wheel design centre position: X = 850.0 mm min
Y = 150.0 mm min
Z = 525.0 mm (allows for min 250 mm dia)

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5. BRAKE SYSTEM

Standard parts used where possible to simplify design and contain costs.
Consideration for speed of changing discs and pads during pitstop.
QDs on caliper lines to allow quick change of complete suspension corner.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 11: Brake System

5.1 Discs and Pads Front and Rear

Carbon, carbon material.
Vented disc design.
Max number holes 500.

Front disc diameter:	380 mm
Rear disc diameter:	355 mm
New front disc thickness:	35 mm
New rear disc thickness:	35 mm
Minimum worn disc thickness	25 mm
New front pad thickness:	27 mm
New rear pad thickness:	25 mm
Minimum worn pad thickness	12 mm

Spline drive disc concept.
AP Racing design and supply.

5.2 Front Brake Caliper

AP Racing CP6160

Piston diameters:	27.00, 31.75, 38.10 mm
Total piston area:	50.1 cm^2
Fluid absorption: 1	2.5 mm^3/bar

Fitted with brake wear LVDT and PT100 temperature sensor.

Mounted in trailing position on front upright.

Max continuous operating temperature:	150 ^{0}C
Max peak operating temperature:	180 ^{0}C

5.3 Rear Brake Caliper

Standard fitment:	AP Racing CP6078
Piston diameters:	27.00, 31.75, 38.10 mm
Total piston area:	50.1 cm^2
Fluid absorption:	12.8 mm^3/bar

Alternative: AP Racing CP6077

Piston diameters:	26.00, 26.99, 31.75 mm
Total piston area:	37.9 cm^2
Fluid absorption:	9.1 mm^3/bar

Mounted in leading position on rear upright.

Max continuous operating temperature:	150 ^{0}C
Max peak operating temperature:	180 ^{0}C

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5.4 Brake Master Cylinders

AP Racing supply.
Conventional twin arrangement.
Fitted with low friction needle roller bearings.
AP available bore size range: 15.8, 16.8, 17.8, 19.0 mm.
Length adjustable via extension rods to suit alternative pedal positions.
Linear 'string' type potentiometers for displacement measurement.

Starting configuration:
Front: 16.8 mm
Rear: 17.8 mm

5.5 Brake Reservoirs

Commercially available plastic bottles supplied by AP
Mounted on front bulkhead bracket.
System to be reviewed after testing when brake wear is better quantified.

Possible race updates:
Separate top-up reservoir connected to both master cylinder reservoirs.
Remote QD for quick-fill during pitstop
Provision for one Gill type level sensor to be included in electrical system

5.6 Brake Balance System

Front bulkhead mounted balance mechanism.
AP type balance bar mechanism with bespoke bracket.
Cockpit mounted driver adjustment.
Simple cable adjustment initially.
Quick-shift version as later update TBA.

5.7 Front Brake Cooling

Caliper and disc cooling provided.
Caliper cooled via bridge ducting air to both sides.
Consideration for access to allow easy change of pads and discs.
Air inlet directly into upright mounted duct.

Required disk mass flow rate:	1.0 – 1.5 kg/s @ 320 kph
Hole cooling:	80 %
Face cooling:	10 % per side
Required caliper mass flow rate:	approx. 20% disc flow rate

Min duct clearance to undeformed tyre:	12.0 mm
Min drum radial clearance to rim, including balance weight:	5.0 mm

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5.8 Rear Brake Cooling

Caliper and disc cooling provided.
Caliper cooled via bridge ducting air to both sides.
Consideration for access to allow easy change of pads and discs.
Air inlet in wheel arch and duct to inner wheel arch.
Independent upright duct.

Required disk mass flow rate:	1.0 – 1.5 kg/s @ 320 kph
Hole cooling:	80 %
Face cooling:	10 % per side

Required caliper mass flow rate: approx. 20% disc flow rate

Min duct clearance to undeformed tyre:	12.0 mm
Min drum radial clearance to rim, including balance weight:	5.0 mm

5.9 Brake Lines

Rigid lines in stainless steel.
Flexible lines in PTFE stainless steel braided hose.
QDs on wishbone lines at chassis and bellhousing junctions to allow quick suspension change.
QD on or near caliper to allow quick caliper removal for brake material change. To be confirmed following brake wear analysis during testing.
Pressure sensors mounted on manifold blocks for front and rear pressure measurement.
AN Motorsport manufacture and supply.

5.10 Outboard Sensors

Race:
Disc IR temperature sensor front and rear.
Caliper mounted LVDT wear sensor front and rear.
Caliper temperature sensor front and rear (CP6078 caliper at rear only).

Test only:
Pad temperature sensors front and rear.
Brake duct Kiel probe sensors front and rear.

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6. PEDALS

Twin pedal arrangement with throttle and brake.
Alternative positions in chassis to suit different driver sizes.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 13.3: Position of the driver's feet

Throttle pedal operative position max forward:	X = 0.0 mm
Throttle to brake pedal lateral centre to centre distance:	150.0 mm

6.1 Brake Pedal

Fully machined design in Aluminium 7075 with bolt on carbon pad.
Shot peened.
Low friction full complement ball pivot bearing: DW4K2
Pad spacers for position adjustment.
Pedal pad centre assumed at 185 mm above pedal pivot for kinematic ratio.
Load application point assumed at 210 mm above pedal pivot for structural analysis.
Lateral position of load application to account for left and right foot braking.
Structural integrity proven by FE analysis.
Pedal pad options to suit right and left foot braking.
Width between 'flags' on pad 120 mm min.

Design position:	X = 85.0 mm at pedal pad load application point
Maximum forwards position:	X = 60.0 mm
Maximum rearwards position:	X = 360.0
Pedal motion ratio:	3.6

Max driver pedal load:	1.2 kN
Design loadcase:	2.0 kN
Load offset:	18.0 to left, centre, 35.0 to right
Minimum safety factor:	Sf = 2.0

6.2 Throttle Pedal

Fully machined in Aluminium 7075 with bolt on carbon pad.
Shot peened.
Low friction full complement ball pivot bearing.
Pad spacers for position adjustment.
Load application point assumed at 185 mm above pedal pivot.
Structural integrity proven by FE analysis.
Twin rotary position sensors mounted on pedal bracket.

Design position:	X = 85.0 mm at pedal pad load application point
Maximum forwards position:	X = 60.0 mm
Maximum rearwards position:	X = 360.0
Pedal motion ratio:	1.5:1 TBA
Max travel at load application point:	80 mm

Design loadcase:	0.5 kN
Minimum safety factor:	Sf = 2.0

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6.3 Throttle Strut

Fluid damped unit.
Travel adjustable via spacers.
Length adjustable via extension rods to suit alternative pedal positions.
Spring preload adjustable via spacers.
Penske design and supply.

Max travel:	TBA mm
Initial spring rate range:	TBA N/mm.

6.4 Pedal Bracket

Simple lightweight design in Aluminium 7075.
Separate brackets for throttle and brake pedals.
Alternative positions in monocoque to suit different driver sizes.
Mounting for heel rest incorporated.
Mounting to chassis via screws and captive nuts in bracket.

Longitudinal mounting hole pitch in chassis:	25.0 mm (half bracket hole pitch).
Longitudinal mounting hole pitch in bracket:	50.0 mm.

6.5 Heel Rest

Simple one-piece carbon construction.
Light but robust.
Alternative positions in chassis to suit pedal bracket position options.
Mounted to pedal brackets.

6.6 Foot Rest

Mounted to LH side of monocoque
Alternative positions in chassis to suit pedal bracket position options.
Width 30 - 40 mm

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7. TRANSMISSION

Xtrac P1324 gearbox (development of P1159D)
Transverse layout with cast Aluminium maincase and rear cover.
Separate cast Aluminium bellhousing.
Single barrel selector with electrical actuation.
Engine mounted clutch.
Engine mounted clutch release.
Torque sensors on clutch shaft and driveshafts.
Twin Bosch bellhousing mounted starter motors.
Bosch alternator mounted on LHS.
Provision for McLaren alternator in bellhousing.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 9: Engine Transmission System

7.1 Weight

Gearbox mass:	80.8 kg
Bellhousing mass:	13.78 kg
Minimum CoG Height:	Z = 150.0 mm

Both above considering the weight perimeter defined in Appendix 2.

7.2 Gearbox Internals

7 speed plus reverse.
Two alternative gear ratio sets.
Ratio gear centre distance 98.425 mm.
Ratio gear widths:

1st	19.0 mm
2nd & 3rd	21.0 mm
4th	19.0 mm.
5th & 6th	17.5 mm
7th	16.0 mm

Bevel ratio:	23/21
Final drive ratio:	13/43
Reverse ratio:	14/29
Materials:	Internals X36C, Xvar1, XM023

7.3 Differential

Xtrac VCNCP
Mechanical bevel, ramp and plate type, with nitrogen pre-charge and viscous coupling.
Maximum nitrogen charge pressure 22 bar.
Ramp options: 45/30, 60/30, 35/25
VC locking torque: 110 Nm (@50 rpm, 80^0 C)

7.4 Selector Mechanism

Selector fork operation by single sequential barrel.
Reverse selection via gearchange barrel.
Barrel operated by MEGA-Line electrical actuator.

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7.5 Maincase and Bellhousing

Precision sand cast Aluminium L169
External bosses to suit rear suspension mounting brackets.
Removable side covers for ratio changing.
Separate diff cover in Aluminium L169 with mounting for rear crash structure.
Engine oil catch-tank incorporated into front of maincase.
Separate bellhousing sand cast in Aluminium L169.
Xtrac design and supply.

7.6 Lubrication System

Eccentric single rotor pump with twin scavenge pick-ups.
Twin 125 micron filters.

Target operating temperature:	100 deg C
Max operating temperature:	120 deg C.
Heat rejection:	10 kW @ max rpm unloaded
Oil quantity:	2.25 litres excluding cooler and lines
Oil flow rate:	TBA l/min @ 7000 rpm
Oil pressure:	Approx 2.0 bar @ 7000 rpm

7.7 Driveshafts

Steel Pankl P102 or Aubert and Duval NC310YW heat treated and shot peened.
MagCanica torque sensor in accordance with regulation requirements.
See Magcanica installation drawing.
Integrated tripod CV joints

Tripod diameter:	38.0 mm
Tripod PCD:	61.0 mm
Length between joint centres:	663.0 mm

Retention by ‘dog bone’ system mounted in outboard hub.
Target mass: 5.5 kg for complete shaft assembly.
Pankl supply.
Maximise stiffness within other design constraints.

Minimum torque capacity:	+/- 5000 Nm to allow for calibration torque.
Calibration torque:	+/- 5000 Nm @ 130 deg C in accordance with FIA/Magcanica sensor requirements.

7.8 Clutch Shaft

Steel NC310YW heat treated and shot peened.
MagCanica torque sensor.
Xtrac supply.
Minimise stiffness within max stress limit

Torque capacity:	TBA Nm
Stiffness:	TBA Nm/deg

Clutch hub spline: ANSI B92.1 29T 24/48 45°PA fillet root side fit

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7.9 Clutch

Sachs pull type carbon/sintered.
Package protect for Sachs or Tilton carbon/carbon type.
Cooled via auxiliary duct.
Stater ring gear mounted to clutch basket.
Package allows for starter rings gear with 81 to 88 teeth.
Initial designed ring gear 81 teeth.

7.10 Clutch Release

Sachs developed hydraulically operated pull type bobbin.
Package protect for Tilton Sachs hydraulically operated push type bobbin.
Fitted to rear of engine via adaptor housing.

7.11 Clutch Disengagement

Disengagement via Megaline clutch actuator.
Operation in accordance with Article 9.4 of the Technical Regulations.

7.12 Sensors

Gear barrel position via MEGA-Line actuator.
Gearbox oil inlet and outlet pressure.
Gearbox oil inlet and outlet temperature.
Output flange speed sensors.
Clutch shaft torque sensor.
Driveshaft torque sensor.

7.13 Endurance Targets

Ratio gears and bearings:	6000 km
Bevel and final drive gears:	12000 km
Driveshafts:	6000 km, plus calibration process.

7.14 Rig Testing

No-load spin test performed at Xtrac to check gearshift and oil system prior to delivery.
Complete drivetrain test on engine dyno.

7.15 Ballast Provision

See Appendix 1.

Design loadcase horizontal:	25 g
Design loadcase vertical:	5 g
Safety factor:	Sf = 1.5

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8. ELECTRICAL ACTUATION SYSTEM

Providing actuation for gearchange and clutch.
Megaline supply
See electrical documentation for full specification details.

8.1 Gearchange Actuator

MEGA-Line E-Shift.
Mounted on RHS of gearbox.
Cooling via auxiliary duct.

8.2 Clutch Actuator

MEGA-Line E-Clutch.
Located in forward part of monocoque.
Reservoir mounted on front bulkhead.

8.3 Clutch Disengagement

Via MEGA-Line E-Clutch with power from separate supply module.

8.4 Brake Balance Adjustment

Allowance in electrical system for fitment of MEGA-Line actuator for testing only.

9. PNEUMATIC SYSTEM

No engine AVS.

9.1 Pneumatic Jacks

Two forward jacks mounted inside monocoque.
One rearward jack mounted to gearbox rear cover.
Filling port position on bodywork in front of rear wheel.
Provision for filling port fitment on either side of the car.
Operated via external air supply in pit.
Quick exhaust valves included.
Krontec supply.

Forward jacks	50.0 mm dia
Rear jack	60.0 mm dia

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10. COOLING SYSTEM

Cooling system to suit Pipo V8 twin turbo engine and Xtrac P1324 gearbox.
Cooler installation to minimise likelihood of damage due to contact, not to impede driver entry/exit and to comply with aerodynamic targets.
Temperature and pressure measurement requirements as defined in separate documentation.
Thermostat included for temperature control.
'Running bleed' system to header tank.

Relevant sections of the 2020 FIA/ACO Le Mans Prototype Hypercar Technical Regulations:
Article 7: Oil and Coolant Systems and Charge Air Cooling

10.1 Cooling Data

Ambient conditions for planned race events evaluated.
Design temperature considered to be 90th percentile for each track.
Offset of +5 deg C to ambient assumed for inlet duct temperature to allow for track temperature effect.

Design Conditions	**Barcelona**	**Mexico**	**Le Mans**	
Inlet duct temperature	40	35	36.5	deg C
Lap average speed	160	151	222	kph
Ambient pressure	998	779	1001	mbar
Air density	1.220	0.905	1.220	Kg/m^3
Engine Water				
Duct U/V	TBA	TBA	TBA	%
Lap average duct air velocity	TBA	TBA	TBA	m/s
Target water temperature out of engine	100	100	90	deg C
Max water temperature out of engine	110	110	110	deg C
Lap average water flow rate	305	303	313	l/min
Lap average water heat rejection	98	92	115	kW
Max system pressure drop	0.40	0.40	0.40	bar
Engine Oil				
Target oil temperature into engine	110	110	110	deg C
Max oil temperature into engine	130	130	130	deg C
Lap average oil flow rate	55.9	55.7	57.6	l/min
Lap average oil heat rejection	35.1	32.3	36.8	kW
Max system pressure drop	0.6	0.6	0.6	bar
Charge Air				
Duct U/V	TBA	TBA	TBA	%
Lap average duct air velocity	TBA	TBA	TBA	m/s
Max compressor outlet air temperature	165	165	161.5	deg C
Max plenum inlet air temperature	60	60	56.5	deg C
Max compressor mass flow	0.5/2	0.41/2	0.5/2	kg/s

Boost pressure	2.5	2.0	2.5	bar abs
Max system pressure drop	300	300	300	mbar

Gearbox				
Duct U/V	TBA	TBA	TBA	%
Lap average duct air velocity	TBA	TBA	TBA	m/s
Target oil temperature out of gearbox	100	100	100	deg C
Max oil temperature out of gearbox	110	110	110	deg C
Gearbox oil flow rate	12.5	12.4	12.7	l/min
Estimated gearbox heat rejection	11.5	10.6	12.9	kW
Gearbox outlet pressure	2.0	2.0	2.0	bar

10.2 Engine Water Cooler

Twin coolers located in sidepod ducts.
Aluminium tube and fin construction.
Single pass.
Wiggins type pipework connections.
Quick-disconnect on inlet pipe for system fill/drain.
Bleed fitting in top corner to suit hose to header tank.
AV mounted to duct.
PWR supply.

Core thickness: 42 mm
Core face area: 265K mm^2

10.3 Thermostat

Cooler bypass for temperature control
BMW type.
Bespoke DMLS aluminium housing.

10.4 Water Pipes

Aluminium pipes for complete cooling circuit.
Wiggins type connectors for all junctions.

Size: 32.0 mm o/d x 1.2 mm wall thickness.

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10.5 Water Expansion Tank

Accumulator air spring non-piston type header tank.
Aluminium construction.
Total capacity 2.5 litres to suit required engine pressure vs temperature characteristic.
PRV on water side.
Maximum pressure 4.75 bar absolute in accordance with Article 7.5 of the Technical Regulations.
Pressure sensor fitted.
Internal level tube with remote QD for level setting.
Site tube for level viewing.
Ports to suit bleed hoses from engine and coolers.

10.6 Engine Oil Cooler

Heat exchange to engine water.
Integrated into engine Vee
PWR supply to Pipo

10.7 Engine Oil Tank

Total capacity TBA litres.
Fitted to front of engine.
Remote QD fitting on bodywork for quick re-fill during pitstops.
Provision for QD fitment on either side of the car.
QD on bottom for draining.
Level sensor included.
Pipo supply.

10.8 Engine Oil Catch-Tank

Catch-tank arrangement meeting requirements of Article 7.9 of the Technical Regulations.
Incorporated into front of gearbox maincase.
Main catch tank capacity 3.0 litres.
Additional catch-tank capacity 1.0 litres.
Fitted with FIA/ACO approved level sensor.

10.9 Engine Oil Pipes

Main engine oil pipes Pipo responsibility.
Specification and size TBA.

10.10 Charge Air Cooler

Twin coolers located in sidepod ducts.
Aluminium tube and fin contraflow design.
Machined end tanks.
Bosses for temperature sensor and wastegate control valve port on exit (cool) end tank.
PWR supply.

Core thickness:	87 mm
Core face area:	112.5K mm^2

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10.11 Charge Air System Pipes

Aluminium pipes for complete charge air system.
Wiggins type connectors for all junctions.

Airbox to compressor pipes:	76.0 mm o/d x 1.0 mm wall thickness.
Compressor to CAC pipes:	50.0 mm o/d x 1.5 mm wall thickness.
CAC to plenum pipes:	65.0 mm o/d x 2.0 mm wall thickness.

10.12 Gearbox Oil Cooler

Located behind airbox and fed by roof mounted ducts.
Aluminium tube and fin design.
Single pass.
Threaded boss connections to suit quick-disconnects.
PWR supply.

Core thickness:	32 mm
Core face area:	108K mm^2

10.13 Gearbox Oil Pipes

Dash 8 flexible hose with QD connections to cooler.

10.14 Air-Conditioning Cooler

Located in front of gearbox cooler and fed by same roof ducts.
PWR supply.
Test item for initial tests.

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11. FUEL SYSTEM

Fuel cell and internals supplied by ATL.
Fuel cell material to FIA FT5-1999 requirements.
Single collector fed by four lift pumps.
Two intermediate Bosch pressure pumps.
Filler coupling in accordance with Appendix J Drawing 252-5 version B
Single fuel flow meter (FFM) fitted externally to the fuel cell.
Fitting via hatch in monocoque seat-back bulkhead.
Access to internals via hatch in top face.

11.1 Capacity

Minimum 12 laps of Le Mans at full speed.
Estimated fuel consumption per stint 107 litres.
CAD volume takes account of internal component volume and foam.
Design allowance of 4mm from inner wetted surface to monocoque inner skin.
Design allowance for 3% volume for foam.
Total capacity including all internals, foam and 10% margin 126 litres

11.2 Fuel Cell Layout

Bag tank containing minimum horizontal and vertical baffles plus foam.
'Big head' fixings for location in monocoque.
Standard ATL flap valves where needed.
Single collector of 6.0 litre capacity.
Four electrically driven filtered lift pumps in corners.
Mounts for two additional pumps as back-up.
Two electrically driven pressure pumps plumbed in parallel for redundancy.
Mount for additional pump as back-up.
Bosch pressure regulator.
Low pressure and intermediate pressure filters.
Level measurement in collector.
Filling vent hose routed from as high in cell as possible.
Cell PRV set at 0.2 bar to maintain pressure in entire system.

Fuel tank outer material:	ATL-818-D Kevlar reinforced
Collector and baffle material:	ATL-826-A Kevlar reinforced

11.3 Lift Pumps

VDO manufacture.
Fabric mounted.
2 off in rear corners.
2 off in front corners.
Mounts included for additional 2 pumps.

11.4 Intermediate Pressure Fuel Pumps

Twin Bosch FP 200 pumps
One in operation and one as back-up.
Fed from the collector.
Fabric mounted in bottom of cell.
Mount included for additional pump
Nominal output pressure 8 bar.

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11.5 Filter

ATL cannister filter
Fabric mounted in bottom of cell.

11.6 Collector

Flexible construction using ATL-826-A Kevlar reinforced material.
Ports for lift pumps.
Level sensor.
Low level switch.
Temperature sensor.
Capacity 6.0 litres

11.7 Upper Hatch

Custom nut-ring, custom Al plate and Viton gasket
Fill and breather connections
Roll-over and vent valve with 0.2 bar blow-off pressure
Twin electrical connectors
Bosch pressure regulator
Cell pressure sensor

11.6 Filler

Staubli SAF 45 Co-axial Coupling.
Option for RH and LH fitting.

11.7 Fuel Flow Meter (FFM)

FIA FFM external to fuel cell in accordance with Article 13.15 of the Technical Regulations.
Option for RH and LH fitting.
Connection to fuel cell and to engine lines via AN Motorsport low pressure drop QD couplings for possible quick change during race.

11.8 Engine Line Breakaway Valve

Self-sealing breakaway valve in accordance with Article 6.3.2 of the Technical Regulations.
AN Motorsport supply QD coupling.

11.9 FIA Sample Port

FIA approved connector on fuel line between FFMs and engine.
Located with FFMs inside regulation defined box.

11.10 Electrical Connectors

Located on upper hatch

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12. ENGINE INSTALLATION

Refer to Pipo documentation.

12.1 Exhaust

Primary and collector to turbo Pipo responsibility, including insulation.
Tailpipe diameter 75 mm.
Stainless steel tube with TBA mm wall thickness.
Turbo exit temperature sensor.
Twin tailpipe lambda sensors: one for control, one for FIA
Individual tailpipes each side.
Tailpipe exits through engine cover.
V-System supply.

12.2 Air Intake Snorkel

Fed by central roof mounted duct.
Lightweight carbon construction.
Fitting for fuel cell breather line.
Podium responsibility with design input from SAD.

12.3 Air Filter

Specification to Pipo requirements.
Fitted in air intake snorkel.
Podium responsibility.
Green Filter supply.

12.4 Heat Shields

Heat shields to protect other components where necessary.
Lightweight construction in high composite temperature material.

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12.5 Auxiliary Cooling

Air take-off from roof mounted ducts feeding air conditioning and gearbox coolers.
Cooling air to be ducted to the components as detailed in the table below:

Component	Approx Duct Dia, mm
Engine front auxiliary drive	40 - 45
Engine mounted alternator	30
Bellhousing mounted alternator	30
Gearbox mounted alternator	30
Engine coils	40 - 45
Turbo wastegate	40 - 45
Engine fuel system	40 - 45
Gearbox actuator	30
Clutch	40 - 45
Starter motors	40 - 45

12.6 Mass and CG Height

Engine mass and CG height to be tracked throughout the design process in accordance with the FIA perimeter definitions.

12.7 Ballast Provision

See Appendix 1.

Design loadcase horizontal: 25 g
Design loadcase vertical: 5 g
Minimum safety factor: Sf = 1.5

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13. FRONT IMPACT ABSORBING STRUCTURE (FIAS)

Lightweight carbon composite construction.
Allows removal of complete front bodywork section, including splitter and forward upper bodywork, for service and in event of damage.
Attached to front of monocoque via 4 pins and quick release cam fixings.
Design to meet the dimensional requirements of Article 15.3.1 of the Technical Regulations.
Design to meet FIA static load and impact test requirements.

13.1 Static Test

Design to be capable of passing the static load test detailed in Article 2.2.1 of the Appendix relating to Article 15.3.2 of the Technical Regulations.
Static load test required on pre-homologation test parts.

Minimum safety factor: Sf = 1.5

13.2 Dynamic Test

Design to be be capable of passing the impact test detailed in Article 2.2.2 of the Appendix relating to Article 15.3.2 of the Technical Regulations.
Impact test required on pre-homologation test parts.

13.3 Mounting to Monocoque

Mounting via 4 off studs in FIAS and eccentric cams in the monocoque.
Cams linked top to bottom for quick operation.

13.4 Electrical Connector

Twin quick-connect electrical connector for lights and sensors.
Self-locating for automatic connection during FIAS change.
On separate loom section to allow replacement in case of damage.

13.5 Towing Eye

Towing eye in compliance with Article 14.12 of the Technical Regulations.

Design loadcase: 25 kN
Minimum safety factor: Sf = 1.5

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14. REAR IMPACT STRUCTURE (RIAS)

Lightweight carbon composite construction.
Allows removal of complete rear bodywork section, including rear wing and floor, for service and in event of damage.
Attached to rear of gearbox via 4 pins and quick release cam fixings.
Design to meet the dimensional requirements of Article 15.4.1 of the Technical Regulations.
Design to meet FIA static load and impact test requirements.
Towing eye to FIA requirements
Loom routed internally with access holes fully closed by grommets.

14.1 Static Test

Design to be be capable of passing the static load test detailed in Article 2.5.1 of the Appendix relating to Article 15.3.2 of the Technical Regulations.
Static load test required on pre-homologation test parts.

14.2 Dynamic Test

Design to be be capable of passing the impact test detailed in Article 2.5.2 of the Appendix relating to Article 15.3.2 of the Technical Regulations.
Impact test required on pre-homologation test parts.

14.3 Rear Wing Attachment

Single pillar rear wing support.

14.4 Rear Floor Attachment

Mount at rear providing direct support for floor centre section.

14.5 Attachment to Gearbox Rear Cover

Mounting via 4 off studs in RIAS and eccentric cams in the gearbox rear cover.
Cams linked top to bottom for quick operation.
Same design as for FIAS.

14.6 Electrical Connector

Quick connect electrical connector for lights and sensors.
Self-locating for automatic connection during change.
On separate loom section to allow replacement in case of damage.

14.7 Towing Eye

Towing eye in compliance with Article 14.12 of the Technical Regulations.

Design loadcase:	16.5 kN
Minimum safety factor:	Sf = 1.2

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15. FRONT SPLITTER

Carbon composite construction.
Main splitter and adjustable flap.
Design to meet dimensional requirements defined in Article 3.5.4 of the Technical Regulations.
Design to meet stiffness requirement defined in Article 3.8.2 of the Technical Regulations.
Stiffness test required on all production parts TBA.
Mounting to have adjustability to ensure compliance with Article 3.9.2 (Tolerances) of the Technical Regulations.

15.1 Mounting

Attached to FIAS via pillars within front bodywork fairing.
Shims to allow for height adjustment.

15.2 Adjustment

Flap to be fitted with quick adjuster for change during a pitstop.
Ability to adjust flap position in <5 seconds.

15.3 Ballast Provision

See Appendix 1.

Design loadcase horizontal:	25 g
Design loadcase vertical:	5 g
Safety factor:	Sf = 2.0

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16. FLOOR

Lightweight carbon composite construction.
Split into main floor section and quickly removable rear section.
Minimum gap at junctions.
Removable lateral gurneys and other parts for aero homologation adjustment.

16.1 Main Floor

Single piece or left and righthand sections TBA.
Attached to monocoque, engine, bellhousing and gearbox.
Additional stays at rear.
Removable for service in garage.
Laser ride height sensors fitted either side at rear.
Pressure tappings as defined by SAD.

16.2 Rearward Floor

Attached to RIAS to allow quick removal in event of damage.

16.3 Skid Block

Design to meet requirements of Article 3.5.6 of the Technical Regulations.
Design in accordance with Drawing 3C of Appendix 1 of the Technical Regulations.
Forward section to be attached to monocoque with floor via a mechanism designed to achieve defined vertical stiffness in compliance with Article 3.8.5
Rear section to be attached to gearbox to achieve vertical stiffness in compliance with Article 3.8.6

16.4 Ballast Provision

See Appendix 1.

Design loadcase horizontal:	25 g
Design loadcase vertical:	5 g
Minimum safety factor:	2.0

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17. REAR WING

Lightweight carbon composite construction.
Design to meet stiffness requirement defined in Article 3.8.4 of the Technical Regulations.

17.1 Mainplane and Flap

Lightweight construction.
Supported via RIAS mounted pillar and bodywork endplates
Fixed element with fixed flap.
Additional gurneys for aero homologation adjustment.
Ultimate load test required on 1st off part TBA.
Stiffness and proof test required on all production parts.

17.2 Rear Wing Endplate (RWEP)

Incorporated into rear bodywork.
Fitted with rear lights in accordance with Article 8.3.2 of the Technical Regulations
Mainplane attached via TBA fixings.

17.3 Adjustment

Complete wing and flap incidence adjustable for testing and aero homologation.
Incidence range: +/- 4^0 in 2^0 increments.

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18. UPPER BODYWORK

External surface definition according to aero design.
Removability of parts in accordance with serviceability requirements and need for replacement in event of damage.
Quickly removeable bodywork consisting of complete forward section, complete rear section, engine cover and sidepods.
Lightweight but stiff composite construction incorporating lightweight core.
Bodywork construction around the front wheels in accordance with Article 3.9.1 of the Technical Regulations.

18.1 Split Lines

Split lines positioned logically for maintainability.
Minimise split lines normal to airflow.

18.2 Front Section

Complete front section removable via FIAS to chassis cam mechanism and over-centre clamps for change during pitstop if required.
Consisting of:

- FIAS
- Front splitter
- Upper bodywork and suspension cover
- Wheel arches
- Lights

18.3 Engine Cover

Design to meet stiffness requirement defined in Article 3.8.3 of the Technical Regulations.
Easily removable for service.
High temperature composite material or titanium for exhaust exit panel.

18.4 Rear Section

Complete rear section removable via RIAS to gearbox cam mechanism and over-centre clamps for change during pitstop if required.
Consisting of:

- RIAS
- Rear wing
- Rear floor
- Rear bodywork
- Wheel arches
- Rear lights

18.5 Sidepods

Removable for service via Tridair fasteners.
Cooler mesh access panel included to allow debris removal during pitstop.

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18.6 Fasteners

Over-centre clamps for front and rear bodywork sections
Tridair fasteners for other removable panels.
Quarter turn fasteners for cooler mesh access panel.
Socket head screws and anchor nuts for panels and parts not requiring regular removal.

18.7 Mirrors

Mirrors fitted in accordance with Article 14.4 of the Technical Regulations.

18.8 Windscreen

Material polycarbonate minimum 6.0 mm thick to meet regulation requirements..
Attachment via maximum 16 -4 Tridair bolts.
Electrical screen heating included.
Design in accordance with Article 3.3.1 of the Technical Regulations.
Viraver supply.

18.9 Doors

Lightwieght carbon composite construction.
Design in accordance with Article 3.2 of the Technical Regulations.
Door opening in accordance with Article 13.10.2 of the Technical regulations.
Windows in polycarbonate 2.0 mm thick.
Window design in accordance with Article 3.3.2 of the Technical Regulations.
Door latch mechanism to be simple and effective.

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19. COCKPIT AND DRIVER INSTALLATION

To meet all requirements of Article 13 of the Technical regulations.

19.1 Seat

Lightweight carbon construction.
Generic seat plus driver specific inserts.
Insert material in accordance with FIA Technical List No 50
Two forward and two rearward mountings.
Design in accordance with load and test requirements detailed in Article 2.7 of the Appendix relating to Article 14.10 of the Technical Regulations.
Tallest driver backside assumed to sit at Z = 18.0 mm

19.2 Seat Belts

Seat belts in compliance with FIA standard 8853-2016.
Installation in accordance with load and test requirements detailed in Article 2.10 of the Appendix relating to Article 14.5 of the Technical Regulations.
Shoulder strap mounting via dog-bone on seat-back bulkhead.
Lap and crotch start mountings via clamp plates onto monocoque floor.
Clamp plates allow removal and replacement of belts without need to re-adjust.
Schrott supply.

19.3 Driver Cooling

Driver cooling to ensure compliance with Article 13.12.3 (Cockpit Temperature) of the Technical Regulations.
Main inlet in nose and routed through FIAS.
Sobek 90mm fan included in standard routing.
Exit ducts for driver body cooling, plus driver adjustable exits on top of dash panel.
Secondary inlets above windscreen to provide flow more directly to FIA sensor.
Air-conditioning included in design, but to be evaluated during testing.
Riley supplied unit located in passenger side foot compartment.

19.4 Drinks System

Complete system mounted in cockpit on RH side.
Capacity 1.0 litres.
Electric pump incorporated.
Progressive Motorsport supply.

19.5 Fire Extinguisher

Installation to meet requirements of Article 14.2 of the Technical Regulations.

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19.6 Ballast Provision

See Appendix 1.

Cockpit ballast to be adjustable in 0.5 kg increments.
Ballast required to be fitted for impact test and to meet regulations requirements.

Design loadcase:	25 g in any direction
Minimum safety factor:	Sf = 2.0

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20. ELECTRICAL SYSTEM

System includes Bosch components where possible.
See electrical documentation for full system specification.
Electrical box positioning as low as possible and with minimised loom lengths.
Electrical system in accordance with all requirements of Article 8 and the relevant sections of Articles 13 and 14 of the Technical Regulations.
Front and rear bodywork sections have quick connectors to allow for replacement during race pitstop.

20.1 Electrical Boxes

Electrical boxes fitted in cockpit RHS.
Positioned as low as possible but with consideration for exchange if necessary.
Boxes on AV mounted trays as required.

20.2 Looms

All looms equipped with MIL spec connectors.
Looms sealed and protected using Raychem heat shrink sleeving and boots.
Detail specification by Podium Engineering.

Loom assembly consisting of:

- Main cockpit loom.
- Engine loom LH, with connectors for separate injector and coil looms.
- Engine loom RH, with connectors for separate injector and coil looms.
- Gearbox loom.
- Front bodywork section loom.
- Rear bodywork section loom.
- Floor loom LH and RH with connectors to allow for floor removal.
- Sidepod loom LH and RH with connectors to allow sidepod removal.
- Individual suspension corner looms to allow replacement of complete corner if necessary.

20.3 External Master Switch and Fire Extinguisher Trigger

Details in accordance with Articles 14.2.2 and 14.16.1
Mounted below screen out of driver's line of sight.

20.4 Cockpit Console

Incorporates driver master switch in accordance with Article 14.3.1
Bosch keypad and switches for multiple functions.

20.5 Cockpit Displays

Rear view camera monitor and marshalling system display in cockpit.

20.6 Cockpit Loom Box

Loom connection box mounted on RHS of cockpit.
Links cockpit loom to rear car looms.
Download connector and USB data port incorporated.

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20.7 Rear Connector Brackets

Rear connector brackets mounted on bellhousing.
Incorporate connectors for upright sensors etc

20.8 Engine Connector Boxes

Plenum mounted connector boxes for engine sensors.

20.9 Battery

Lithium ion type battery.
Mounted in RHS of cockpit in accordance with Article 8.2.1 of the Technical regulations.
Accessible in case of need to exchange.

Mass:	TBA kg
Nominal voltage:	13.2 V
Nominal capacity:	20 Ah

20.10 Transponders

See electrical system documentation for details.

20.11 Marshalling System

See electrical system documentation for details.

20.12 Lighting

Installation in accordance with Article 8.3 of the Technical regulations.
See electrical system documentation for details.
Headlamps to be best in class.
NextSolution supply.

20.13 Windscreen Wiper System

Bosch WDA LIN
See electrical system documentation for details.

20.14 Windscreen Washer System

Complete system mounted in cockpit on RH side.
Capacity 0.6 litres.
Electric pump incorporated.
Progressive Motorsport supply.

20.15 Sensors

Sensor requirements and specifications as detailed in separate documents.

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Appendix 1. Ballast Provision

Ballast Position	X	Y	Mass kg	Increment kg
Forward chassis – in front of pedal box bulkhead	-200	0	15.0	5.0
Forward chassis – below chassis under driver legs	300	0	30.0	5.0
Centre chassis – above skid block	1310	0	13.0	5.0
Side chassis – total both sides	1080	0	20.0	5.0
Sump	2267		10.0	5.0
Bellhousing	2680	0	20.0	5.0
Gearbox	2995	0	20.0	5.0
Floor			0.0	
Chassis BoP	1675		50.0	5.0
Cockpit trim ballast			5.0	0.5

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Appendix 2. Component Test Requirements

Component	Test Required	Which Parts	Who or Where
ARBs	Fatigue test TBA	Most critical parts	Pankl
PAS Rack	Calibration Functionality	All All	Team
Steering Column	Impact test Proof test Fatigue test Maximum load test Homologation impact	1 part All 1 part 1 part 1 part	Peak Technology Politecnico di Milano
Transmission and Actuation System	Calibration Functionality	Complete assembly	Team
FIAS	Static load test Impact test	Until Pass Until Pass	Politecnico di Milano
RIAS	Static load test Impact test	Until Pass Until Pass	Politecnico di Milano
Front Splitter	FIA stiffness check Proof test TBA	All	Team Supplier
Skid Block Front and Rear	FIA stiffness check	All	Team
Rear Wing Assembly	Ultimate test FIA stiffness Proof test TBA	1 part All All	TBA Team Supplier
Monocoque	Homologation Static pre-test	1 part	Politecnico di Milano
Headrest support & door	Homologation	1 part	Politecnico di Milano
Seat	Homologation	1 part	Politecnico di Milano

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Appendix 3. Contact Patch Loads

Table to be added.

(Note that the coordinate system matches the car CAD definition. Hence acceleration is -ve and deceleration is +ve.)

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