TATUUS
RACE CAR MANUFACTURER

T-421 USER MANUAL

Release 2.1.0
(08/06/2023)

CONTENTS

1 GENERAL INFORMATION

1.1 RELEASES

Modifications from previous release are in purple.

1.1.1 Release list

Version	Release Date	Author	Notes
1.07	26/11/2021	Tatuus	Startup version
1.08	12/01/2022	Tatuus	First release
1.09	04/05/2022	Tatuus	2.2 Added Homologation number 11.2.3 Added Lithium Battery information 11.2.5 Added Jump battery information 11.2.6 Added Fire UP/ switch off best practices 11.2.7 Added powerbox information 13.11 Added Gearbox Assembly/disassembly information
2.0.0	20/02/2023	Tatuus	2023 Version. Document name update. 2.7.1 Chassis Belleville washer stacking order 5.2 Front wishbones brackets assembly 11.2.3 Updated Lithium Battery information 14.1.6 Damped Shaft Belleville washer stacking order
2.1.0	07/06/2023	Tatuus	1.5 Mileage chart 3.8.2 Heel rest 11.2.3 Battery 13.9 Special tools 14.1.7 ESA rocker bolts

1.2 TECHNICAL CONTACTS

1.2.1 Chassis

Tatuus Racing SpA
Via G. Verga, 12
20863 Concorezzo (MB) - Italy
Tel: +39 039 6040828
Fax: +39 039 6041764
Web: www.tatuus.it

1.2.2 Engine

AUTOTECNICA
Via A. Bernardi, 3
26041 Casalmaggiore (CR) - Italy
Tel. +39 0375 40174
Email: INFO@AUTOTECNICAMOTORI.IT
Web: www.autotecnicamotori.it

1.2.3 Gearbox

SADEV
6 rue Grand'Montains
85110 Saint Prouant
Tel: +33 2 51 66 42 68
Fax: +332 51 66 49 60
Email : sadev@sadev-tm.com
Web: www.sadev-tm.com

1.2.4 Electronic

1.2.5 Tires

1.2.6 Brakes

T.M. Tecnologie Meccaniche S.r.l.
via dei Pioppi, 30
Padulle di Sala Bolognese – 40010 (BO)
Tel +39 051 829092
Email: info@tmperformance.com

1.2.7 Dampers

ANDREANI GROUP INTERNATIONAL
Strada della Romagna, 361
(Loc. Colombarone)
61121 Pesaro (PU)
Tel. (+39) 0721 209020
Email: info@andreanigroup.com

1.2.8 Seat belts – Fire Extinguisher

1.3 General Agreement and Warranty

Tatuus is proud of the quality, success and reputation of their products and is delighted that you have chosen to use the T421 chassis.
The design of each chassis is the subject of much research and development, technical analysis and detailed testing. However, as with all motorsport products, it is vital that they are correctly maintained and adjusted for each individual circumstance. This manual is intended to ensure that you obtain the maximum performance and reliability from this chassis.
We would stress that after each event or prolonged period of running (suggested to be 5'000km) the chassis should be carefully inspected and stripped as appropriate.
This manual contains mileage recommendations for critical components detailed in section 1.5. If in doubt please contact our Commercial Department who will advise you or, if necessary, put you in contact with one of our engineers.

It is important to ensure that all adjustments and tolerances are as specified. The use of parts not supplied by Tatuus will automatically invalidate any warranty or other liability which would normally be assumed by Tatuus.

Your attention is drawn in particular to the following statement:
'Goods intended for motorsport or any related application, or for product development, evaluation or experimentation are supplied subject to the Customer recognizing that such goods may operate under extreme loads and conditions and that it is the Customer's responsibility to ensure that the goods are correctly inspected, adjusted and maintained at all times to suit the specific conditions in which they may be used.'

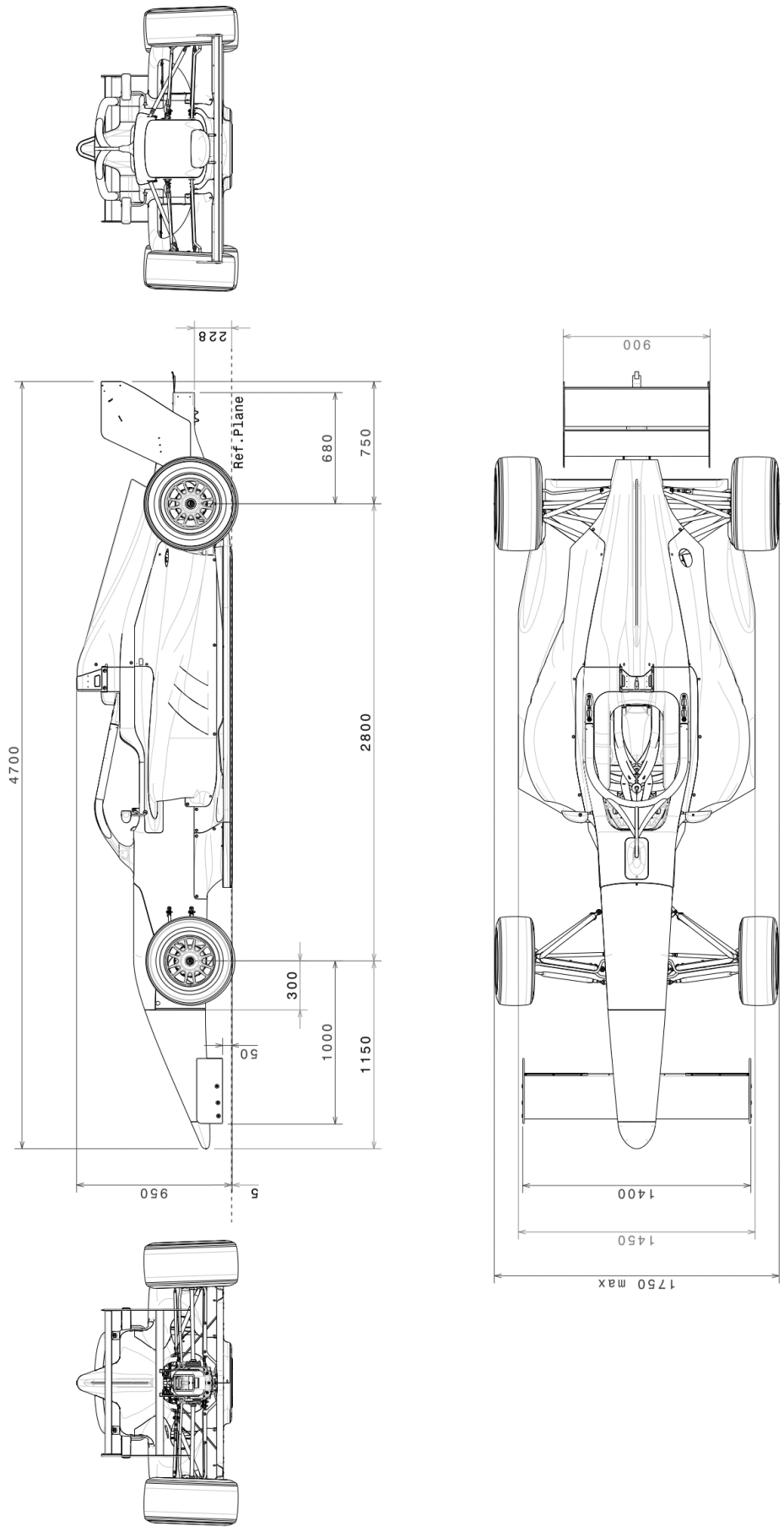
'Lightweight and weight optimized components are supplied subject to warranty only against manufacturing defects. It is possible that in certain conditions operating life may be reduced. Similarly, prototype, experimental or components manufactured to the Customer's design are supplied subject to warranty only against manufacturing defects.

Furthermore, such components, by their very nature, are not warranted as to their suitability for use or performance.'

'Tatuus shall have no liability to the Customer (other than liability for death or personal injury resulting from Tatuus' negligence) for any loss or damage of any nature arising from any breach of any expressed or implied warranty, term or condition of the contract or from any negligence or breach of statutory or other duty on the part of Tatuus in connection with the performance or purported performance of or failure to perform the contract other than as set out in this Condition. In no circumstances shall Tatuus be liable for any claims for indirect or consequential injury or damage (including loss of profits) arising from any such matters.'

1.4 Overview

Front track	1515 mm
Rear track	1470 mm
Wheelbase	2800 mm
Overall length	4700 Max mm
Overall width	1750 Max mm
Overall Height	950 mm (from reference plane)
Chassis	Composite Carbon fiber sandwich with Al/Nomex honeycomb with integrated side anti-intrusion panels, FIA F4/2022-2nd Gen (Ann.J Art.274A) homologated.
Bodywork	Carbon fiber
Front suspension	Pushrod / twin damper / spring
Rear suspension	Pushrod / twin damper / spring
Springs	Eibach, 36mm
Dampers	Andreani
Brakes Calipers	TM
Wheels	OZ Racing
Engine	Autotecnica Motori
Exhaust	Aros
Electronics	Magneti Marelli / Next Solution
Gearbox	SADEV SLR75
Gearshift	Magneti Marelli ESA 2
Steering wheel	TATUUS / Next Solution
Battery	MegaLife
Fuel cell	PREMIER FT3-1999
Seat	Carbon fiber extractable shell with gap fillers. Three sizes of seat available.
Seat belts	Sabelt
Fire Extinguisher	OMP


228
Ref. Plane
680
750
2800
4700
300
1000
1150
50
950
5
900
1400
1450
1750 max

1.5 MILEAGE CHART

The following chart should be used to ensure that component life is not exceeded and premature failures are prevented by regular inspection. Check and replace in accordance with the recommended distances below. Mark all parts for mileage tracing purposes and note in build records.
All parts not included in the list require inspection after 20,000km. Visual inspection should identify any parts with cracks, scratches, significant wear or corrosion.

NOTES: The table below is provided for guidance on the expected life of key components based on Tatuus' experience of this product in similar applications, however no warranty is implied by figures stated above and mileage targets are no substitute for testing and regular inspection of the chassis. **Check all components after any accident or abnormal usage. In doubt, replace the components.**

For safety reasons, please contact immediately Tatuus if you discover premature wear or problems.

Many of the components stated above with a maximum 'typical' life of 20'000km may be found to perform successfully for extended mileage however extended running above 20'000km is done at customer's risk.

	Inspection [km]	**Limit [km]**
Chassis		
Survival cell	10'000	20'000
Front crashbox	10'000	20'000
Rear crashbox	10'000	20'000
Wheel tethers		12 months
Rear Crashbox tether		12 months
Nosebox studs	2'500	5'000
Engine studs	5'000	10'000
Floor stays	2'500	5'000
Brake pedal	2'500	10'000
Brake balance bar	2'500	10'000
Throttle pedal	2'500	10'000
Front suspension		
Upright	5'000	10'000
Wheel bearing	5'000	10'000
Hubs	10'000	20'000
Hub bolts	2'500	5'000
Wheel spindle	5'000	10'000
Drive pegs	2'500	5'000
Wishbones**	2'000	10'000
Push-rods**	2'000	10'000
Suspension clevis**	2'000	10'000
Front ackermann	2'500	5'000
Front anti-roll bar	2'500	5'000
Rocker assembly	5'000	10'000

For items marked with ** the recommended inspection is a die penetrants check

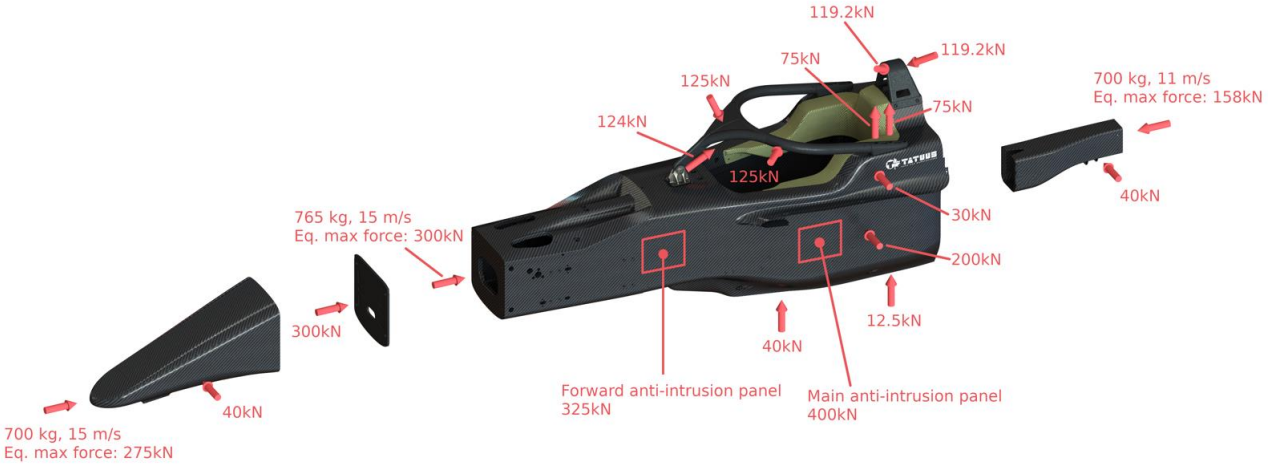
	Inspection [km]	Limit [km]
Steering		
Steering/toe arms**	2’000	10’000
Steering column**	5’000	10’000
Steering rack	5’000	10’000
Rack/pinion	5’000	10’000
Ball joint	1’250	5’000
Rear suspension		
Upright	5’000	10’000
Wheel bearing	5’000	10’000
Outer hub	10’000	20’000
Inner hub	5’000	10’000
Hub bolts	2’500	5’000
Wheel spindle	5’000	10’000
Drive pegs	2’500	5’000
Wishbones**	2’000	10’000
Push-rods**	2’000	10’000
Track-rods**	2’000	10’000
Suspension bracket**	5’000	10’000
Track rod brackets	2’000	10’000
Bottom forward bracket	5’000	10’000
Bottom wishbone bracket**	5’000	10’000
Rear upright bracket**	5’000	10’000
Rear anti-roll bar	2’500	5’000
Rocker assembly	5’000	10’000
Front Wing		
Front wing	5’000	15’000
Front pillars	5’000	15’000
Rear wing		
Rear wing	5’000	15’000
Rear pillars	5’000	10’000
Rear endplates	5’000	15’000
Transmission		
Wheel shaft	5’000	10’000
Slave cylinder (sealings)	5’000	10’000
Release bearing	5’000	10’000
Gearbox		
Gearbox internals		see SADEV
ESA II	5’000	10’000
ESA II rubber mounting	1’000	3’000

For items marked with ** the recommended inspection is a die penetrants check

2 SAFETY

This chapter enlist the Homologated Safety Devices, these parts cannot be modified or repaired without the approval of Tatuus.

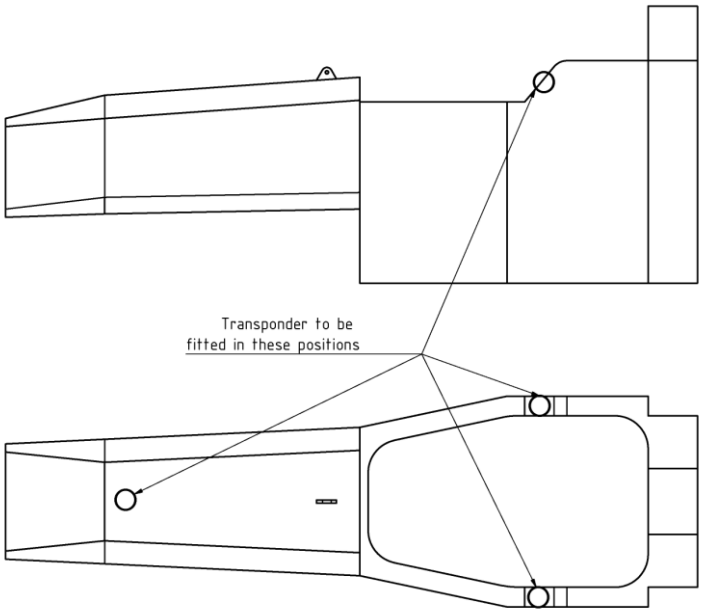
2.1 HOMOLOGATION



FIA Homologation number 2021-05-F4-Tatuus

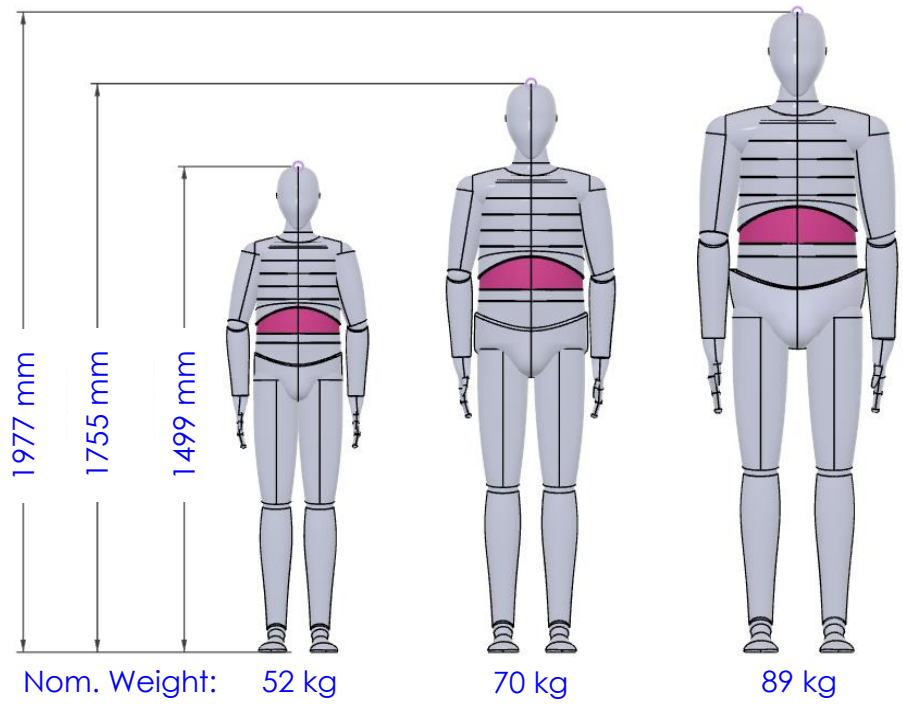
2.2 SURVIVAL CELL

The survival cell is the main safety and structural component of the car and it has been approved by the FIA, great attention must be paid in checking for structural failure not later than two years after delivery from Tatuus factory, and after each major accident. Chassis must be checked and repaired by a center authorized by Tatuus.



2.3 EXTRACTABLE SEAT & GAP FILLERS

The F4 cockpit has been design in a way that drivers with a spread of body size from 1.50m to 1.97m may be fitted in the car. In order to fit correctly the drivers and achieve a limitation of the seat foam inserts thickness of 50mm, different size of extractable seats (small, medium and large) are available.



To ease the choice of seat size, a possible solution could be to consider values in between the 3 above to set the ranges, please refer to the table below.

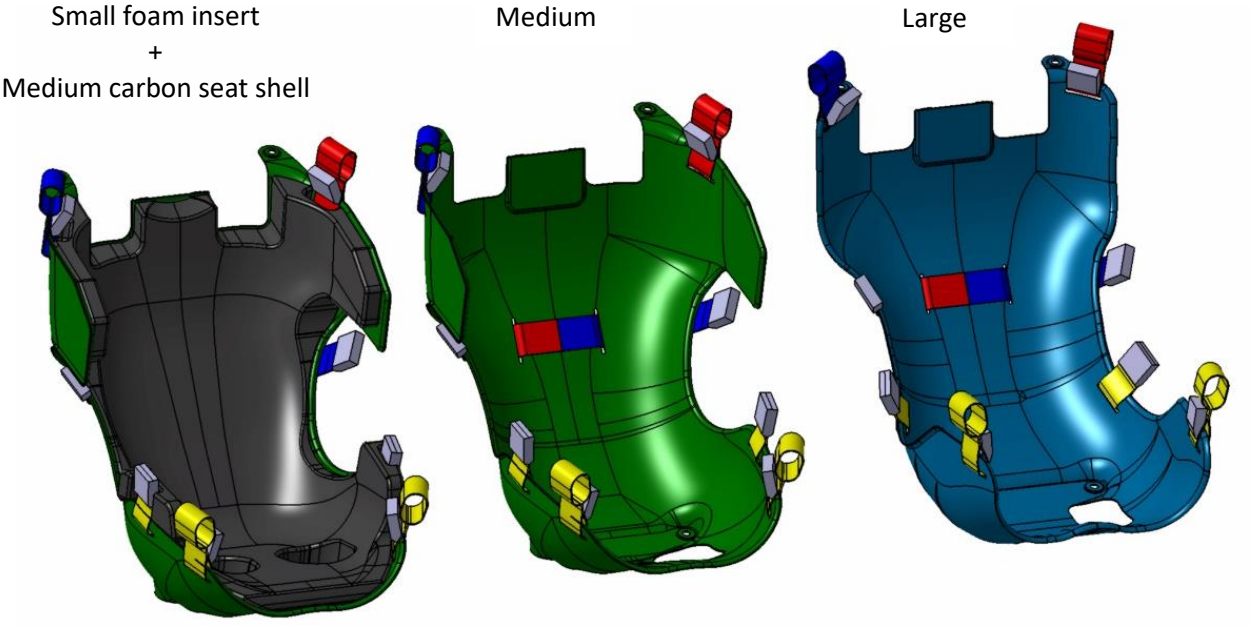
SMALL range	up to 1670 mm
MEDIUM range	1670 mm – 1830 mm
LARGE range	Over 1830 mm

The values in the table are to be considered as a reference example.

Small:
Small foam insert
+
Medium carbon seat shell

Medium

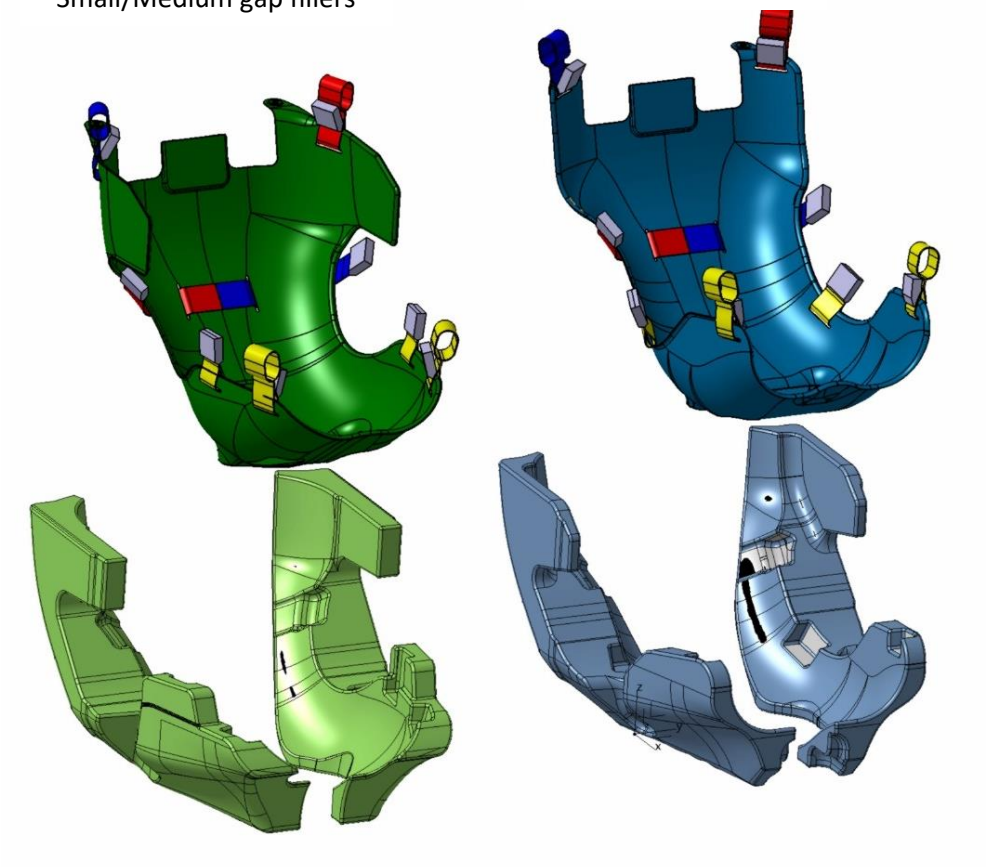
Large



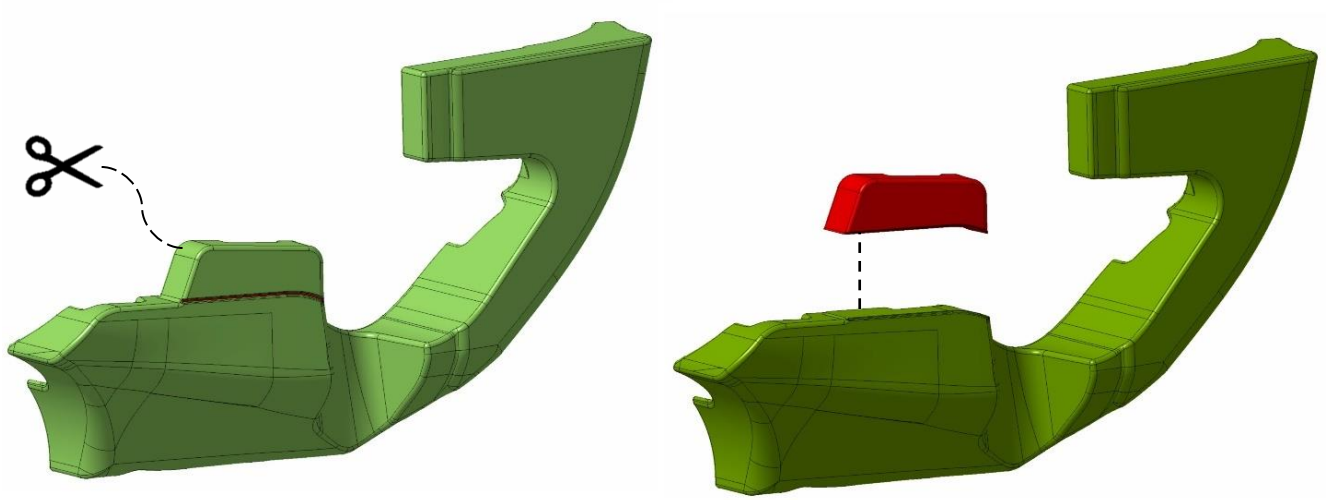
Additional gap filler must be used to fill the gap between the carbon seat shell and the survival cell. Two different size of gap filler are available for the different size of the seat shell.

Small/Medium gap fillers

Large gap fillers

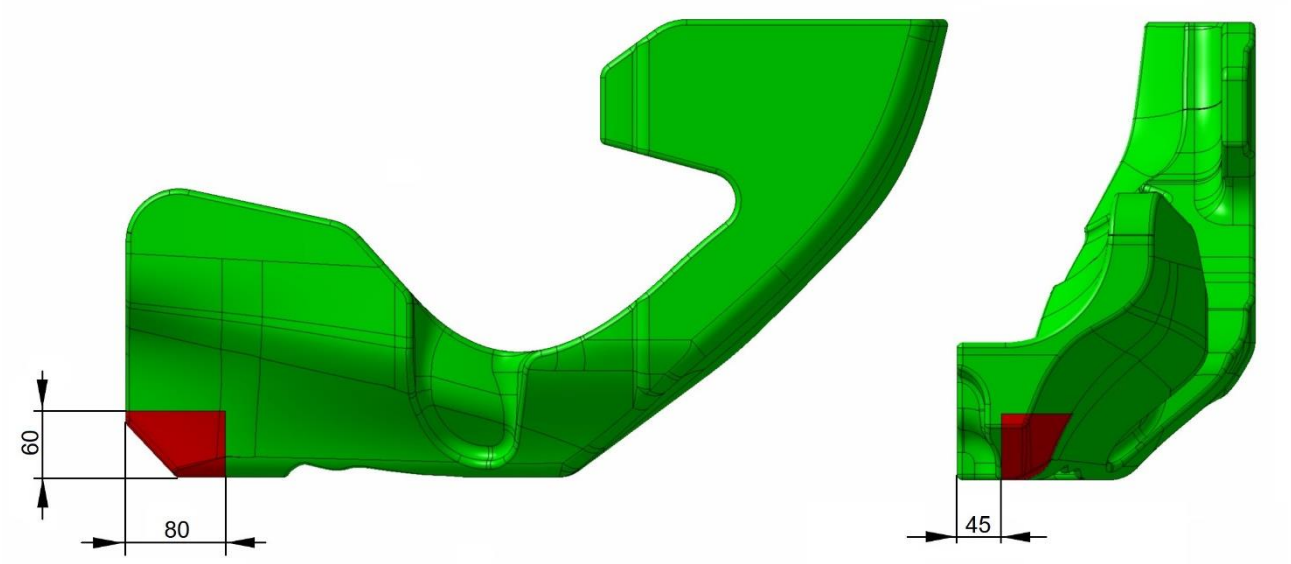


For the sole purpose of improving the habitability and the driver comfort it is allowed to cut the foam of the medium gap filler in the indicated area.



The trimmed gap filler cannot be longer used in addiction with the small size seat.

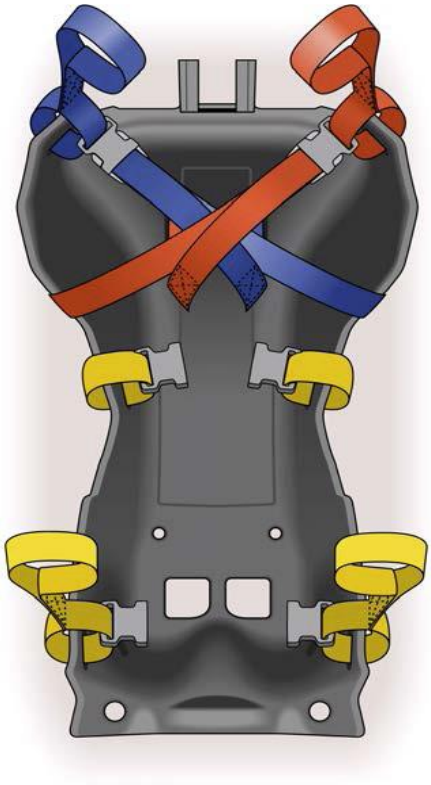
Cut-outs for the routing of break/clutch/extinguisher lines, wiring looms and similar are permitted in the large gap filler, the highlighted area below indicates the maximum recess allowed.
The recess must be located on the survival cell side, leaving minimum foam thickness of 45mm (measured along the lateral axis of the car) per side.



The seat must be removable without the need to cut any of the seat belts or remove the harness buckle.

The shoulder and lap belts must fall away over the seat edges as it is withdrawn and the crotch straps must pass freely through the seat bottom hole or holes, which must be located in front of the driver's crotch.

Any seat liner must have the same holes as the seat shell, identical and perfectly aligned with them in order to prevent the harness straps being trapped.
However, if the lap straps have to pass through holes in the seat, it is necessary to fit the car with a harness having the buckle attached to a shoulder belt, given that the buckle will not pass between the driver's body and the side of the seat.



Any seat made from foam must be covered with a non-flammable and non-combustible material.

2.4 DRIVER PADDING

As per FIA regulation:

Rear area of headrest padding [14.6.2]

> *If necessary, and only for driver comfort, an additional piece of padding no greater than 10mm thick may be attached to this headrest provided it is made from the same material.*

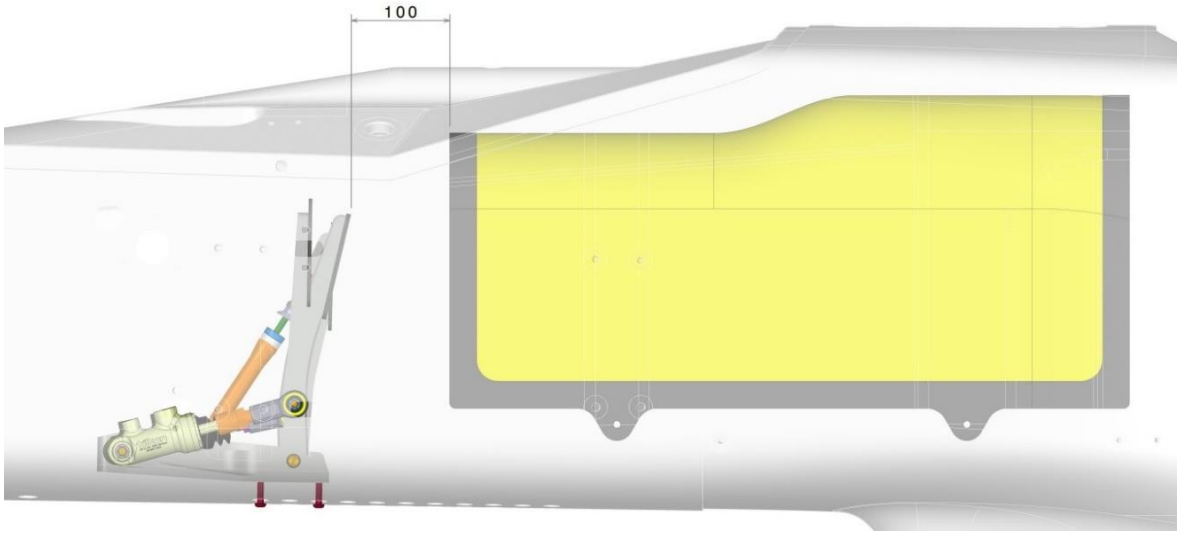
Side areas of headrest padding [14.6.3]

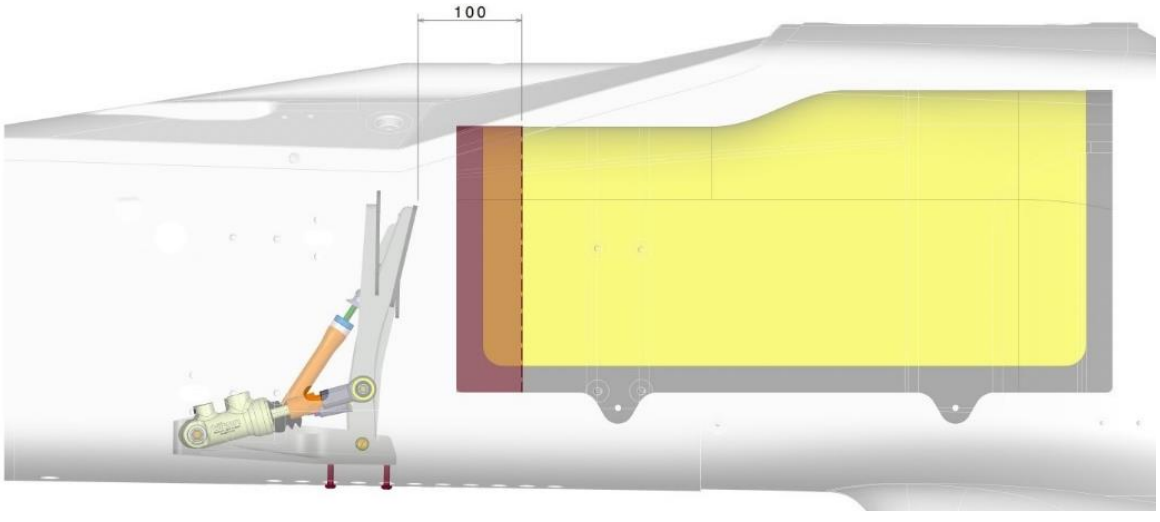
> *If necessary, and only for driver comfort, an additional piece of padding no greater than 20mm thick may be attached to this headrest provided it is made from the same material which incorporates a low friction surface.*

Leg padding [14.6.5]

> *The leg padding must cover the area […] 100mm behind the face of the rearmost pedal when in the inoperative position.*

Teams are therefore allowed to cut the padding/reduce the foam insert according to pedals installation.

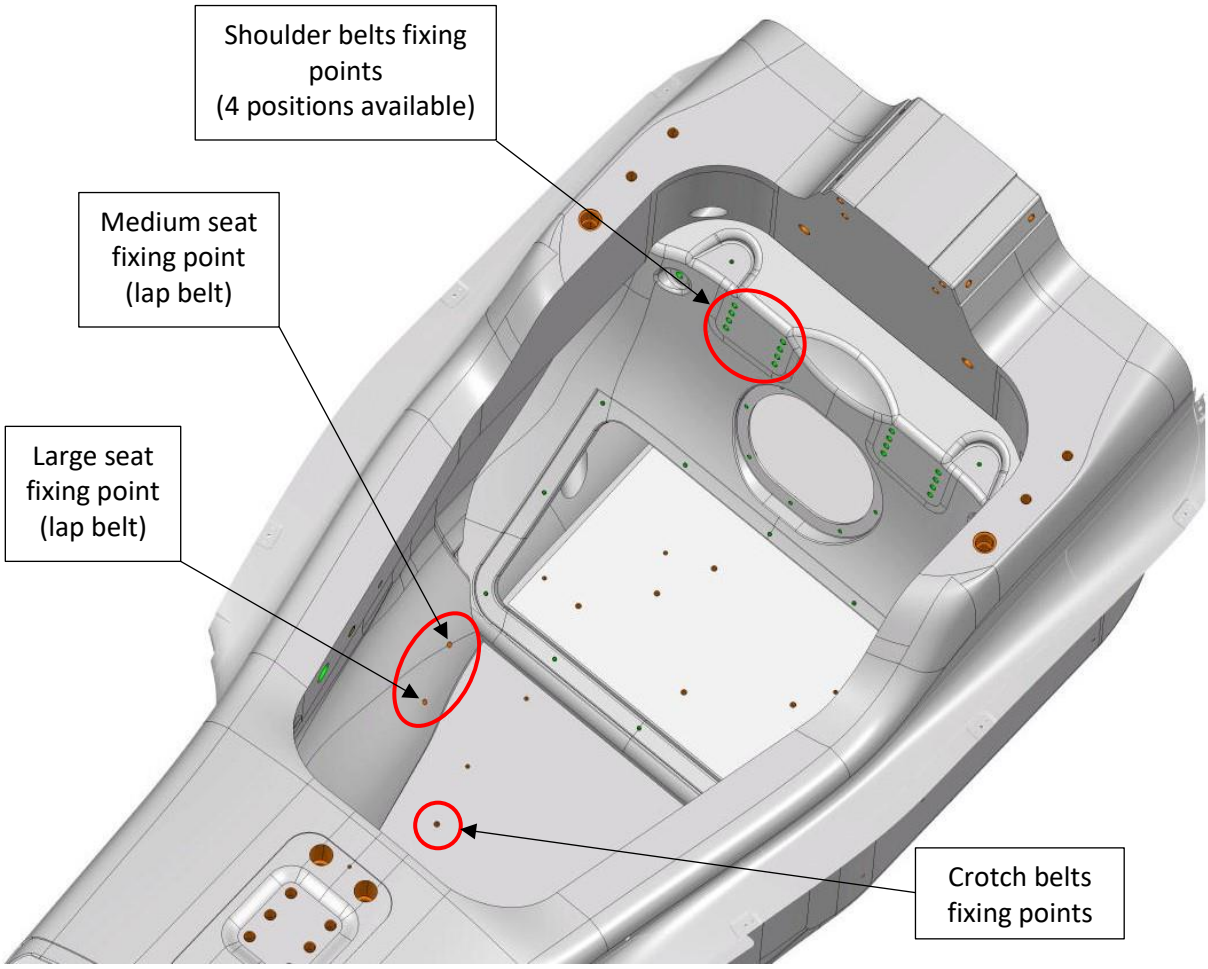




3

2.5 SEAT BELTS

The straps must be securely fixed to the car and must comply with FIA standard 8853-2016.



2.6 DRIVER INSTALLATION

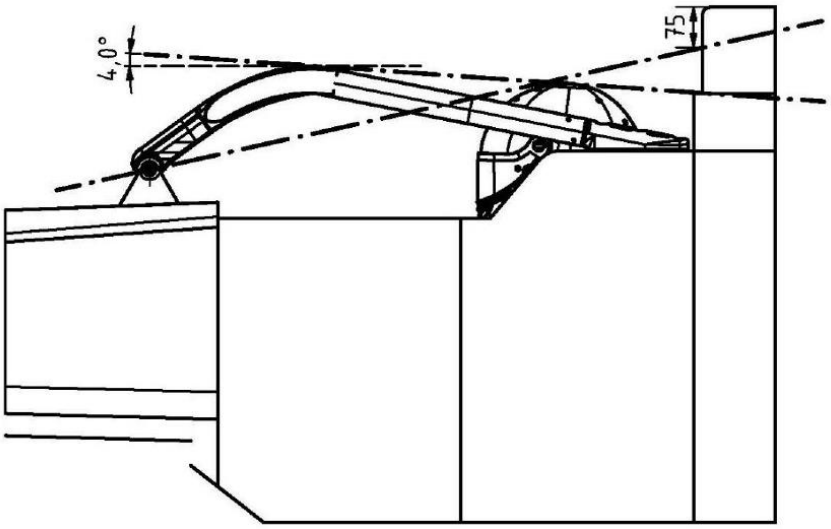
Please find below the relevant articles from the FIA Formula F4 2nd GEN Technical Regulation

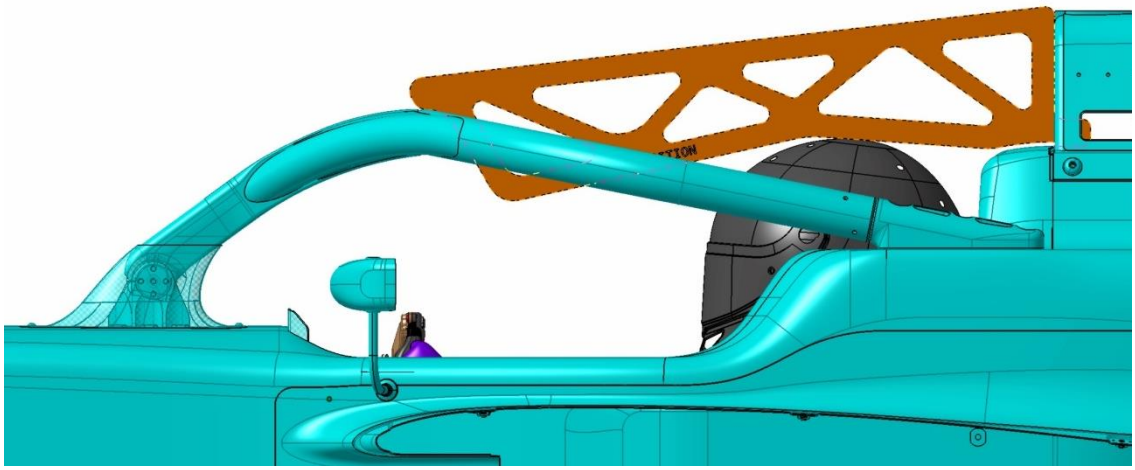
14.7.5
Any seat made from foam must be covered with a non-flammable and non-combustible material. The thickness of any foam insert is limited to maximum 50mm

The foam thickness is measured as the following:

- Behind and underneath the driver parallel to the car center plane
- Beside the driver normal to the car center plane

15.2.1
Referring to the following drawing, the driver's helmet and steering wheel must be arranged such that they lie below the following two lines:
- a line drawn between the front fixing axis of the secondary roll structure and a point 75mm vertically below the highest point of the principal roll structure.
- a line, tangent to the highest point of the secondary roll structure at an angle of 4.0° to the reference plane.



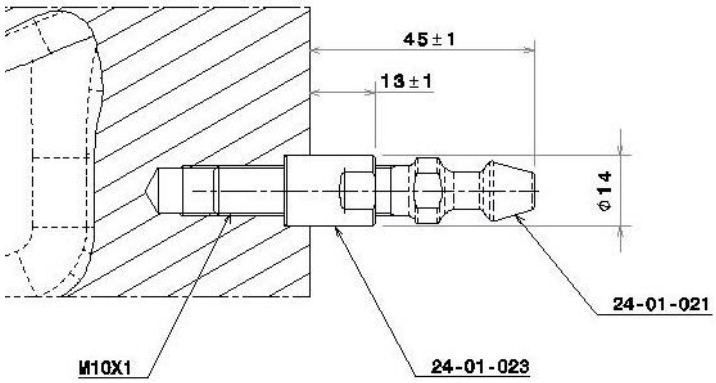


2.7 FRONT IMPACT STRUCTURE

The front impact is one of the major safety and structural component of the car and it has been approved by the FIA. Great attention must be paid in checking for structural failure not later than two years after delivery from Tatuus factory, and after each major accident. The structure must be checked and repaired by a center authorized by Tatuus.

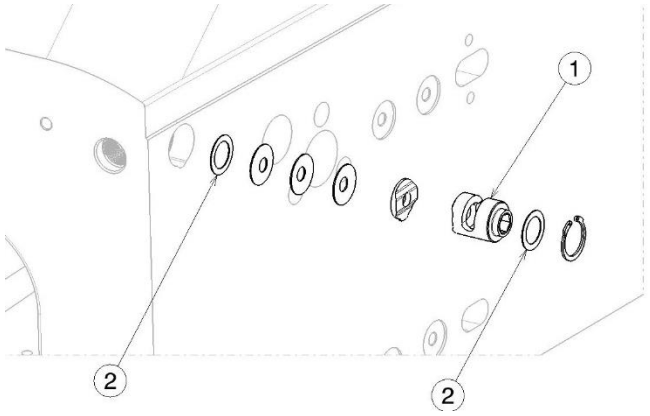
2.7.1 Retention system adjustment

The retaining pins of the front impact structure must be properly set to ensure the correct installation.

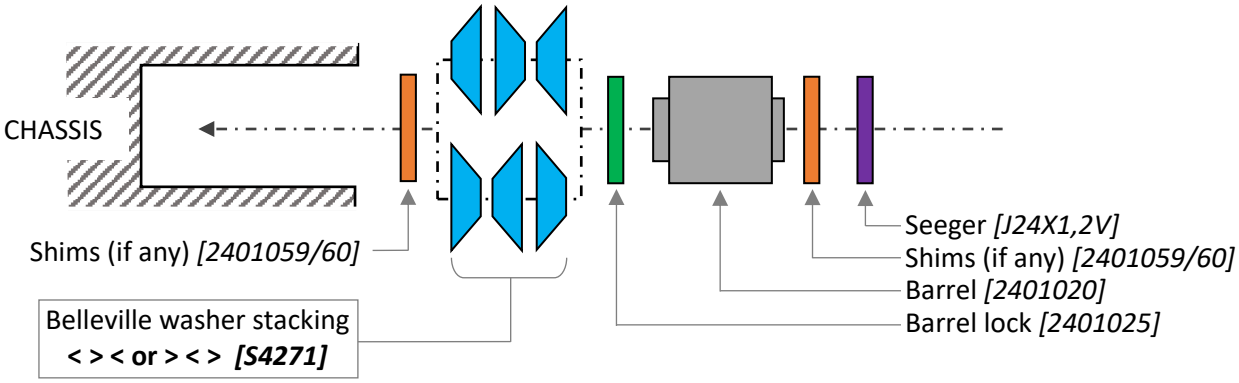


2.7.2 Quick release adjustment

The locking mechanism on the chassis side is shown in the picture below:



The stacking order of the Belleville washers **must follow the order shown below**
(chassis side | Belleville washers following "**< > <**" or "**> < >**" stack | barrel side):



It is possible to adjust the axial play of the quick release barrel nut stacking or removing items #2: Quick release shims.

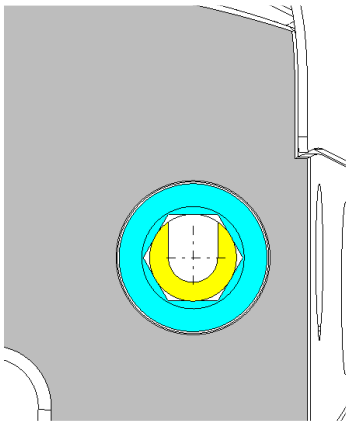
The shims are available in two different thicknesses, 0.3 mm and 0.5 mm. Please find below a table with the reference part number.

Part number	Description
2401059	0.5 mm Quick release barrel shim
2401060	0.3 mm Quick release barrel shim

The number and stack of shims are free.

If the shims are installed pay particular attention to the alignment of the barrel nut profile and the axis of the centering bush. With reference to the picture below:

- In yellow the barrel nut in lock closed position
- In light blue the centering bush



Be careful to avoid any excessive misalignment to prevent damages to the centering bushing and to the retaining pins.

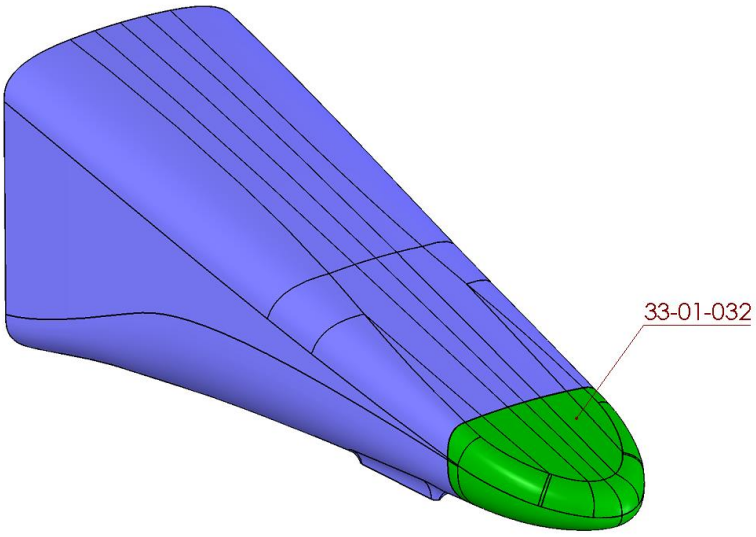
2.7.3 Front nose repair specification and procedure

2.7.3.1 Applicable requirements

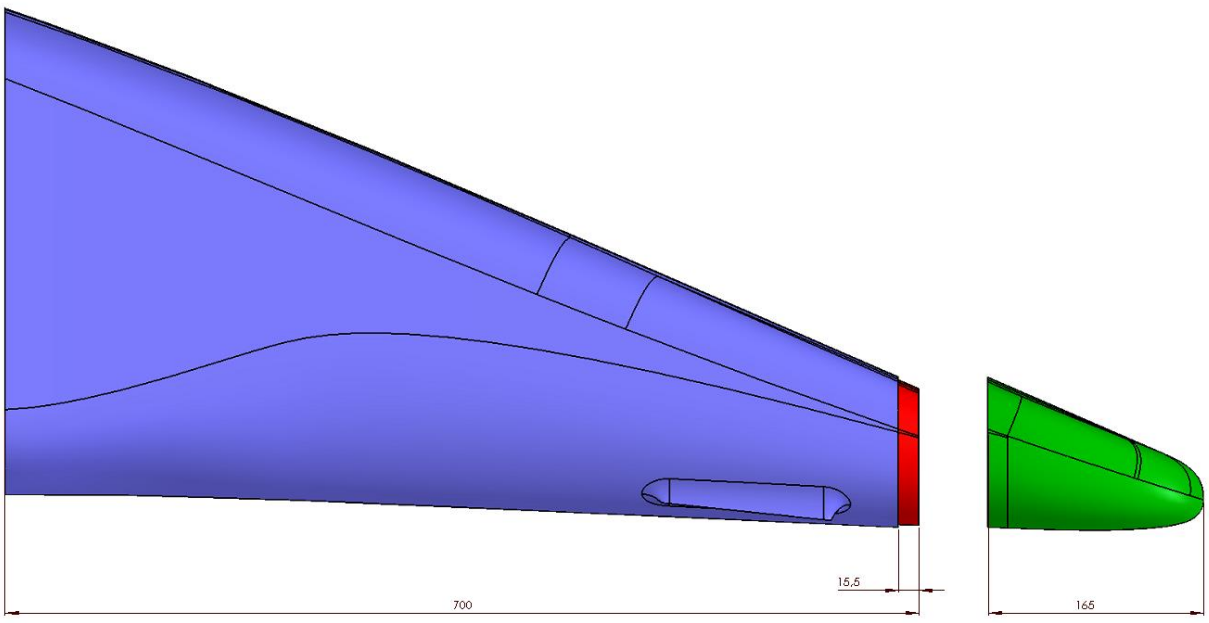
The following procedure is applicable only when the damage is contained in the first 150mm from the nose tip (700mm from the nose/FAIP interface), all the other damages must be inspected by the manufacturer.

2.7.3.2 Replacement procedure

Spare nose tip is available as spare part, the reference code is 33-01-032



1. Trace a line parallel to the chassis bulkhead 700 mm from the bulkhead, you should find the line 15 mm from the old nose tip junction.
2. Cut off the nose tip forward the traced line.
3. Using sandpaper on the outer surface, reduce the thickness of the crashbox by about 1mm for a length of 15-25 mm (red area).



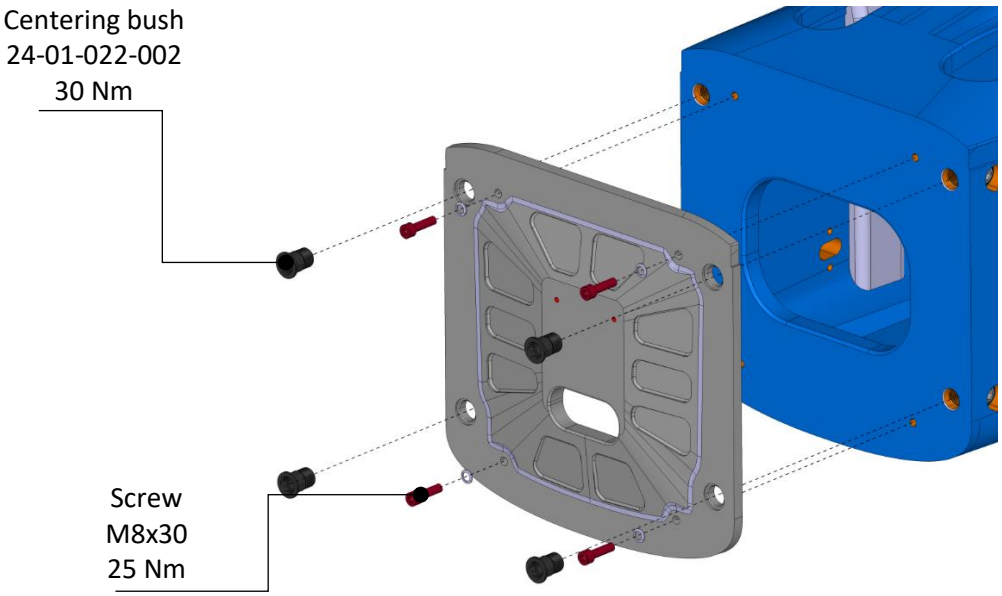
4. Attention must be paid to sandpaper the outer surface; at the depth of 1 mm you should find the resin between first and second ply.
5. Use sandpaper on the new nose tip inner surface to produce a rough surface that will match the outer surface of the crashbox.
6. Spread specific resin 3M 9323 over the junction surface, carefully respect the percentage between resin and catalyst:
7. 3M 9323 Mixing specification:

	Resin	Catalyst
Weight ratio	100 g	27 g
Volume ratio	100 g	31 g

8. Position the new nose tip cleaning the excess of resin; new nose tip can be hold in position with high temperature tape.
9. Cure the assembly on the oven following the specific temperature cycle for 3M 9323: 2 hours at 60°C.

2.8 FRONT ANTI INTRUSION PANEL

In order to give additional protection, the F4 car is equipped with a homologated frontal anti intrusion panel (FAIP) able to withstand a 30 ton frontal load, it must be permanently attached to the survival cell and cover the entire surface of the front bulkhead.



2.9 REAR IMPACT STRUCTURE

The rear impact is one of the major safety and structural component of the car and it has been approved by the FIA, great attention must be paid in checking for structural failure not later than two years after delivery from Tatuus factory, and after each major accident. In general evident damages must be inspected by the manufacturer, the structure must be checked and repaired by a center authorized by Tatuus.

2.10 HALO

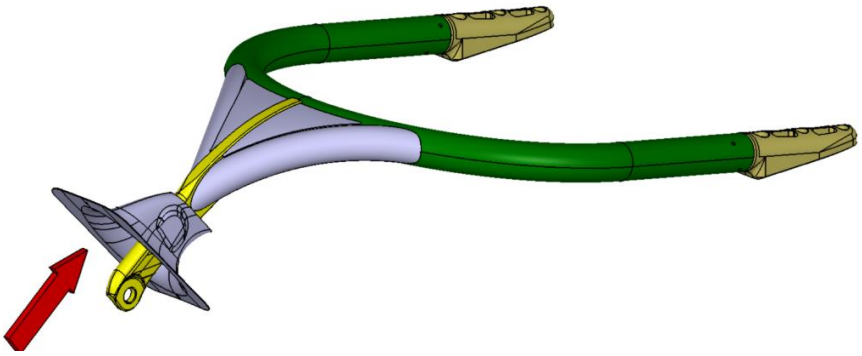
2.10.1 Installation procedure

General notes:

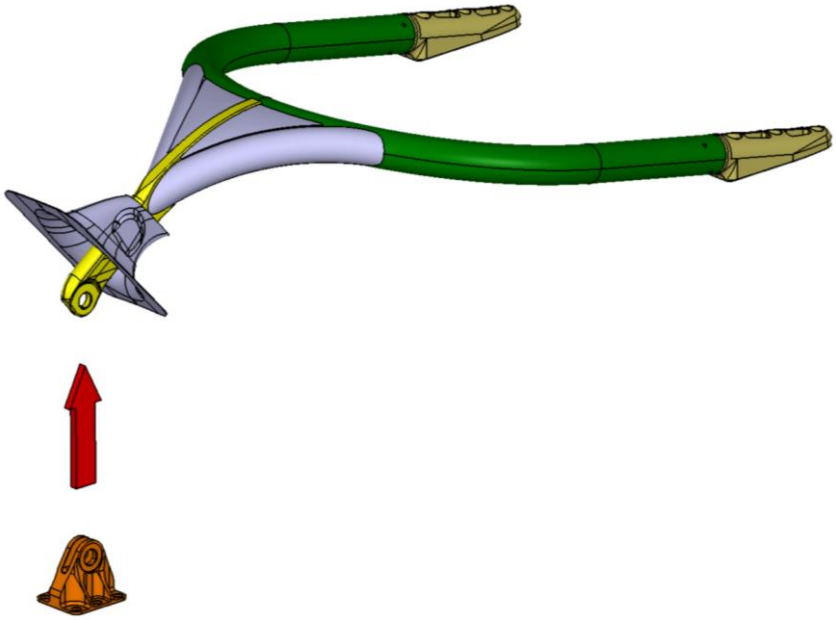
	grey arrow: unscrew/screw but **not tighten**
	green arrow: screw **and tighten**

When installing the HALO, apply on the bolts some water and oxidation resistant grease. For example, the PETRONAS TUTELA Z2 grease is suitable for this purpose.

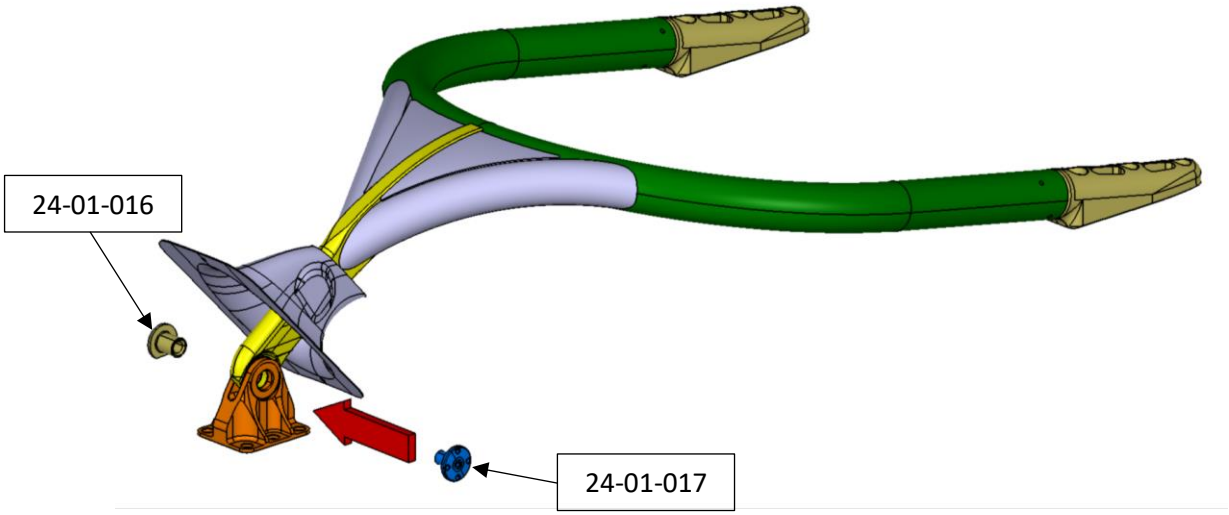
1. Insert the front fairing (33-01-043) on the HALO center bar



2. Install the front bracket (28-01-010) on the HALO



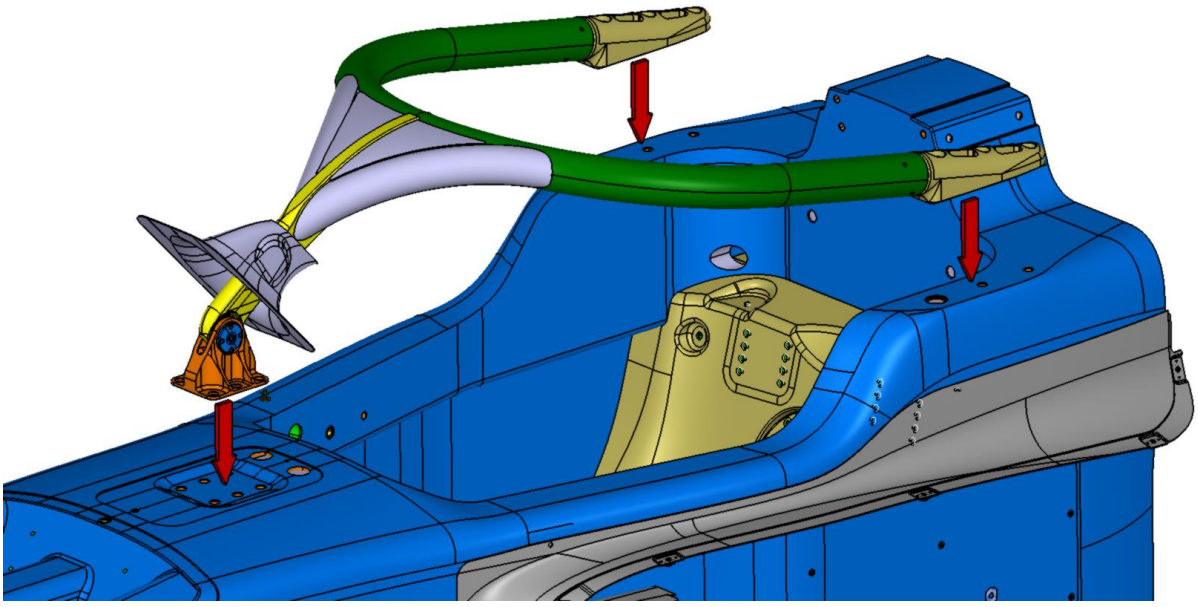
3. Fasten the HALO front fixing screw (24-01-017) and pin (24-01-016). **Do not apply any tightening torque**.



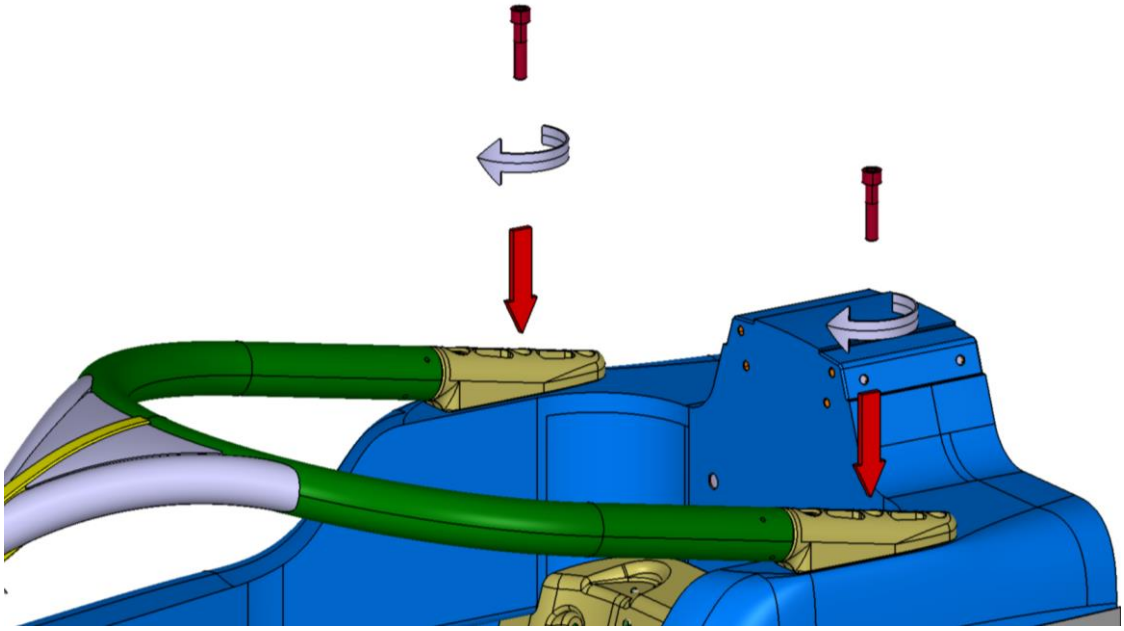
4. Please note that the HALO front fixing screw (**24-01-017**) shall be on the **left side** and the HALO front fixing pin (**24-01-016**) shall be on the **right side**.

5. **Do not apply any tightening torque.** Screw the HALO front fixing screw (24-01-017) until the screw's under-head gets in contact with the plane of the counterbore on the front bracket. At this point do not apply any tightening torque **but** loose the HALO front fixing screw (24-01-017) one turn (counterclockwise).

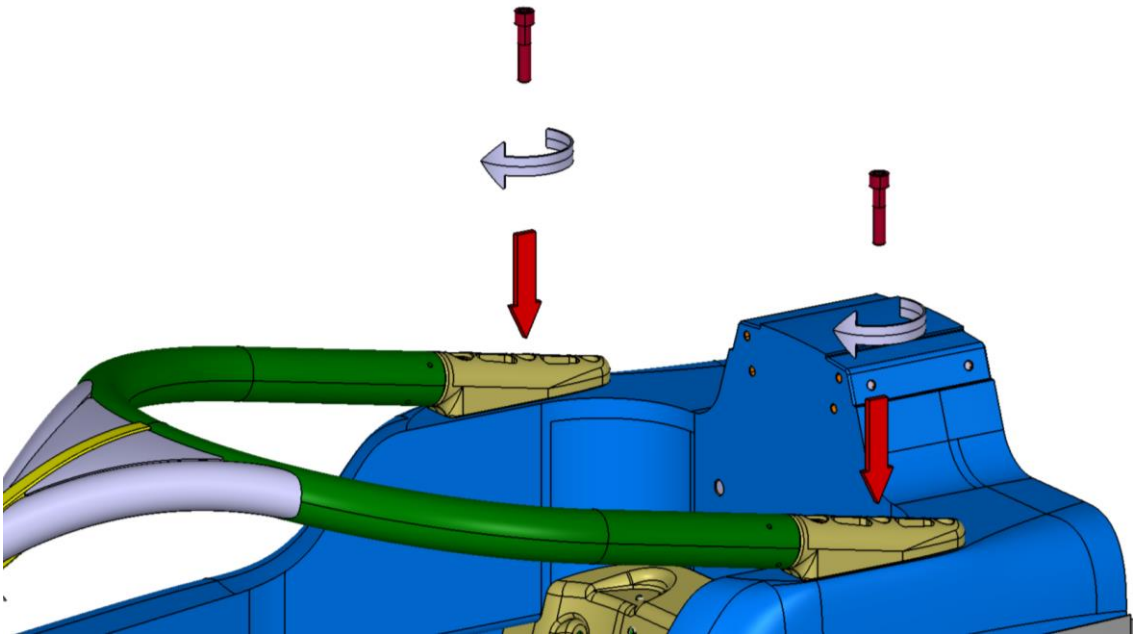
6. Place the assembly obtained at point 3 on the chassis.



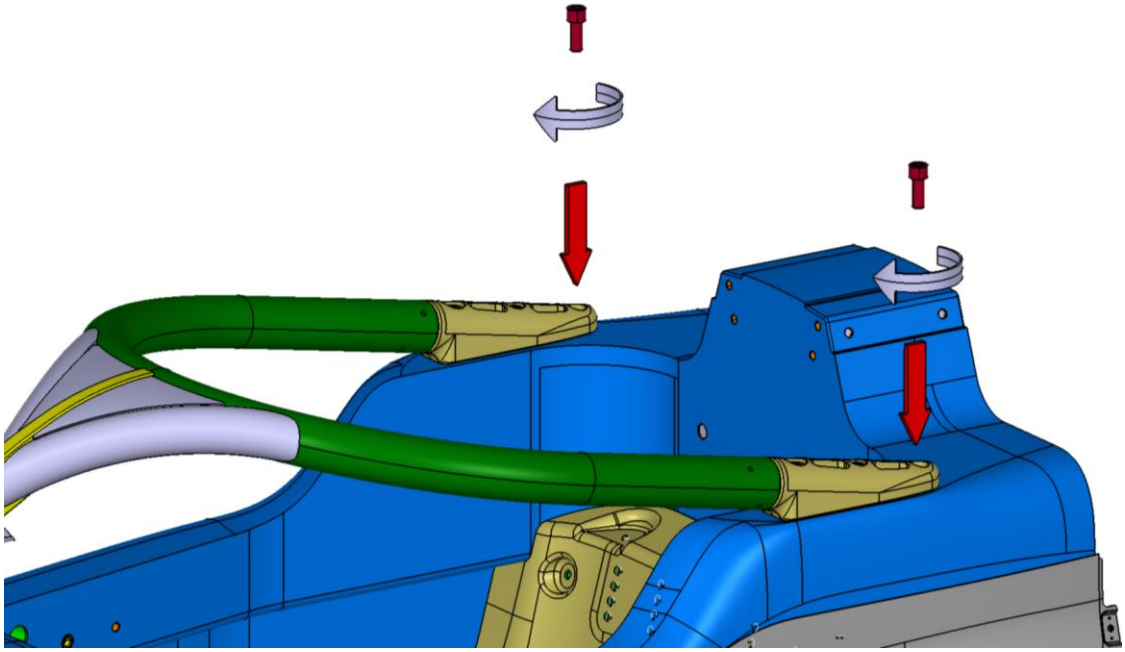
7. Fasten the two shoulder bolts (24-01-033). **Do not apply any tightening torque.** Screw the bolts until the screw's underhead gets in contact with the plane of the counterbore on the HALO foot. At this point do not apply any tightening torque **but** loose the bolt one turn (counterclockwise).



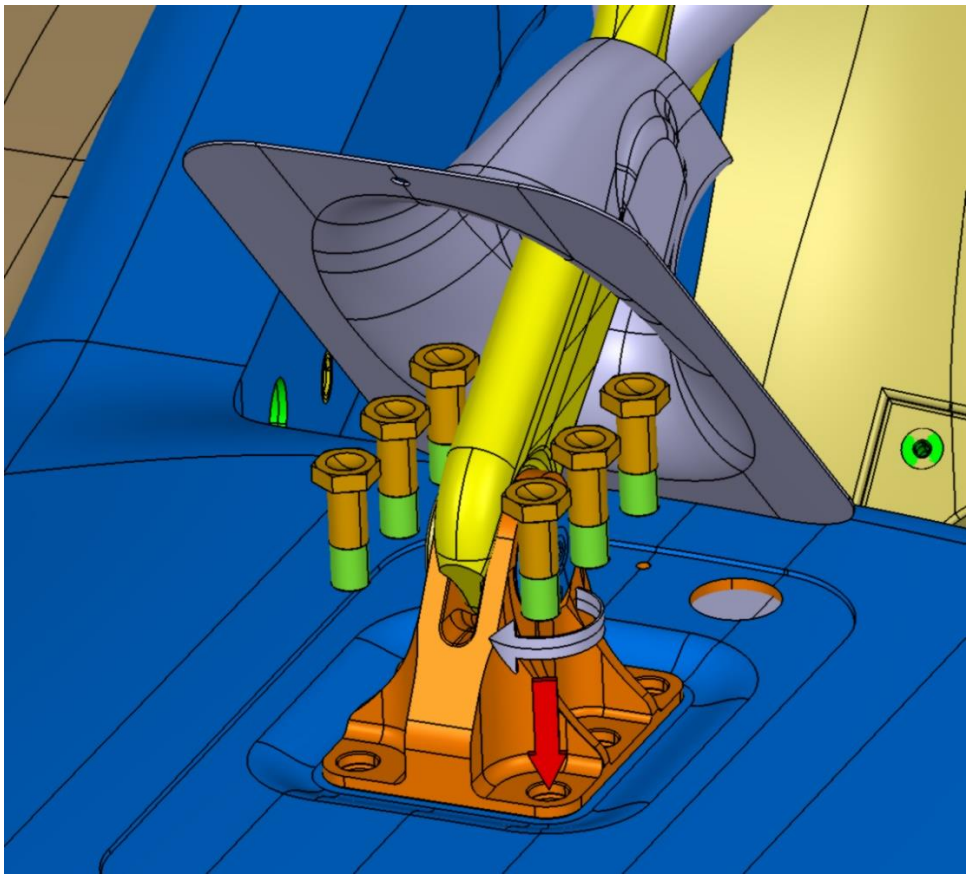
8. Fasten the two M12X55 bolts. **Do not apply any tightening torque.** Screw the bolts until the screw's underhead gets in contact with the plane of the counterbore on the HALO foot. At this point do not apply any tightening torque **but** loose the bolt one turn (counterclockwise).



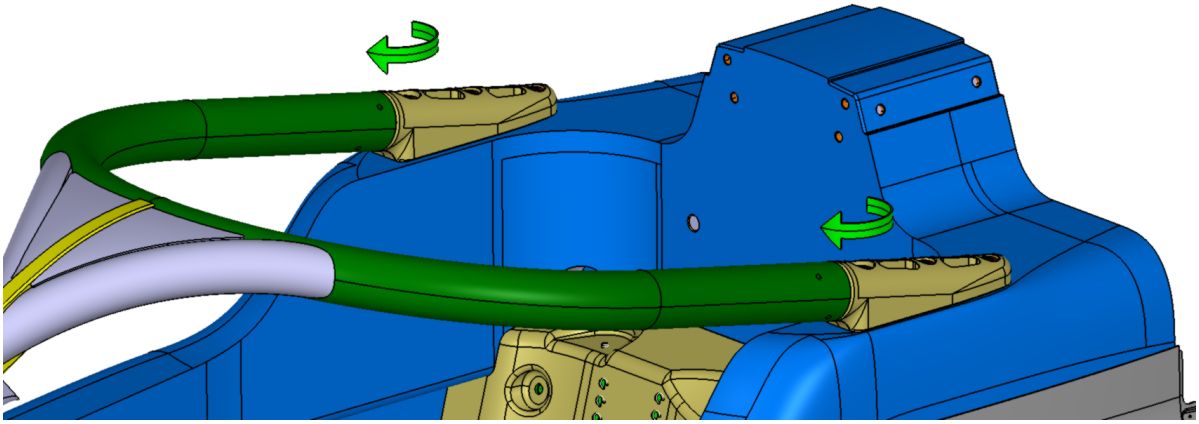
9. Fasten the two M12X30 bolts. **Do not apply any tightening torque.** Screw the bolts until the screw's underhead gets in contact with the plane of the counterbore on the HALO foot. At this point do not apply any tightening torque **but** loose the bolt one turn (counterclockwise).



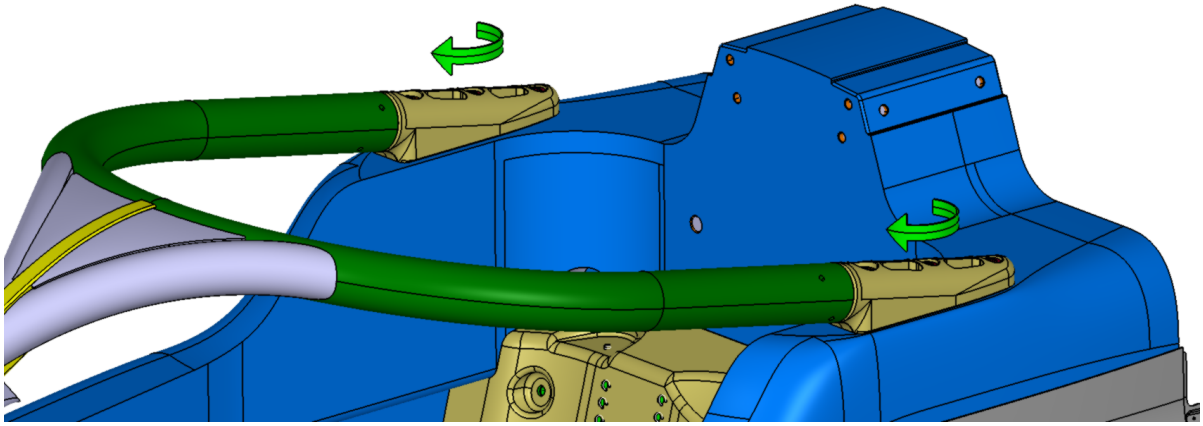
10. Fasten the six NAS6207-12 bolts. **Do not apply any tightening torque.** Screw the bolts until the screw's underhead gets in contact with the plane of the counterbore on the front bracket. At this point do not apply any tightening torque **but** loose the bolt one turn (counterclockwise).



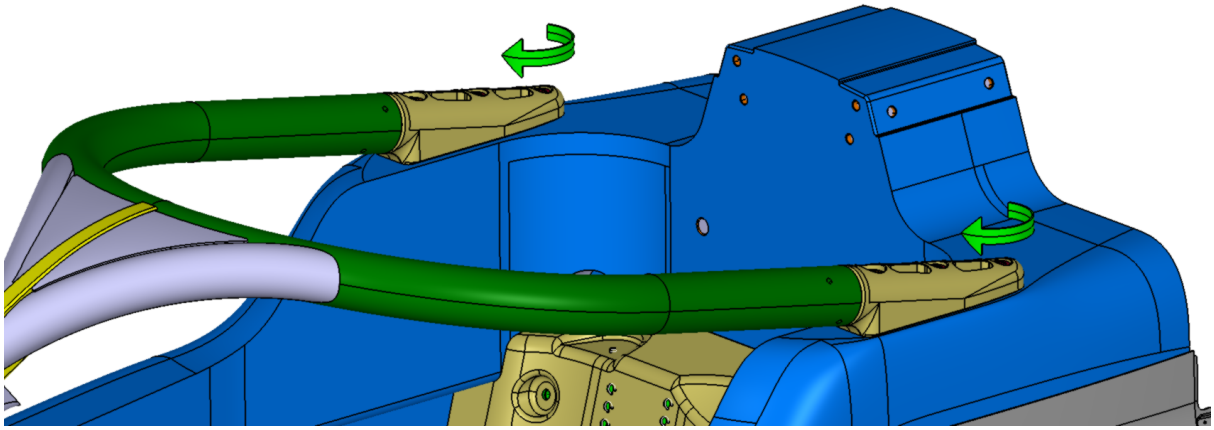
11. Tighten the two shoulder bolts 24-01-033. **Do not tighten to target value one bolt first and then the other.** Apply the tightening torque gradually, keeping the balance on the two bolts. Target value is **51Nm.**



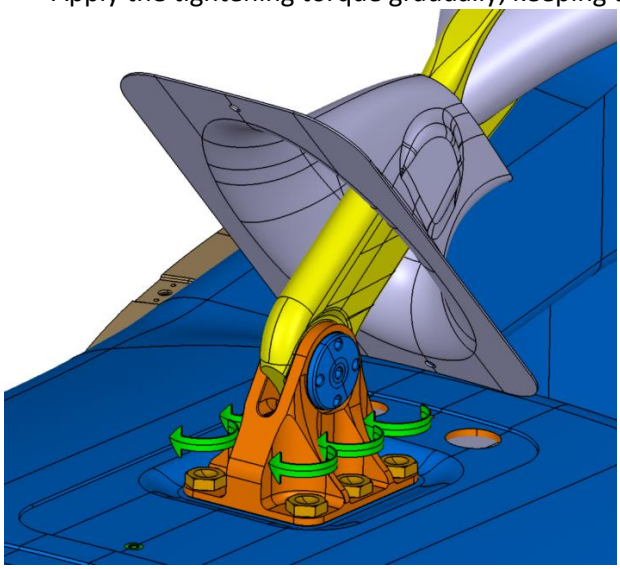
12. Tighten the two M12X55 bolts. **Do not tighten to target value one bolt first and then the other.** Apply the tightening torque gradually, keeping the balance on the two bolts. Target value is **51Nm.**

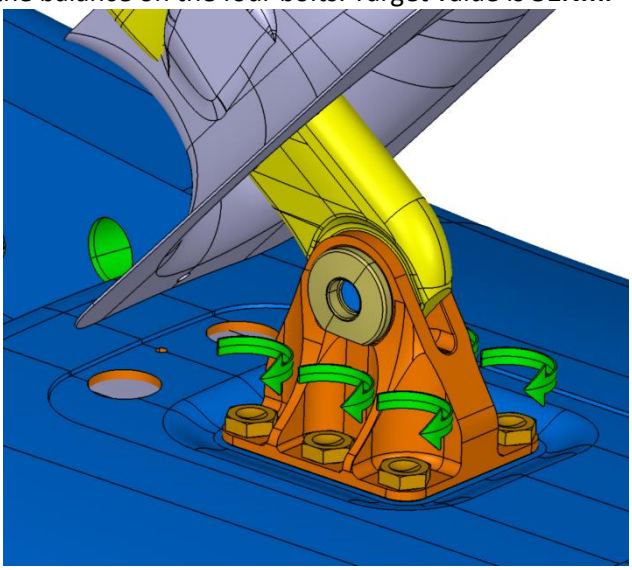


13. Tighten the two M12X30 bolts. **Do not tighten to target value one bolt first and then the other.** Apply the tightening torque gradually, keeping the balance on the two bolts. Target value is **51Nm.**



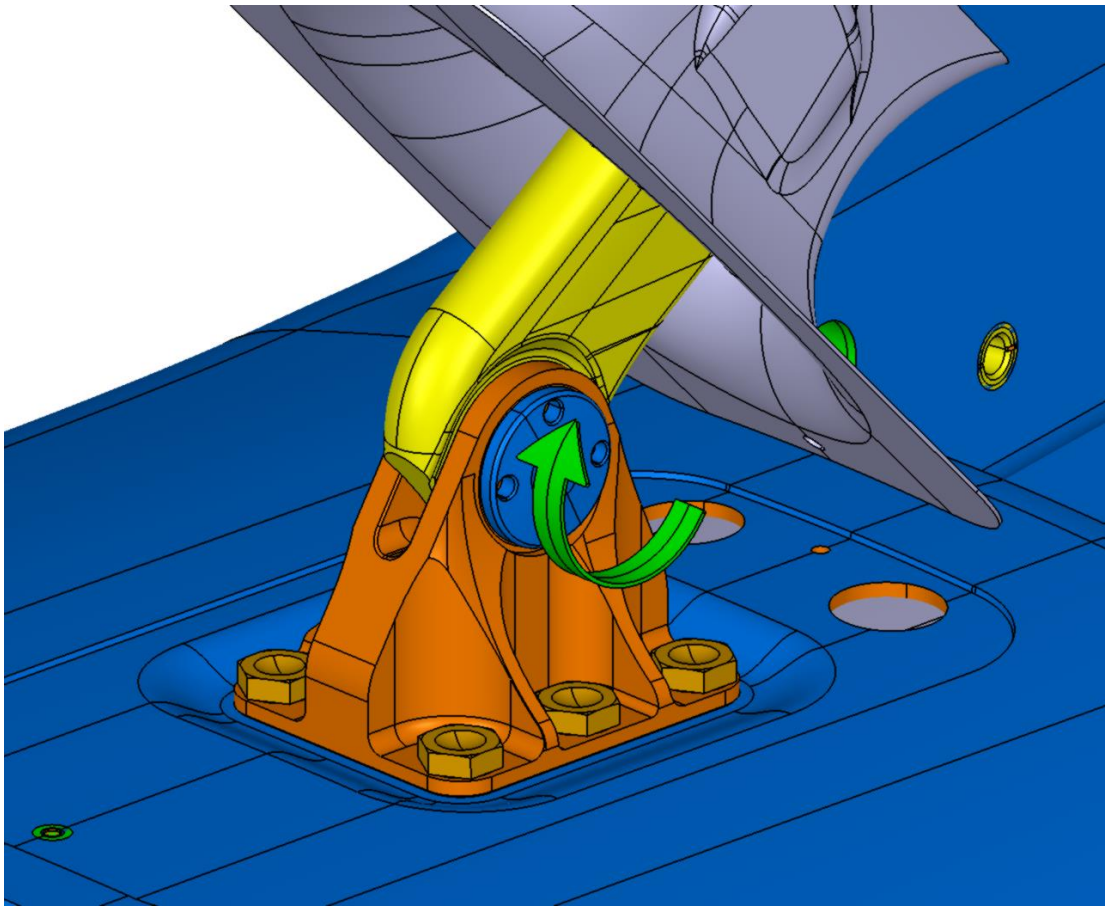
14. Tighten the six NAS6207-12 bolts. **Do not tighten to target value one bolt first and then the other.** Apply the tightening torque gradually, keeping the balance on the four bolts. Target value is **51Nm.**



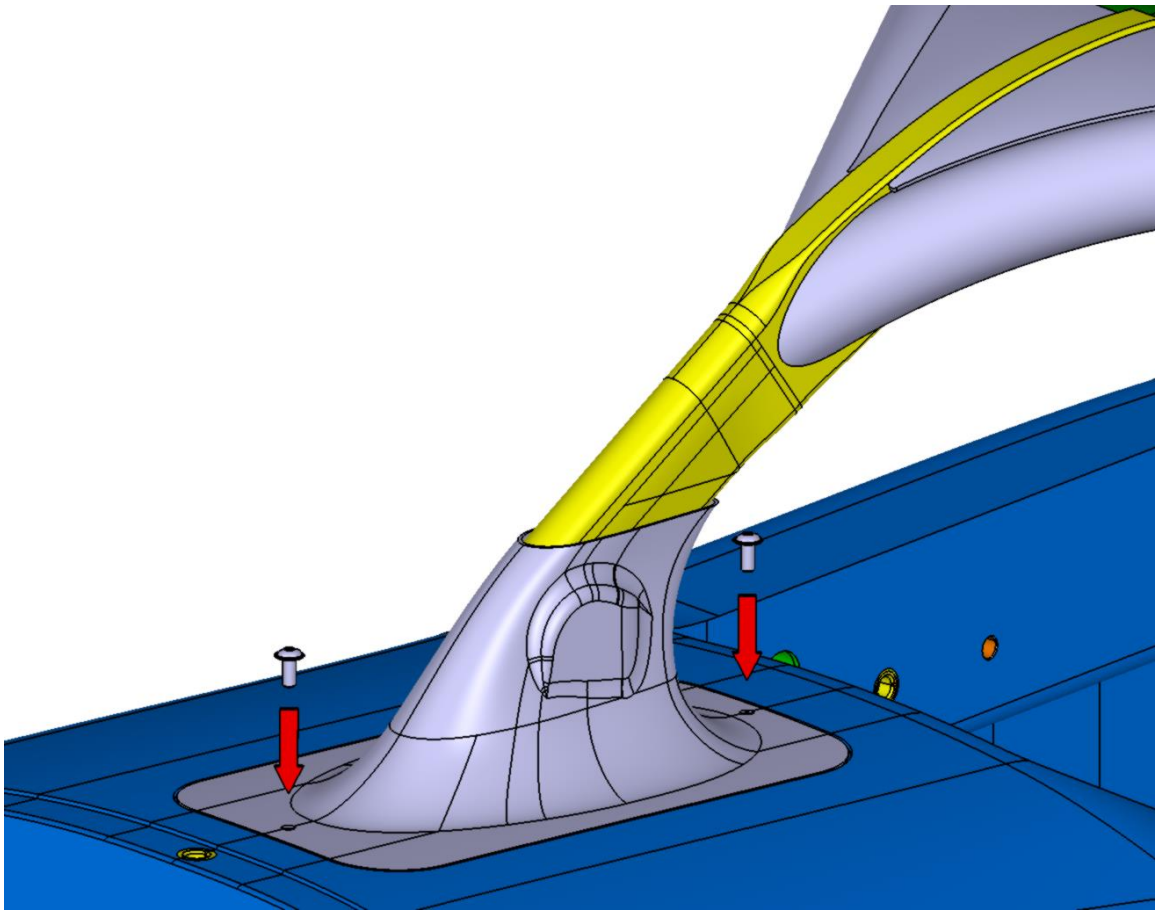


15. Double check the tightening torque on each bolt starting from the two shoulder bolts (24-01-033), then on the M12 bolts and finally on the NAS6207-12 bolts.

16. Tighten the HALO front fixing screw (**24-01-017**)

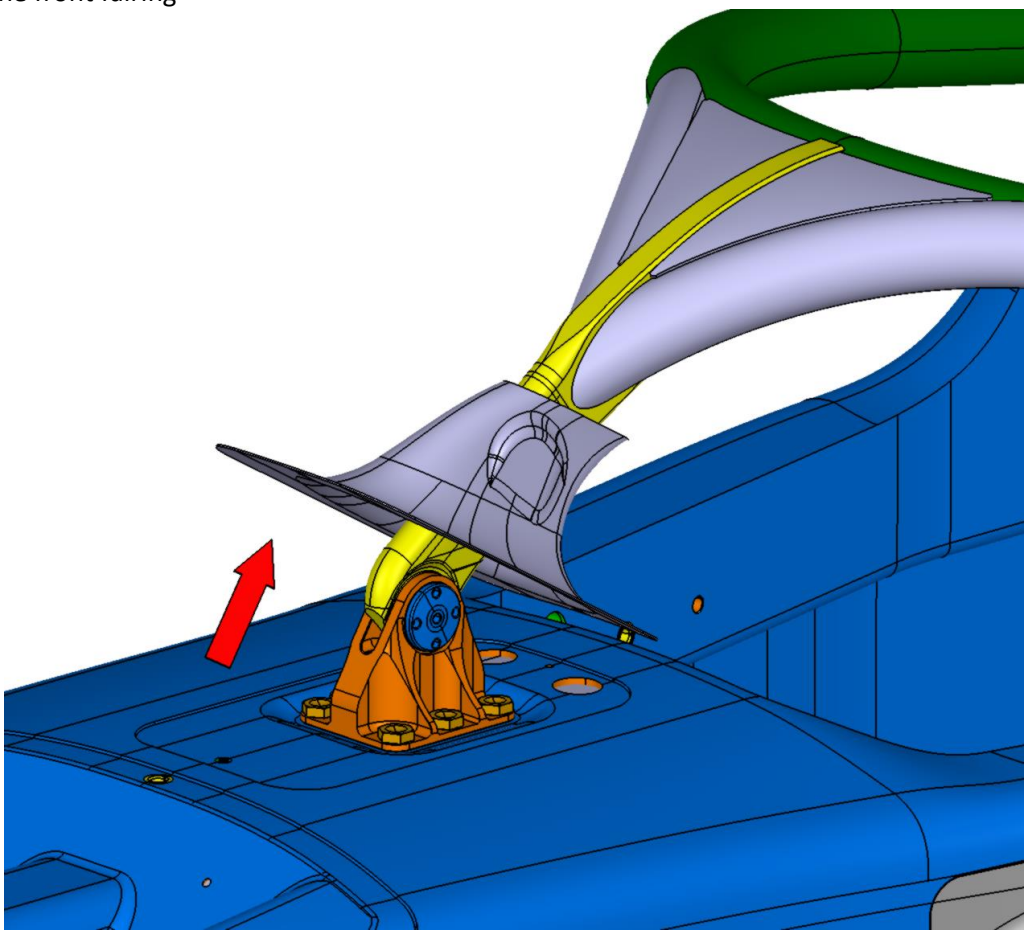


17. Position the front fairing (33-01-043) and fix it with two button head bolts (UNI7380-TX-M5X10).

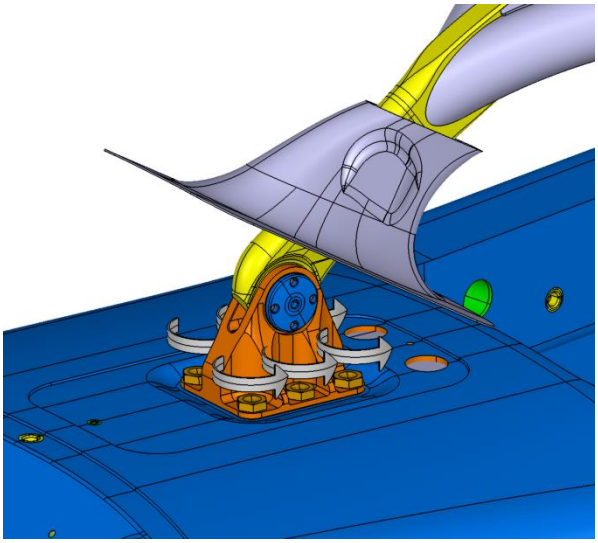


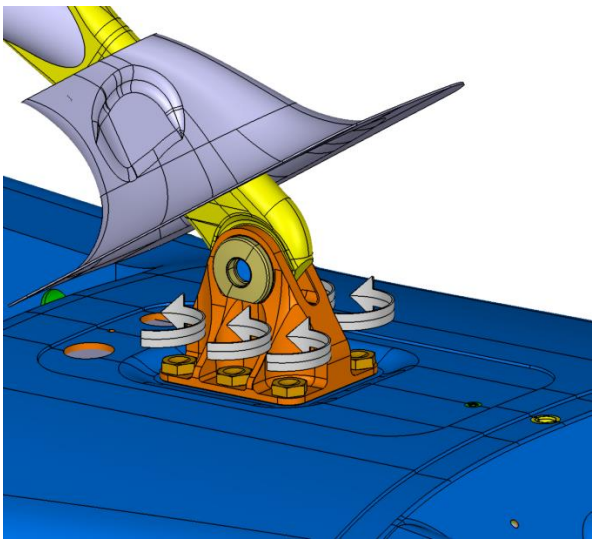
2.10.2 Disassembly procedure

1. Lift the front fairing

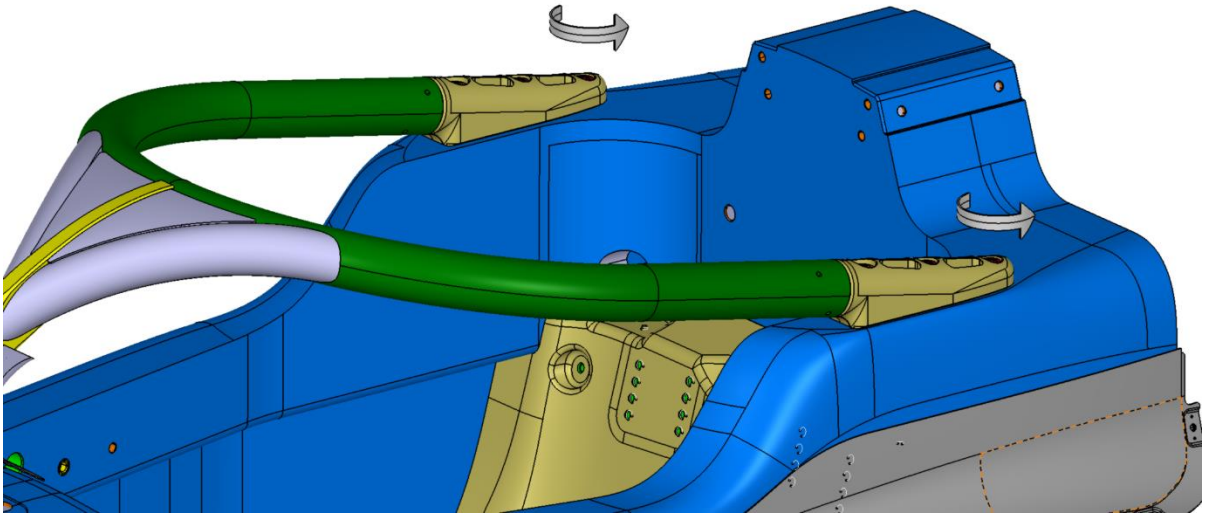


2. Unscrew and remove the six NAS6207-12 bolts. **Do not unscrew one bolt first and then the others.** Loose the bolts gradually, keeping the balance on all of them.

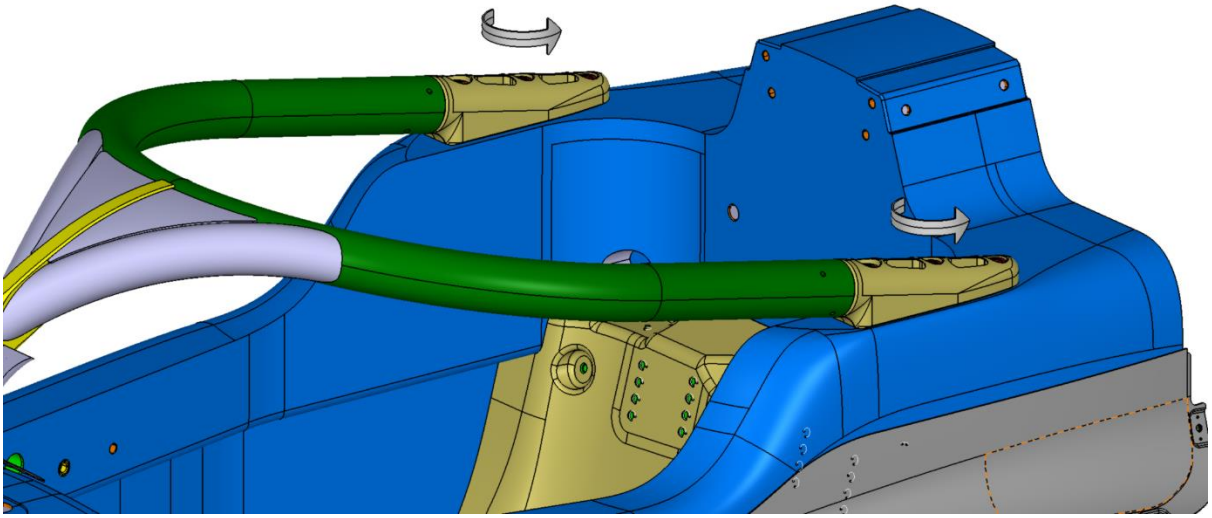




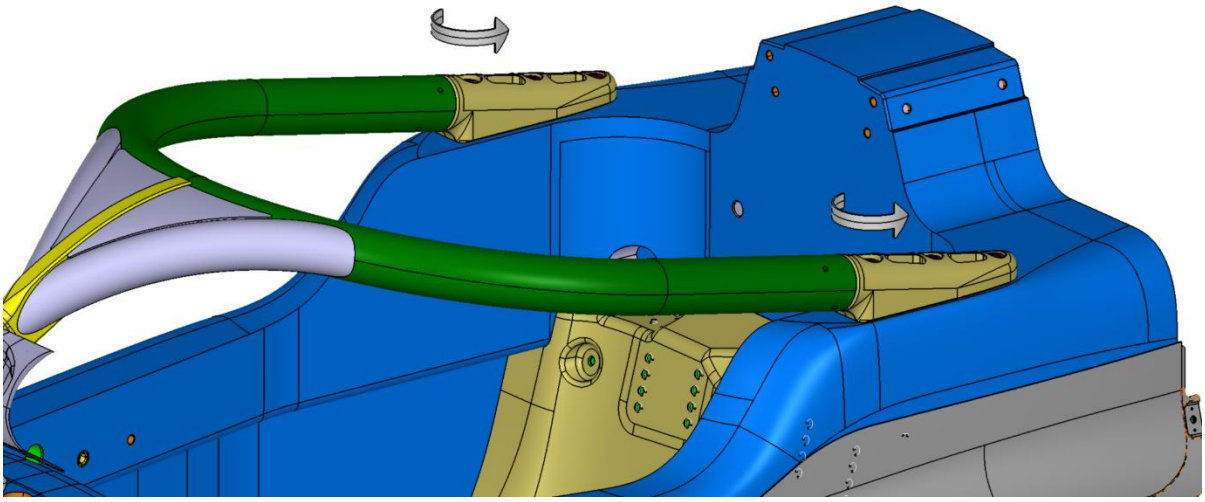
3. Unscrew and remove the M12X30 bolts. **Do not unscrew one bolt first and then the other.** Loose the bolts gradually, keeping the balance on the two bolts.



4. Unscrew and remove the M12X55 bolts. **Do not unscrew one bolt first and then the other.** Loose the bolts gradually, keeping the balance on the two bolts.



5. Unscrew and remove the two shoulder bolts (24-01-033). **Do not unscrew one bolt first and then the other.** Loose the bolts gradually, keeping the balance on the two bolts.



2.10.3 HALO painting and certification

It is reminded the HALO is a type 1 component. As stated by the FIA technical regulation:

"Type 1: These parts must be supplied by the manufacturer and used exactly as supplied. Repairs may be carried out only by the manufacturer."

"The adding of color or thin adhesive film up to a thickness of 0.5 mm is not considered as a modification, provided that the color or film fulfils only an optical function."

By the requirements above, it is not allowed to the team/customer to remove the paint from the HALO, please note it comes from Tatuus only painted black.

In addition, by FIA requirement the HALO must be equipped with a homologation label and FIA hologram. Both the label and the hologram must only be fitted by Tatuus.

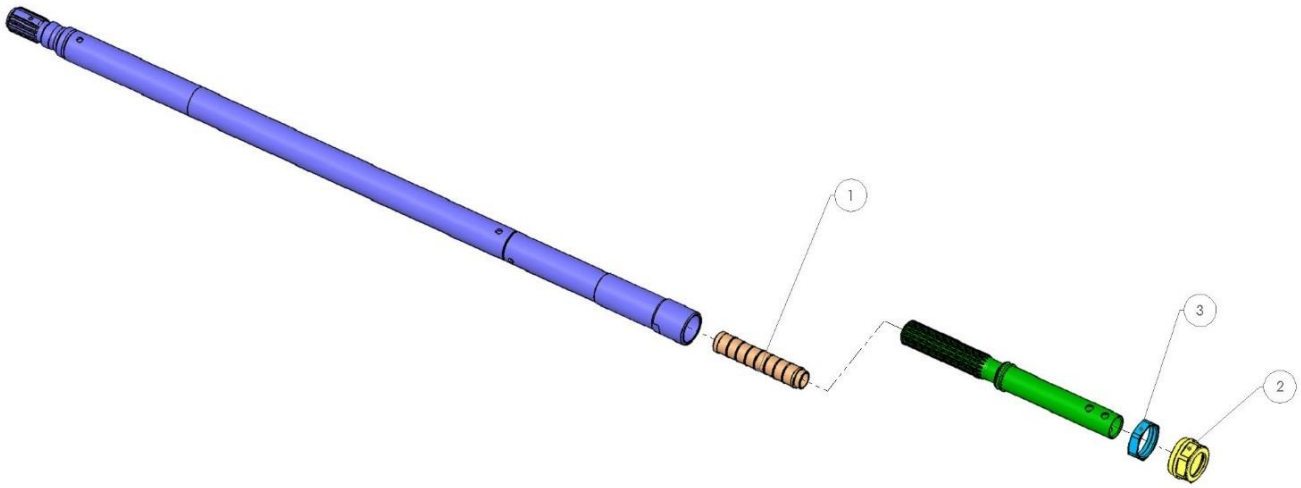
The homologation label and the hologram must be visible, they cannot be covered by wrapping or paint. It is suggested to protect the homologation label and the hologram with a transparent film (i.e., helicopter tape).

If the hologram needs to be re-placed or re-fitted, the HALO should come back to Tatuus for inspection and re-certification. Please get in contact with Tatuus for timeline and quote for the activity.

2.11 Steering Column

The steering column has an integrated collapsible section ① to absorb impact energy. Extreme attention must be paid on this part to avoid any damage or overload.

IMPORTANT: in case of impact the aluminum crashbox ① must be replaced and the column carefully inspected.



2.12 Wheel Tethers

Cortex 6kJ (FIA 8864-2013 standard)

It is recommended to replace wheel tethers if:

- The cable has been on the car for more than 12 months
- Accident
- The cable has been damaged, i.e. the braid or tape have been damaged exposing the fiber
- The cable has been over-tensioned

2.13 Rear Crashbox Tethers

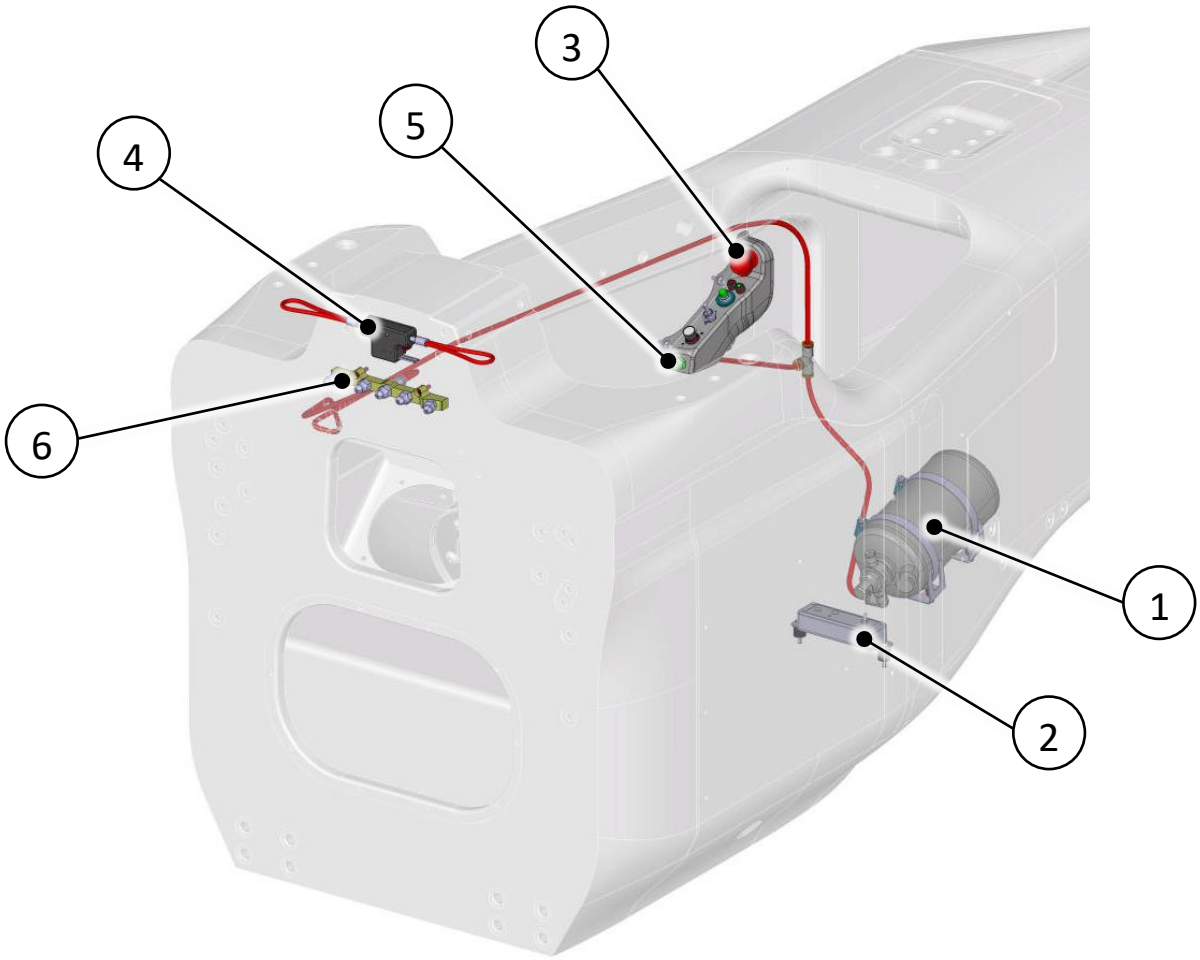
Cortex 3kJ (FIA 8864-2013 standard)

It is recommended to replace crashbox tethers if:

- The cable has been on the car for more than 12 months
- Accident
- The cable has been damaged, i.e., the braid or tape have been damaged exposing the fiber
- The cable has been over-tensioned

2.14 Fire Extinguisher

The car is equipped with an electrically actuated fire extinguishing system.



Extinguisher system components:

1. OMP CEFAL3 0.9 lt. ecolife extinguisher bottle
2. Control box
3. Cockpit extinguisher button
4. Marshal extinguisher switch
5. Cockpit nozzle
6. Engine nozzle

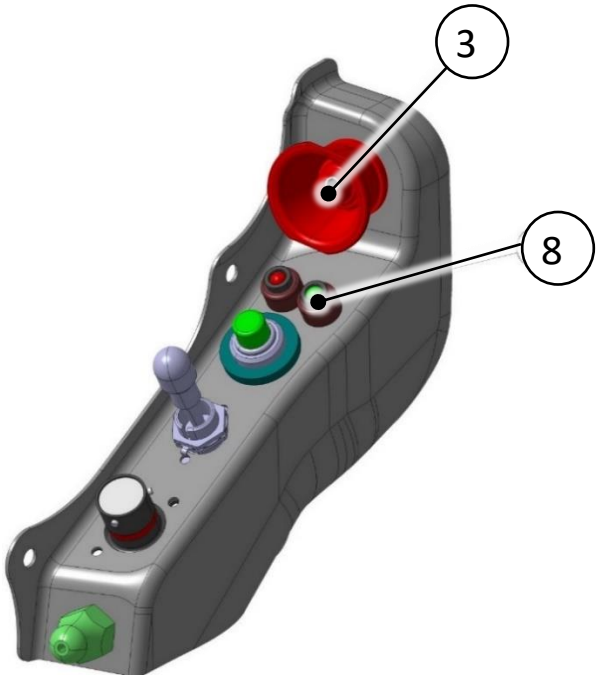
Homologation:
FIA 2000 OM. ECOLIFE GOLD ONE SEAT N° EX.036.11

The fire extinguisher is activated and the extinguishant is discharged from the nozzles by pressing the “Fire” button ③ on the cockpit panel or by pulling the pip pin of the marshal switch ④ located behind the rollhoop.
The extinguishant is discharged via 6 nozzles, one on the cockpit ⑤, five in the engine bay ⑥.
The system, if engaged, is designed to completely power off the electric system of the car.

2.14.1 Fire extinguisher setup

The fire extinguisher system must be checked and armed each time before an event where the car is driven on the racetrack. Check that the switch on the control box ② is in the ON (armed) position before using the vehicle.

On the cockpit panel, when the switch is set to ON, the GREEN LED ⑧ will turn ON.



When the lever switch on the control box ② is in the OFF (Test) position, the extinguishing system is disabled, the GREEN LED ⑧ turns OFF.

Warning:

Before every race, replace the battery in the control box ②. If the battery is low, the system will not activate. Before every race, make sure that the needle on the bottle gauge is in the green zone. When the bottle gauge needle is outside the green zone, the extinguishing system is drained and must be charged.

2.14.2 Fire extinguisher system Test Mode

Switch the control unit to OFF mode on the control box ②, press the button ③ or pull the marshal switch ④, the LED ⑩ will turn ON, thus indicating that the system is connected correctly.
The LED on the extinguisher control box verifies the functionality of the system and turns on ONLY when the extinguisher bottle is connected to the system. If the LED does not turn on after having connected the system, check the connections and/or try replacing the battery.

2.14.3 Fire extinguisher maintenance

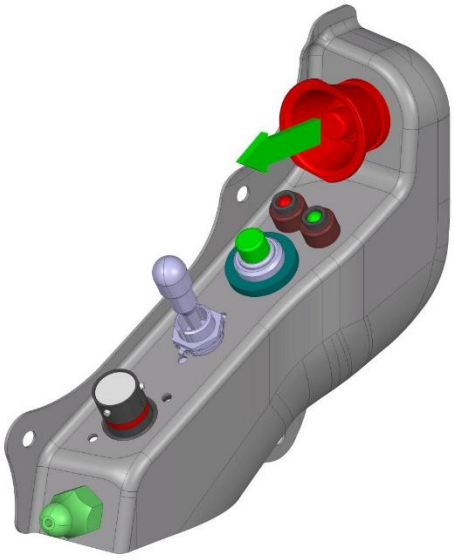
Before connecting the control unit to the bottle, use a multimeter to check on connector ⑨ that:

- If control unit lever switch is in OFF position, when either the activation button ③ or the marshal switch ④ is activated, the potential difference between the ends of the wires is about 7 - 8V
- If control unit lever switch is in ON position, when either the activation button③ or the marshall switch ④ is activated, the potential difference between the ends of the wires is about 9V. When neither of the buttons are activated the potential difference between the ends of the wires is 0V.

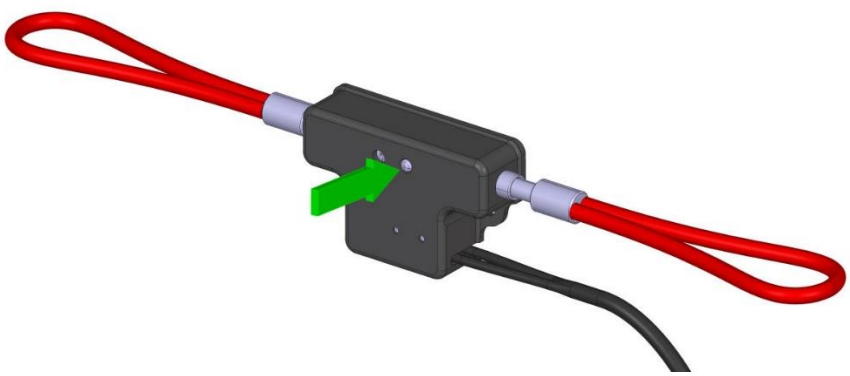
(PLEASE NOTE: after pushing either of the activation buttons, potential built up in the system needs to be discharged before it gets back to zero. This can easily be achieved by touching the connectors).

2.14.4 Activating devices

- Cockpit panel: push-pull button ③. WARNING, once activated the button must be pulled to be rearmed.



- Marshal switch: located behind the main rollhoop. WARNING, once activated the unit must be rearmed releasing the lock pin.



In the event of fire extinguisher activation, pay attention to clean all the extinguisher foam from the electrical connections. Special attention should be directed to the connectors involved in the extinguisher system as well as the internal electronics of the control box.

2.15 RAIN LIGHT

The F4 car must have three rear lights in working order throughout the events.
The rain light features 16x High intensity LED
A minimum of 85% of the LED's must be operational at any time.

2.15.1 Rain Light modes

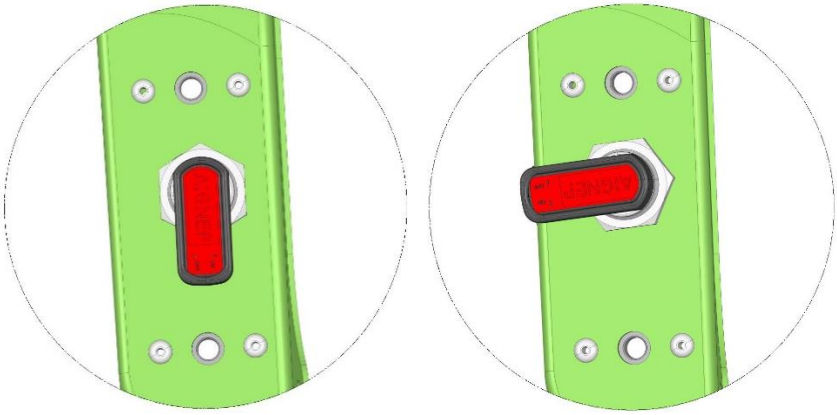
The three lights operate different modes according to car condition:

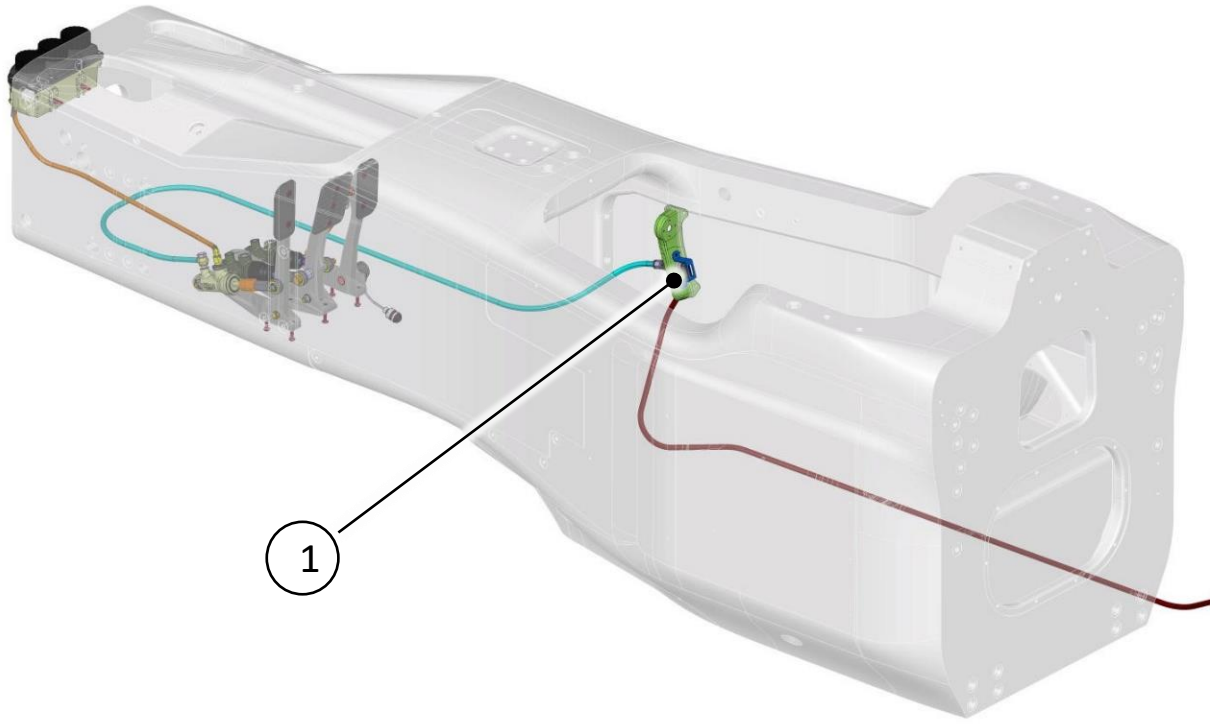
- Main switch ON: 4Hz Flashing rain light/1Hz Flashing tail light
- IGN ON + Engine OFF/Stall: 10Hz flashing
- Rain Light ON: 4Hz flashing
- Pit Limiter ON: 1Hz flashing

2.16 CLUTCH DISENGAGEMENT

In case of a sudden stall, the car can still be moved following this procedure:

1. Press the clutch.
2. Turn the valve (90° deg. Clockwise).
   To avoid an improper/unwanted use, the valve ① is protected by a cover.
3. Release the clutch pedal (note: the pedal might remain pushed).
4. The car can be moved.





2.17 FIA THROTTLE FAIL SAFE

The car is equipped with a FIA throttle fail safe algorithm, which, in case throttle and brake pedal are pressed at the same time, overrides the throttle and cuts the engine.

	Abarth
Car Speed	> 10 km/h
Engine rpm	> 2'000 rpm
Brake Pressure (Front and/or Rear)	> 50 bar
Throttle Pedal	> 70 %
Time	> 150 ms

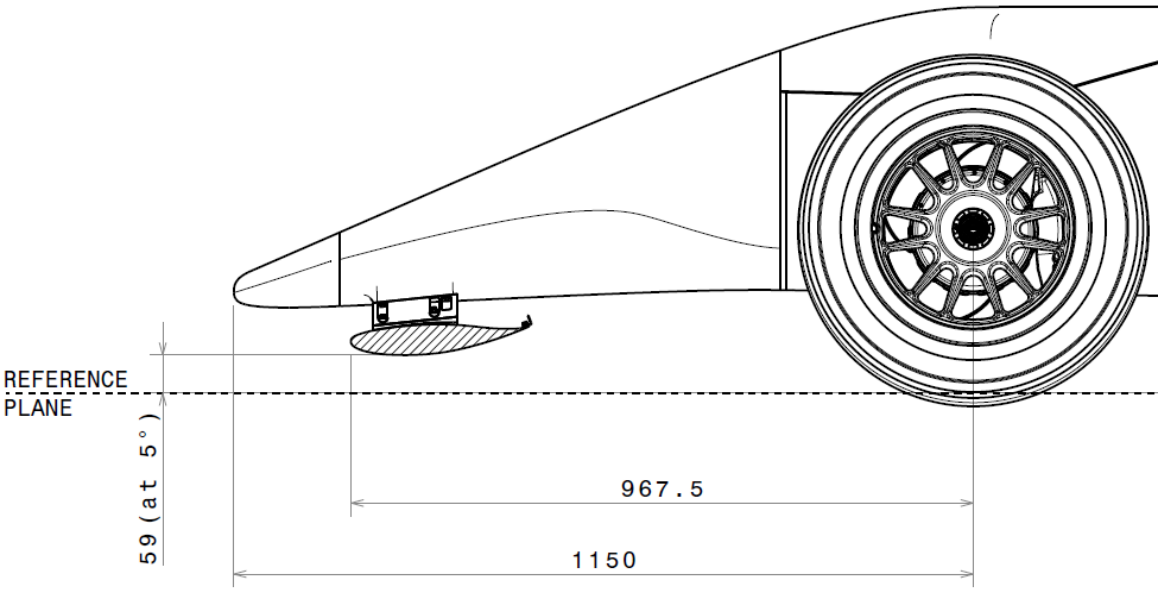
If Throttle Fail Safe strategy occurs, a full power cycle (Ign + Main) is needed to reset it and restart the engine.

3 CHASSIS

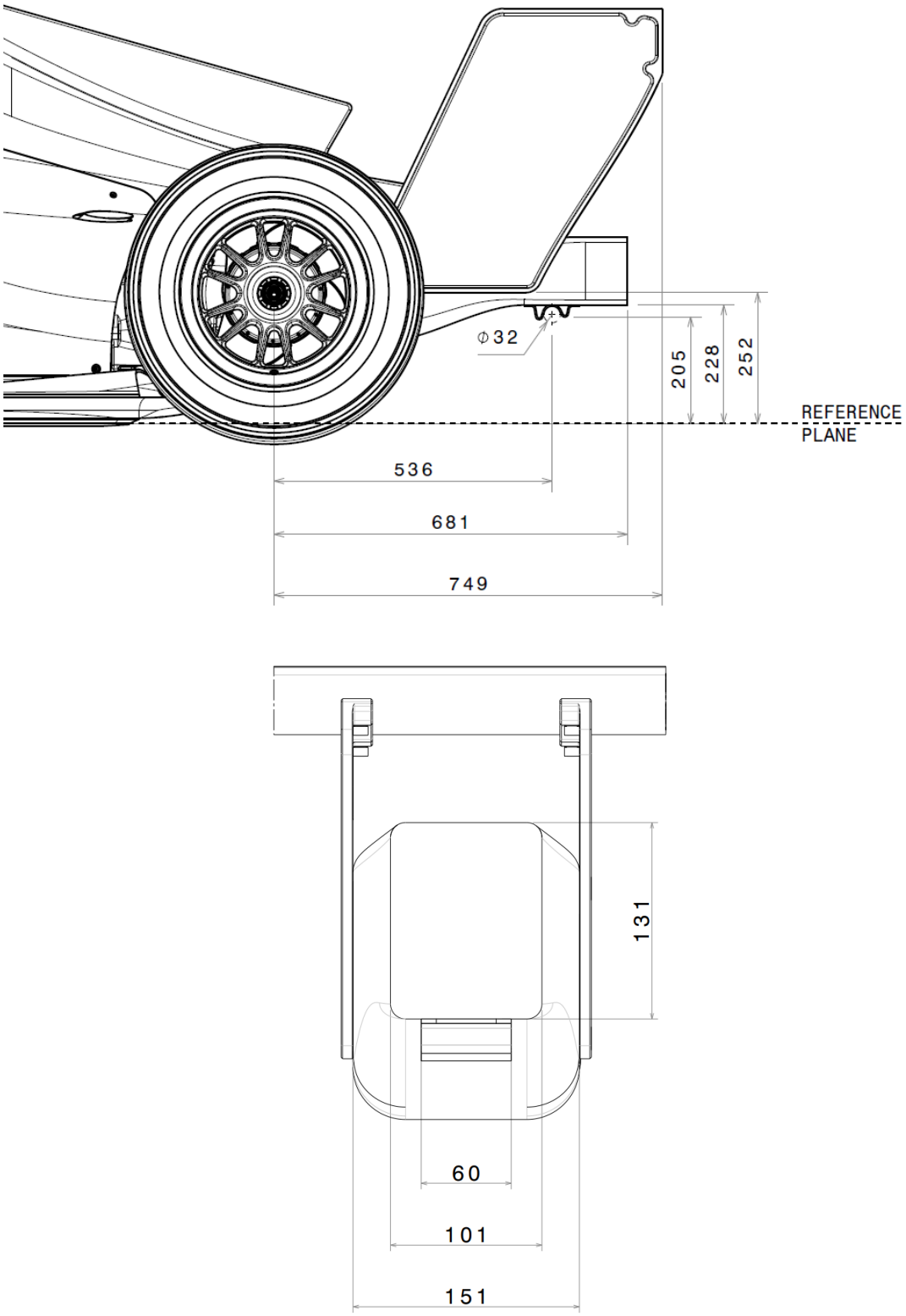
3.1 WORKSHOP TOOLS

3.1.1 Front Jacking

The highlighted area is suitable to carry the weight of the car, the jack plate should fit as better as possible the underwing surface.

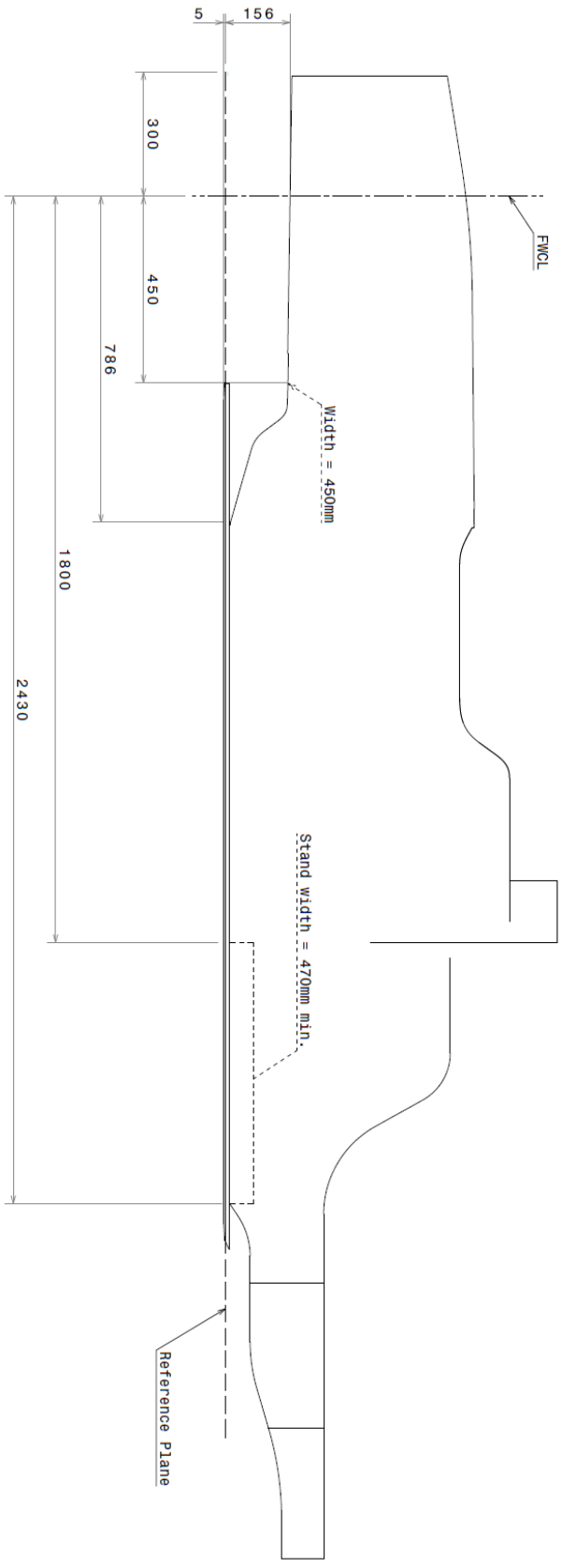


3.1.2 Rear Jacking



The highlighted jacking points are suitable to carry the weight of the car.

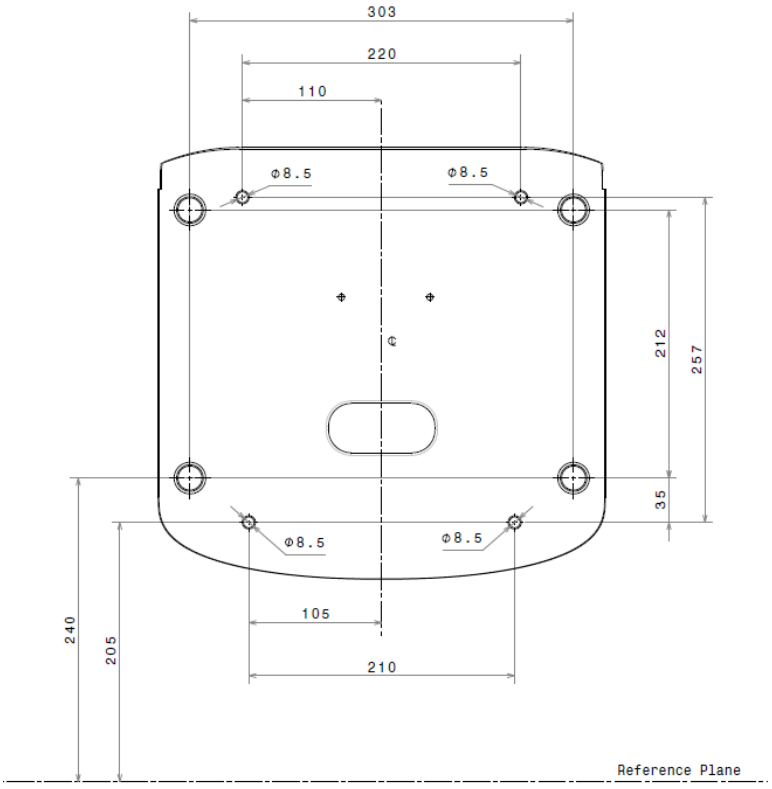
3.1.3 Stands Position/Width

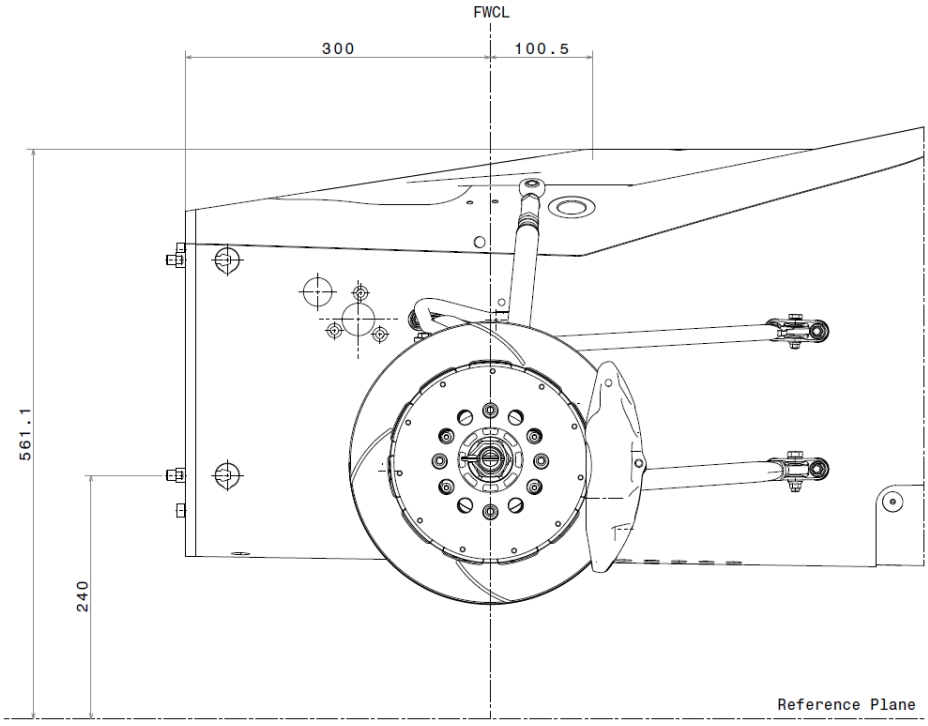


3.2 SETUP TOOLS

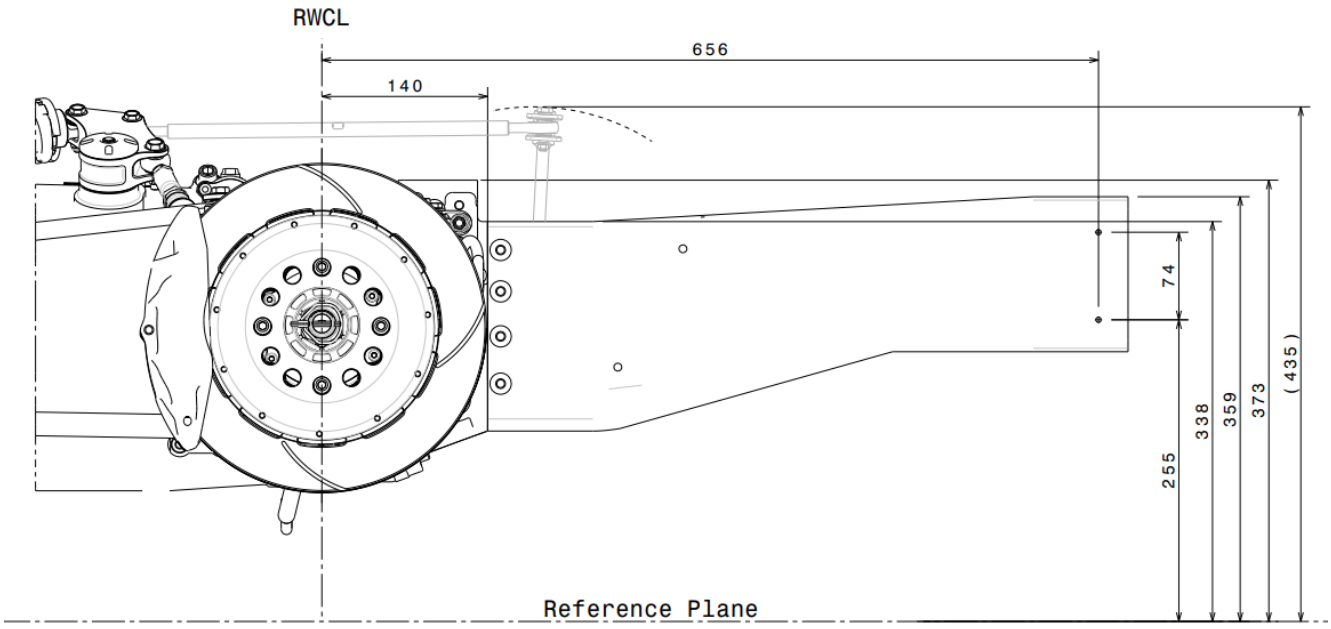
Here below some views of the main reference points

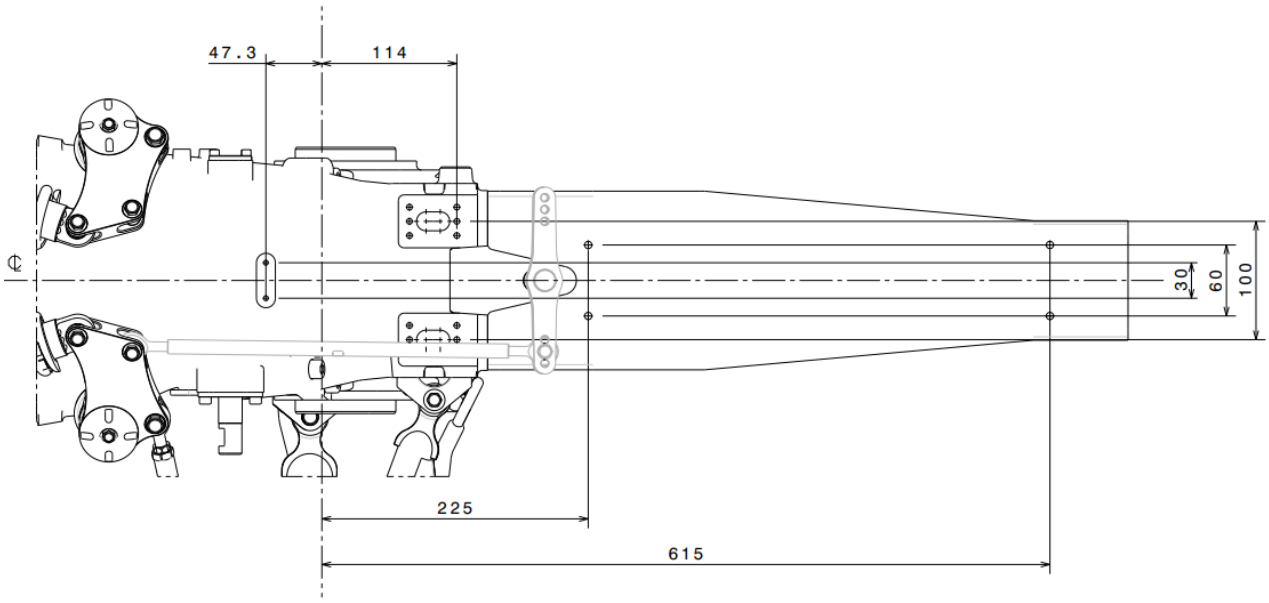
3.2.1 Front references





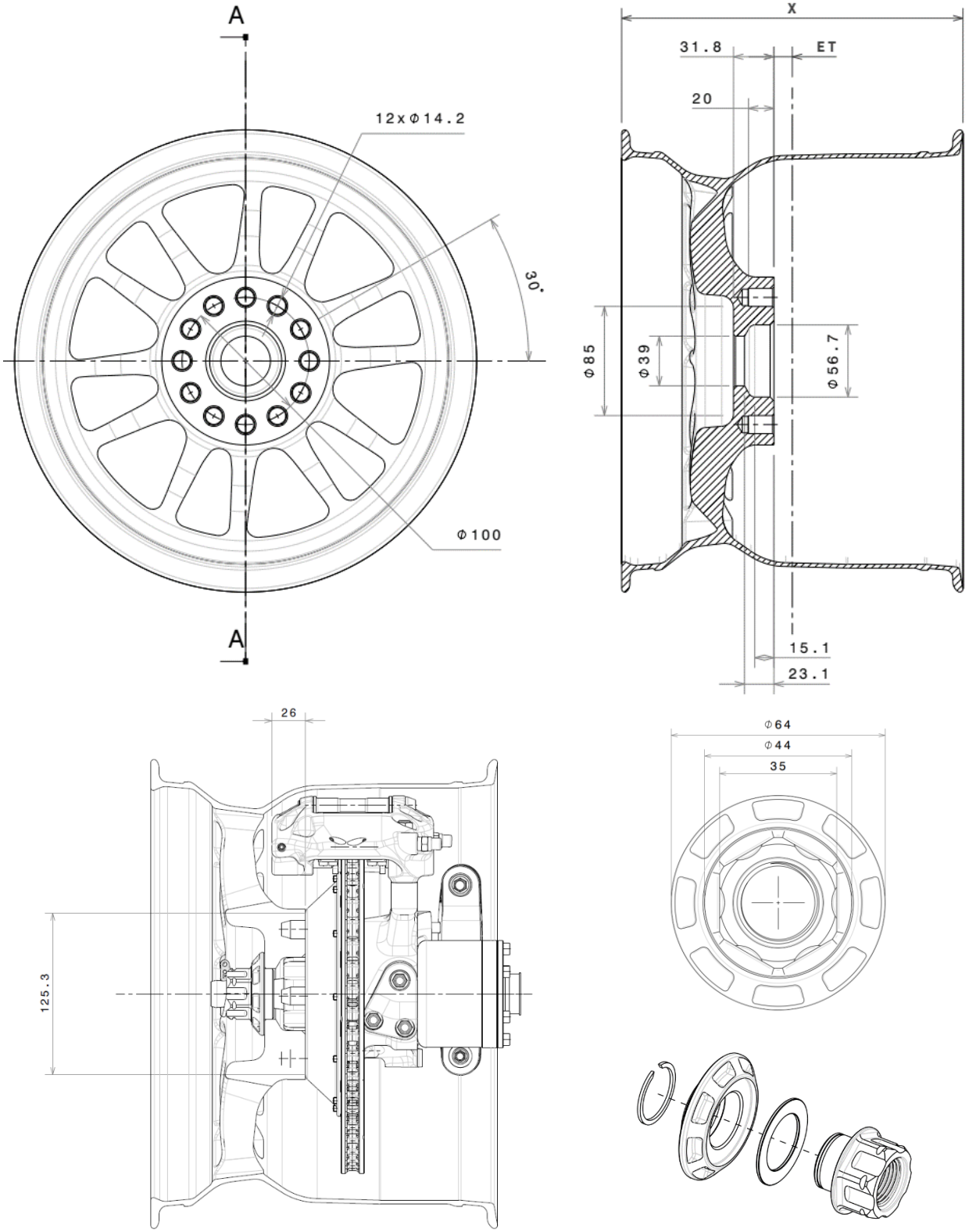
3.2.2 Rear references





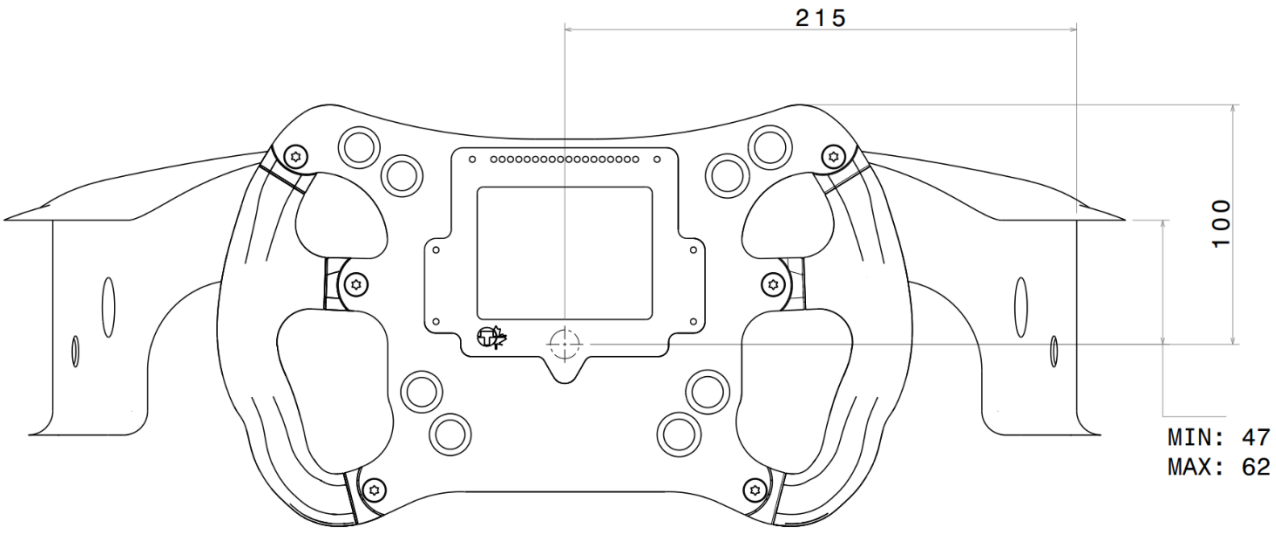
3.2.3 Wheel hub

ET	Front	21.2 mm
	Rear	13.7 mm
X	Front	218 mm
	Rear	269 mm



Wheel nuts socket wrench dimension: 35 mm

3.2.4 Straight steering wheel position



3.3 STANDARD SET-UP

Standard set-up sheet, refer to specific chapter for adjustment details:

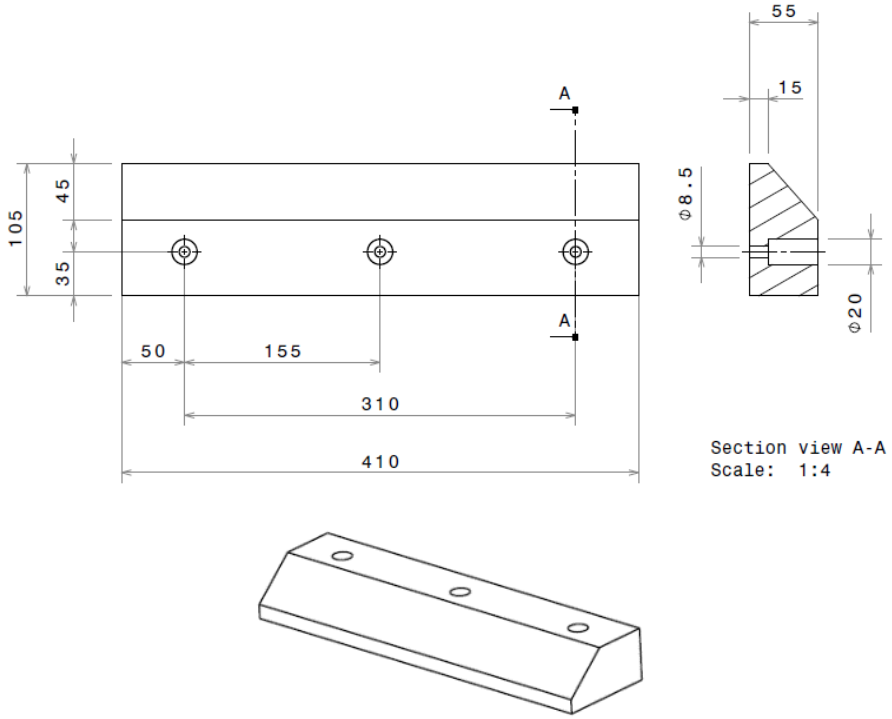
3.3.1 Road Course Set-Up

		FRONT	REAR
GEOMETRY	Ride Height [mm] Reference Plane	18	38
	Camber [deg]	-4.0°	-3.0°
	Caster [deg]	9.4°	/
	Toe (Total) [deg]	+20’	0°
	Rear Suspension position	/	BE24
SUSPENSIONS	Springs [lb/in]	700	900
	Spring preload [Turn]	1	1
	Anti-roll [mm]	22	14
	Anti-roll blade	S/S	H/H
	Damper bump [0 click: full closed]	10	6
	Damper reb [0 click: full closed]	12	6
AERO	Wing position	3°	6° (A5)
	Gurney [mm]	15	--

3.4 WEIGHT AND BALLAST

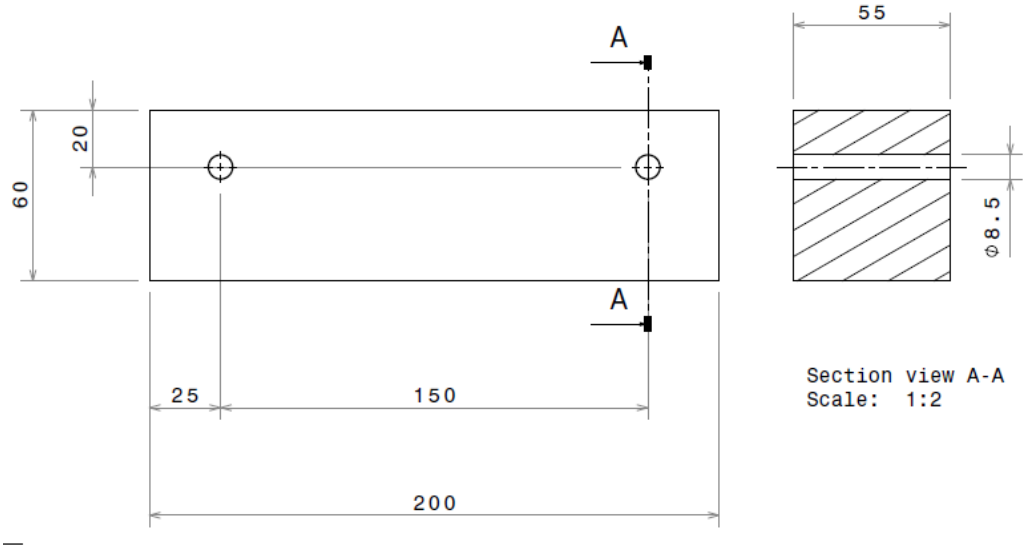
The T421 chassis has two locations for the ballast installation, the following drawings are a simple guideline to achieve the maximum allowed weight using steel. Shape and weight (limited to the maximum value shown below) is free. Length of the screws are free but must respect the Diameter listed below. Please refer to the relevant sporting regulations for possible restrictions.

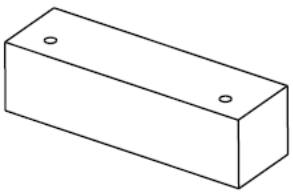
3.4.1 Ballast Position 1



Maximum weight in position 1: 15.0 kg.
Fixing: 3 x M8 CSCH screws.

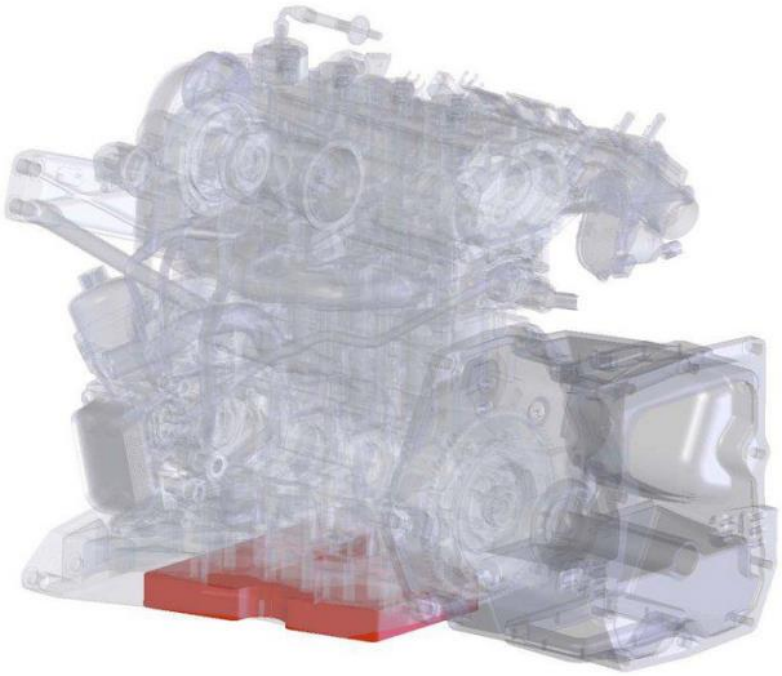
3.4.2 Ballast Position 2

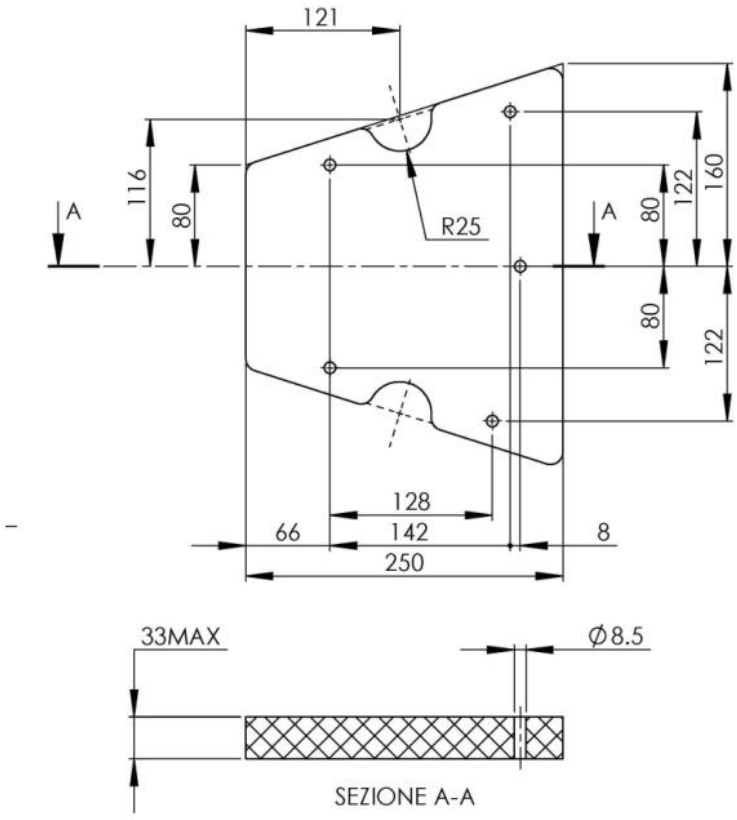




Maximum weight in position 2: 5.0 kg.
Fixing: 2 x M8 CSCH screws.

3.4.3 Engine Ballast

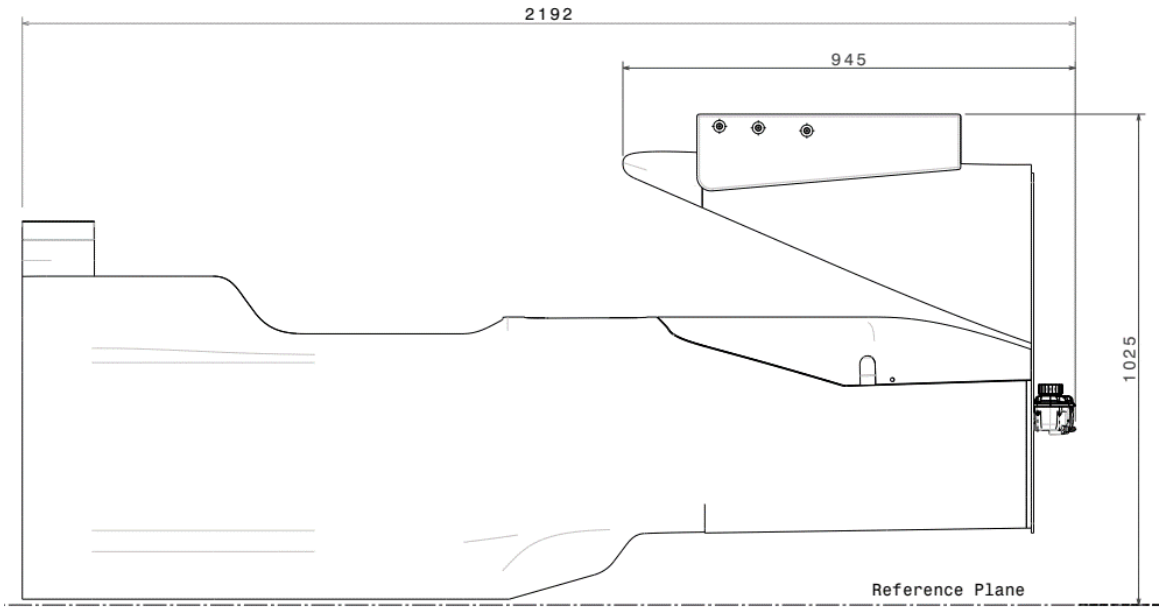


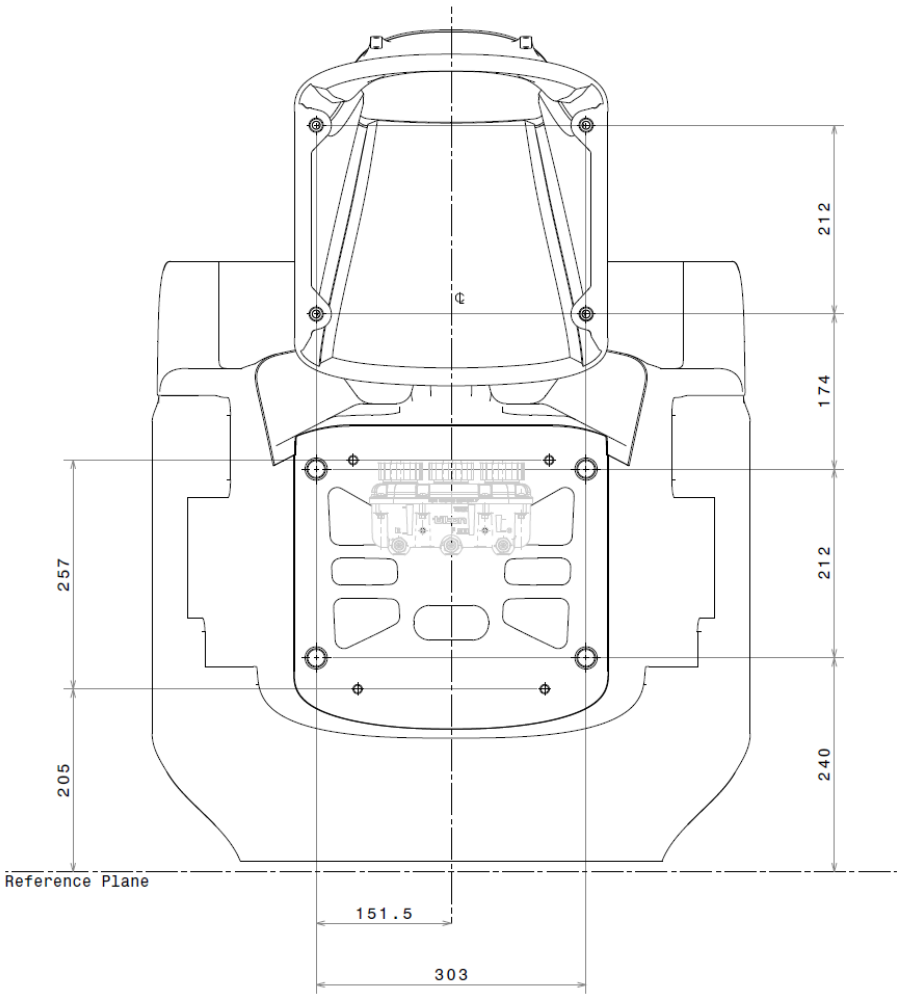


Max 20.0 kg, fixation 5x M8 bolts (Preliminary plan above).
Please refer to the engine manufacturer for further details and prescriptions.

3.5 DIMENSION FOR TRANSPORTATION

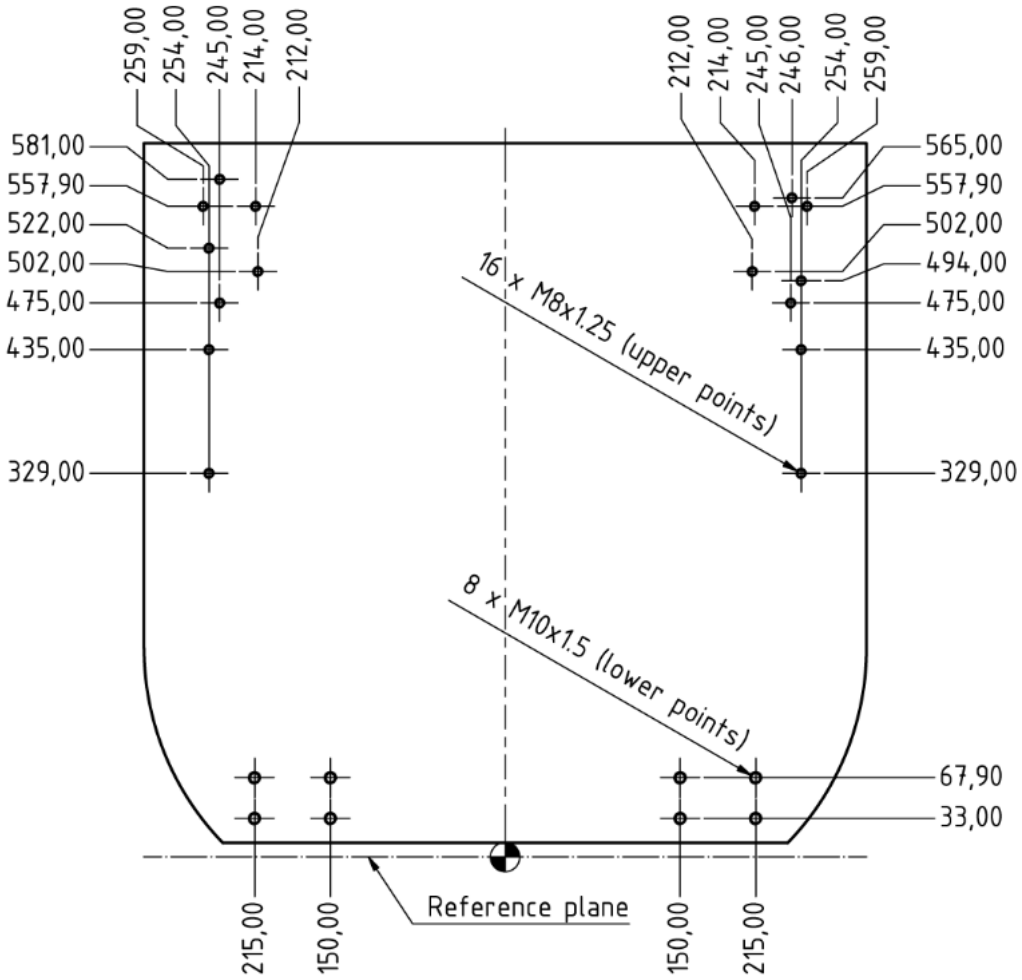
3.5.1 Nosecone reverse position





3.5.2 Power Unit -to-chassis mounting points

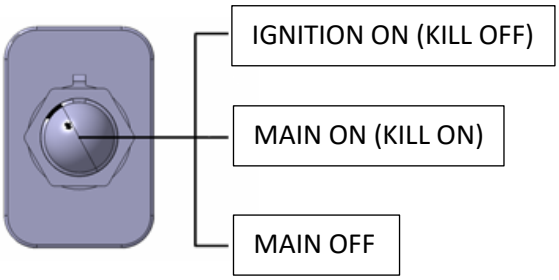
As per FIA F4 - 2nd Gen Technical Regulations the Power Unit-to-chassis mounting points are arranged in accordance with the following Drawing:



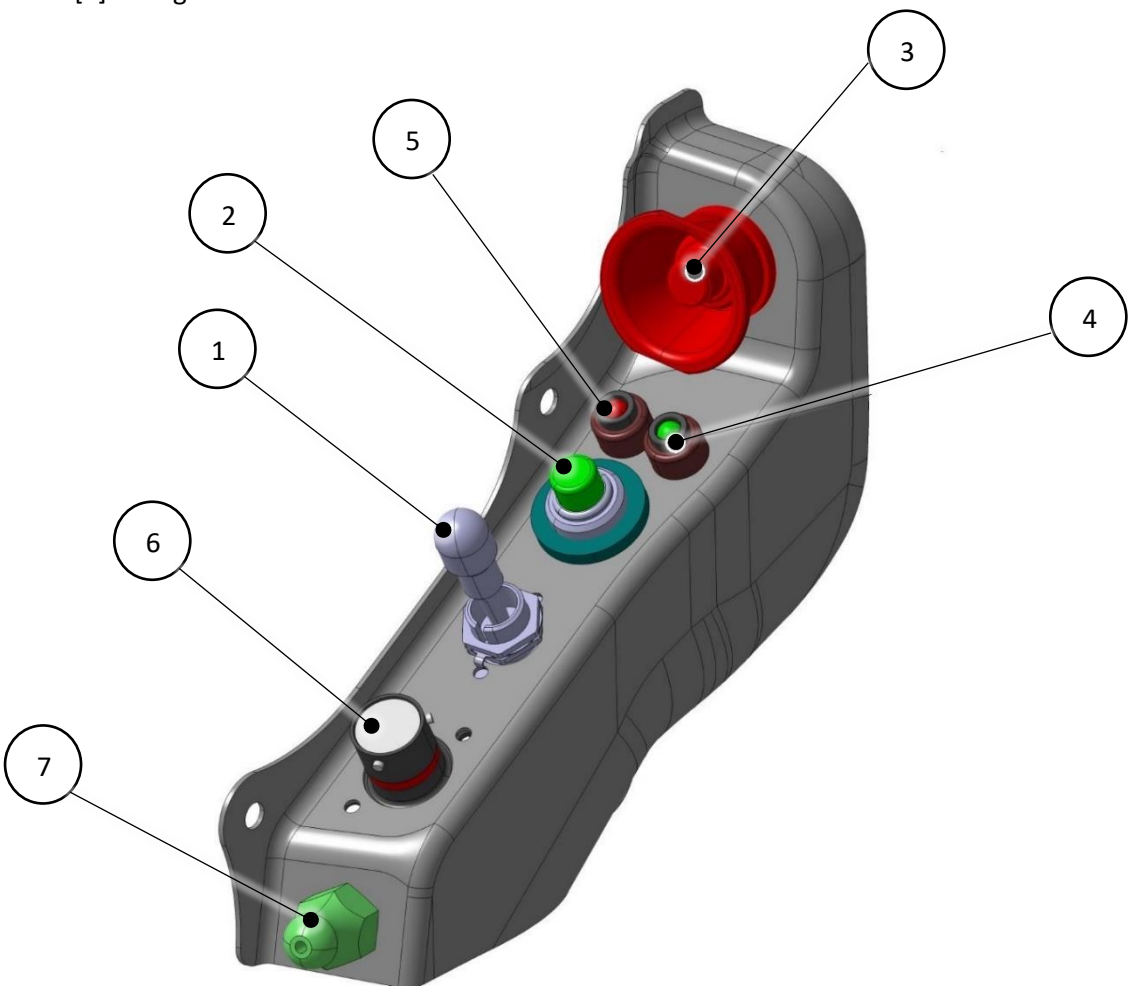
3.6 CONTROLS AND DISPLAY

3.6.1 Cockpit Controls

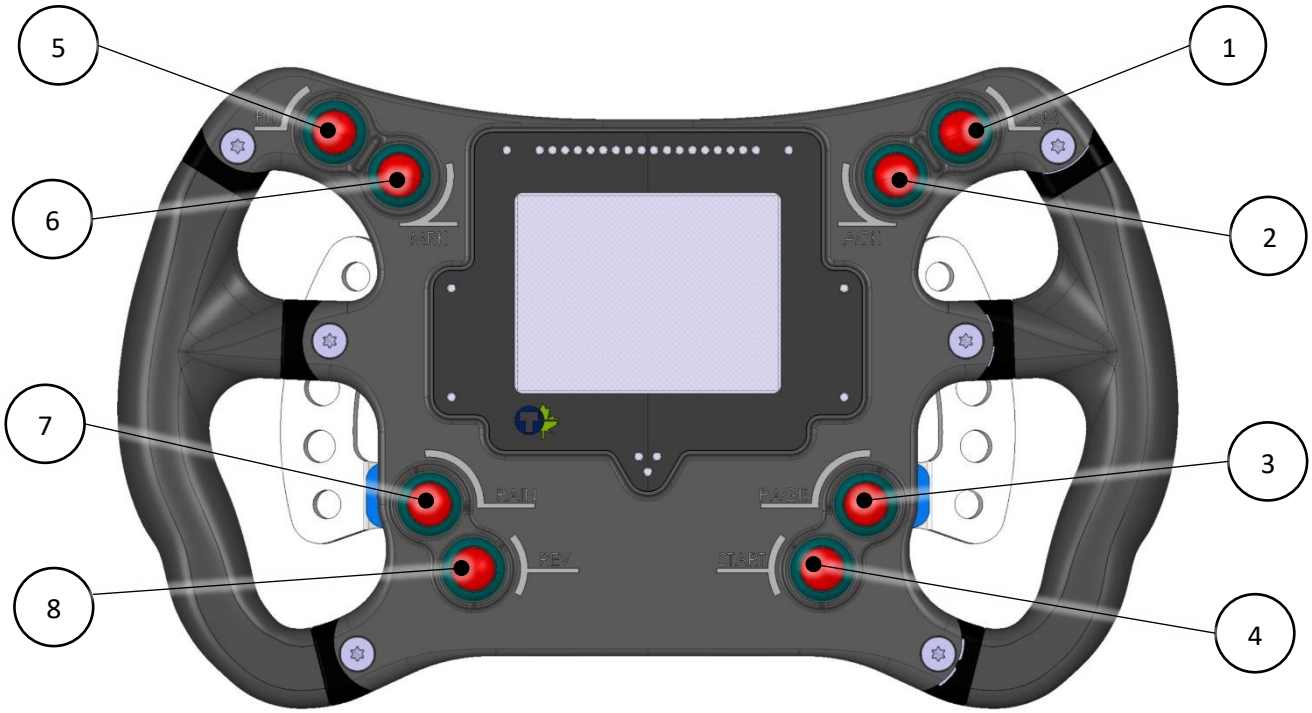
- [1] Main power switch:
  - Position 1: Main OFF
  - Position 2: Master switch ON
  - Position 3: Ignition ON



- [2] Starter button (YELLOW)
- [3] Fire Extinguisher
- [4] Fire extinguisher status (green when armed)
- [5] ADR status
- [6] Communication Port (depending on ECU configuration)
- [7] Extinguisher nozzle



3.6.2 Steering Wheel Controls



- Button ①: **RADIO PTT**, the button signal is forwarded to the radio plug (see wiring diagram for pinout).
- Button ②: **ACKNOWLEDGE**, when pressed all the alarms are skipped, critical alarms will persist. Long pressure (4 seconds) will reset chassis sensors (steering angle, accelerometers).
- Button ③: **Display PAGE**, a single short push will scroll pages, pushing the button for longer than 0.5 sec will return to the driver's page.
- Button ④: **START**/KILL, only when IGN is ON this button act as a starter. When the engine is ON a long pressure will kill the engine.
- Button ⑤: **PIT LIMITER**, when pushed the ECU will set engine rev limiter to control pit-limited speed (if wheel speeds are available).
- Button ⑥: **MARK**, when pushed the ECU will register the input in the log file. Double click will activate fuel pump (for fuel drain purpose).
- Button ⑦: **RAIN Light**, when pushed the ECU will activate the rain light, a blue flag will be active on the left bottom corner of the dash.
- Button ⑧: **REVERSE**, when pushed the REVERSE gear is requested to the shifter, it only acts when the car is steady and the AKN button is pushed.

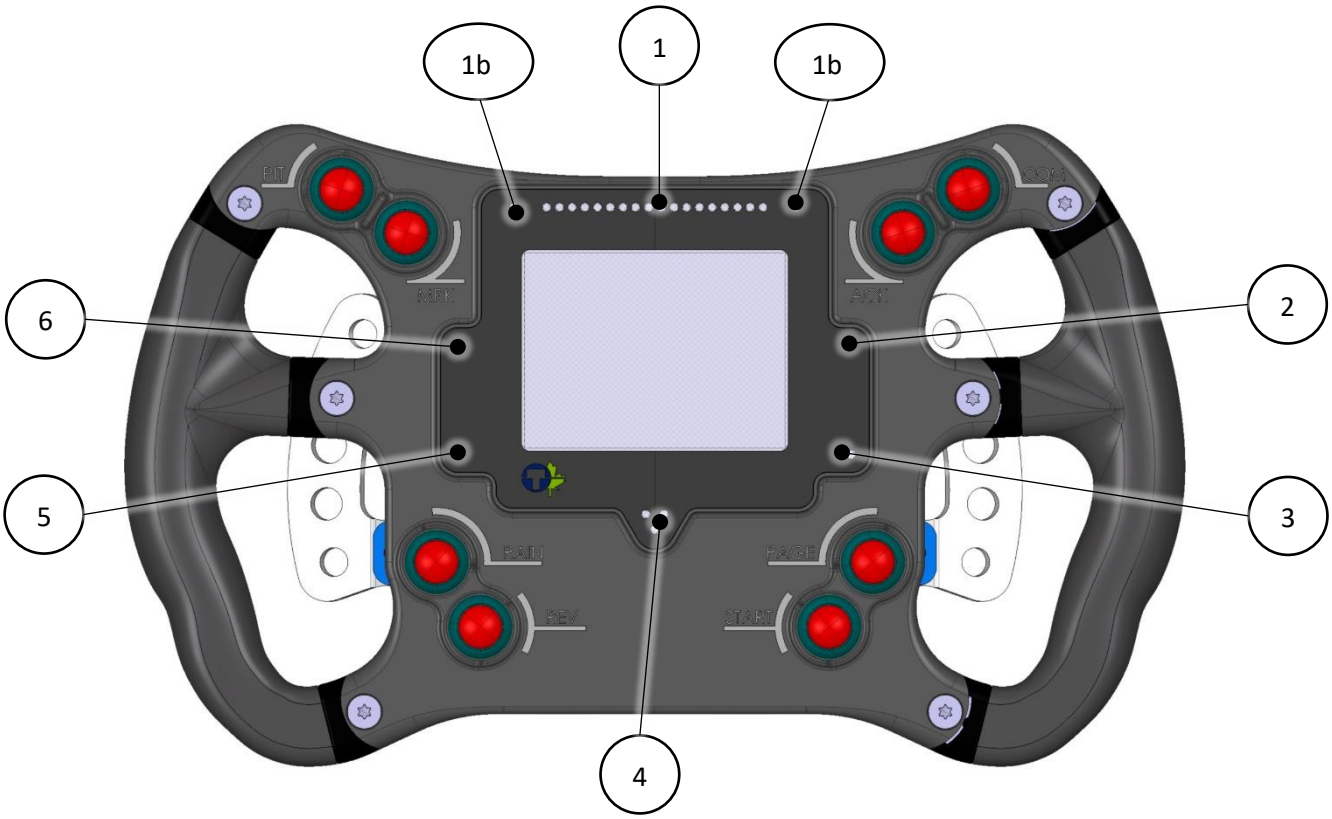
In the logged data are available the channels:

- Dash_Button: bitmapped, triggers value 1 on relevant bit if one of the button has been pushed.

Please refer to the table below showing bitmap configuration for the channel above

bit	15	14	13	12	11	10	9	8
Dash_Button	REVERSE	RAIN	MARKER	PIT LIMITER	START	PAGE	AKN- 1	RADIO

3.6.3 Steering Wheel Display

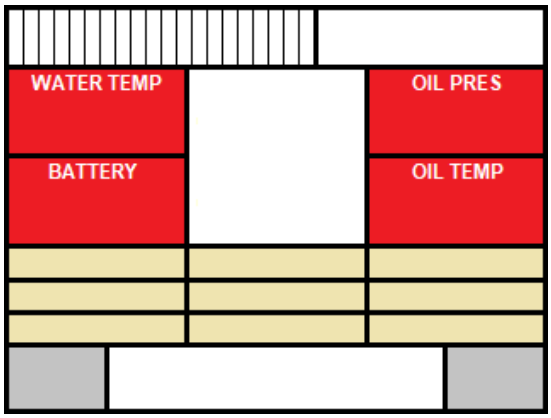


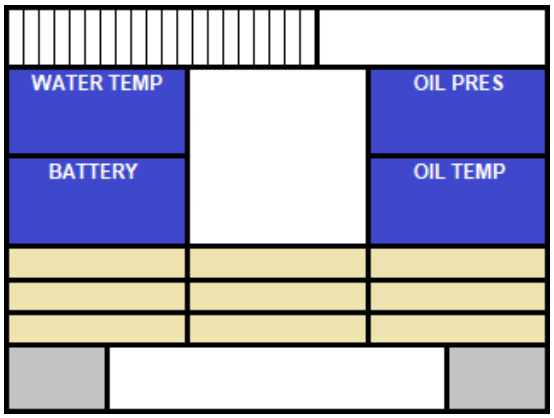
- LED strip #1: Shift lights
- LED strip #1b: Blue LED are ON when pit limiter is engaged
- Alarm ②: Low Oil Pressure
- Alarm ③: High Oil Temperature
- Alarm ④: 3x RED LED will blink when a general alarm is on, the display will highlight the relevant value and will show a text message
- Alarm ⑤: Electric Fault
- Alarm ⑥: High Coolant Temperature

3.6.3.1 Page #1: Driver page

The first page of the display shows the following values:

- Water Temperature
- Engine Oil Pressure
- Battery Voltage
- Oil Temperature
- Warning boxes

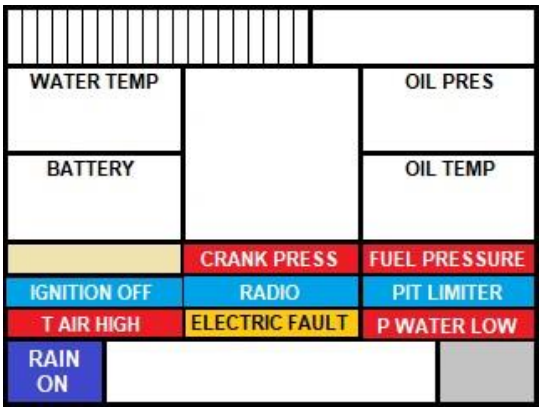




All the value boxes turn red when the value is over the maximum (alarm values are set by engine control), and blue when the value is below the minimum.

In the first page of the display are shown also the following warning messages:

- Crank pressure (if available from ECU)
- Fuel pressure
- Ignition off (KILL)
- Radio
- Pit limiter
- T air high
- Electric fault
- P water low (if available from ECU)
- Rain on



Alarm messages can be skipped pushing AKN button.

In the logged data are available the channel:

- DashAlarm: bitmapped, triggers value 1 on relevant bit if one of the alarms has been shown.

Please refer to the table below showing bitmap configuration for the channel above:

bit	11	10	9	8	7	6	5	4	3	2	1	0
DashAlarm	P WATER LOW	T AIR HIGH	KILL	PIT LIM	T OIL LOW	T WATER LOW	P CRABKCASE H	P FUELL LOW	T OLI HIGH	V BATT	P OIL	T WATER HIGH

3.6.3.2 Page #2: Setting page

This page summarizes the parameters useful for the sensor setting.

P Brake F bar	P Brake R bar	Brake Bias %	Steer Pot mV
TPS1 mV	TPS2 mV	Pedal 1 mV	Pedal 2 mV
Ped %	Gear Pot mV	ESAP mV	E-Throttle Not Active Setup

- P Brake F: Front brake pressure [bar]
- P Brake R: Rear brake pressure [bar]
- Brake Bias: percentage of front brake pressure over total brake pressure (Front+Rear) [%]
- Steer Pot: absolute position of steering potentiometer [mV], it should be set @ 2500mV when the steering wheel is straight
- TPS1 / TPS2: Throttle valve absolute position [mV] (if available from ECU)
- Pedal 1 / Pedal 2: Throttle pedal absolute position [mV], used to adjust pedal position before throttle calibration process. Please refer to the engine manual for thresholds for resting position and full throttle.
- Pedal: percentage of Throttle pedal
- Gear Pot: gear barrel absolute position [mV], the value must be
  - Neutral: 1100mV +/- 10mV
  - 1st gear: 1630mV +/- 10mV
- ESAP: absolute actuator position [mV], the value should be between 0 and +/-30mV when actuator is not operational.

- E-Throttle: throttle calibration messages
  - 

Push Throttle Pedal to full throttle
  - 

Release Throttle Pedal to rest position
  - 

Wait for the Throttle Valve learning
  - 

Throttle calibration process completed successfully
  - 

Throttle calibration process NOT completed

3.6.3.3 Page #3: Logger page

This page contains the channels logged by the data systems and allows to check the zero procedure. all the channels are set to zero when ACK button is pressed longer than 1 second.

FL Shock mm	**FL Speed** Km/h	**FR Speed** Km/h	**FR Shock** mm
Steer Ang deg	**Acc X** mg	**Acc Y** mg	
RL Shock mm			**RR Shock** mm

- FL Shock: Front Left damper position [mm].
- FR Shock: Front Right damper position [mm]
- RL Shock: Rear Left damper position [mm]
- RR Shock: Rear Right damper position [mm]
- FL Speed: Front Left wheel speed [km/h]
- FR Speed: Front Right wheel speed [km/h]
- Steer Angle: Steering wheel position [deg]
- Acc X: longitudinal acceleration [mg] from external accelerometer
- Acc Y: lateral acceleration [mg] from external accelerometer

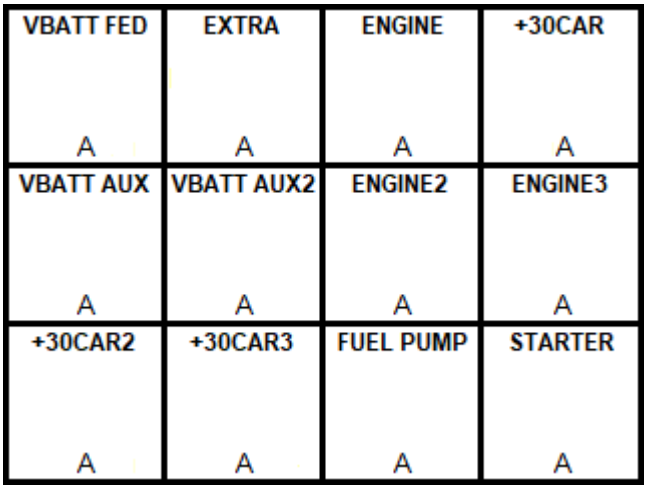
All the listed channels except wheel speeds are set to zero when ACK button is pressed longer than 1 second.

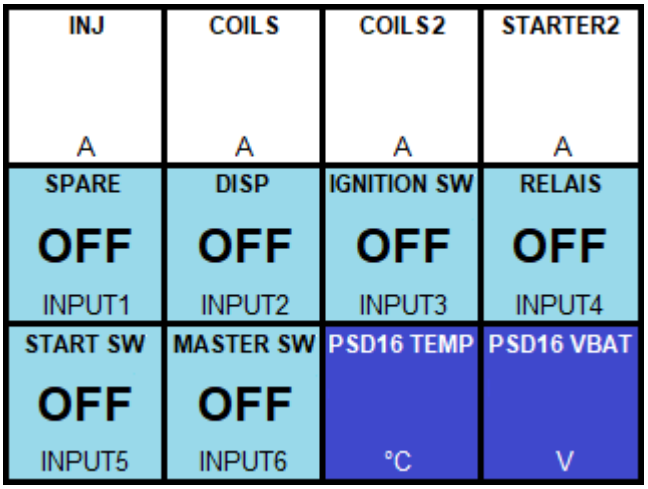
Damper position sensors and external accelerometer are optional parts. Please refer to the T-421 Spare parts catalogue.

3.6.3.4 Page #4: Electric Power Distribution

This page shows the power system of the car, each box contains the current drawn by the relevant line.
The background of the boxes is

- White: if the relevant power line is not commanded
- Yellow: if the relevant power line is active. In this case the current consumption is displayed
- RED: if the relevant line has been shut down(i.e. short-circuit detected).
  In this case an alarm showing ELEC F will pop up in page #1

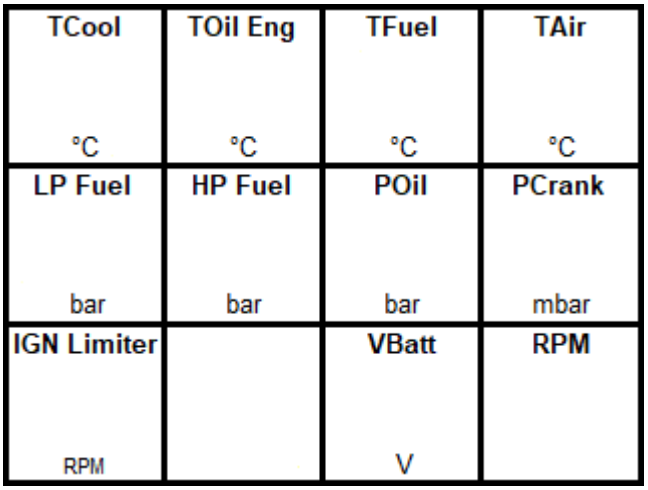




The powerbox pages show also the status of the inputs. Please refer to powerbox chapter for further details.

3.6.3.5 Page #5: Engine warmup

This page contains the engine parameters, it could be useful while starting and warming the engine.



- TCool: Engine Coolant Temperature [°C]
- Toil Engine: Engine Oil Temperature [°C]
- TFuel: Fuel temperature [°C] (if available from ECU)
- TAir: Air Temperature[°C]
- LPFuel: Low pressure Fuel [bar] (if available from ECU)
- HPFuel: High pressure Fuel [bar] (if available from ECU)
- Poil: Engine Oil Pressure [bar]
- PCranck: Engine Case Pressure [mbar] (if available from ECU)
- IGN Limiter: Ignition Limiter threshold [RPM] (if available from ECU)
- VBatt: Battery Voltage [V]
- RPM: Engine revs [RPM]

3.6.3.6 Page #6: Gearbox page

This page contains the gearbox parameters, it could be useful while testing and warming the gearbox.

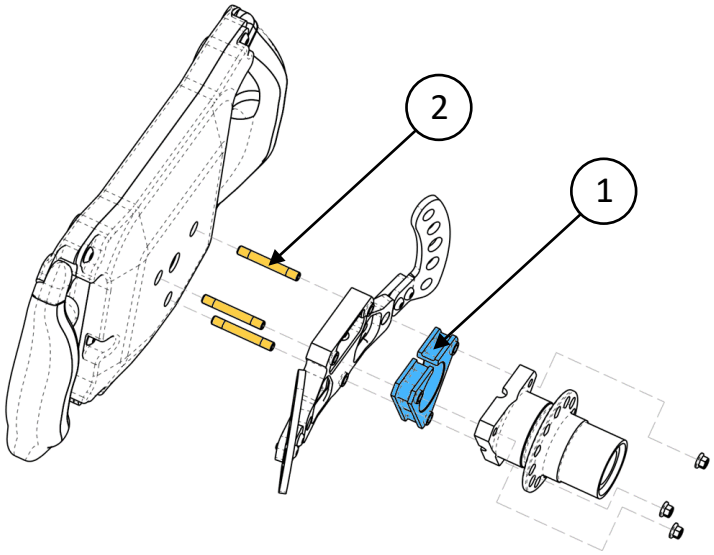
Pad Dwn		Gear	Pad Up
PClutch bar	TOilG °C	Gear Pot mV	ESAP mV
		VBatt V	RPM

- Pad Dwn: Box turns green when paddle input is active
- Pad UP: Box turns green when paddle input is active
- Gear: Gear number [1 to 6]
- PClutch: Clutch Pressure [bar] (if available)
- ToilG: Gearbox Oil Temperature [°C] (if available)
- Gear Pot: Gear barrel absolute position [mV]
- ESAP: absolute actuator position [mV]
- VBatt: Battery Voltage [V]
- RPM: Engine revs [RPM]

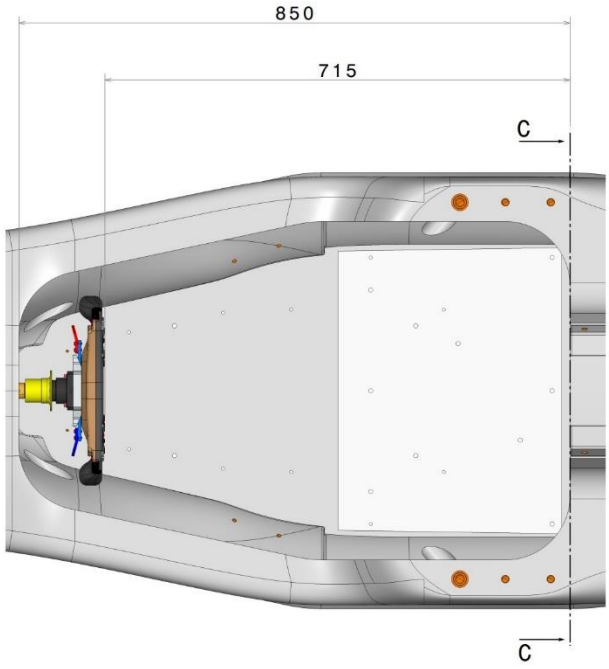
3.7 DRIVER INSTALLATION

3.7.1 Steering Wheel Longitudinal Adjustment

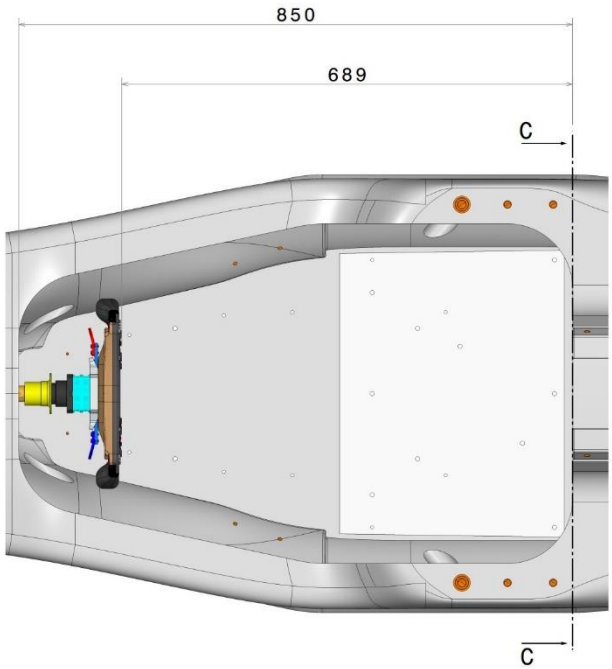
The longitudinal position of the steering wheel is limited by FIA regulation.
The spacers ① allow the adjustment of the steering wheel depth, each spacer add 13mm and can be stack up to two.



Different stack of ① requires different studs ② length. Check the Spare parts Catalogue for the options.



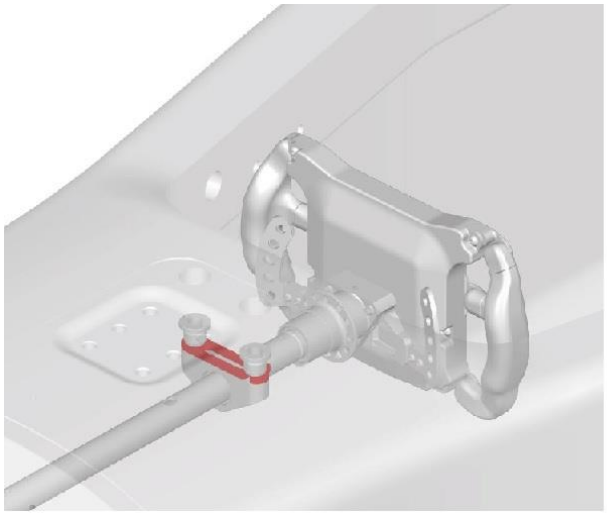
Steering wheel longitudinal position without any spacer

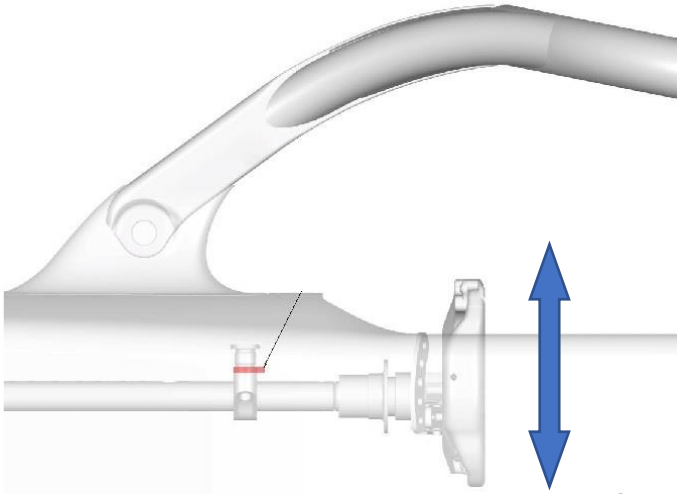


Steering wheel longitudinal position with two spacers

3.7.2 Steering Wheel Vertical Adjustment

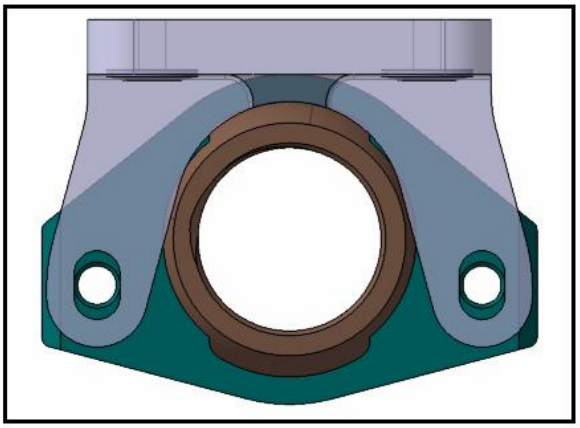
The steering wheel height is adjustable adding or removing spacers from the column bracket.

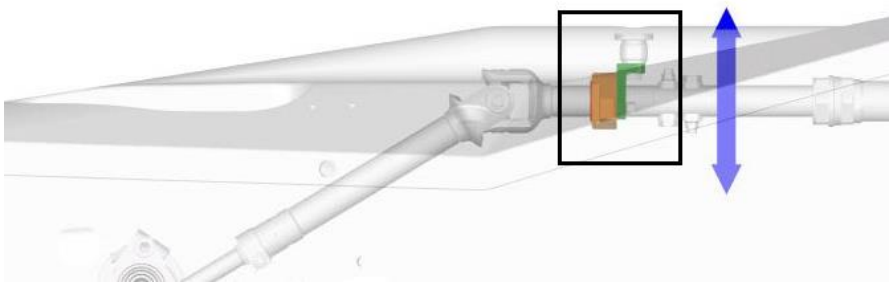




Std: 1 shim (0 mm)
Min: no shim (+5 mm)
Max: 3 shim (-10 mm)

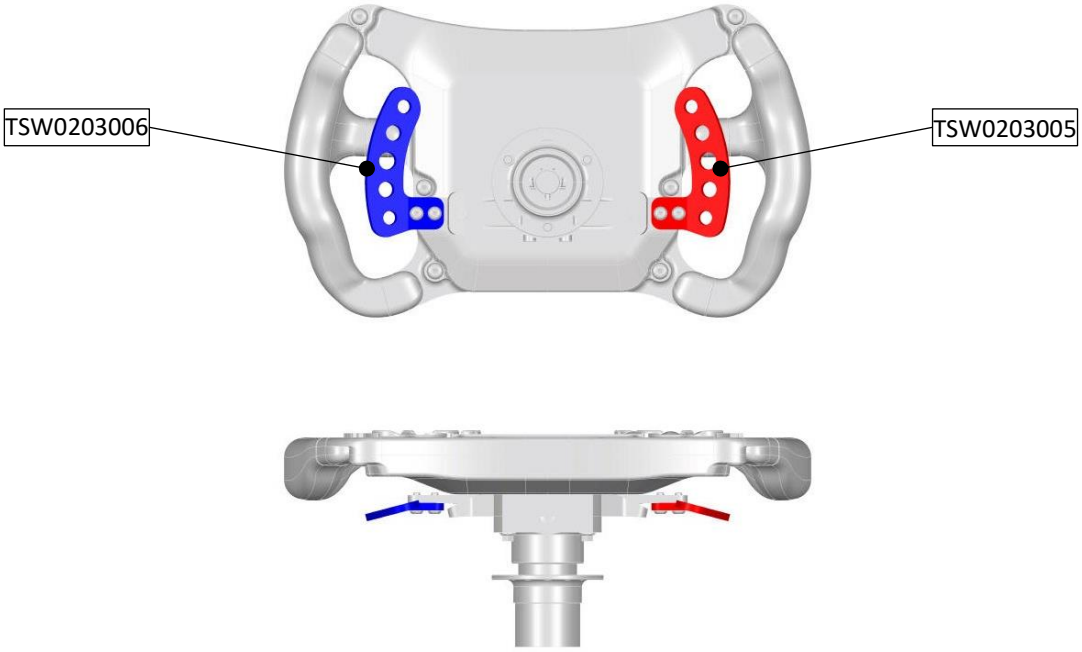
After any stack setting, it is reminded to check the correct alignment of the forward column bracket. Adjust its vertical position if necessary.



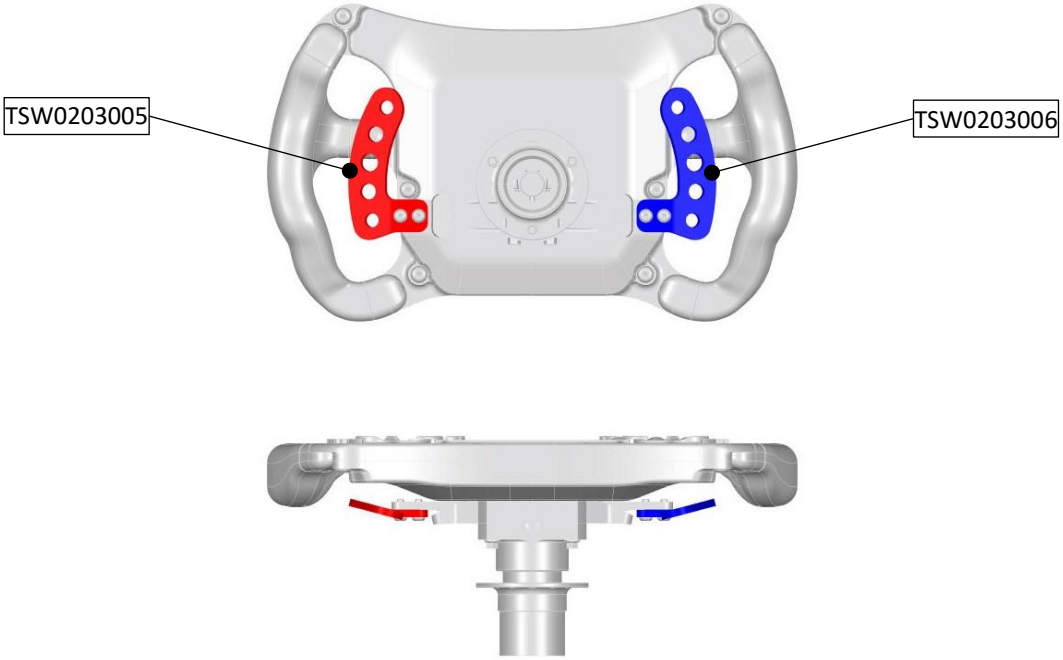


3.7.3 Gearshift paddles

Please find below the standard delivery configuration for the gearshift paddles. The steering wheel comes with the paddle TSW0203006 on the RH side and with the TSW0203005 on the LH side

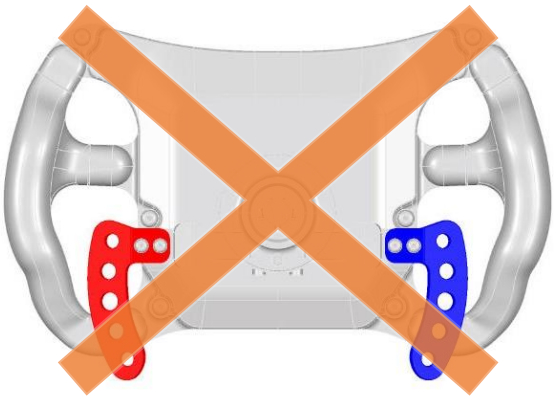


To improve driver ergonomics the paddles may be considered as alternative items. Please find in the picture below a possible configuration with paddles reverted compared to the standard delivery configuration.

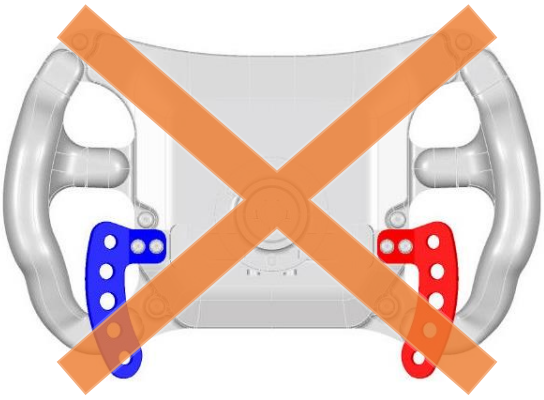


Please refer to the relevant sporting regulations for possible restrictions.

It is necessary that the longer tip of the paddle faces upwards, the configurations below must not be used.



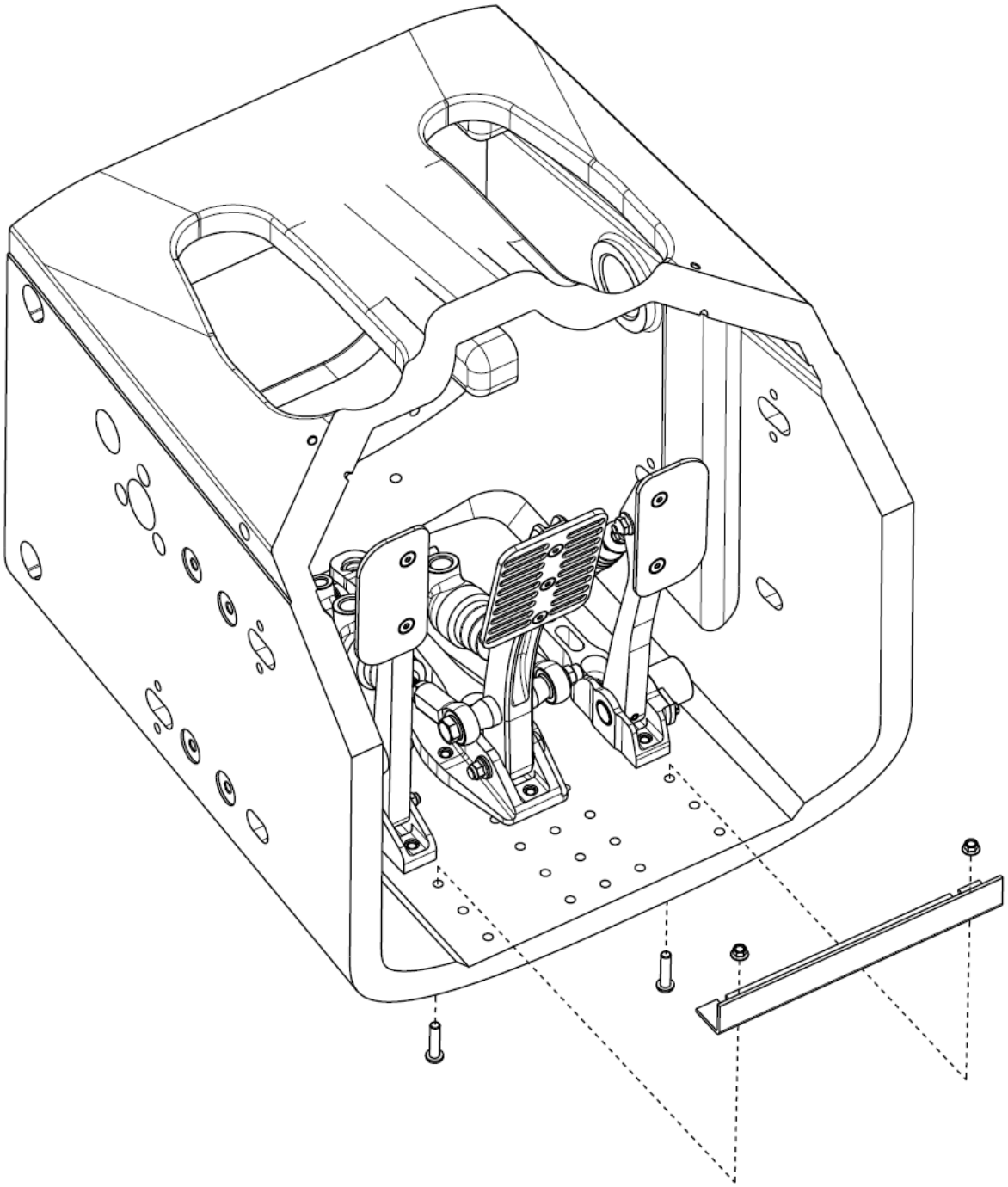
NOT ALLOWED



NOT ALLOWED

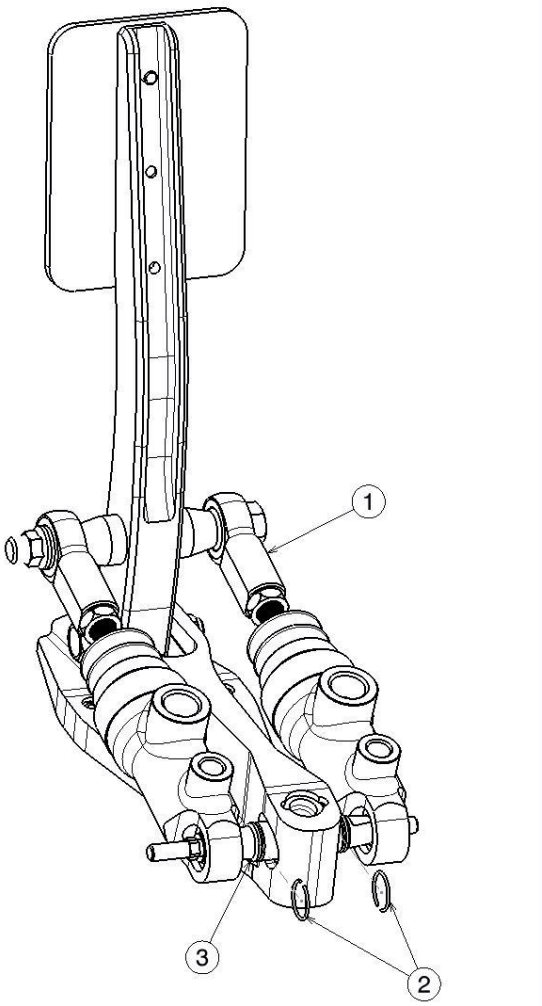
3.8 PEDALS

The three pedals may be placed independently, all of these are “standalone”.



3.8.1.1 Brake pedal

Rest position adjustment: operating on the rod end ① the pedal plate can be moved



It is recommended to inspect and set the brake balance ③ in order that the adjustment stops ② are correctly in position and far from their contact.

It is recommended to replace the balance bar and the pedal base every 10’000 km.

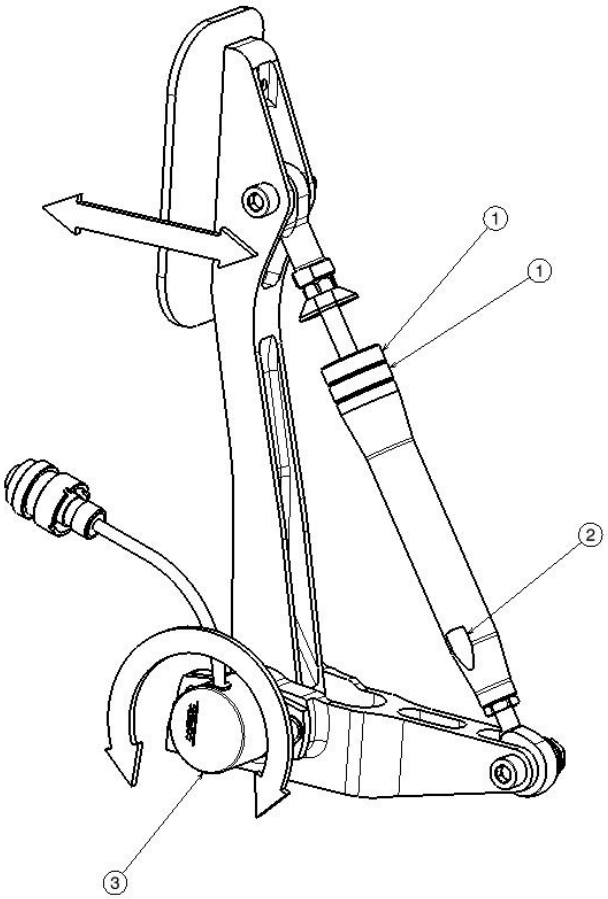
3.8.1.2 Throttle pedal

Rest position adjustment: operating on the bottom rod ends the pedal plate can be moved.

Stroke/full stroke: the stroke and the final position can be adjusted adding or removing shims ① on the damper shaft.

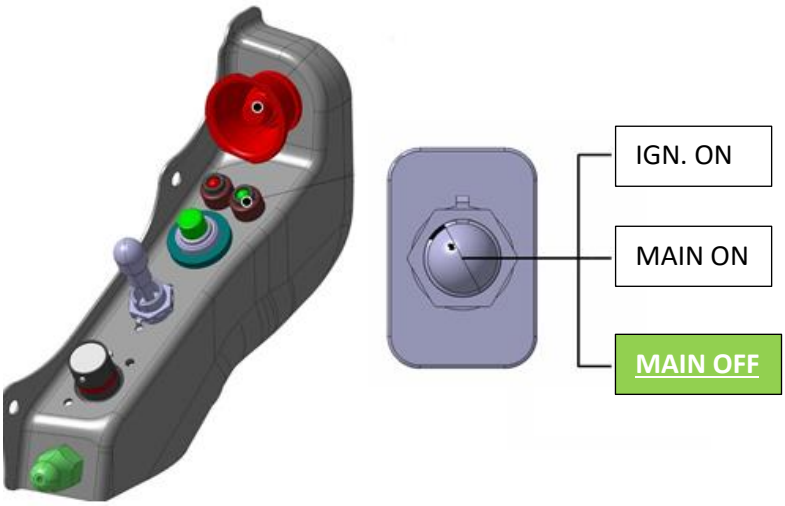
The throttle potentiometer has to be checked after every pedal adjustment in order to meet the calibration thresholds. Please refer to the Engine Manual for the thresholds for full stroke and resting position.

After every operation on the pedal the throttle learning must be repeated.



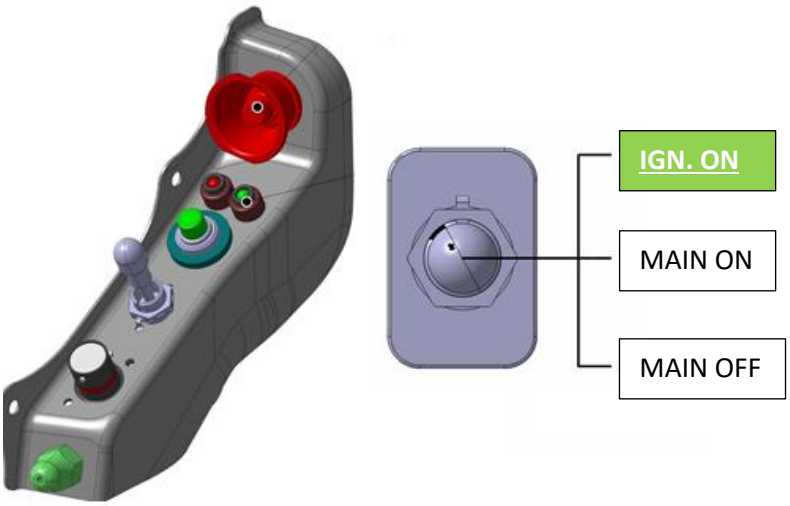
3.8.1.3 Throttle pedal learning

1. **Adjust** the pedal potentiometer position according to the threshold for the rest and full stroke position stated in the engine manual.
2. **Switch OFF** the car



3. **Push and hold** the throttle pedal to full stroke

4. **Switch ON** in IGNITION ON condition



5. The steering wheel powers up on the page 2. Check for the bottom right corner of the dash. When the box shown below appears, **release** the throttle pedal

6. On the bottom right corner of the dash will be displayed the message below

During this waiting period the throttle body is commanded by the ECU from full closed to full stroke, then back to full closed. It is possible to hear it moving.

7. If the pedal learning is completed successfully the dash will display the message below

Power cycle the car: switch OFF and then ON the electric system in order to save the learning executed.

If the pedal learning is not successful the message below is displayed

In this case, switch off the car and check for possible issues preventing the pedal learning procedure.

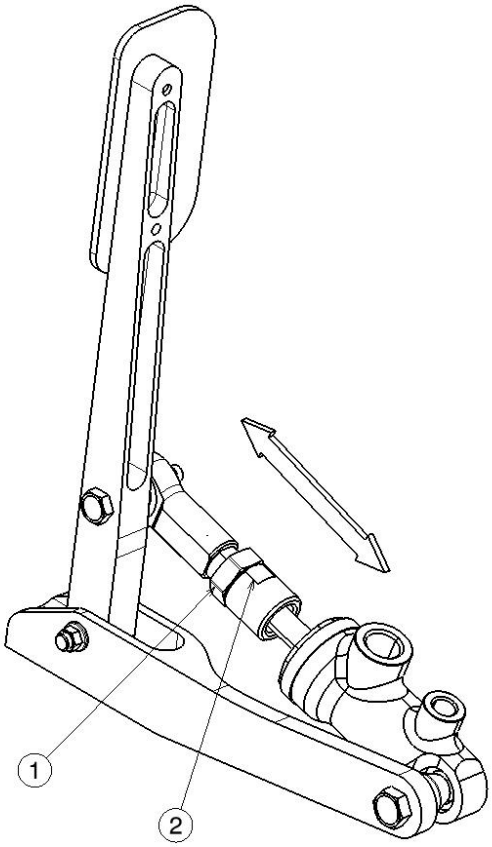
Most common causes of failed pedal learning procedures are:

- Main switch in MAIN on condition and not in IGN ON condition.
- Full stroke and rest position of the pedal out of threshold. Switch ON the car and check on the dashboard page 2 the values Pedal 1 and Pedal 2
- Faulty readings of the pedal position sensor. Switch ON the car and check on the dashboard page 2 the values Pedal 1 and Pedal 2.

3.8.1.4 Clutch pedal

Rest position adjustment: operating on the rod end the pedal plate can be moved.

Stroke/full stroke: the stroke and the final position can be adjusted operating on the bush ②, counter nut ① must then be locked.



The standard master cylinder for clutch actuation is a 5/8", here below a guideline of theoretical strokes to operate the clutch mechanism compared to the optional master cylinders available:

Master cylinder [mm]	**5/8" (15.88mm)**	**3/4" (19.05mm)**	**13/16" (20.64mm)**
Slave cylinder displacement [mm]	2.5	2.5	2.5
Master cylinder displacement [mm]	11.7	8.1	6.9
Pedal "top" displacement [mm]	53	37	31

3.8.2 Heel rest

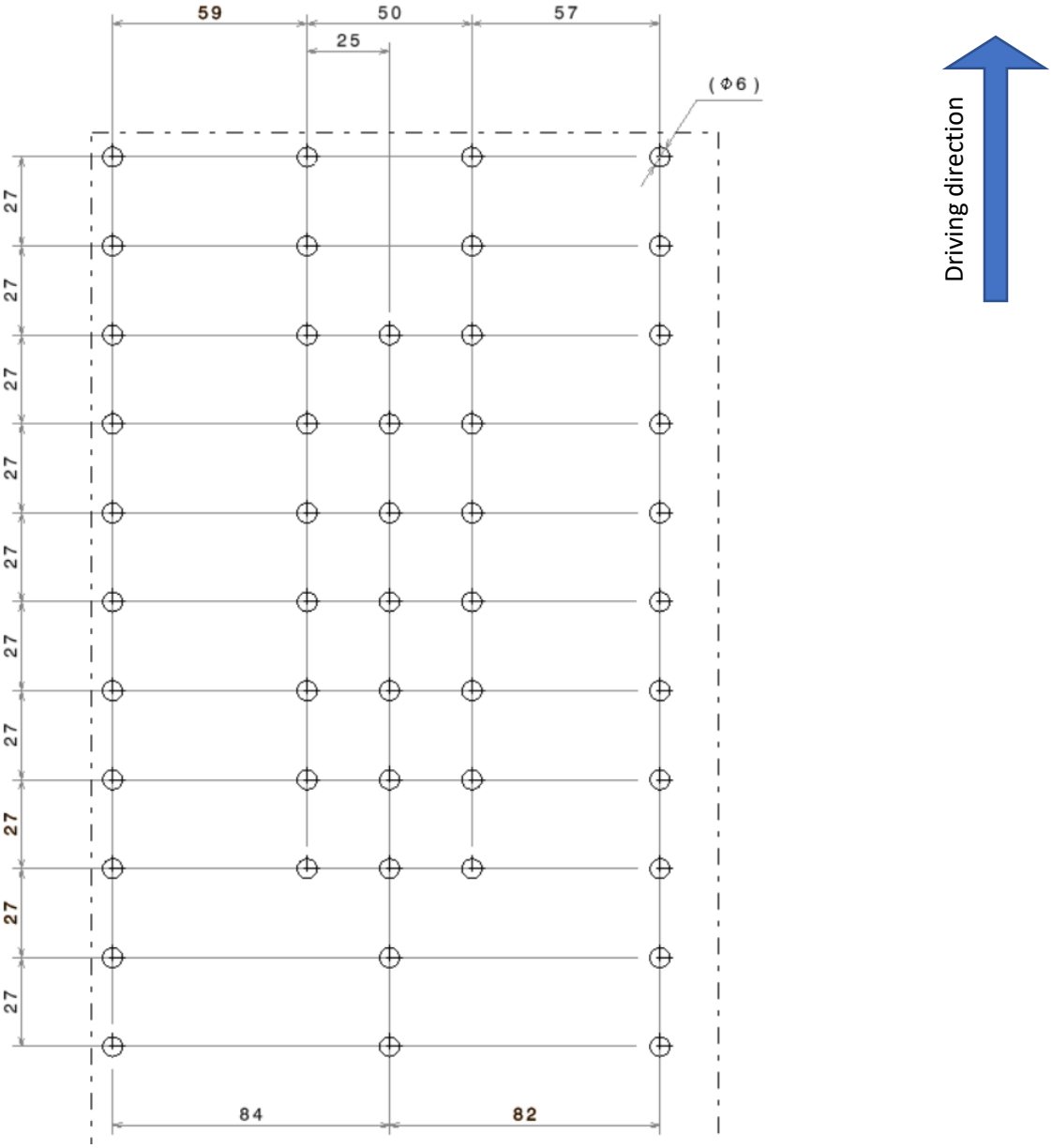
An heel rest may be fitted, provided that it fulfills just the functions listed below

- support the driver's heel
- allow to raise the driver's feet

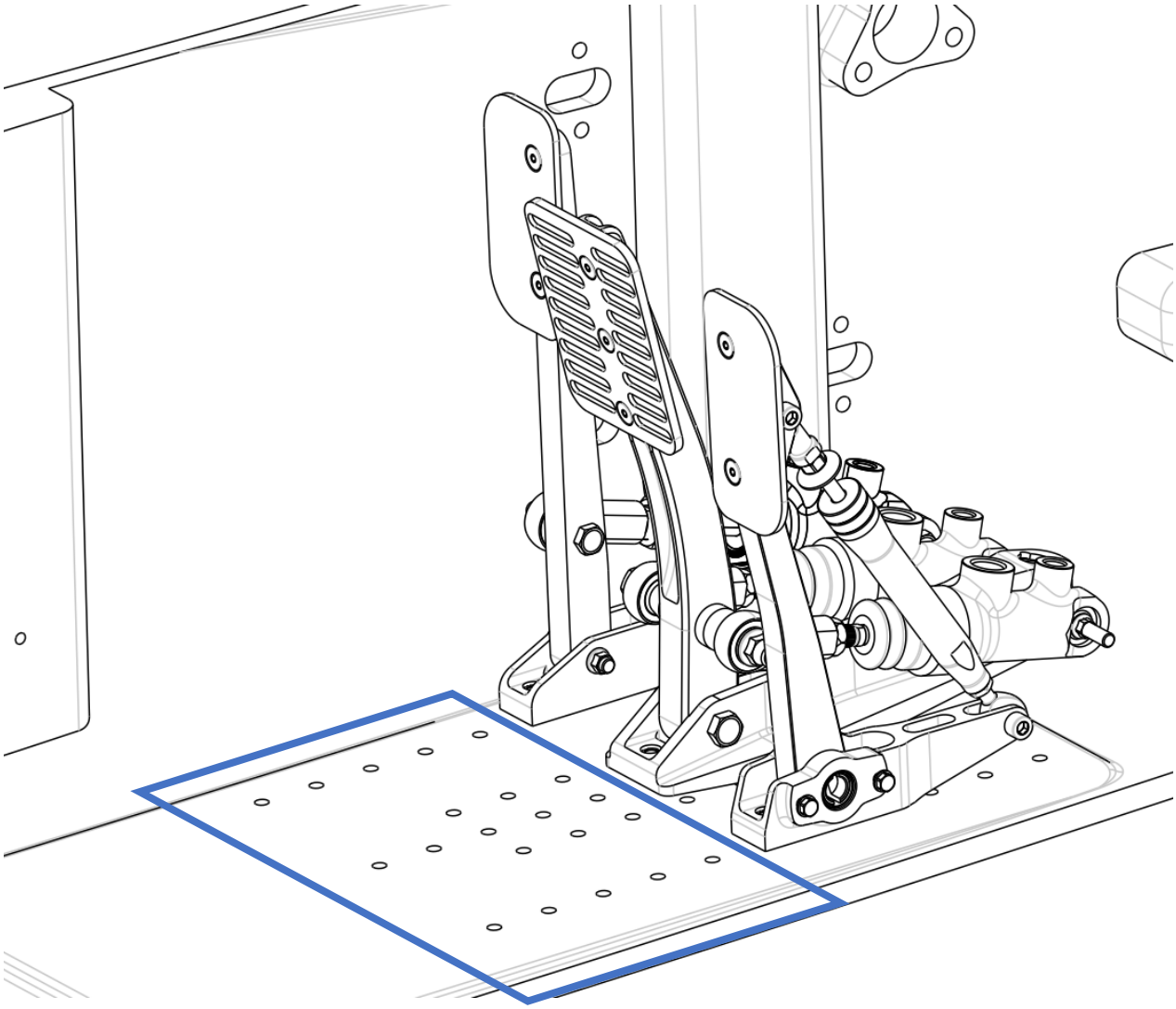
The heel rest should be made of homogeneous material.

While manufacturing the heel rest make sure that it does not put any sharp edge in place.

Please find in the drawing below the pedal board mounting holes pattern for reference



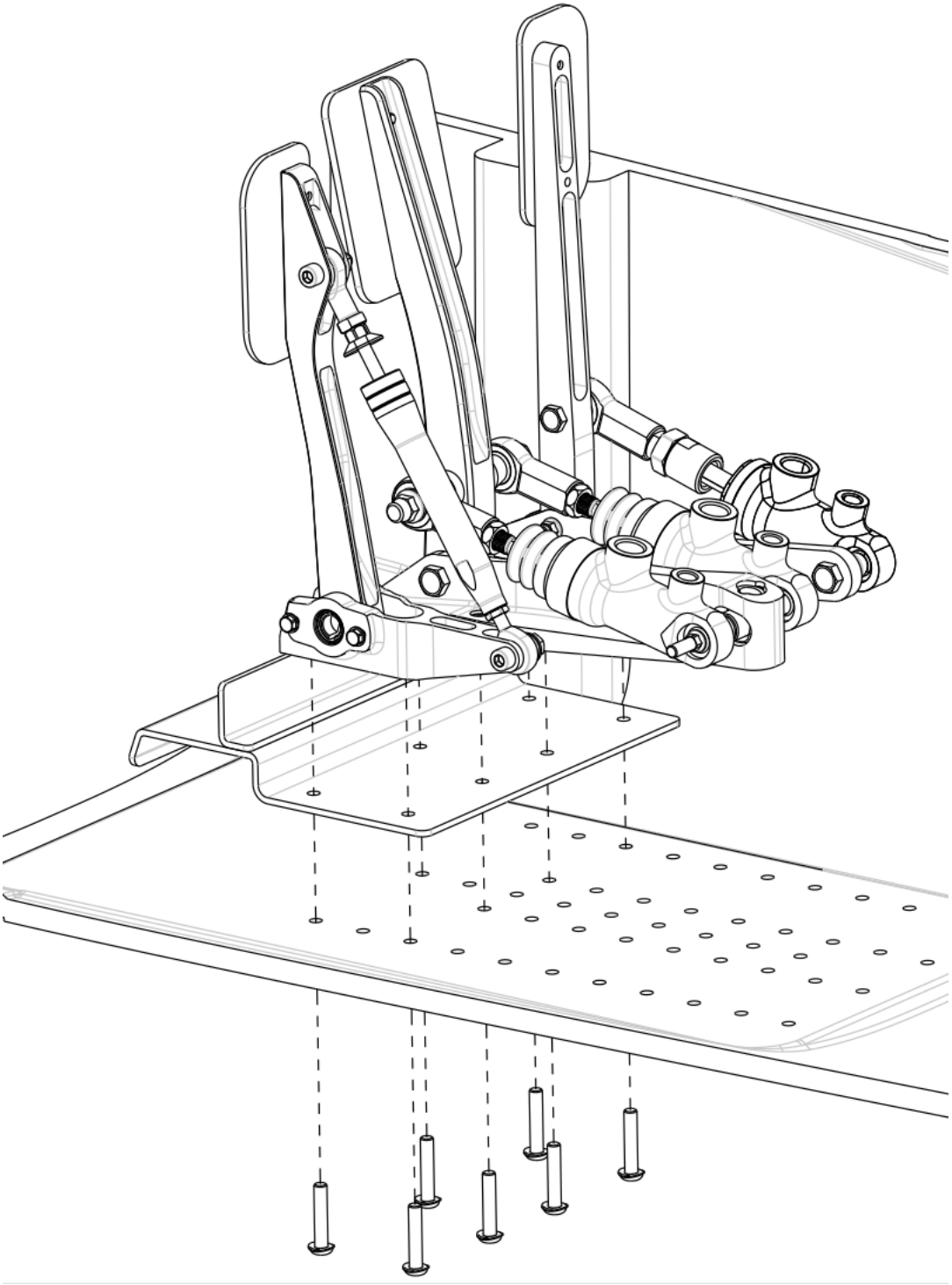
To assure pedals and heel rest stability it is recommended to bolt the heel rest on the unused holes placed rearwards of the pedals. Please refer in the picture below to the blue highlighted area



If not possible to bolt the heel rest on the unused holes:

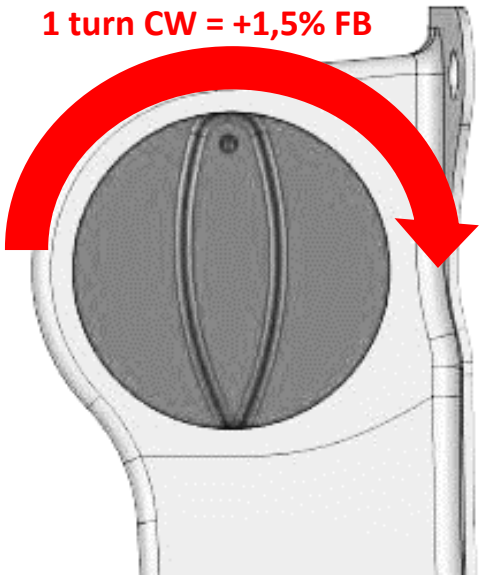
- it should be held on the same bolts used to fit the pedals.
- it should be placed between the pedal base and the internal chassis floor in a way that the bottom surface of the pedal bases are fully supported by the heel rest.
- It should be fixed with holes, oblong profiles (like keyhole or button hole) are not possible.
- the length of the bolts to install the pedals shall be increased accordingly to the heel rest thickness.

Please refer to the pictures below as reference example.



3.8.3 Brake Bias

The brake bias knob is located on the right-hand side of the driver seat.
Rotating clockwise will shift the brake balance towards front: with the standard master cylinders (Front = 19.05 mm, Rear = 20.68 mm) 1 complete turn give a +1.5% front balance.



Brake pressure (Front and Rear) and Brake Bias, defined as

$$PBrake_{FRONT}\% = \frac{PBrake_{FRONT}}{PBrake_{FRONT} + PBrake_{REAR}}$$

can be checked on page 2 of the steering wheel.

3.8.4 Brake Bias Cable

Two options are available, standard length with p/n 2420007 and short version with p/n 2420009.

4 AERODYNAMICS

4.1 GENERAL NOTES

Drag [SCx]: total drag (including wheels) of the car resolved to the tire contact point.
Downforce [SCz]: total downforce generated by the car.
Front downforce: downforce acting at the front contact patches.
Rear downforce: downforce acting at the rear contact patches.
Balance %F: percentage of the total downforce acting at the front contact patches.
E = L/D: vehicle efficiency

All dimensions are full scale.

Aerodynamic loading is a function of atmospheric conditions:

- 5°C increase in ambient temperature from ISA conditions result in a 2.7% reduction in aerodynamic forces.
- 10 mbar increase in air pressure from ISA conditions results in a 1% increase in aerodynamic forces.
- 50% increase in humidity from ISA conditions results in a 0.3% reduction in aerodynamic loading.

4.2 AERODYNAMIC SENSITIVITY

4.2.1 Aerodynamic maps datum point:

FRONT RIDE HEIGHT:	15 mm
REAR RIDE HEIGHT:	35 mm
FRONT WING ASSY ANGLE:	5° + GF15
REAR WING TOP ASSEMBLY ANGLE:	C1 (12°)

Front Ride Height (FRH) is the distance between the ground and a point intersection of the Reference Plane (5mm above the lower surface of the skid block when new, plane between the skid block and the wooden plank) with a plane orthogonal to both the Reference Plane and the car symmetry plane passing on the Front Wheel Centre Line.
Rear Ride Height (RRH) is the distance between the ground and a point intersection of the Reference Plane (5mm above the lower surface of the skid block when new, plane between the skid block and the wooden plank) with a plane orthogonal to both the Reference Plane and the car symmetry plane passing on the Rear Wheel Centre Line.

At the datum point aerodynamic coefficients will be:

SC_Z = 100%

SC_X = 100%

$\%F = \frac{SC_{Z_{FRONT}}}{SC_{Z_{TOT}}}$ = 40%

4.2.2 Aerodynamic sensitivity definition

All maps' points are percentual variations with respect to the aerodynamic datum point (shown in par.4.2.1). So, if the datum point is:

SC_Z = 100%
SC_X = 100%
$\%F$ = 40%

A variation of (e.g.) -15% of all the coefficients will bring to:

$\widetilde{SC_Z}$ = 100% * (100%-15%) = 85%
$\widetilde{SC_X}$ = 100% * (100%-15%) = 85%
$\widetilde{\%F}$ = 40% * (100%-15%) = 34%

4.3 Front Wing Setting

Front flap angle is adjustable with shims:

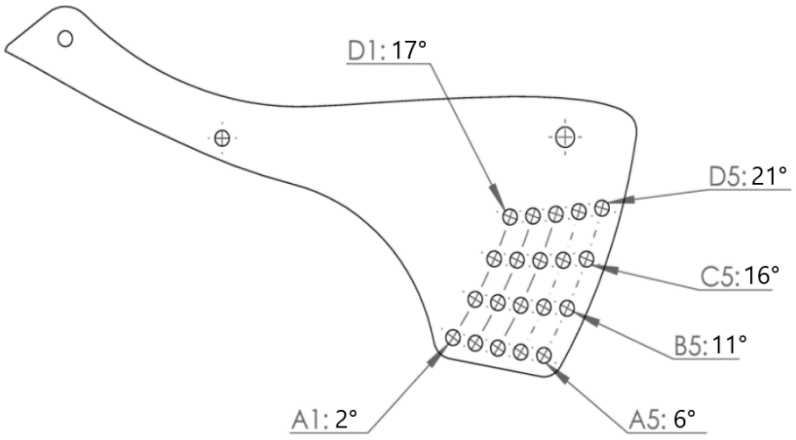
- 16 14 04 035 FW adjuster 3°
- 16 14 04 015 FW adjuster 5°
- 16 14 04 032 FW adjuster 7°

On the Front Wing it is allowed the use of the homologated gurney flaps:

- 16 14 04 023 (LH side)
- 16 14 04 024 (RH side)

4.4 Rear Wing Setting

Rear wing angle in the following tables is the angle between the tangent on the upper side of the rear wing (without gurney flap) and the reference plane:



	A	B	C	D
1	2°	7°	12°	17°
2	3°	8°	13°	18°
3	4°	9°	14°	19°
4	5°	10°	15°	20°
5	6°	11°	16°	21°

TATUUS recall that, by FIA Technical Regulation, the use of gurney flaps on any of the rear aerofoils is currently not allowed.

4.5 WING SENSITIVITY

The following tables report the percentage changes from the datum point resulting from the change of flap angles (FW = Front Wing Angle / RW = Rear Top Wing Angle).

4.5.1 Wing Sensitivity with FW gurney flaps h15 installed

	%F		FW →		
			3	5	7
RW ↓	A1	2	+11.2%	+26.0%	+38.4%
	A2	3	+8.1%	+22.9%	+35.3%
	A3	4	+5.0%	+19.8%	+32.2%
	A4	5	+2.1%	+16.9%	+29.3%
	A5	6	-0.7%	+14.1%	+26.5%
	B1	7	-3.3%	+11.5%	+23.9%
	B2	8	-5.9%	+8.9%	+21.3%
	B3	9	-8.3%	+6.5%	+18.9%
	B4	10	-10.6%	+4.2%	+16.6%
	B5	11	-12.8%	+2.0%	+14.4%
	C1	12	-14.8%	+0.0%	+12.4%
	C2	13	-16.7%	-1.9%	+10.5%
	C3	14	-18.5%	-3.7%	+8.7%
	C4	15	-20.2%	-5.4%	+7.0%
	C5	16	-21.8%	-7.0%	+5.4%
	D1	17	-23.2%	-8.4%	+4.0%
	D2	18	-24.5%	-9.7%	+2.7%
	D3	19	-25.7%	-10.9%	+1.5%
	D4	20	-26.8%	-11.9%	+0.4%
	D5	21	-27.7%	-12.9%	-0.5%

	SCz		FW →		
			3	5	7
RW ↓	A1	2	82.3%	85.8%	86.8%
	A2	3	83.9%	87.4%	88.5%
	A3	4	85.5%	89.0%	90.1%
	A4	5	87.1%	90.6%	91.6%
	A5	6	88.6%	92.1%	93.1%
	B1	7	90.1%	93.5%	94.6%
	B2	8	91.5%	94.9%	96.0%
	B3	9	92.8%	96.3%	97.3%
	B4	10	94.1%	97.6%	98.6%
	B5	11	95.4%	98.8%	99.9%
	C1	12	96.6%	100.0%	101.1%
	C2	13	97.7%	101.2%	102.2%
	C3	14	98.8%	102.3%	103.4%
	C4	15	99.9%	103.4%	104.4%
	C5	16	100.9%	104.4%	105.4%
	D1	17	101.9%	105.3%	106.4%
	D2	18	102.8%	106.2%	107.3%
	D3	19	103.6%	107.1%	108.1%
	D4	20	104.4%	107.9%	109.0%
	D5	21	105.2%	108.7%	109.7%

	SCx		FW →		
			3	5	7
RW ↓	A1	2	89.8%	91.1%	92.4%
	A2	3	90.6%	92.0%	93.3%
	A3	4	91.5%	92.9%	94.2%
	A4	5	92.4%	93.8%	95.1%
	A5	6	93.3%	94.7%	96.0%
	B1	7	94.2%	95.6%	96.9%
	B2	8	95.1%	96.4%	97.7%
	B3	9	96.0%	97.3%	98.6%
	B4	10	96.9%	98.2%	99.5%
	B5	11	97.8%	99.1%	100.4%
	C1	12	98.7%	100.0%	101.3%
	C2	13	99.6%	100.9%	102.2%
	C3	14	100.4%	101.8%	103.1%
	C4	15	101.3%	102.7%	104.0%
	C5	16	102.2%	103.6%	104.9%
	D1	17	103.1%	104.4%	105.7%
	D2	18	104.0%	105.3%	106.6%
	D3	19	104.9%	106.2%	107.5%
	D4	20	105.8%	107.1%	108.4%
	D5	21	106.7%	108.0%	109.3%

4.5.2 Wing Sensitivity with FW gurney flaps h15 NOT installed

	%F		FW →		
			3	5	7
RW ↓	A1	2	-20.8%	-6.0%	+9.2%
	A2	3	-23.9%	-9.1%	+6.0%
	A3	4	-27.0%	-12.1%	+3.0%
	A4	5	-29.9%	-15.1%	+0.1%
	A5	6	-32.7%	-17.8%	-2.7%
	B1	7	-35.3%	-20.5%	-5.4%
	B2	8	-37.9%	-23.1%	-7.9%
	B3	9	-40.3%	-25.5%	-10.4%
	B4	10	-42.6%	-27.8%	-12.7%
	B5	11	-44.8%	-29.9%	-14.8%
	C1	12	-46.8%	-32.0%	-16.9%
	C2	13	-48.7%	-33.9%	-18.8%
	C3	14	-50.5%	-35.7%	-20.6%
	C4	15	-52.2%	-37.4%	-22.3%
	C5	16	-53.8%	-38.9%	-23.8%
	D1	17	-55.2%	-40.4%	-25.3%
	D2	18	-56.5%	-41.7%	-26.6%
	D3	19	-57.7%	-42.9%	-27.8%
	D4	20	-58.7%	-43.9%	-28.8%
	D5	21	-59.7%	-44.9%	-29.8%

	SCz		FW →		
			3	5	7
RW ↓	A1	2	75.7%	78.0%	80.1%
	A2	3	77.1%	79.5%	81.6%
	A3	4	78.4%	80.9%	83.1%
	A4	5	79.8%	82.3%	84.5%
	A5	6	81.1%	83.6%	85.9%
	B1	7	82.3%	84.9%	87.2%
	B2	8	83.5%	86.1%	88.5%
	B3	9	84.7%	87.3%	89.7%
	B4	10	85.8%	88.5%	90.9%
	B5	11	86.9%	89.6%	92.0%
	C1	12	87.9%	90.6%	93.1%
	C2	13	88.9%	91.7%	94.2%
	C3	14	89.8%	92.6%	95.2%
	C4	15	90.8%	93.6%	96.1%
	C5	16	91.6%	94.5%	97.0%
	D1	17	92.4%	95.3%	97.9%
	D2	18	93.2%	96.1%	98.7%
	D3	19	94.0%	96.9%	99.5%
	D4	20	94.6%	97.6%	100.2%
	D5	21	95.3%	98.3%	100.9%

	SCx		FW →		
			3	5	7
RW ↓	A1	2	87.9%	89.4%	90.5%
	A2	3	88.7%	90.2%	91.4%
	A3	4	89.6%	91.1%	92.3%
	A4	5	90.4%	92.0%	93.2%
	A5	6	91.3%	92.8%	94.0%
	B1	7	92.1%	93.7%	94.9%
	B2	8	93.0%	94.5%	95.8%
	B3	9	93.8%	95.4%	96.6%
	B4	10	94.6%	96.3%	97.5%
	B5	11	95.5%	97.1%	98.4%
	C1	12	96.3%	98.0%	99.2%
	C2	13	97.2%	98.8%	100.1%
	C3	14	98.0%	99.7%	101.0%
	C4	15	98.8%	100.5%	101.8%
	C5	16	99.7%	101.4%	102.7%
	D1	17	100.5%	102.2%	103.6%
	D2	18	101.4%	103.1%	104.4%
	D3	19	102.2%	103.9%	105.3%
	D4	20	103.0%	104.8%	106.2%
	D5	21	103.9%	105.6%	107.0%

4.6 RIDE HEIGHT SENSITIVITY

The Ride Height Sensitivity is referred to a configuration with gurney flaps installed.
The following tables report the percentage changes from the datum point resulting from the change of the ride heights (FRH = Front Ride Height / RRH = Rear Ride Height):

%F		RRH →																						
		20	22,5	25	27,5	30	32,5	35	37,5	40	42,5	45	47,5	50	52,5	55	57,5	60	62,5	65	67,5	70	72,5	75
FRH ↓	5	+1,9%	+3,9%	+5,8%	+7,7%	+9,7%	+11,6%	+13,5%	+15,4%	+17,4%	+19,3%	+21,2%	+23,2%	+25,1%	+27,0%	+29,0%	+30,9%	+32,8%	+34,8%	+36,7%	+38,6%	+40,6%	+42,5%	+44,4%
	6	+0,6%	+2,5%	+4,4%	+6,4%	+8,3%	+10,2%	+12,2%	+14,1%	+16,0%	+18,0%	+19,9%	+21,8%	+23,7%	+25,7%	+27,6%	+29,5%	+31,5%	+33,4%	+35,3%	+37,3%	+39,2%	+41,1%	+43,1%
	7	-0,8%	+1,2%	+3,1%	+5,0%	+6,9%	+8,9%	+10,8%	+12,7%	+14,7%	+16,6%	+18,5%	+20,5%	+22,4%	+24,3%	+26,3%	+28,2%	+30,1%	+32,1%	+34,0%	+35,9%	+37,8%	+39,8%	+41,7%
	8	-2,1%	-0,2%	+1,7%	+3,7%	+5,6%	+7,5%	+9,5%	+11,4%	+13,3%	+15,3%	+17,2%	+19,1%	+21,0%	+23,0%	+24,9%	+26,8%	+28,8%	+30,7%	+32,6%	+34,6%	+36,5%	+38,4%	+40,4%
	9	-3,5%	-1,5%	+0,4%	+2,3%	+4,2%	+6,2%	+8,1%	+10,0%	+12,0%	+13,9%	+15,8%	+17,8%	+19,7%	+21,6%	+23,6%	+25,5%	+27,4%	+29,4%	+31,3%	+33,2%	+35,1%	+37,1%	+39,0%
	10	-4,8%	-2,9%	-1,0%	+1,0%	+2,9%	+4,8%	+6,8%	+8,7%	+10,6%	+12,6%	+14,5%	+16,4%	+18,3%	+20,3%	+22,2%	+24,1%	+26,1%	+28,0%	+29,9%	+31,9%	+33,8%	+35,7%	+37,7%
	11	-6,2%	-4,3%	-2,3%	-0,4%	+1,5%	+3,5%	+5,4%	+7,3%	+9,3%	+11,2%	+13,1%	+15,1%	+17,0%	+18,9%	+20,9%	+22,8%	+24,7%	+26,6%	+28,6%	+30,5%	+32,4%	+34,4%	+36,3%
	12	-7,5%	-5,6%	-3,7%	-1,7%	+0,2%	+2,1%	+4,1%	+6,0%	+7,9%	+9,8%	+11,8%	+13,7%	+15,6%	+17,6%	+19,5%	+21,4%	+23,4%	+25,3%	+27,2%	+29,2%	+31,1%	+33,0%	+35,0%
	13	-8,9%	-7,0%	-5,0%	-3,1%	-1,2%	+0,8%	+2,7%	+4,6%	+6,6%	+8,5%	+10,4%	+12,4%	+14,3%	+16,2%	+18,2%	+20,1%	+22,0%	+23,9%	+25,9%	+27,8%	+29,7%	+31,7%	+33,6%
	14	-10,2%	-8,3%	-6,4%	-4,4%	-2,5%	-0,6%	+1,4%	+3,3%	+5,2%	+7,1%	+9,1%	+11,0%	+12,9%	+14,9%	+16,8%	+18,7%	+20,7%	+22,6%	+24,5%	+26,5%	+28,4%	+30,3%	+32,3%
	15	-11,6%	-9,7%	-7,7%	-5,8%	-3,9%	-1,9%	+0,0%	+1,9%	+3,9%	+5,8%	+7,7%	+9,7%	+11,6%	+13,5%	+15,4%	+17,4%	+19,3%	+21,2%	+23,2%	+25,1%	+27,0%	+29,0%	+30,9%
	16	-12,9%	-11,0%	-9,1%	-7,1%	-5,2%	-3,3%	-1,4%	+0,6%	+2,5%	+4,4%	+6,4%	+8,3%	+10,2%	+12,2%	+14,1%	+16,0%	+18,0%	+19,9%	+21,8%	+23,8%	+25,7%	+27,6%	+29,5%
	17	-14,3%	-12,4%	-10,4%	-8,5%	-6,6%	-4,6%	-2,7%	-0,8%	+1,2%	+3,1%	+5,0%	+7,0%	+8,9%	+10,8%	+12,7%	+14,7%	+16,6%	+18,5%	+20,5%	+22,4%	+24,3%	+26,3%	+28,2%
	18	-15,6%	-13,7%	-11,8%	-9,8%	-7,9%	-6,0%	-4,1%	-2,1%	-0,2%	+1,7%	+3,7%	+5,6%	+7,5%	+9,5%	+11,4%	+13,3%	+15,3%	+17,2%	+19,1%	+21,1%	+23,0%	+24,9%	+26,8%
	19	-17,0%	-15,1%	-13,1%	-11,2%	-9,3%	-7,3%	-5,4%	-3,5%	-1,5%	+0,4%	+2,3%	+4,3%	+6,2%	+8,1%	+10,0%	+12,0%	+13,9%	+15,8%	+17,8%	+19,7%	+21,6%	+23,6%	+25,5%
	20	-18,3%	-16,4%	-14,5%	-12,6%	-10,6%	-8,7%	-6,8%	-4,8%	-2,9%	-1,0%	+1,0%	+2,9%	+4,8%	+6,8%	+8,7%	+10,6%	+12,6%	+14,5%	+16,4%	+18,3%	+20,3%	+22,2%	+24,1%
	21		-17,8%	-15,8%	-13,9%	-12,0%	-10,0%	-8,1%	-6,2%	-4,2%	-2,3%	-0,4%	+1,5%	+3,5%	+5,4%	+7,3%	+9,3%	+11,2%	+13,1%	+15,1%	+17,0%	+18,9%	+20,9%	+22,8%
	22		-19,1%	-17,2%	-15,3%	-13,3%	-11,4%	-9,5%	-7,5%	-5,6%	-3,7%	-1,7%	+0,2%	+2,1%	+4,1%	+6,0%	+7,9%	+9,9%	+11,8%	+13,7%	+15,6%	+17,6%	+19,5%	+21,4%
	23			-18,5%	-16,6%	-14,7%	-12,7%	-10,8%	-8,9%	-6,9%	-5,0%	-3,1%	-1,2%	+0,8%	+2,7%	+4,6%	+6,6%	+8,5%	+10,4%	+12,4%	+14,3%	+16,2%	+18,2%	+20,1%
	24			-19,9%	-18,0%	-16,0%	-14,1%	-12,2%	-10,2%	-8,3%	-6,4%	-4,4%	-2,5%	-0,6%	+1,4%	+3,3%	+5,2%	+7,1%	+9,1%	+11,0%	+12,9%	+14,9%	+16,8%	+18,7%

SCz	RRH →																						
	20	22,5	25	27,5	30	32,5	35	37,5	40	42,5	45	47,5	50	52,5	55	57,5	60	62,5	65	67,5	70	72,5	75
5	113,6%	114,1%	114,5%	115,0%	115,5%	115,9%	116,4%	116,8%	117,3%	117,8%	118,2%	118,7%	119,1%	119,6%	120,1%	120,5%	121,0%	121,4%	121,9%	122,4%	122,8%	123,3%	123,7%
FRH 6	112,0%	112,4%	112,9%	113,4%	113,8%	114,3%	114,7%	115,2%	115,7%	116,1%	116,6%	117,0%	117,5%	118,0%	118,4%	118,9%	119,3%	119,8%	120,3%	120,7%	121,2%	121,6%	122,1%
7	110,3%	110,8%	111,3%	111,7%	112,2%	112,6%	113,1%	113,6%	114,0%	114,5%	114,9%	115,4%	115,9%	116,3%	116,8%	117,2%	117,7%	118,2%	118,6%	119,1%	119,5%	120,0%	120,5%
↓ 8	108,7%	109,2%	109,6%	110,1%	110,5%	111,0%	111,5%	111,9%	112,4%	112,8%	113,3%	113,8%	114,2%	114,7%	115,1%	115,6%	116,1%	116,5%	117,0%	117,5%	117,9%	118,4%	118,8%
9	107,1%	107,5%	108,0%	108,4%	108,9%	109,4%	109,8%	110,3%	110,7%	111,2%	111,7%	112,1%	112,6%	113,1%	113,5%	114,0%	114,4%	114,9%	115,4%	115,8%	116,3%	116,7%	117,2%
10	105,4%	105,9%	106,3%	106,8%	107,3%	107,7%	108,2%	108,7%	109,1%	109,6%	110,0%	110,5%	111,0%	111,4%	111,9%	112,3%	112,8%	113,3%	113,7%	114,2%	114,6%	115,1%	115,6%
11	103,8%	104,3%	104,7%	105,2%	105,6%	106,1%	106,6%	107,0%	107,5%	107,9%	108,4%	108,9%	109,3%	109,8%	110,2%	110,7%	111,2%	111,6%	112,1%	112,5%	113,0%	113,5%	113,9%
12	102,2%	102,6%	103,1%	103,5%	104,0%	104,5%	104,9%	105,4%	105,8%	106,3%	106,8%	107,2%	107,7%	108,1%	108,6%	109,1%	109,5%	110,0%	110,4%	110,9%	111,4%	111,8%	112,3%
13	100,5%	101,0%	101,4%	101,9%	102,4%	102,8%	103,3%	103,7%	104,2%	104,7%	105,1%	105,6%	106,0%	106,5%	107,0%	107,4%	107,9%	108,3%	108,8%	109,3%	109,7%	110,2%	110,6%
14	98,9%	99,3%	99,8%	100,3%	100,7%	101,2%	101,6%	102,1%	102,6%	103,0%	103,5%	103,9%	104,4%	104,9%	105,3%	105,8%	106,2%	106,7%	107,2%	107,6%	108,1%	108,5%	109,0%
15	97,2%	97,7%	98,2%	98,6%	99,1%	99,5%	100,0%	100,5%	100,9%	101,4%	101,8%	102,3%	102,8%	103,2%	103,7%	104,1%	104,6%	105,1%	105,5%	106,0%	106,4%	106,9%	107,4%
16	95,6%	96,1%	96,5%	97,0%	97,4%	97,9%	98,4%	98,8%	99,3%	99,7%	100,2%	100,7%	101,1%	101,6%	102,0%	102,5%	103,0%	103,4%	103,9%	104,3%	104,8%	105,3%	105,7%
17	94,0%	94,4%	94,9%	95,3%	95,8%	96,3%	96,7%	97,2%	97,6%	98,1%	98,6%	99,0%	99,5%	99,9%	100,4%	100,9%	101,3%	101,8%	102,2%	102,7%	103,2%	103,6%	104,1%
18	92,3%	92,8%	93,2%	93,7%	94,2%	94,6%	95,1%	95,5%	96,0%	96,5%	96,9%	97,4%	97,8%	98,3%	98,8%	99,2%	99,7%	100,1%	100,6%	101,1%	101,5%	102,0%	102,5%
19	90,7%	91,1%	91,6%	92,1%	92,5%	93,0%	93,4%	93,9%	94,4%	94,8%	95,3%	95,7%	96,2%	96,7%	97,1%	97,6%	98,1%	98,5%	99,0%	99,4%	99,9%	100,4%	100,8%
20	89,0%	89,5%	90,0%	90,4%	90,9%	91,3%	91,8%	92,3%	92,7%	93,2%	93,7%	94,1%	94,6%	95,0%	95,5%	96,0%	96,4%	96,9%	97,3%	97,8%	98,3%	98,7%	99,2%
21		87,9%	88,3%	88,8%	89,3%	89,7%	90,2%	90,6%	91,1%	91,6%	92,0%	92,5%	92,9%	93,4%	93,9%	94,3%	94,8%	95,2%	95,7%	96,2%	96,6%	97,1%	97,5%
22		86,2%	86,7%	87,2%	87,6%	88,1%	88,5%	89,0%	89,5%	89,9%	90,4%	90,8%	91,3%	91,8%	92,2%	92,7%	93,1%	93,6%	94,1%	94,5%	95,0%	95,4%	95,9%
23			85,1%	85,5%	86,0%	86,4%	86,9%	87,4%	87,8%	88,3%	88,7%	89,2%	89,7%	90,1%	90,6%	91,0%	91,5%	92,0%	92,4%	92,9%	93,3%	93,8%	94,3%
24			83,4%	83,9%	84,3%	84,8%	85,3%	85,7%	86,2%	86,6%	87,1%	87,6%	88,0%	88,5%	88,9%	89,4%	89,9%	90,3%	90,8%	91,2%	91,7%	92,2%	92,6%

SCx	RRH →																						
	20	22,5	25	27,5	30	32,5	35	37,5	40	42,5	45	47,5	50	52,5	55	57,5	60	62,5	65	67,5	70	72,5	75
5	100,5%	100,7%	100,8%	100,9%	101,0%	101,1%	101,2%	101,4%	101,5%	101,6%	101,7%	101,8%	101,9%	102,1%	102,2%	102,3%	102,4%	102,5%	102,6%	102,8%	102,9%	103,0%	103,1%
FRH 6	100,4%	100,5%	100,6%	100,8%	100,9%	101,0%	101,1%	101,2%	101,3%	101,5%	101,6%	101,7%	101,8%	101,9%	102,1%	102,2%	102,3%	102,4%	102,5%	102,6%	102,8%	102,9%	103,0%
7	100,3%	100,4%	100,5%	100,6%	100,8%	100,9%	101,0%	101,1%	101,2%	101,3%	101,5%	101,6%	101,7%	101,8%	101,9%	102,0%	102,2%	102,3%	102,4%	102,5%	102,6%	102,7%	102,9%
↓ 8	100,2%	100,3%	100,4%	100,5%	100,6%	100,8%	100,9%	101,0%	101,1%	101,2%	101,3%	101,5%	101,6%	101,7%	101,8%	101,9%	102,0%	102,2%	102,3%	102,4%	102,5%	102,6%	102,7%
9	100,0%	100,2%	100,3%	100,4%	100,5%	100,6%	100,7%	100,9%	101,0%	101,1%	101,2%	101,3%	101,4%	101,6%	101,7%	101,8%	101,9%	102,0%	102,1%	102,3%	102,4%	102,5%	102,6%
10	99,9%	100,0%	100,2%	100,3%	100,4%	100,5%	100,6%	100,7%	100,9%	101,0%	101,1%	101,2%	101,3%	101,4%	101,6%	101,7%	101,8%	101,9%	102,0%	102,1%	102,3%	102,4%	102,5%
11	99,8%	99,9%	100,0%	100,1%	100,3%	100,4%	100,5%	100,6%	100,7%	100,8%	101,0%	101,1%	101,2%	101,3%	101,4%	101,5%	101,7%	101,8%	101,9%	102,0%	102,1%	102,3%	102,4%
12	99,7%	99,8%	99,9%	100,0%	100,1%	100,3%	100,4%	100,5%	100,6%	100,7%	100,8%	101,0%	101,1%	101,2%	101,3%	101,4%	101,5%	101,7%	101,8%	101,9%	102,0%	102,1%	102,2%
13	99,5%	99,7%	99,8%	99,9%	100,0%	100,1%	100,2%	100,4%	100,5%	100,6%	100,7%	100,8%	100,9%	101,1%	101,2%	101,3%	101,4%	101,5%	101,7%	101,8%	101,9%	102,0%	102,1%
14	99,4%	99,5%	99,7%	99,8%	99,9%	100,0%	100,1%	100,2%	100,4%	100,5%	100,6%	100,7%	100,8%	100,9%	101,1%	101,2%	101,3%	101,4%	101,5%	101,6%	101,8%	101,9%	102,0%
15	99,3%	99,4%	99,5%	99,6%	99,8%	99,9%	100,0%	100,1%	100,2%	100,4%	100,5%	100,6%	100,7%	100,8%	100,9%	101,1%	101,2%	101,3%	101,4%	101,5%	101,6%	101,8%	101,9%
16	99,2%	99,3%	99,4%	99,5%	99,6%	99,8%	99,9%	100,0%	100,1%	100,2%	100,3%	100,5%	100,6%	100,7%	100,8%	100,9%	101,0%	101,2%	101,3%	101,4%	101,5%	101,6%	101,7%
17	99,1%	99,2%	99,3%	99,4%	99,5%	99,6%	99,8%	99,9%	100,0%	100,1%	100,2%	100,3%	100,5%	100,6%	100,7%	100,8%	100,9%	101,0%	101,2%	101,3%	101,4%	101,5%	101,6%
18	98,9%	99,0%	99,2%	99,3%	99,4%	99,5%	99,6%	99,7%	99,9%	100,0%	100,1%	100,2%	100,3%	100,4%	100,6%	100,7%	100,8%	100,9%	101,0%	101,1%	101,3%	101,4%	101,5%
19	98,8%	98,9%	99,0%	99,2%	99,3%	99,4%	99,5%	99,6%	99,7%	99,9%	100,0%	100,1%	100,2%	100,3%	100,4%	100,6%	100,7%	100,8%	100,9%	101,0%	101,1%	101,3%	101,4%
20	98,7%	98,8%	98,9%	99,0%	99,1%	99,3%	99,4%	99,5%	99,6%	99,7%	99,8%	100,0%	100,1%	100,2%	100,3%	100,4%	100,5%	100,7%	100,8%	100,9%	101,0%	101,1%	101,3%
21		98,7%	98,8%	98,9%	99,0%	99,1%	99,3%	99,4%	99,5%	99,6%	99,7%	99,8%	100,0%	100,1%	100,2%	100,3%	100,4%	100,5%	100,7%	100,8%	100,9%	101,0%	101,1%
22		98,5%	98,7%	98,8%	98,9%	99,0%	99,1%	99,2%	99,4%	99,5%	99,6%	99,7%	99,8%	100,0%	100,1%	100,2%	100,3%	100,4%	100,5%	100,7%	100,8%	100,9%	101,0%
23			98,5%	98,7%	98,8%	98,9%	99,0%	99,1%	99,2%	99,4%	99,5%	99,6%	99,7%	99,8%	99,9%	100,1%	100,2%	100,3%	100,4%	100,5%	100,6%	100,8%	100,9%
24			98,4%	98,5%	98,7%	98,8%	98,9%	99,0%	99,1%	99,2%	99,4%	99,5%	99,6%	99,7%	99,8%	99,9%	100,1%	100,2%	100,3%	100,4%	100,5%	100,6%	100,8%

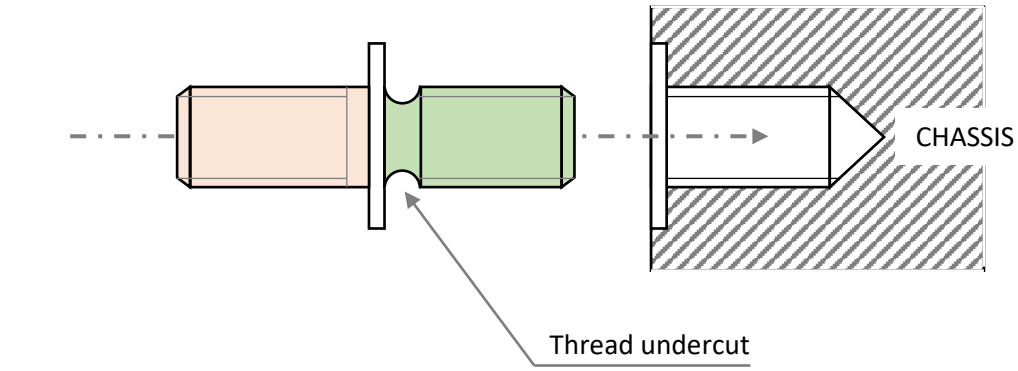
5 SUSPENSIONS

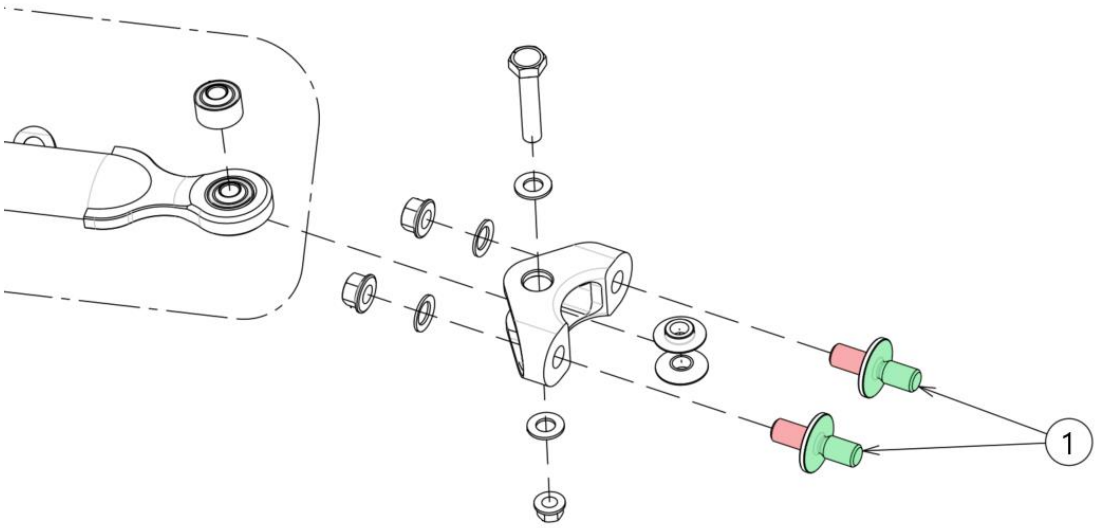
5.1 MEASUREMENT STANDARD

- ***REFERENCE PLANE***: it is the plane where skid block and wooden plank are in contact, the skid block is then the only suspended part of the car sitting below this plane.
- ***RIDE HEIGHT:*** it is measured at the intersection between the vertical plane passing through the axle and the vehicle center line. Zero when reference plane is coincident with ground, positive change when the car is raised.
- ***TOE:*** Zero when wheels are parallel, positive change when toe-out.
- ***CAMBER:*** Zero when wheels are vertical, positive change when the top of the wheel is outward
- ***CASTOR:*** Zero when steering axis is vertical, positive change when the contact patch is behind the intersection of steering axis and ground.

5.2 FRONT WISHBONES BRACKETS ASSEMBLY

During the assembly pay attention to the orientation of the wishbones brackets studs (items #1 below), **the thread undercut side is the one that must be assembled in the chassis**.

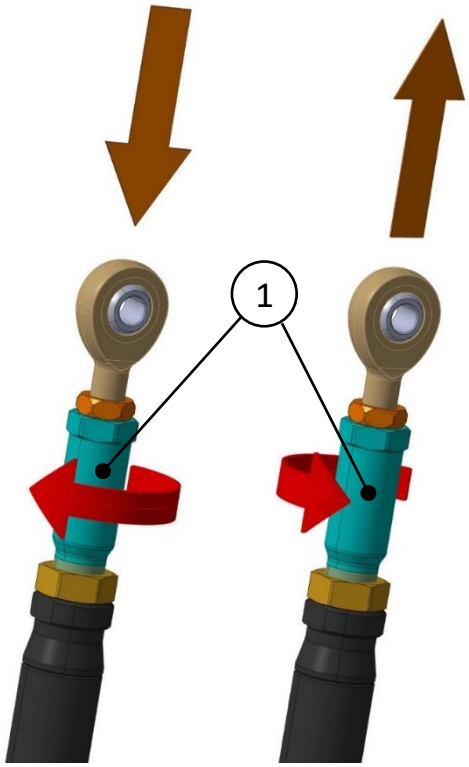




5.3 GEOMETRY ADJUSTMENTS

5.3.1 Ride height adjustment

Act on the adjustment element ① on the pushrod to modify the ride height of the car.

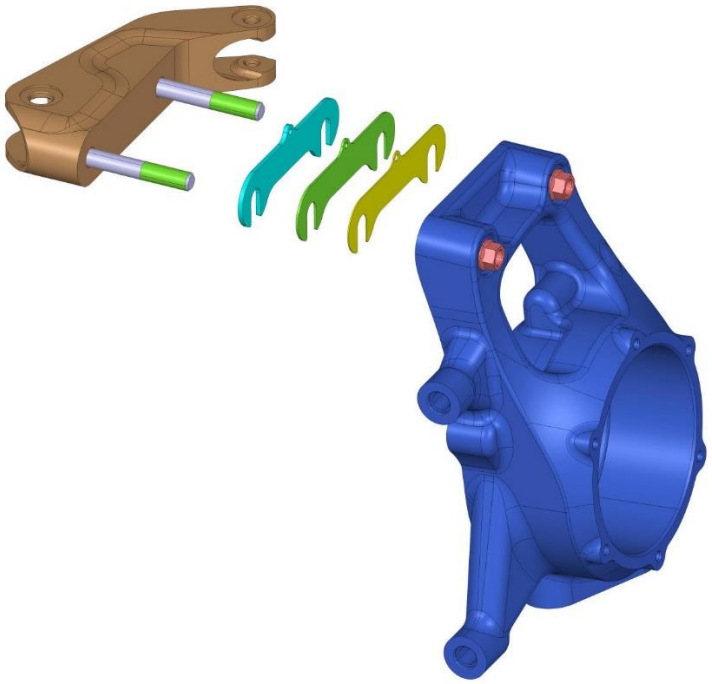


Refer to the table below for the effect of the adjustments on the front and rear ride height.

Ride height adjustment	Front Ride Height change	Rear Ride Height change
+1 turn	+5.4mm	+6.5mm

5.3.2 Camber adjustment

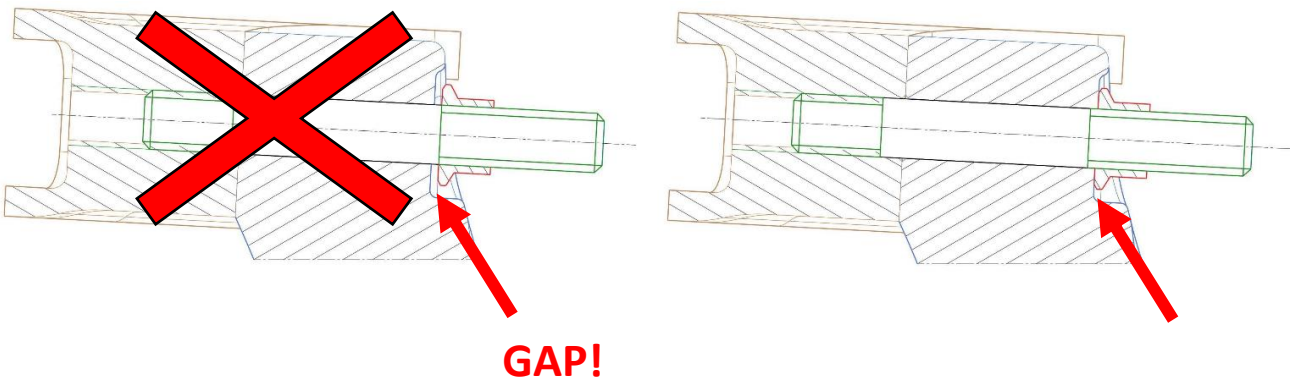
Front camber is set changing the shims stack between Ackermann and the upright:



Camber adjustment	Front	Rear
	Camber change	**Camber change**
+1 mm	+0.42 deg (+25’)	+0.3 deg (+18’)
Max camber shim	13 mm	11 mm
Min camber shim	0 mm	0 mm

Warning:

After any camber settings, check the proper tightening of the nuts and ensure the correct clamping of the Ackermann on the upright.



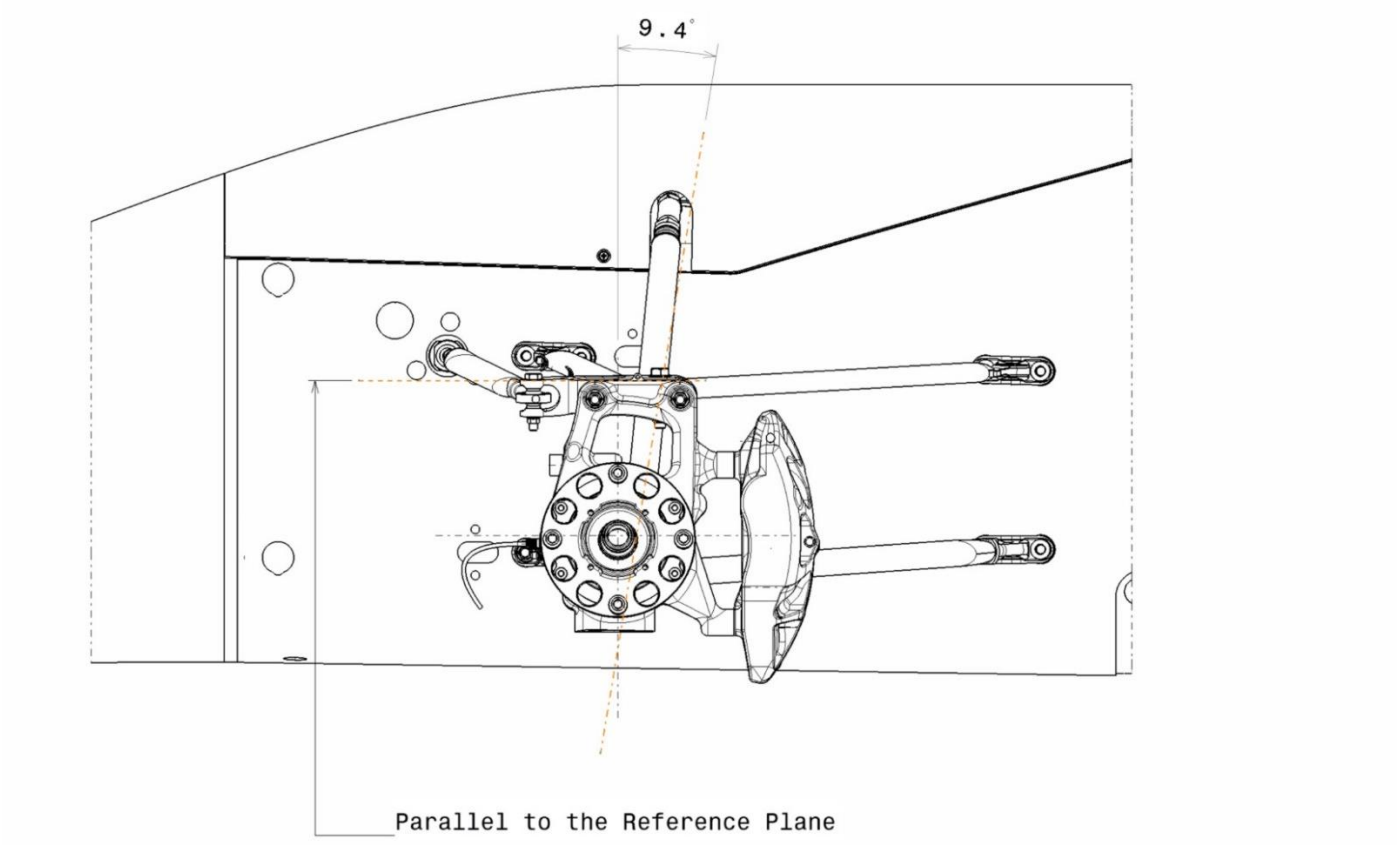
5.3.3 Toe adjustment

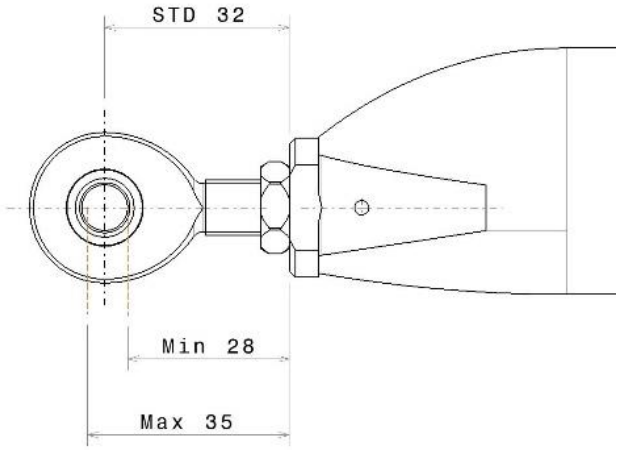
Toe can be adjusted by the steering arm length

Toe adjustment	Front	Rear
	Total Toe Change	**Total Toe Change**
+1 turn	+1.12 deg (+1°07’)	+1 deg

5.3.4 Caster adjustment

The apparent caster is measured on the top of the front upright (when steer angle is zero), measuring an angle of 0° (parallel) to the reference plane equals to 9.4° of caster angle.

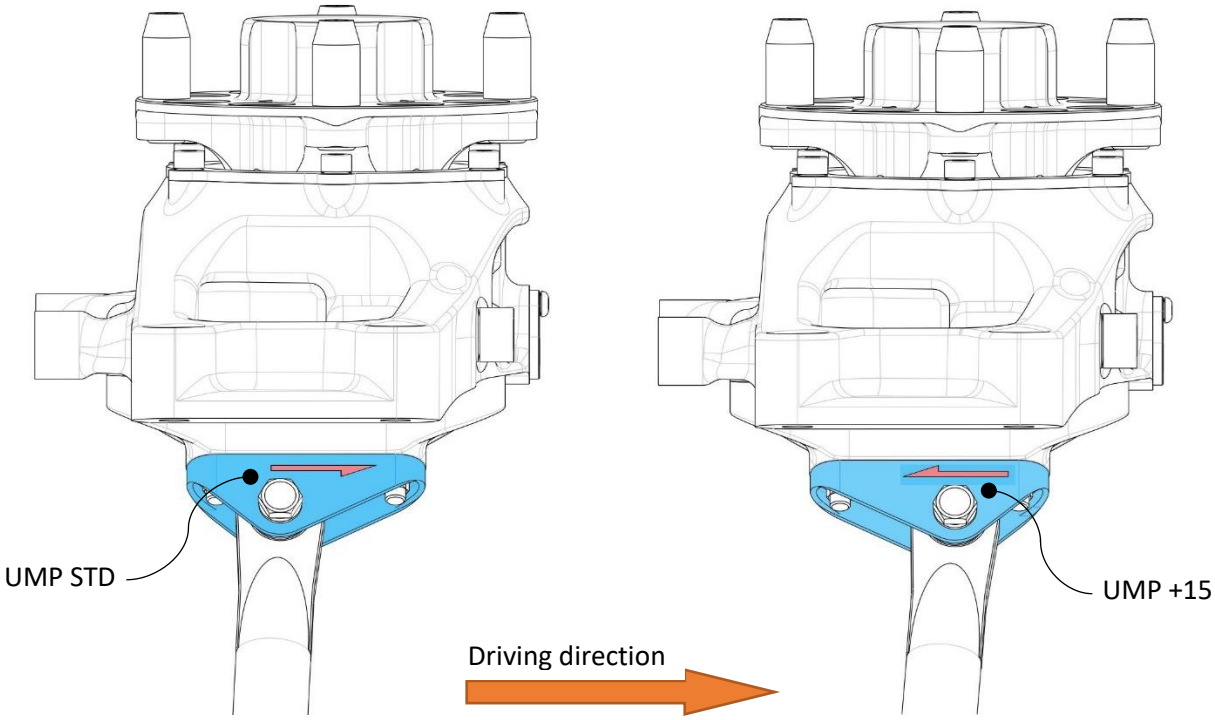




Caster adjustment	Front	Rear
	Caster Change	
+1turn	+0.47 deg (+28’12”’)	n.a.

5.3.5 UMP adjustment

The front pushrod is directly installed on the upright, its pick-up point can be adjusted longitudinally (laser marked arrow forward/rearward) resulting in a different weight transfer as function of the steering angle. The farthest the point is from steer axis the higher will be the weight transfer and by consequence the steering effort.



The following table summarize the possible configuration and the distance pickup to steering axis.

	UMP STD		UMP +15mm	
STEER	Inner Wheel drop	Outer Wheel drop	Inner Wheel drop	Outer Wheel drop
[deg]	[mm]	[mm]	[mm]	[mm]
0	0,0	0,0	0,0	0,0
10	-0,2	0,2	0,2	-0,2
20	-0,4	0,4	0,4	-0,4
30	-0,7	0,6	0,6	-0,6
40	-0,9	0,8	0,8	-0,8
50	-1,1	1,0	1,0	-1,0
60	-1,4	1,2	1,1	-1,2
70	-1,6	1,4	1,3	-1,4
80	-1,9	1,6	1,5	-1,7
90	-2,1	1,8	1,7	-1,9

5.4 VERTICAL STIFFNESS

5.4.1 Front vertical stiffness

The table below resumes stiffness options available and relevant stiffness at the wheel:

Spring stiffness [lb/in]	700	900	1000	1100
Ground stiffness [daN/mm]	10.3	13.2	14.7	16.2

Motion ratio (wheel/damper): 1.1
Springs can be preloaded acting on the damper/spring platform, the pitch of the thread is 1.5mm.

5.4.2 Rear vertical stiffness

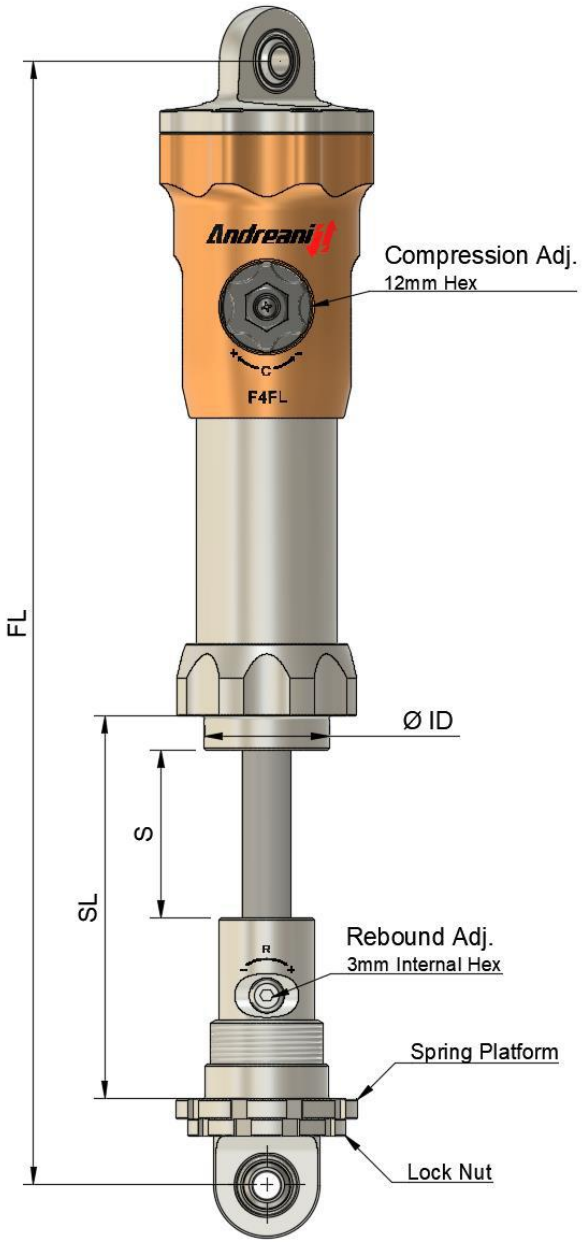
The table below resumes stiffness options available:

Spring stiffness [lb/in]	700	900	1000	1100
Ground stiffness [daN/mm]	8.3	10.7	11.9	13.1

Motion ratio (wheel/damper): 1.23
Springs can be preloaded acting on the damper/spring platform, the pitch of the thread is 1.5mm.

5.5 DAMPERS

ANDREANI Formula Light damper is based on mono tube design for competition purposes, the 2-Way adjustment mechanisms allow maximum control over the damping forces generated.



Technical specification

FL	Full length	320 mm
S	Stroke	48 mm
SL	Spring max length	109 mm
ID	Spring inner diam	36 mm
C	Compression pos.	12 Click
R	Rebound pos.	16 Click

5.5.1 Adjust damping

Turn the adjuster clockwise to fully closed position (position "0"). Turn counterclockwise to open and count the clicks until reaching the recommended number of clicks.
For example, rebound adjustment:
HARD Click position 0
SOFT Click position 16

Caution:
Do not force, delicate sealing surfaces may be damaged.

5.5.2 Spring preload

Use a C-Spanner for unlock the lock nut. Turn the spring platform clockwise to increase the spring preload. Turn counterclockwise to decrease it. Lock the setting with the lock nut. Tightening torque 15-25Nm.

Caution:
Do not adjust the spring platform so that the spring has a clearance. It shall always be mounted with preload.

Damper identification

F4FL	Front left
F4FR	Front right
F4RL	Rear left
F4RR	Rear right

Curve	Compression Position	Rebound Position
RED	C2	R2
BLUE	C12	R16

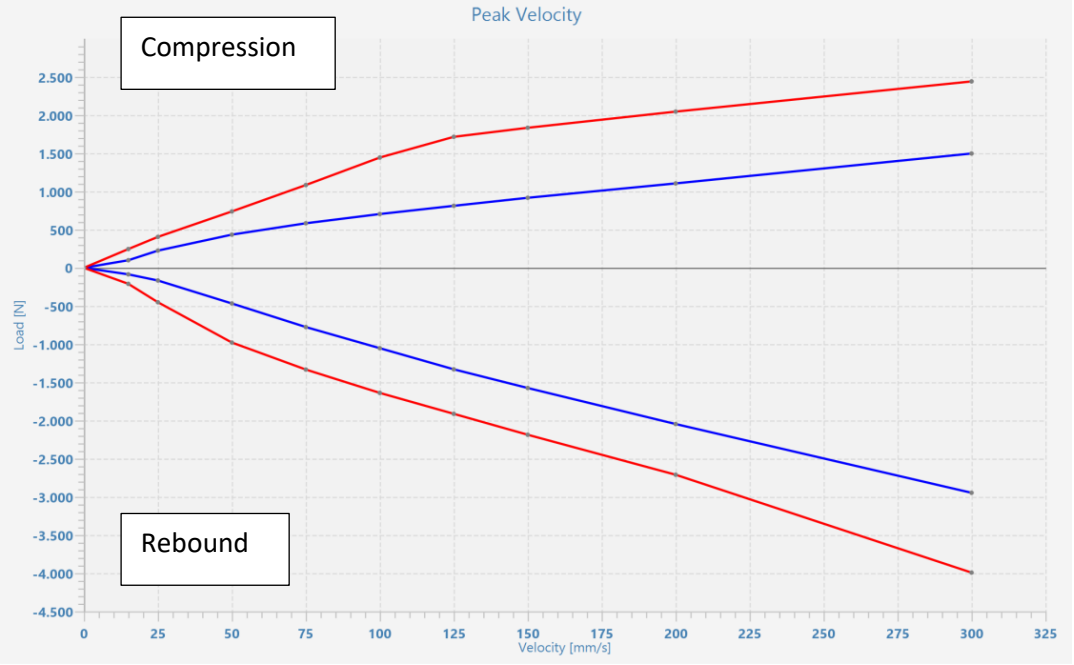


Table 1The graph illustrated is to be considered indicative. The curves produced may undergo variations based on the test conditions.

5.5.3 Cleaning

Clean the shock absorber externally with a soft detergent. Use compressed air. Be careful that all dirt is removed. Keep the shock absorber clean and spray it with oil (WD40, CRC 5-56 or equivalent) after washing. Wipe off excessive oil with a cloth. Do not use strong chemicals, i.e. strong solvents or wheel cleaning detergents, and/or a hard brush for cleaning as it may discolor and change the appearance of the shocks surface treatments.

5.5.4 Inspection

Check ball joints for possible excessive play or stiction.
Check the piston shaft for leakage and damage.
Check the shock absorber body for external damage.

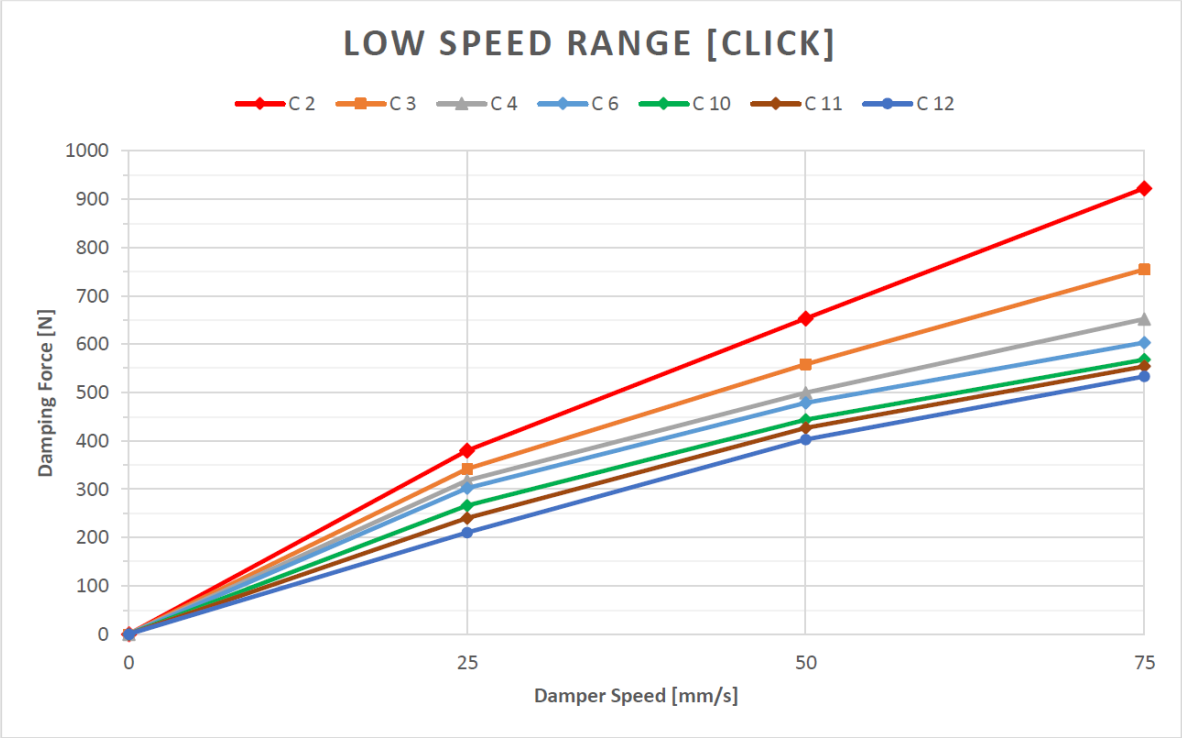
5.5.5 Recommended Service Intervals

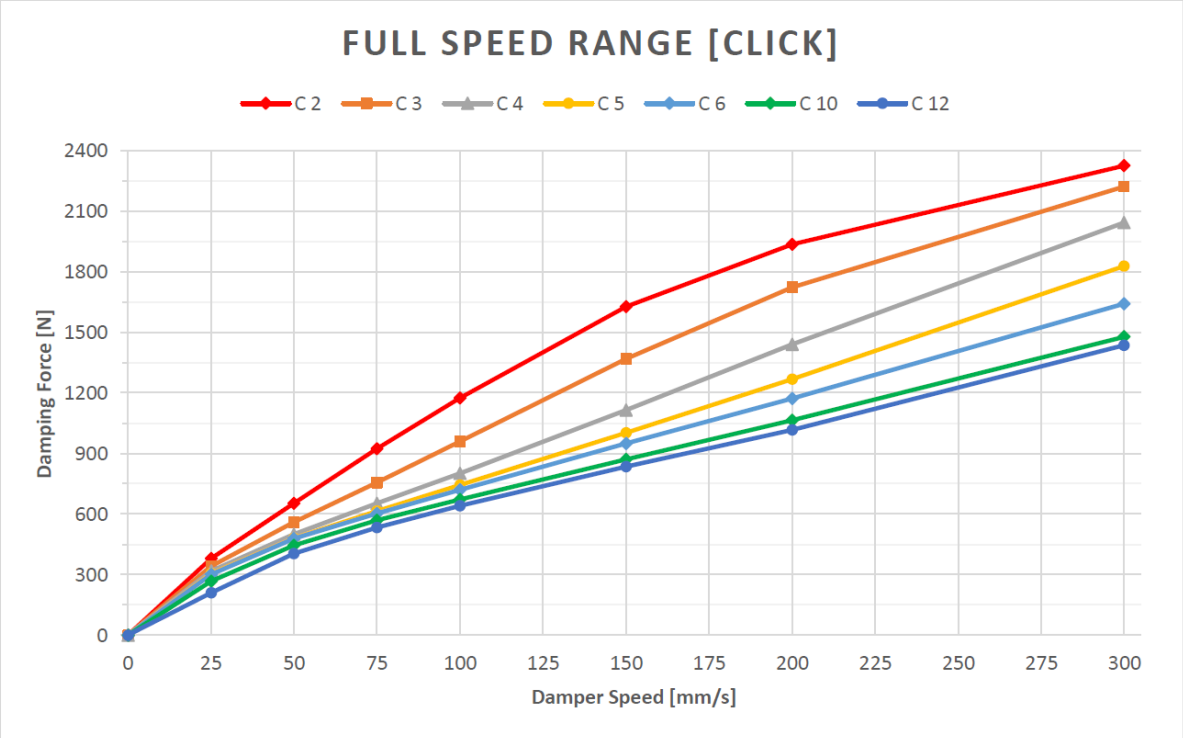
Every 5000 km
Maintenance and repairs must be carried out at Andreani group.

WARNING

- The damper contains pressurized nitrogen gas (N2). Do not open, service or modify this product.
- This damper was developed and designed exclusively for a specific vehicle model and should only be installed on the intended vehicle model in its original condition as delivered from the vehicle manufacturer.

5.5.6 Compression damping curve





5.5.7 Rebound damping curve

5.6 ROLLING STIFFNESS

5.6.1 Front roll stiffness

The motion ratio of the front anti-roll bar is:

Blade length [mm]	129.5	119.5	109.5
$\phi_{Anti\text{-}rollbar}/\ \phi_{Chassis}$ [deg/deg]	9	10	11

The ratio represents the torsion angle of the antiroll bar resulting from a roll of 1° on the chassis.

The following table summarizes anti-roll bar options available:

Rollbar diameter [mm]	22.0			25.0		
Blade length [mm]	129.5	119.5	109.5	129.5	119.5	109.5
ARbar Torsion stiffness [daN*mm/deg]	19642			29905		
Roll stiffness (@ ground) [daN*m/deg]	1650	1970	2370	2511	2994	3603

5.6.2 Rear roll stiffness

The motion ratio of the front anti-roll bar is:

Blade length [mm]	70	60	50
$\phi_{Anti\text{-}rollbar}/\ \phi_{Chassis}$ [deg/deg]	7	8.1	9.7

The ratio represents the torsion angle of the antiroll bar resulting from a roll of 1° on the chassis.

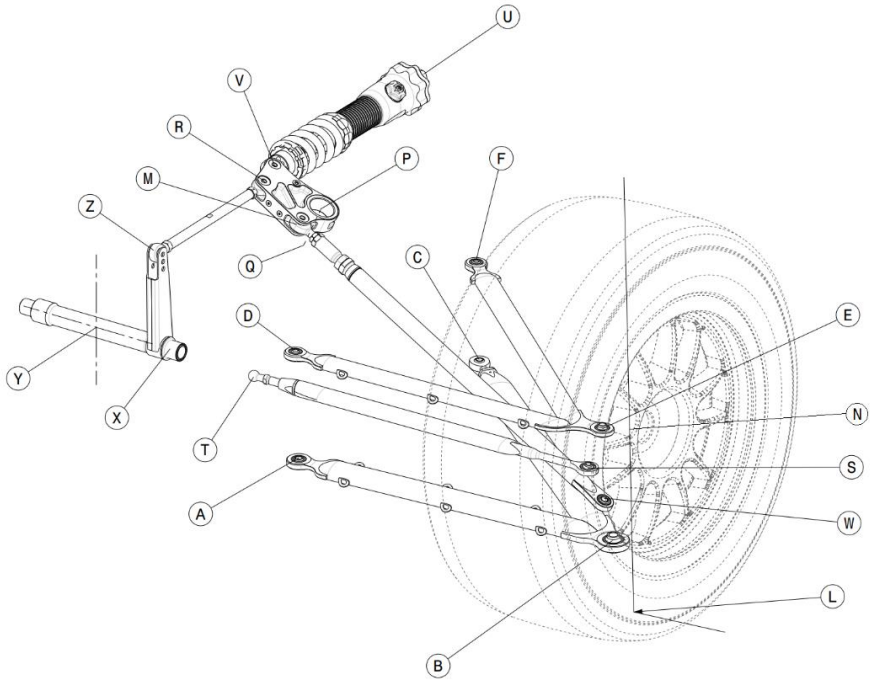
The following table summarizes anti-roll bar options available:

Rollbar diameter [mm]	10.0			14.0		
Blade length [mm]	70	60	50	70	60	50
ARbar Torsion stiffness [daN*mm/deg]	1030			3960		
Roll stiffness (@ ground) [daN*m/deg]	50	67	95	200	250	364

5.7 SUSPENSION GEOMETRY

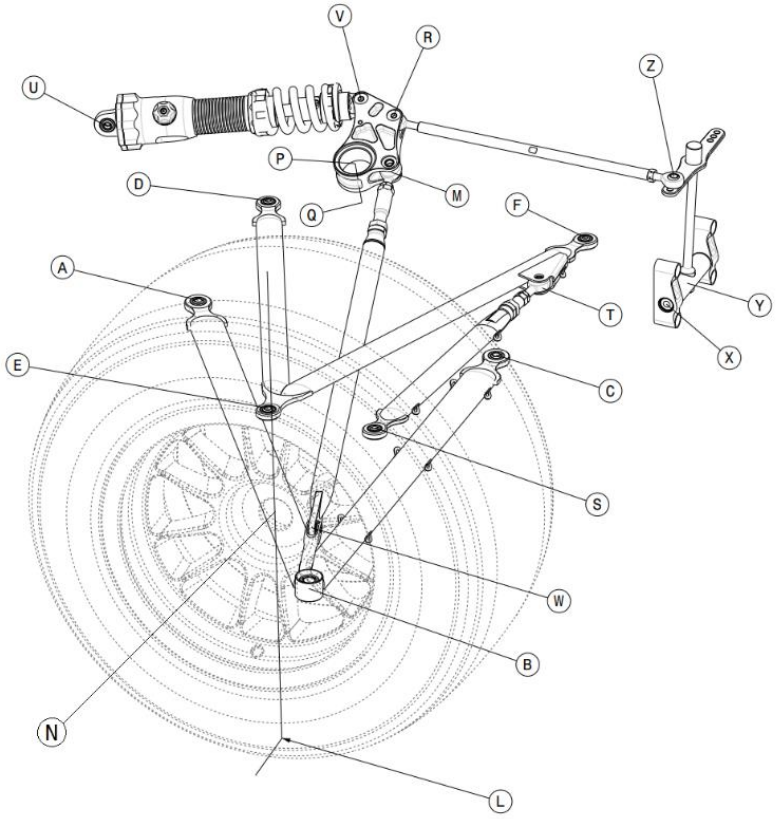
5.7.1 Front suspension geometry

The origin is located at the intersection of front wheel axle and reference plane, the coordinate of the contact point is then below the reference plane by a value of Rd-Zn where Rd is the Rolling Radius of the tire and Zn is the z coordinate of point N.



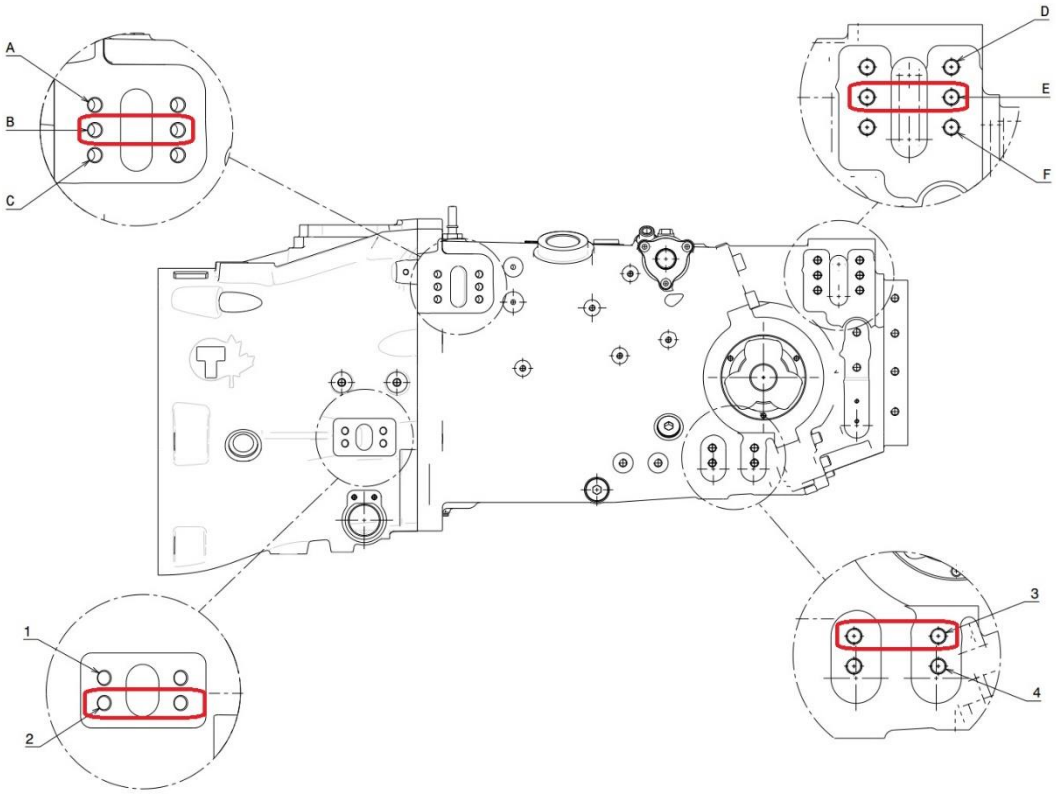
	X	Y	Z
A	-50,0	210,8	243,9
B	9,0	657,5	225,1
C	300,0	232,1	246,0
D	-50,0	210,8	392,9
E	32,1	628,0	364,2
F	300,0	232,1	382,5
S	-64,4	677,5	361,6
T	-130,0	205,9	393,5
N	0,0	757,5	253,0
L	0,0	757,5	Z_N-R_d
U	389,0	80,0	561,5
V	82,4	81,3	560,8
P	80,0	156,0	522,1
Q	80,0	133,0	477,7
M	41,0	154,4	522,9
W	16,0	648,6	267,0
X	-170,0	90,0	420,5
Y	-170,0	0,0	420,5
Z	-170,0	90,0	550,0
R	46,2	91,6	555,5

5.7.2 Rear suspension geometry



	X	Y	Z
A	-370,0	141,0	169,2
B	-11,5	669,0	163,0
C	-10,0	115,4	164,7
D	-280,7	146,1	325,4
E	-85,0	615,1	348,5
F	95,0	101,0	336,8
S	47,7	614,9	353,1
T	84,6	213,5	340,4
N	0,0	735,0	249,0
L	0,0	735,0	Z_N-R_d
U	-485,0	135,0	381,1
V	-206,3	43,3	419,0
P	-180,0	123,5	385,9
Q	-180,0	85,3	293,5
M	-140,8	116,2	388,9
W	-37,2	592,7	192,1
X	179,0	60,0	250,0
Y	179,0	0,0	250,0
Z	187,8	60,0	417,5
R	-160,3	55,6	413,9

Pick up nomenclature according to the following image.



The following table summarize the pickup point coordinates of the standard configuration (BE23). The origin is located at the intersection of rear wheel axle and reference plane, the coordinate of the contact point is then below the reference plane by a value of Rd-Zn where Rd is the Rolling Radius of the tire and Zn is the z coordinate of point N.

5.7.3 Anti-effects

The following tables show the anti-effects of the car for the ensuing settings:

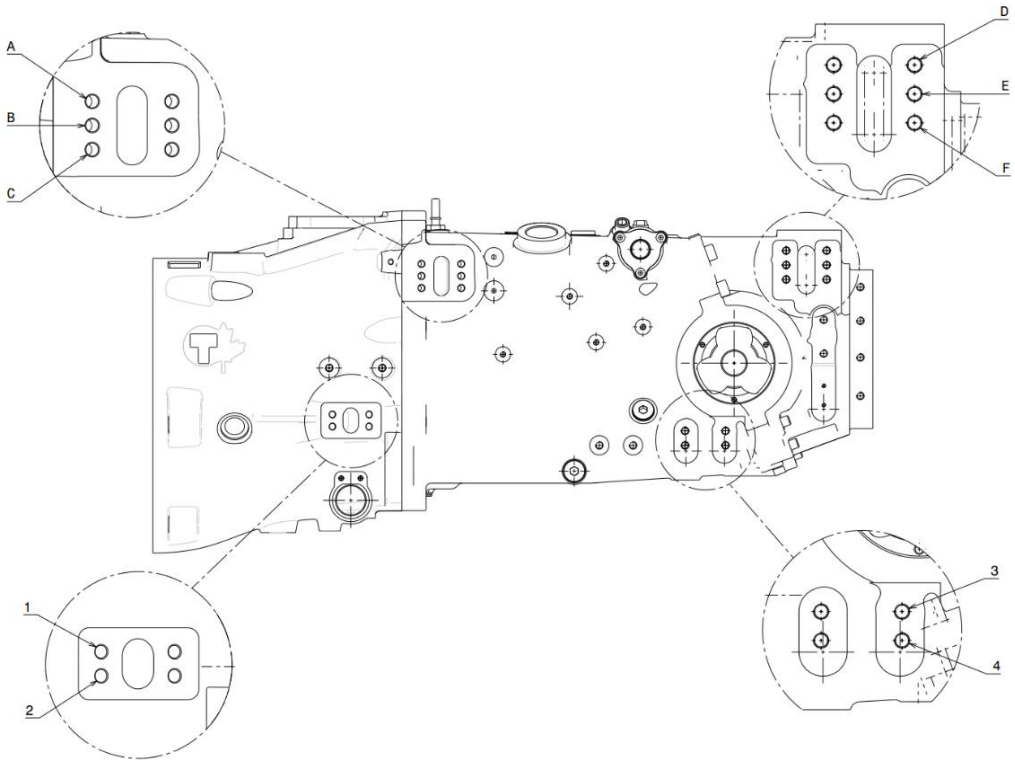
- Front wheel hub: 253mm over reference plane
- Rear wheel hub: 249mm over reference plane

The RC height is related to the reference plane.

5.7.3.1 Front

Pick Up position	RC height (mm)	α_{anti_Dive} [°]
STD	-3,5	3.8

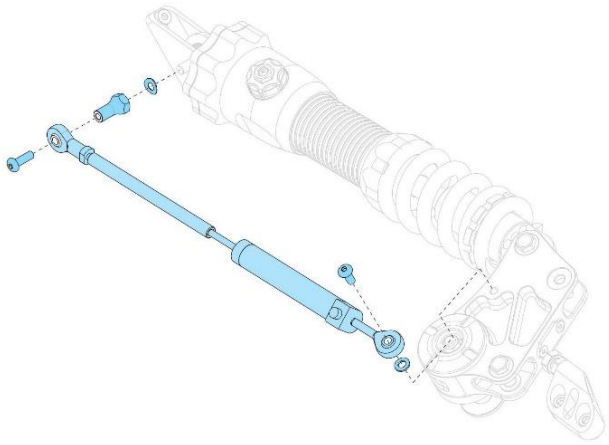
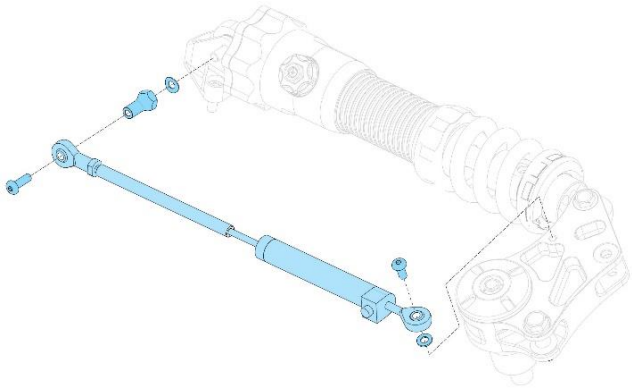
5.7.3.2 Rear



Pick Up position	RC height (mm)	α_{anti_Lift} [°]	α_{anti_Squat} [°]
AD13	-17,6	7,3	0,4
AD14	-55,6	11,6	1,6
AD23	-19,4	3,6	-0,6
AD24	-57,5	8,0	0,6
AE13	-5,7	5,2	1,4
AE14	-43,6	9,5	2,6
AE23	-7,5	1,4	0,4
AE24	-45,6	5,8	1,6
BD13	-9,0	9,1	-0,4
BD14	-46,4	13,4	0,8
BD23	-10,8	5,5	-1,5
BD24	-48,3	9,8	-0,3
BE13	2,7	7,1	0,5
BE14	-34,7	11,4	1,7
BE23 (STD)	1,0	3,3	-0,5
BE24	-36,5	7,7	0,7
BF13	14,6	4,9	1,5
BF14	-22,8	9,3	2,7
BF23	12,9	1,2	0,5
BF24	-24,6	5,5	1,7
CE13	10,7	8,9	-0,3
CE14	-26,1	13,1	0,9
CE23	9,1	5,2	-1,4
CE24	-27,9	9,5	-0,1
CF13	22,4	6,8	0,6
CF14	-14,5	11,1	1,9
CF23	20,8	3,1	-0,4
CF24	-16,2	7,4	0,8

5.8 OPTIONAL DAMPER SENSORS

The dampers sensor kit is available from Tatuus.
Front and rear rockers are designed for the installation of dedicated linear sensors assembly, a specific adaptor allows to install the potentiometers on the shock absorbers clamps on the chassis side.

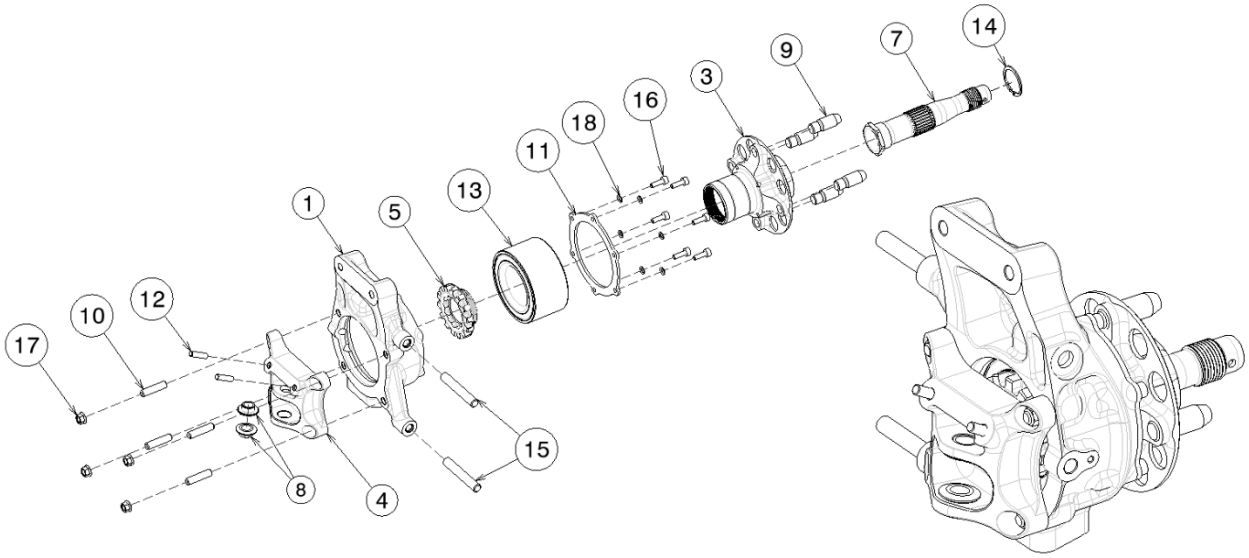
FRONT	REAR
	
Motion ratio	**Motion ratio**
Wheel/Pot: 2 [mm/mm]	**Wheel/Pot**: 2 [mm/mm]
Spring/Pot: 1,8 [mm/mm]	**Spring/Pot**: 1,6 [mm/mm]

For the optional sensors and adaptor looms, please refer to the T-421 spare parts catalog. For the analog spare input configuration in data logging, please refer to the engine manufacturer.

Warning:
Please refer to the sporting regulation about the installation and use of the damper sensors in the official events.

5.9 SUSPENSION MAINTENANCE

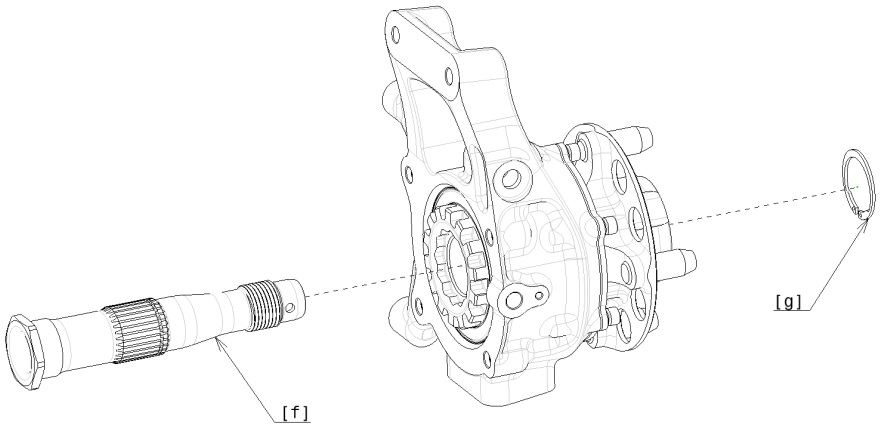
5.9.1 Upright Maintenance



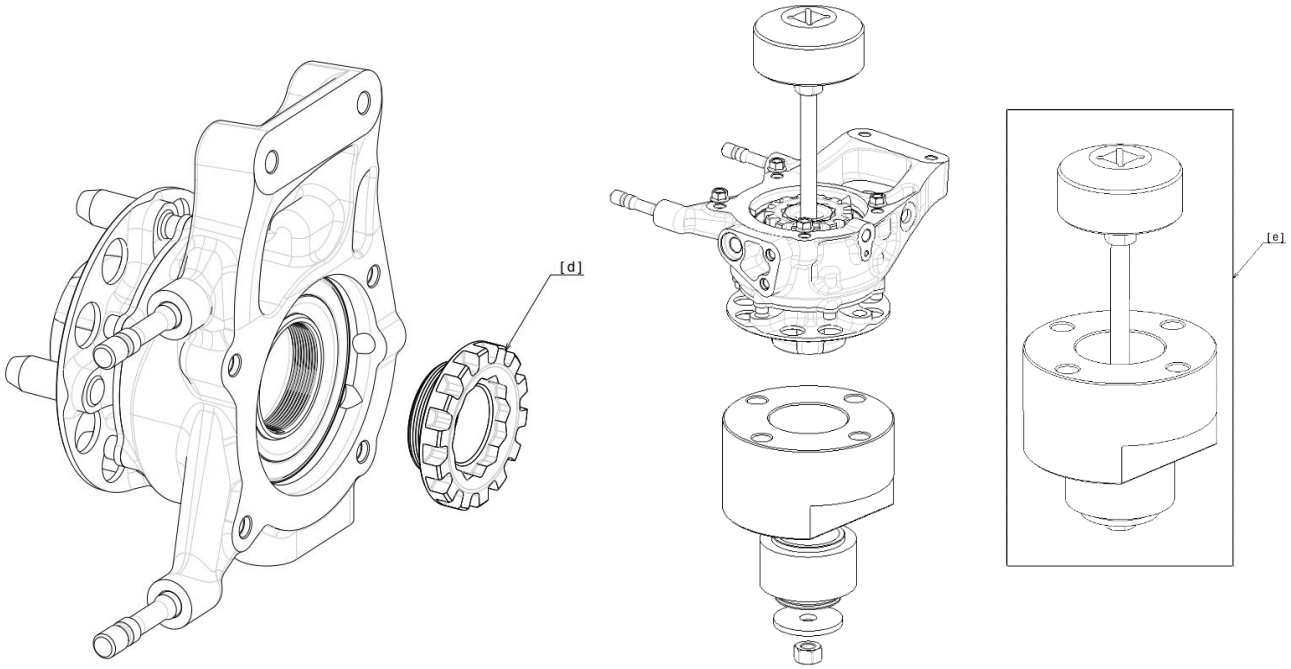
5.9.2 Upright Disassembly

The upright can be disassembled for inspection:

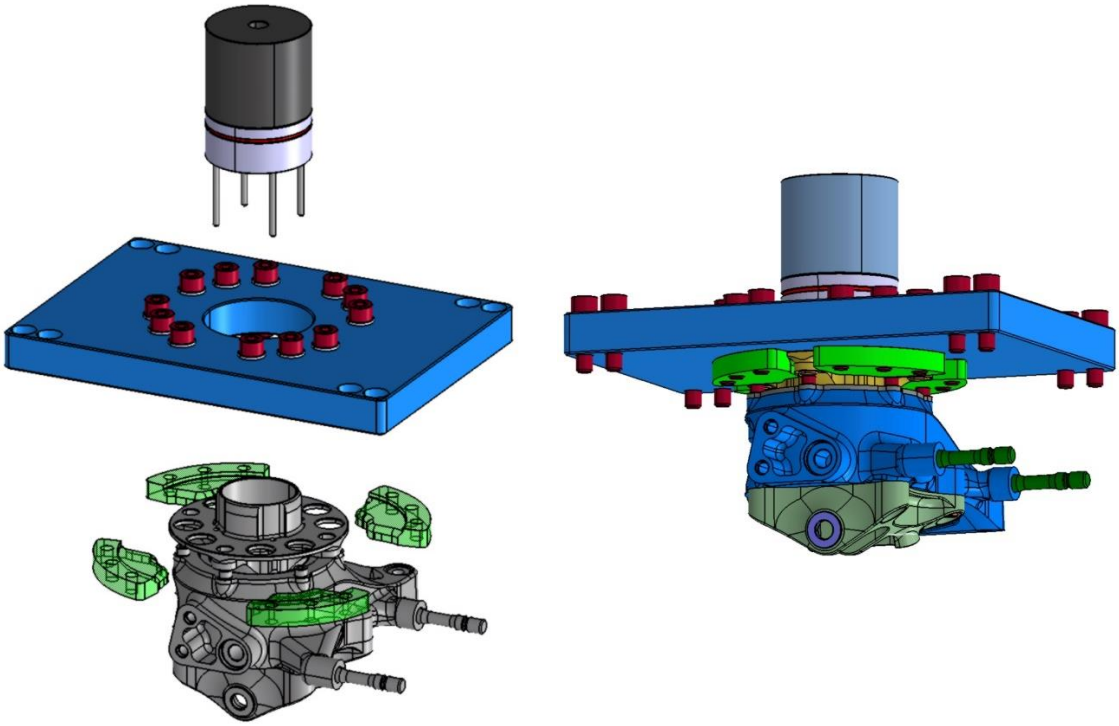
1. Remove the seeger [g] and the wheel axle [f].

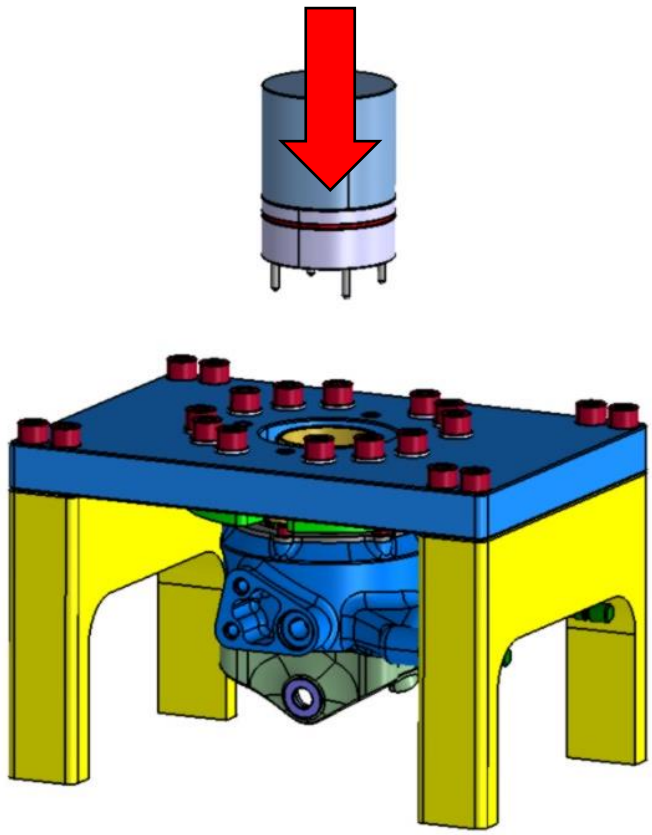


2. Apply unlock spray.
3. Using the special tool [e] (pn. 3391010, available on Spare Part Catalogue), unscrew and remove the ring nut [d].

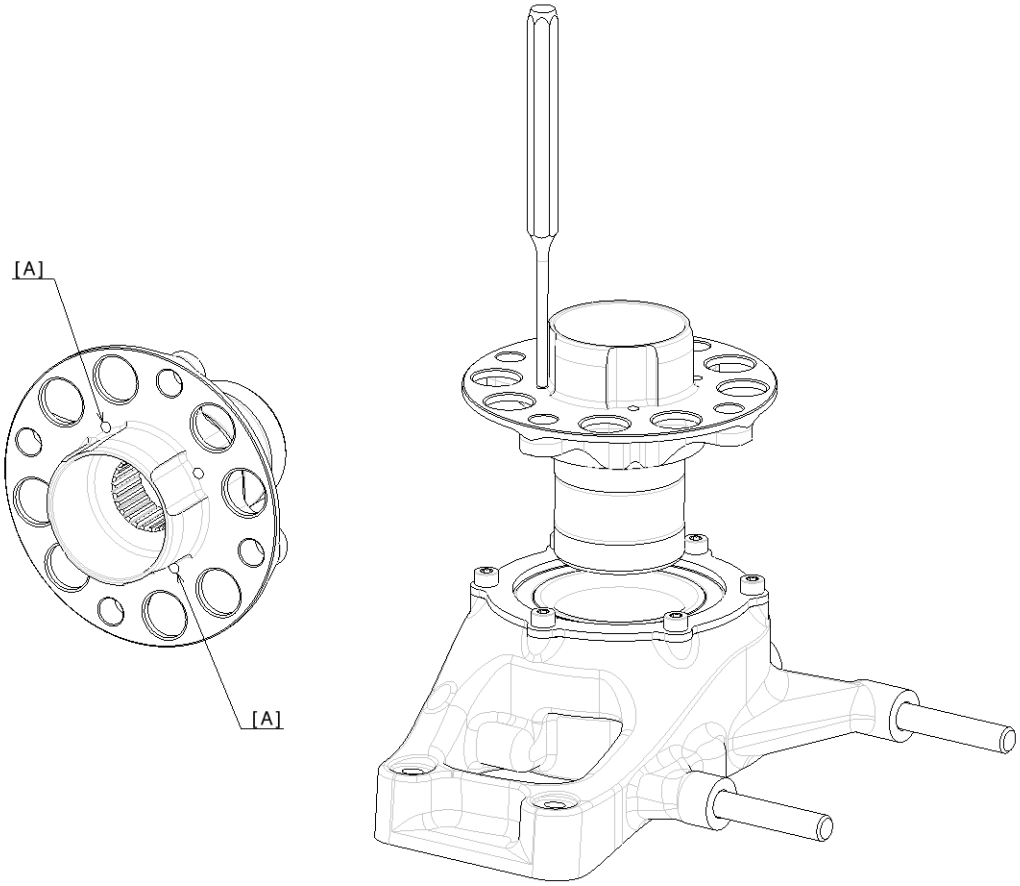


4. Press the hub out. It is suggested to do this operation with a hydraulic press. Pictures below shows the procedure using a TATUUS' special tool available upon request (ref p/n 3391005).
   To avoid buckling and misalignment problems the procedure should be done with the pins as short as possible in the very first phase of stroke. Once the first part of extraction stroke switch to longer pins and complete the extraction. Different lengths of the pins should be used during the extraction. Do not heat the upright assembly before removing the hub. Cooling the hub (only the hub) before pressing out, i.e. filling it with dry ice, could make the extraction easier.

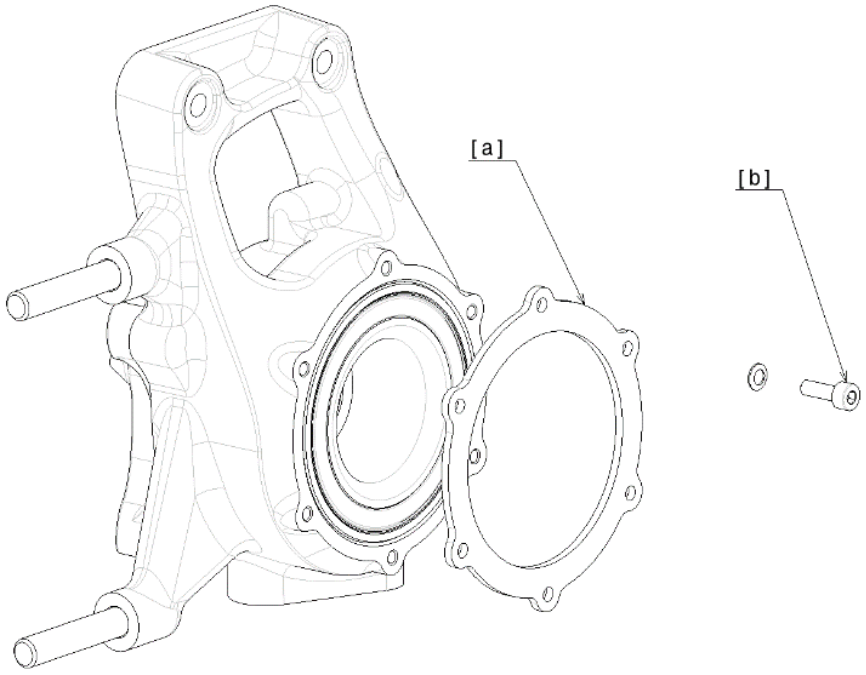




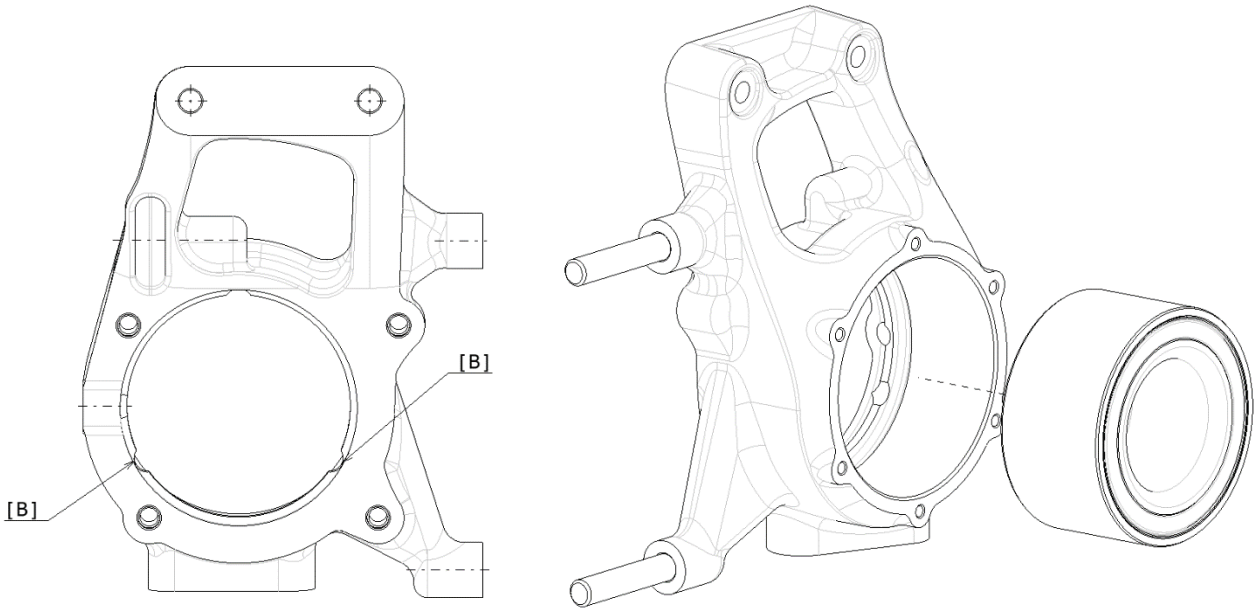
5. For the final phase of the extraction remove the hub with a drift punch through the 4mm holes [A].



6. Remove the bearing retention ring (a).



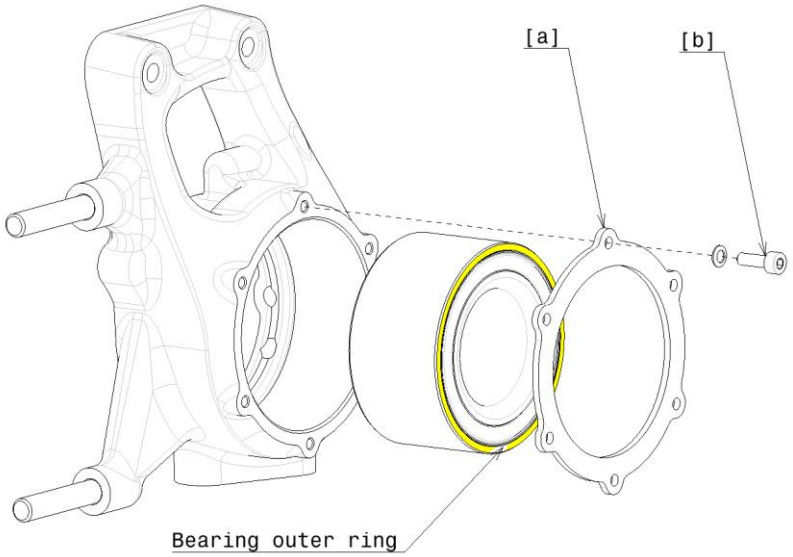
7. Heat the upright and bearing subassembly up to about 120°C.
8. Once heated, use the machined slot [B] to press out the bearing acting on the outer bearing ring.



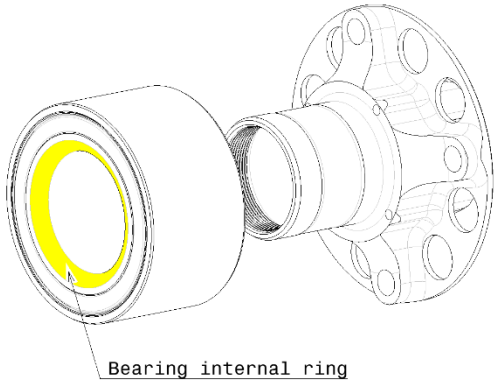
5.9.3 Upright Assembly

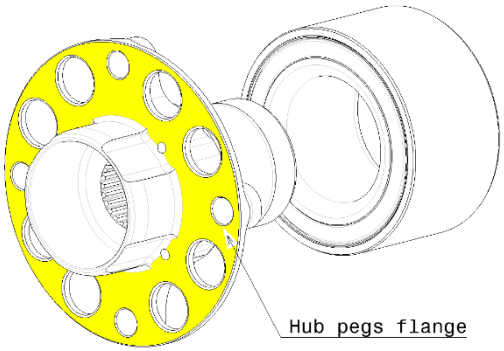
Here below the assembling procedure:

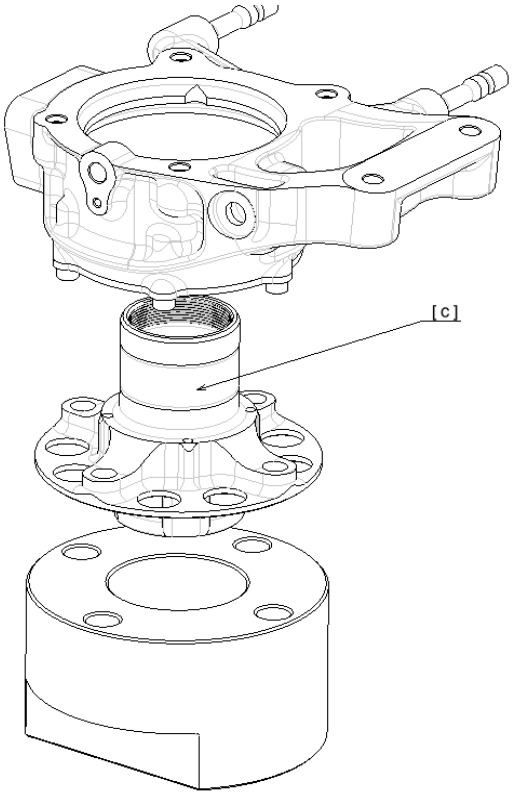
1. Heat the upright to about 120°C and cool the bearing to about -20°C.
2. Put the bearing into the housing acting on the outer race (a press can make the procedure quicker, maximizing the temperature difference effect).
3. Fit the external rim [a], then tight the 6x M5 screws (8 Nm, Loctite 243).



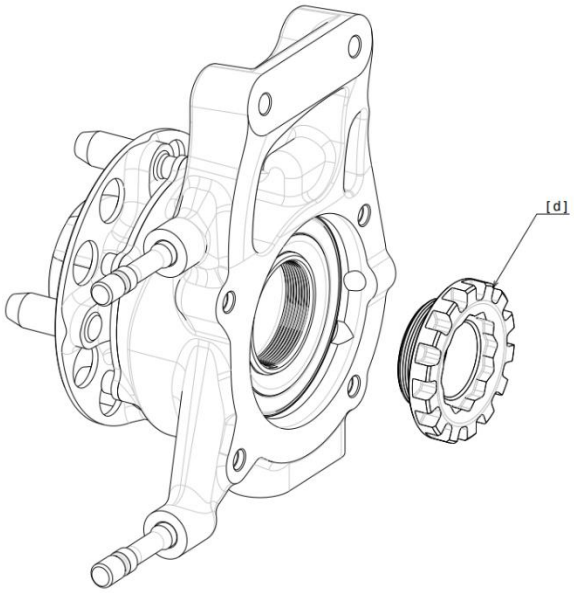
4. Heat the upright and bearing subassembly to about 120°C and cool the hub to about -20°C.
5. Put the hub in the upright. Use a press to make the procedure quicker, maximizing the temperature difference effect. Act on the bearing internal ring, reacting on the hub pegs flange, paying high attention to the correct alignment of the component.

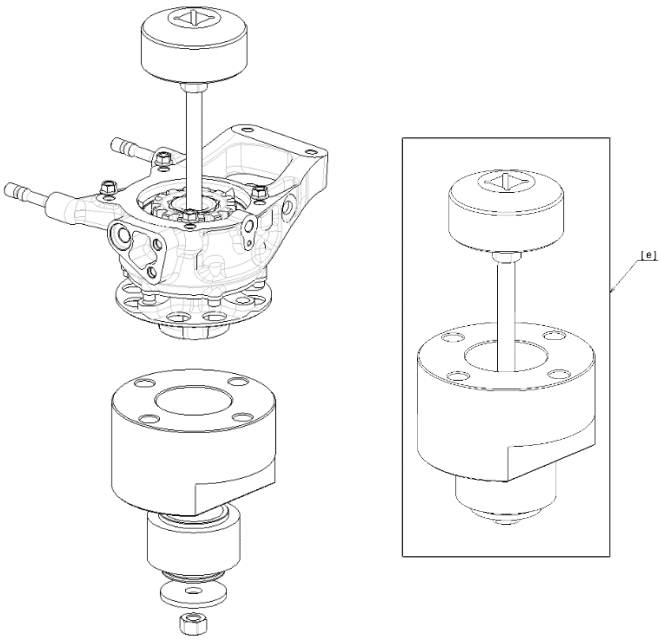




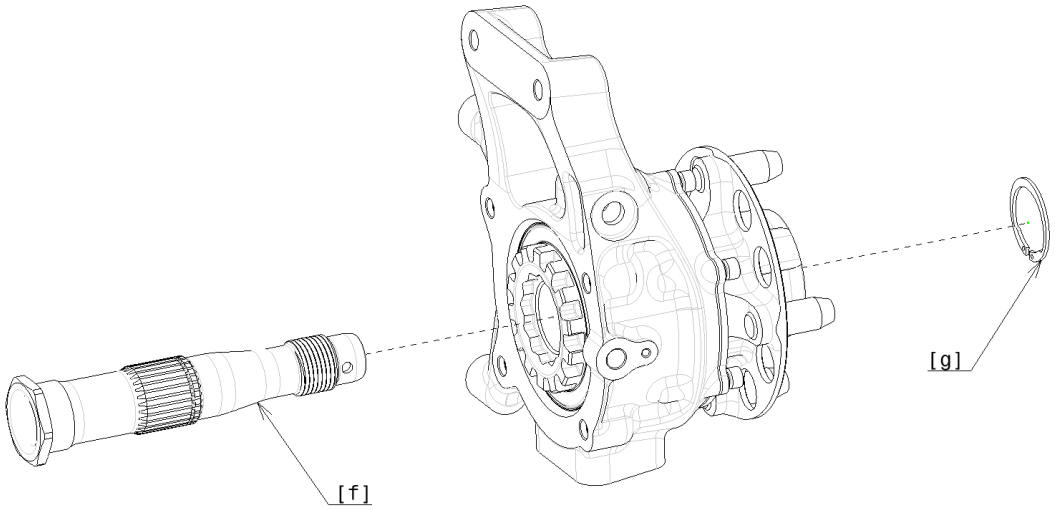


6. Fit the ring nut [d]
7. Using the special tool [e] (pn. 3391010, available on Spare Parts List) tight the ring nut to 500Nm.





8. Insert the wheel axle [f] and secure the seeger [g].


[f]
[g]

6 STEERING

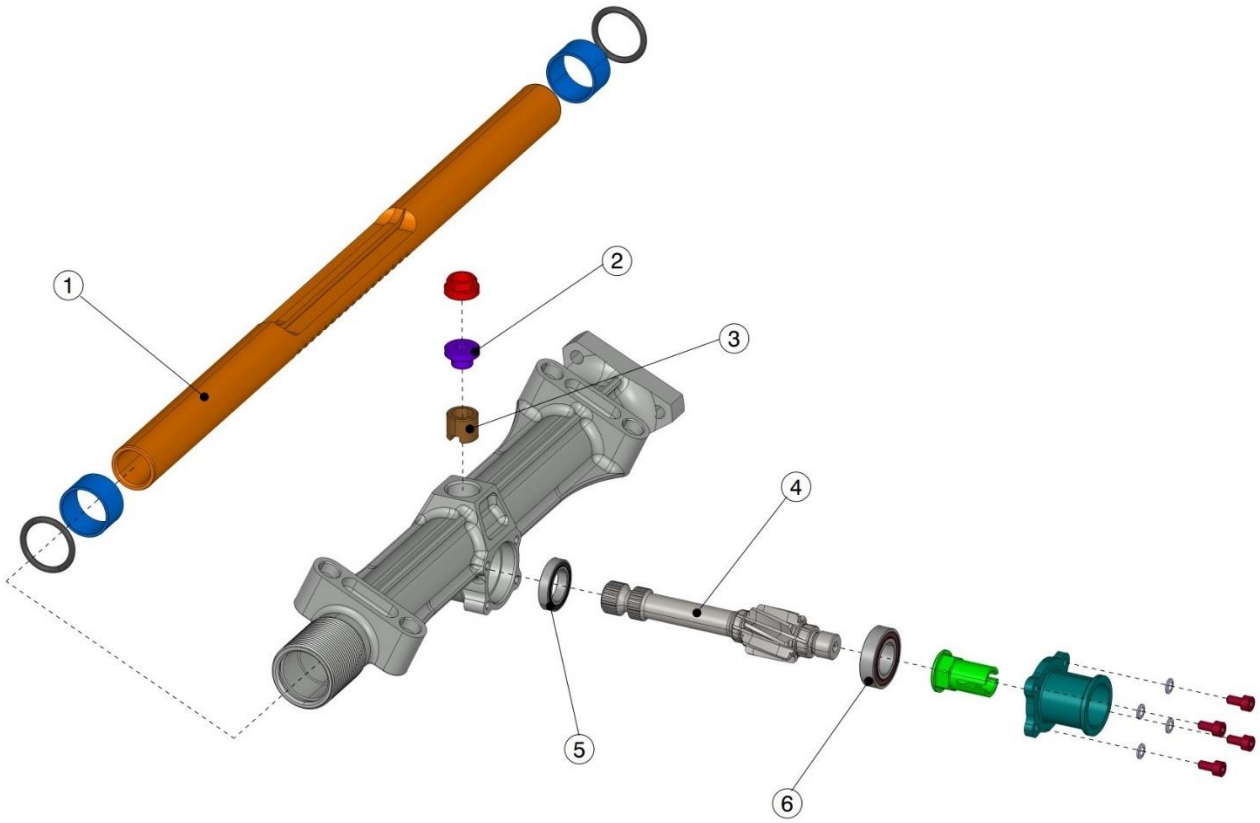
6.1 STEERING GEOMETRY

Standard ratio: 8 teeth pinion
Pinion primitive diameter: 17.3 mm
Steering ratio: 11.7 °/°

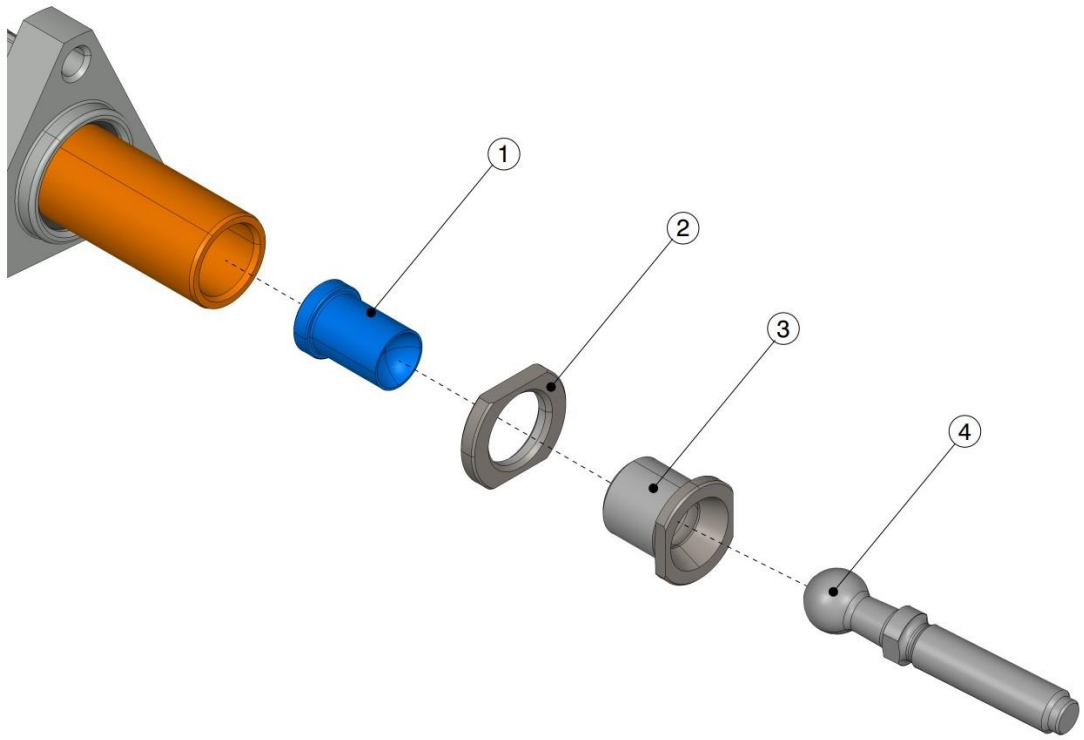
6.2 STEERING MAINTENANCE

The steering rack must be periodically inspected:

- rack pinion play: the preload can be set acting on the bush [2], its position should be regularly inspected to follow system wearing, periodically inspect bush [3];
- pinion [4]: regularly inspect and lubricate;
- bearings [5-6].



Rack end assy: allow some preload [2-3] to avoid any free play during the setting up, periodically change the bush [1].



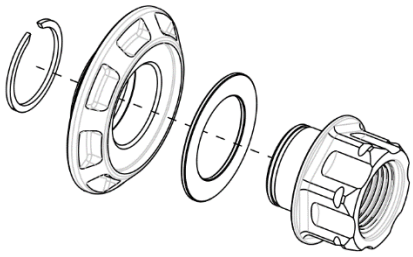
7 WHEELS AND TIRES

7.1 WHEELS

Front wheels: OZ Wheels 8.0”x13”
Rear wheels: OZ Wheels 10.0”x13”

7.2 WHEEL NUT

Wheel nut tightening torque: 220 Nm



7.3 TIRES

Refer to the documentation provided by the championship tire manufacturer.

8 BRAKE SYSTEM

8.1 BRAKE SYSTEM SETUP

Master cylinder suggested configuration:

	FRONT ø	REAR ø
Standard	19.05 mm	20.64mm

The following table shows the front brake balance when the balance bar is set at the mid adjustment (master cylinders have the same distance from trunnion):

FRONT \ REAR	5/8" (15.88mm)	3/4" (19.05mm)	13/16" (20.64mm)	7/8" (22.23mm)	1" (25.4mm)
5/8" (15.88mm)	50%	59%	63%	*DO NOT USE*	*DO NOT USE*
3/4" (19.05mm)	*DO NOT USE*	50%	54%	57.6%	*DO NOT USE*
13/16" (20.64mm)	*DO NOT USE*	*DO NOT USE*	50%	53.7%	60%
7/8" (22.23mm)	*DO NOT USE*	*DO NOT USE*	*DO NOT USE*	50%	56%
1" (25.4mm)	*DO NOT USE*	*DO NOT USE*	*DO NOT USE*	*DO NOT USE*	50%

8.2 BRAKE SYSTEM BEDDING-IN

The brake bedding-in procedure is a process of repeatedly and quickly heating and cooling the brakes, in a way that the pad deposits a uniform layer of its material on the disk surface and to evenly remove the thin anti-corrosion coating of the disk.
Correct bedding-in procedure is necessary not only for optimum performance of the system, but also to avoid onset of judder (vibration felt through brake and steering).

Brake bedding-in process:

1. Check the disc before use, in particular its surface conditions. To avoid contamination during bedding, if needed, cleaning of the disk surface with sandpaper above FEPA 600, brake cleaner or similar is possible.
2. In order to prevent unpredictable heat transfer on disc surface, and resultant thermal deformation (cracks, vibrations) the bedding should be achieved by application of groups of constant pressure stops (for a total of about 30 stops) with gradual increasing of the initial speed (and total brake energy).
   These braking must be done far from the tyre adhesion limit (50÷60% of the max race pedal pressure) in order to achieve a corresponding gradual increase of torque and temperature to the brake system and promote a regular third layer deposit. Between the stops let the system to cool down to avoid overheating. During this phase the friction coefficient starts high and then decreases to the stabilization level, so in the first phase avoid too hard braking to avoid overheating.
3. Toward the end of the bedding the disc surface is become completely and uniformly settled and the friction efficiency optimized, so at this point no risk of uneven heat distribution and distortion should exist. After the constant braking pressure and the subsequent layer formation (step 2) a series of 4÷5 high deceleration stops are desirable in order to set up the layer and guarantee a correct functioning.

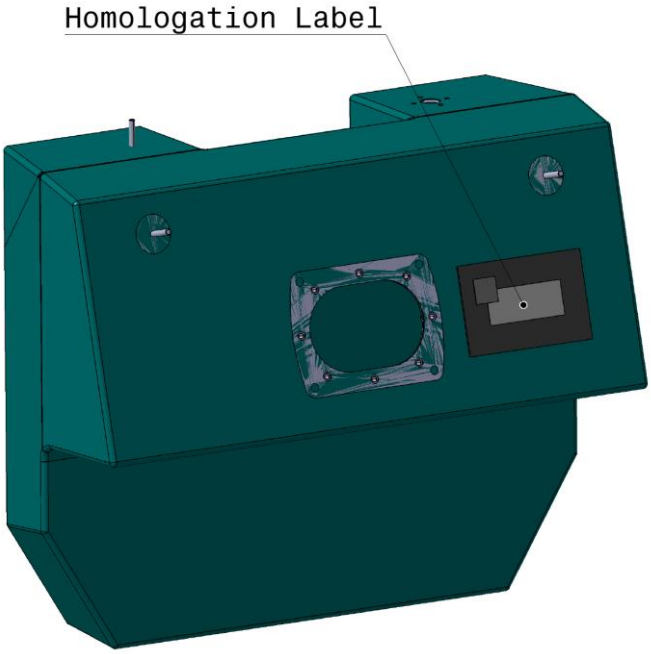
Be aware that incorrectly bedded brakes can reduce the controllability and the lifetime of the pads and discs. The maximum braking performance can only be achieved by correctly bedded brake parts.

This procedure should be performed on a safe part of the circuit, away from traffic, as you have to be able to repeatedly stop quickly.

9 FUEL SYSTEM

9.1 FUEL TANK FUEL CELL

Premier FT3/99
Rubber bladders should be used for no more than 5 years after the date of manufacture, unless inspected and recertified by the manufacturer for a period of up to another 2 years.

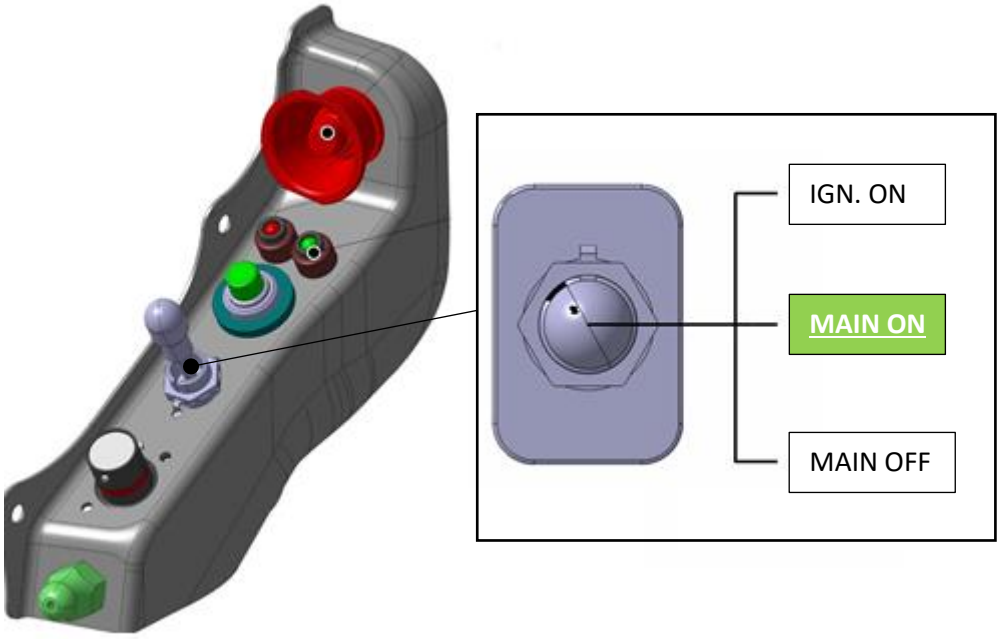


Fuel cell contains a maximum of approximately **45 liters**

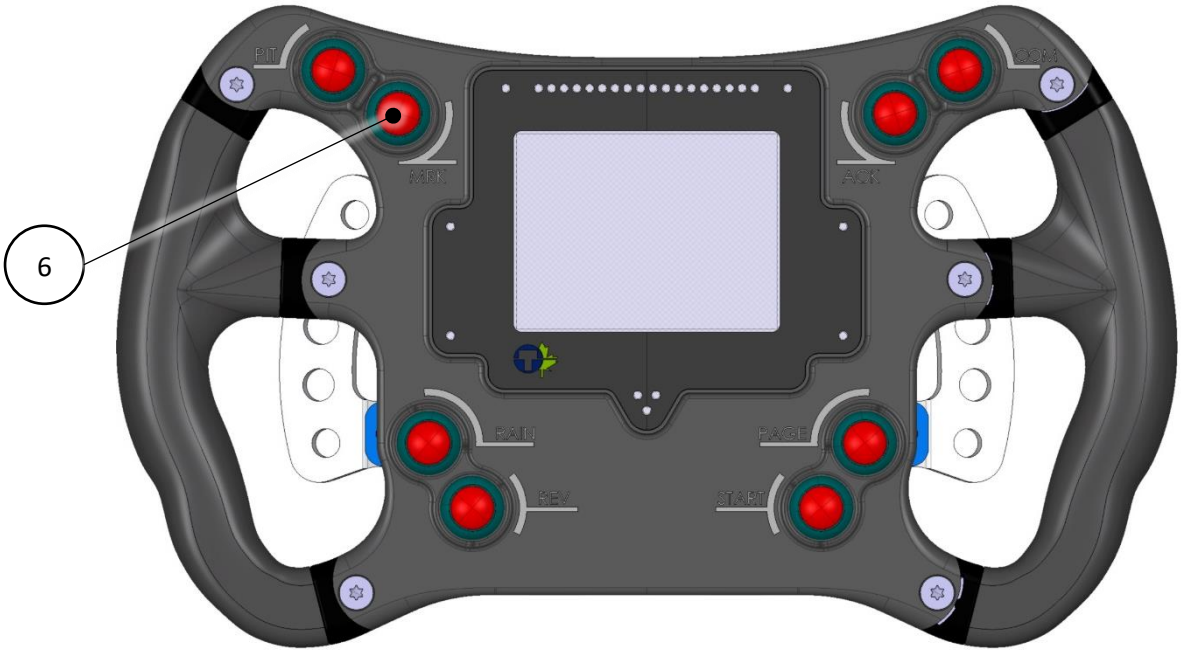
Before installing the bladder, make sure that the chassis compartment is free of sharp edges and clean.
It is recommended to protect the outer surfaces of the fuel bladder from scratching over carbon fibers, customers are invited to protect the carbon surfaces that are in contact with the bladder with PVC tape (i.e. Permacel) or Neoprene foam Sheet.

9.2 FUEL DRAIN PROCEDURE

- Main switch in **ON** position



- **Double click** MARK button ⑥ to activate fuel pump (for fuel drain purpose).



- **Single click** MARK button ⑥ to deactivate fuel pump.

9.3 FUEL COUPLING

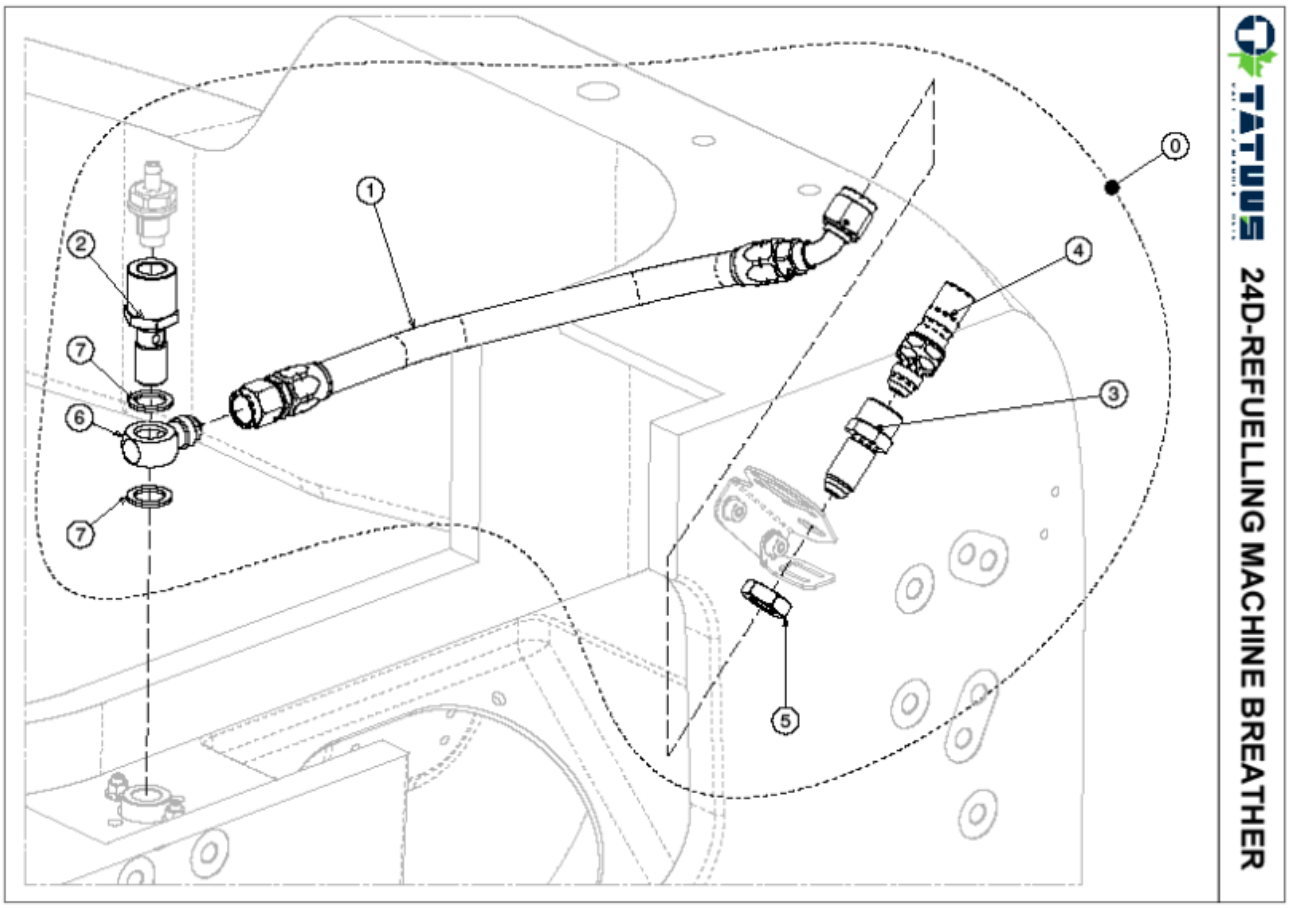
The feeding line to the engine is equipped with a safety dry-break:
Staubli SPT08.3655/L/JV
SPT08.7655/L/JV

The fuel tank port is equipped with a dry break
- Filling Port: Staubli N00916298 (on board)
- Mating Port:
    - o Staubli N009 161 98 (fuel bottle)
    - o Staubli SPT12.1658/L/JV (fuel machine)

SPT 12		Threads F	L (mm)	JV	JKV
Male thread socket		UNF 7/8 - 14" JIC DASH 10	19	SPT 12.1657/L/JV	SPT 12.1657/L/JKV
		UNF 1 1/16 - 12" JIC DASH 12	21.9	SPT12.1658/L/JV	SPT 12.1658/L/JKV
Non threaded socket		-	-	N 009 161 98	N 010 830 07

9.4 FUEL MACHINE OPTIONS

An optional system can be installed to have a breather valve dry coupled.



24D - FUEL SYSTEM

#	Part Number	Descrizione	Description	Qty
			COMMON PARTS	
0	2424019	Assieme sfiato per macchina benzina	Refuelling machine breather assy	0
1	2424008	Tubo sfiato quick refuel	Breather hose, quick refuel system	1
2	2424014	Adattore dash 6	Dash 6 adaptor	1
3	ADMF-06X20-06X8	Adattatore	Adaptor	1
4	SPT087655L	Raccordo a sgancio rapido	Quick disconnect coupler	1
5	AN92406	Dado esagonale	Hexagon nut	1
6	77606D	Banjo #6	Banjo adaptor #6	1
7	RR1420	Rondella di Rame	Copper washer	2

The breathing line to the tank is equipped with a safety dry-break Staubli SPT08.7655/L/JV, the mating port (machine side) have to be SPT08.3655/L/JV.

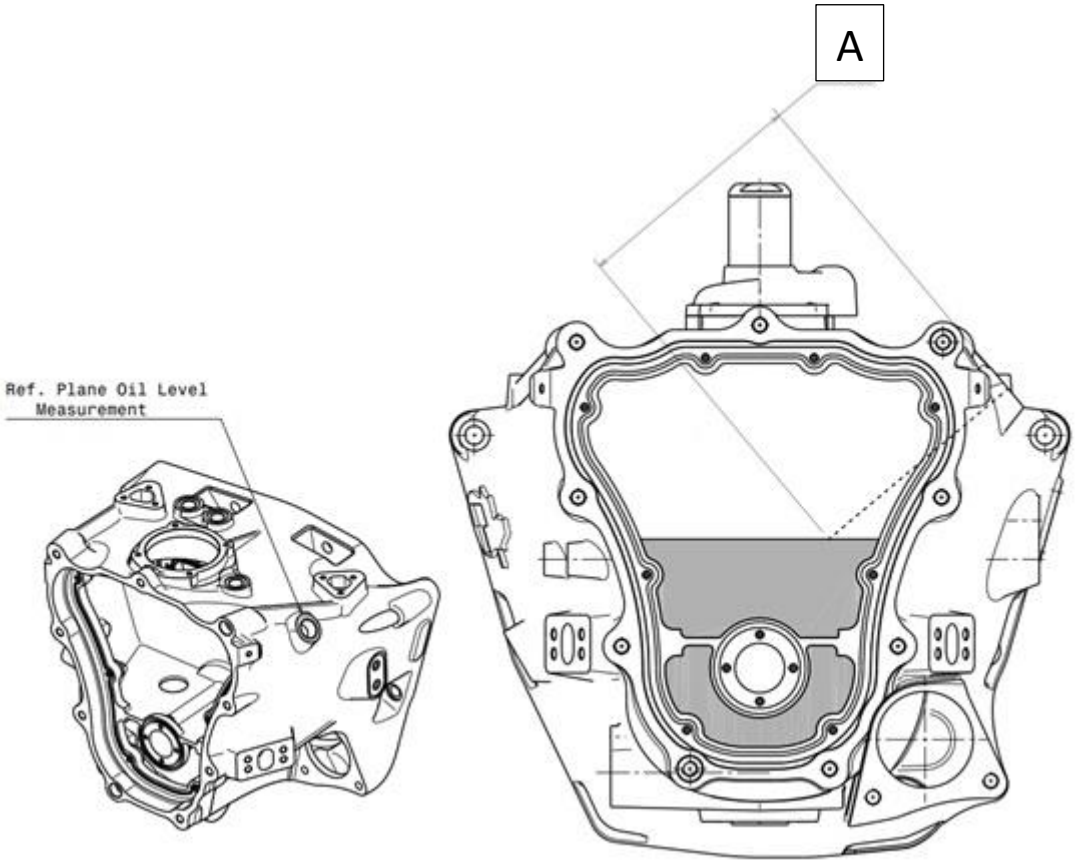
10 OIL SYSTEM

The oil tank is located within the gearbox bellhousing.
Some oil may overflow into the catch tank, so regularly drain and clean it to optimize oil level.

It is recommended to follow the procedure below in order to have a consistent level measurement:

- Turn on the engine;
- Warm up temperatures (oil at 80°C);
- Run the engine for 30 second at 3000rpm;
- Turn off the engine by the steering wheel start/kill button or with the main switch in **ON** position
- Measure the oil level. With reference to the picture below: from the filler plug plate the oil level [A] should be 150mm.

Further information about oil level procedure is available in the engine technical manual.



Warning: Do not turn off the engine putting the main switch in **OFF** position, the impulsive power off may cause serious damages to the electronics due to hard electrical spikes.

11 ELECTRIC SYSTEM

11.1 OVERVIEW

The wiring loom is split in four main parts:

- Chassis harness
- Engine harness
- Gearbox harness
- GCC/EGA harness

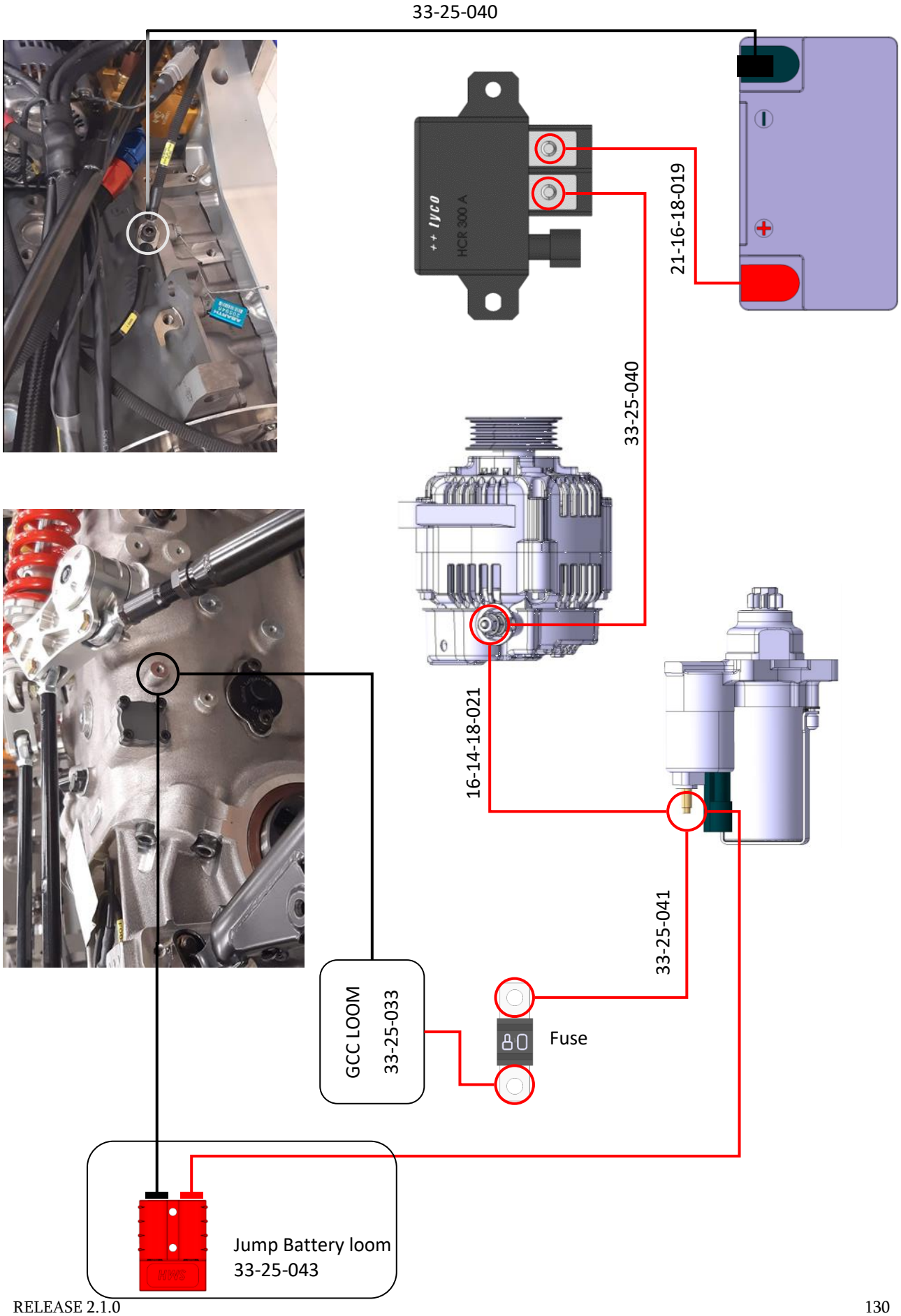
The power system (+12V) includes

- Battery: installed in the cockpit behind driver seat
- Main switch: electrically operated, located on the battery carrier
- Generator: installed on the engine
- Powerbox: current distribution is provided to the vehicle by a power distribution module
- Starter: direct power connection
- ESA (gear actuator): fused power connection

11.2 POWER SYSTEM

11.2.1 Power loom routing

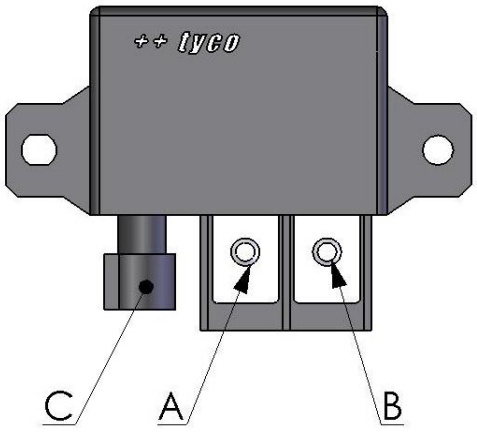
Please find in the following picture power loom routing


33-25-040
++ TYCO
HCR 300 A
21-16-18-019
33-25-040
16-14-18-021
33-25-041
GCC LOOM
33-25-033
80
Fuse
Jump Battery loom
33-25-043

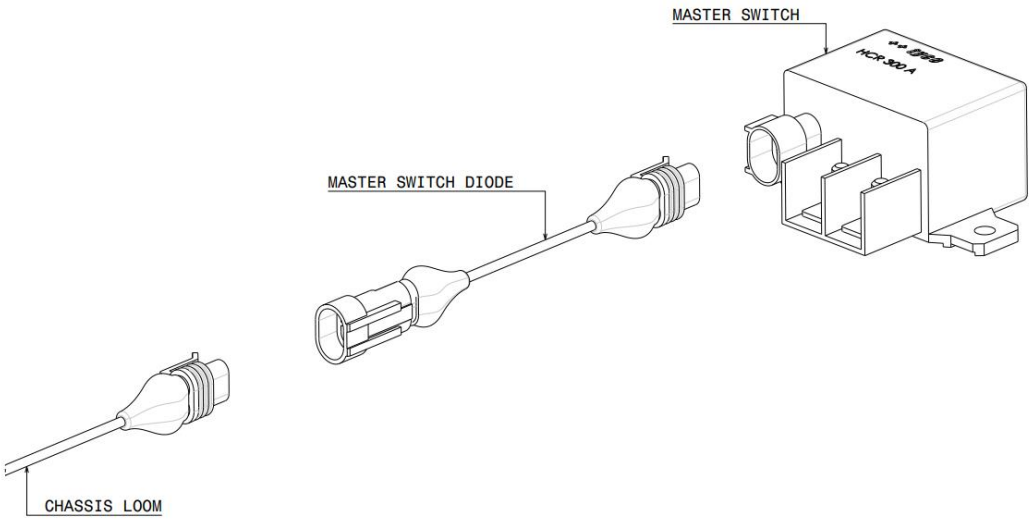
11.2.2 Main switch

The master switch is actuated by the cockpit panel and emergency switches, connection schematics:

A	• +12V Generator (loom 33-25-040) • +12V Chassis loom ring (“Main Switch” on Chassis Loom)
B	• +12V Battery (loom 21-16-18-019) • Main switch coil supply (“TYCO Main Switch” on Chassis Loom)
C	• Chassis loom connector (“Solenoid” on Chassis Loom).



An additional master switch diode (cod.161518035) should be installed as shown below.



11.2.3 Battery

The car is equipped with 14 Ah AGM battery.

The battery is a crucial component interacting with engine and gearbox management systems. Pay particular attention to its charge level especially if you are running reset procedures.

It is particularly important to keep the SOC (state of charge) of the battery at an high rate, running with the battery at low SOC may reduce its performance and affect the battery SOH (state of health).

NOTE: brand new batteries should undergo a full charging cycle (with specific charger) before the first use.

NOTE: to extend the battery life and prevent noisy battery voltages it is recommended to keep the SOC and SOH of the battery under control and include the battery charging in the standard routines of maintenance of the car.

NOTE: the jump battery connector is not directly connected to the battery, it is isolated by the master switch. If the battery charger is plugged to the jump battery connector it will **not** charge the battery (if main switch is OFF). It is recommended to use a separarte harness for the in-car charging.

NOTE: running engine at low revs will not charge battery!

NOTE: if the battery power is low high current consumptions (like a gearshift actuation/recharge) can result in an engine stall, keeping higher revs and generator in charge will fix this occurrence.

11.2.4 Battery installation

It is recommended to apply a minimum of 5mm of padding, below and on the top of the battery case, and a 2mm padding per side in order to protect the battery from excessive vibration.
The padding also protects the battery casing from getting damaged. It is recommended using closed cell neoprene.
It is also important that when strapping the battery in place, the padding is not excessively compressed, as this would minimize its effect.
It is also recommended that the battery cables are fully supported so they do not add any extra stress onto the battery terminals. If they are too short, the engines vibrations when revved will be transferred through the cable to the battery. If the cables are too long, they may weight enough to move when accelerating, braking or cornering, adding extra stress to the battery terminals.

A battery, which has been damaged due to vibration, will show a good open circuit voltage (12.8v or more), but when loaded, the voltage drops to zero. The battery casing usually also shows signs of wear on the casing.
It is also important that when attaching cables to the battery terminals, that the retaining nut is tightened to 4Nm and no higher.

11.2.5 Jump battery

It is suggested the use of a jump battery during the engine crank and during the garage/pits and grid operations.

The car is equipped with Lithium battery. A specific Jump battery suitable with Lithium batteries is necessary.

The rear wing pillar has a double thread suitable for the Anderson SB50 plug.

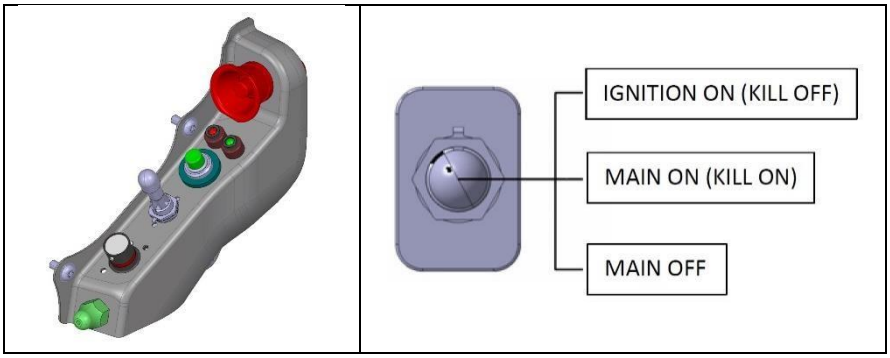
NOTE: when the jump battery is plugged IN, the Powerbox turns ON. If it is necessary to make a power cycle it is recommended to disconnect the jump battery.

NOTE: the jump battery connector is not directly connected to the battery, it is isolated by the master switch.

11.2.6 Fire-UP/Switch-OFF Procedures

The following procedures best practices are suggested with the aim to reduce the risks of damages to the electronics due to hard electrical spikes.

Best Practices in Fire-UP/Switch-OFF



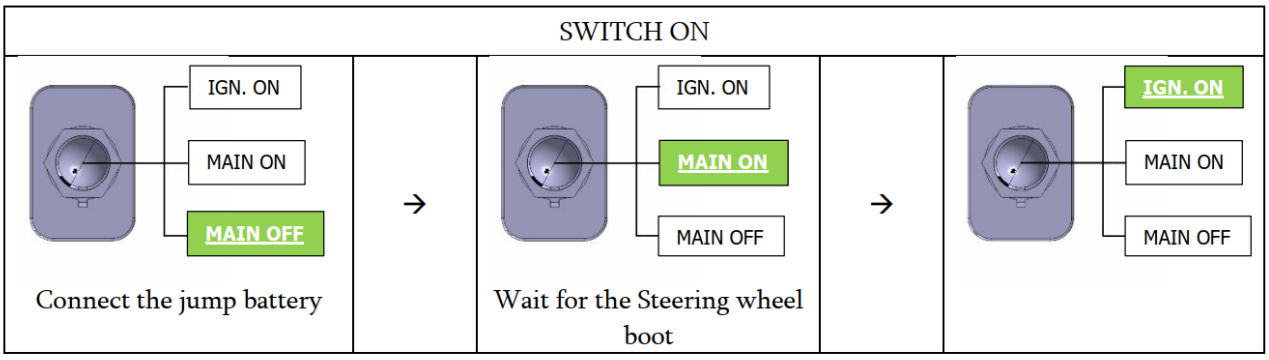
Whenever is possible plug-in the jump battery BEFORE toggling the Main switch in MAIN ON position.

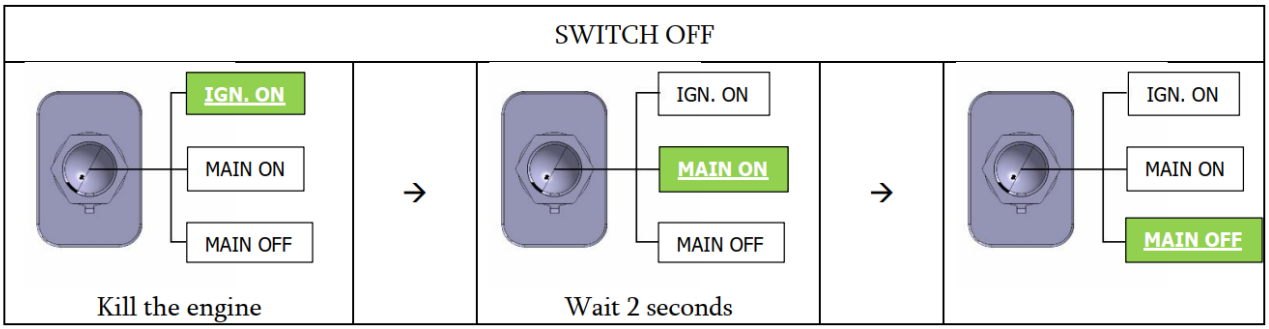
It is recommended to switch-off the engine by pushing Start button on the Steering wheel, alternatively toggle the Main switch in the middle position (MAIN ON).

Avoid to toggle the Main switch impulsively from IGNITION ON to MAIN OFF (or vice versa), it may cause serious damages to the electronics due to hard electrical spikes.

Use the jump battery whenever possible, in example during box/pre-grid activity that needs the car switched on (MAIN ON/IGNITION ON).

See the following pictures as best practices reference.





11.2.7 Power-box

The car is equipped with a Power Distribution Module, usually referred to as power-box.
The Power-box manages the current distribution on the power lines listed on the following paragraphs. 16 power lines are available. The lines are subdivided in 2 groups: HP lines (total of 6) and LP lines (total of 10). Some of the lines are merged in order to meet the power requirements of the devices connected.

User devices connected to customer available connections (CAN AUX ports, Radio, Power AUX) must not exceed 5A in total and 2A per power supply pin.

WARNING: **Do not disconnect the powerbox connection when power is ON!**

If the power-box detects an overcurrent on one of the lines, it acts shutting off the power supply in the relevant line. Please note that a cut on a power line implies an abnormal draw of current, most of the time due to a short-circuit on the devices powered by the line or on the wiring loom. It is recommended to check for the source of the electrical fault to avoid damages to the electrical components.
If the power-box cuts a line, it needs to be re-set in order to power the line cut again. To re-set the power-box it is necessary a power cycle (the jump battery must be disconnected).
Evidence of line being cut are available on dashboard and data logging. If a line is turned off the alarm “ELEC-F” is displayed on the dashboard. The powerbox page displays the line turned off with red background.
In the logged data are available the channels:

- PSD_HP_Alarm_1_6: bitmapped, triggers value 1 on relevant bit if one of the HP lines has been shut off
- PSD_LP_Alarm_1_8: bitmapped, triggers value 1 on relevant bit if one of the LP lines (from number 1 to number 8) has been shut off
- PSD_LP_Alarm_9_10: bitmapped, triggers value 1 on relevant bit if one of the LP lines (number 9 and 10) has been shut off

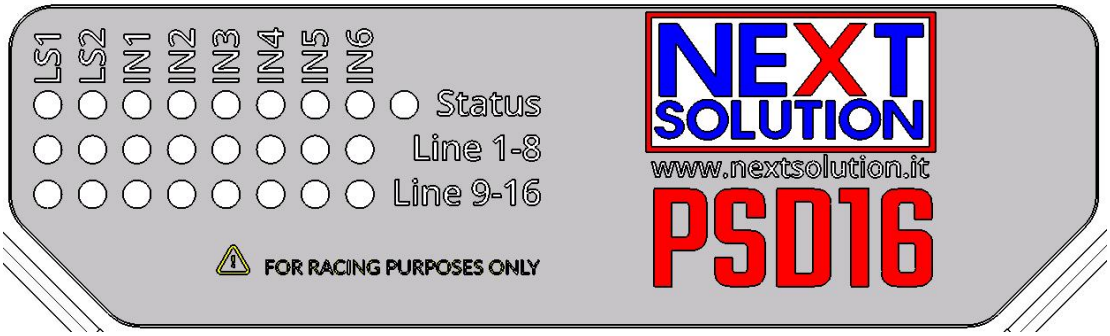
Please refer to the tables below showing bitmap configuration for the channels above

bit	7	6	5	4	3	2	1	0
PSD_HP_Alarm_1_6			Starter - 2	Coils - 2	Coils - 1	Injection	Starter - 1	Fuel pump

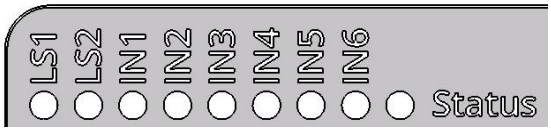
bit	7	6	5	4	3	2	1	0
PSD_LP_Alarm_1_8	Engine 3	Engine 2	AUX 2	AUX	+30 CAR 1	Engine 1	EXTRA	FED

bit	7	6	5	4	3	2	1	0
PSD_LP_Alarm_9_10							+30 CAR 3	+30 CAR 2

The powerbox features an on board led indicator panel. Please find it reported in picture below

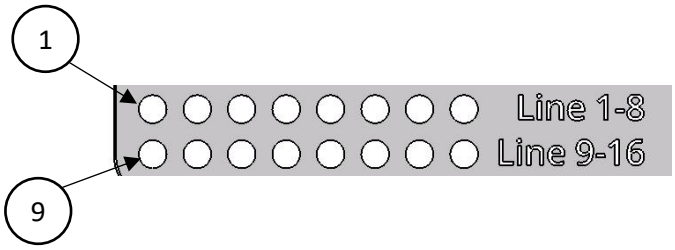


First row led strip



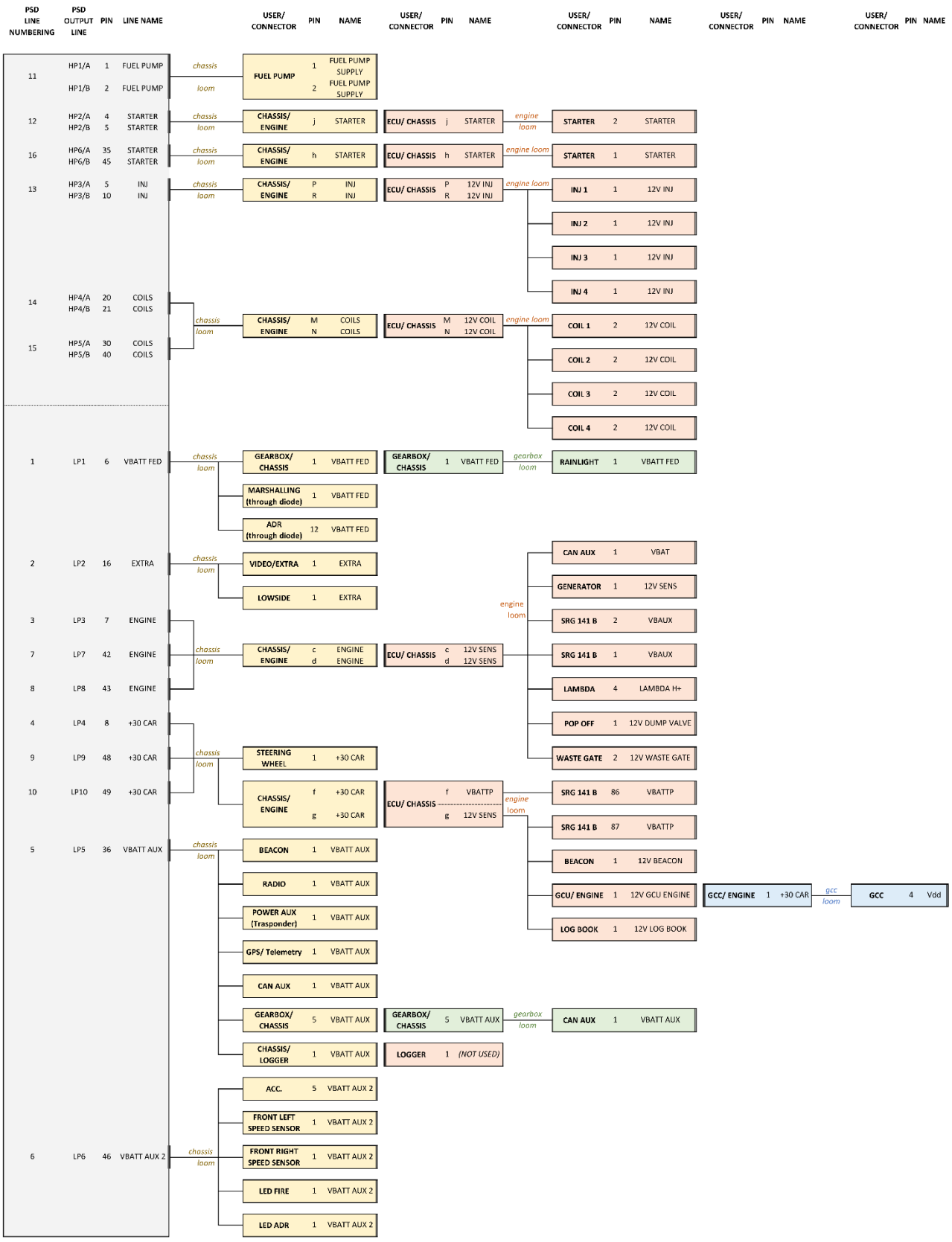
- LS1, LS2 : not used
- IN1 – IN6: show the status of the input activation. With reference to paragraph **Error! Reference source not found.** when the main switch is ON, the led “IN6” turns on; when IGNITION switch is ON, the led “IN6” and the led “IN3” turn on
- Status: turns on when the power box is powered. Please note: when the Jump battery is plugged in and the main switch is OFF, the status led blinks.

Second and third row led strips



- Line 1-8 and Line 9-16: show the status of the relevant line. To understand which function is associated to each line, please refer to the first column (“PSD line numbering”) in the connection map in the next page. The led is normally green or blue. If the led is red, it indicates the relevant line has been cut due to overcurrent detected.

Please find in the following picture the powerbox line connection map:



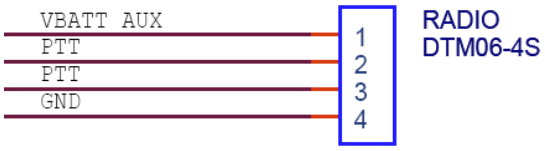
11.3 WIRING

11.4 ELECTRICAL SCHEMATICS

Refer to PDF files available in the Tatuus' sharezone for electrical schematics.

11.4.1 Radio plug

A radio connector is provided in the chassis wiring, it provides a 12V power and repeat the switch of the steering wheel on pins #2/#3.
Mating connector DTM04-4P.



11.4.2 CAN lines

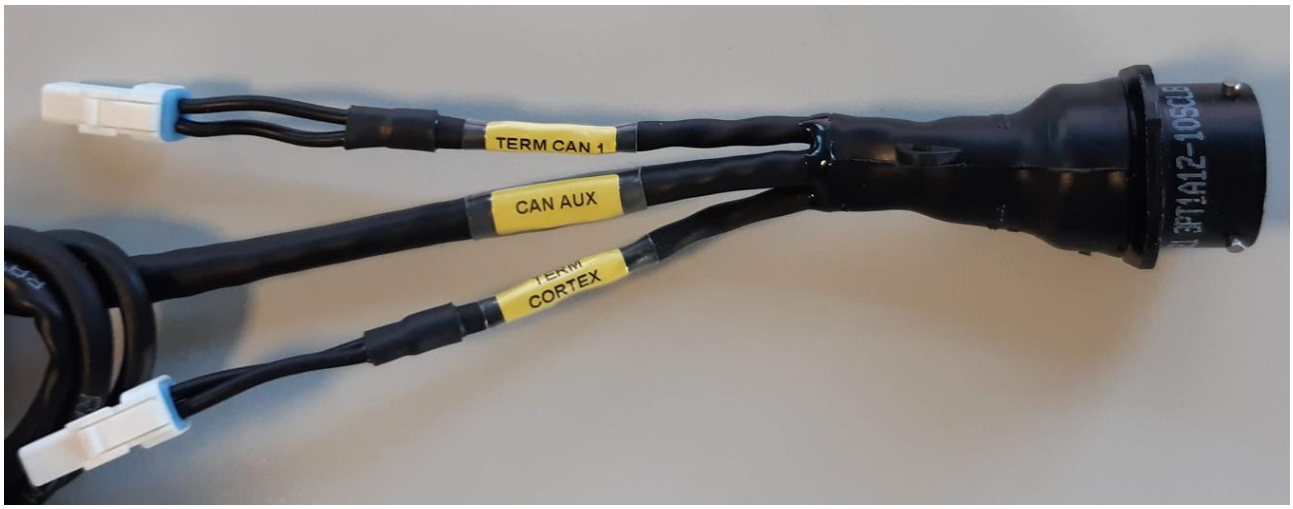
The system architecture feature 3 CAN lines.

- CAN 0: system dedicated is used to connect ECU, GCU, Steering wheel.
- CAN 1: dedicated CAN line for "federation" devices: RAIN Light, ADR.
- CAN Cortex: "user" can. It is used by low priority devices.

Can auxiliary connection and can terminations are available on:

- Chassis loom: located in the cockpit beside the fire extinguisher bottle
- Gearbox loom: located on the top rear end of the gearbox. Please remind the gearbox loom is equipped with connectors for the Endplate lights that are compatible with can termination ones. Pay attention to not invert them.

Please find below a picture showing the Auxiliary can connector and CAN termination connection.

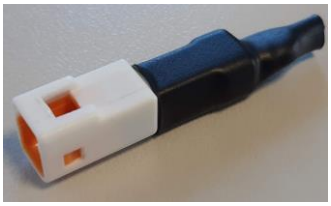


Please find below a table showing which device is connected to can line and which are the connectors where the can line is available.

	CAN-line			
CAN Numbering	**1**	**2**	**3**	
CAN name	**CAN-0**	**CAN-1**	**CAN-Cortex**	**Type**
Powerbox	X			device
Steering wheel	X	X		device
ECU	X	X	X	device
GCC	X			device
CAN AUX CHASSIS LOOM	X	X	X	connector
CAN AUX GBOX LOOM		X	X	connector
GPS/Telemetry			X	device-optional
Rear light		X		device
ADR		X		device
Camera			X	device
Logger download in chassis			X	connector

11.4.3 CAN termination

Can lines need to be terminated at the extreme ends. Each end should be fitted with a 120 Ω resistance. If the line is properly terminated the resistance on the can line should be 60 Ω. Please find in the picture below a picture of the CAN plug termination.



Please find below a table showing the CAN termination

	Termination end 1	Termination end 2
CAN-0	ECU	Chassis loom (integrated)
CAN-1	Chassis loom (CAN plug)	Gearbox loom (CAN plug)
CAN-Cortex	Chassis loom (*please read below*)	Chassis loom (CAN plug)

NOTE: If the car is equipped with AIM SmartyCAM GP HD 2.2, the CAN Plug termination on CORTEX CAN on Chassis loom must not be installed.

11.4.4 Sensors

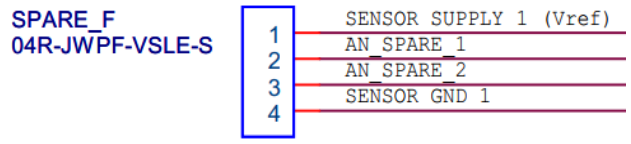
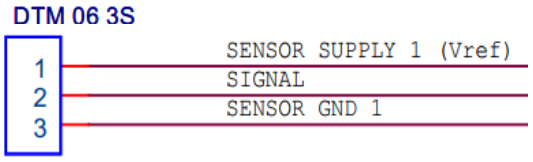
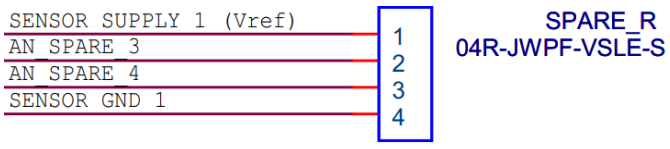
The T-421 chassis is delivered with the following chassis sensors:

- Pedal position sensor: twin way contactless rotary sensor.
- Brake pressure sensors: 100bar pressure sensor.
- Steering position sensor: contactless rotary sensor.
- Front wheel speed sensors
- Gear position sensor: contactless rotary sensor.
- Gear actuator sensor: contactless rotary sensor.
- Paddle shift position sensor: hall effect position sensors

Further available options are:

- Analog input spare
  The chassis wiring is equipped with 5 additional analog inputs:
  - 2 inputs are available at the front of the car on the chassis loom
  - 1 input is available in the engine compartment on the gearbox loom
  - 2 inputs are available at the rear end of the car on the gearbox loom.

Please refer to the pictures below for the connectors on the looms.

Chassis loom spare analog inputs connector	
Gearbox loom spare analog input connectors	 

For optional sensors and adaptor looms please refer to the T-421 spare parts catalogue.
For the analog spare inputs configuration in data logging, please refer to the engine manufacturer.

- ADR
  The wiring loom is compatible with FIA 8872-2018 units, a plug is available behind the driver's seat. To install ADR devices in the car an adaptor plate is available with p/n 33-25-003. This plate is compatible with EMM ADR4 and Motec ADR2

- External accelerometer
  Connection plug is available behind the driver's seat. A specific optional accelerometer and adaptor plate to install it are available. Please refer to the T-421 spare parts catalogue.

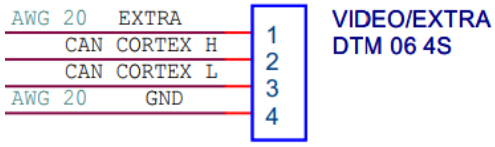
- GPS unit
  An optional 10Hz unit compatible with data logging system, standard and high gain antennas are available. Please refer to the T-421 spare parts catalogue. Dedicated connection is available at the

front end of the chassis. The antenna may be installed on the front damper deck below the Kevlar patch of the damper cover.

For optional sensors and devices allowed use please refer to the Sporting Regulation of the relevant Championship.

11.4.5 Video system

AIM smarty cam GP HD 2.2 is supplied together with the car. The Smarty cam unit should be connected to the VIDEO/EXTRA connector on the chassis loom. A junction loom is necessary and is supplied together with the camera system



The pre- installed video system is configured to be compatible with the data logger data stream in order to display data overlay on the video.

11.4.6 VREF list

Loom	VREF 1	VREF 2	VREF 3	VREF 4
Chassis loom	Front Brake Pressure Rear Brake Pressure Steering Position External accelerometer Analog spare input 1 Analog spare input 2	Throttle Pedal (B)	Throttle Pedal (A)	
Gearbox loom	Analog spare input 3 Analog spare input 4 Analog spare input 5	Gear position		
Engine loom		DBW	Manifold Pressure Turbo Pressure	Water pressure sensor Temp/Press fuel Crank pressure Oil pressure S-CAM

Sensors in **light blue** are connected to the chassis loom.
Sensors in **green** are connected to the gearbox loom.
Sensors in **black** are connected to the engine loom.

12 ENGINE

For any technical information contact the engine suppliers

13 TRANSMISSION

13.1 SADEV GEARBOX

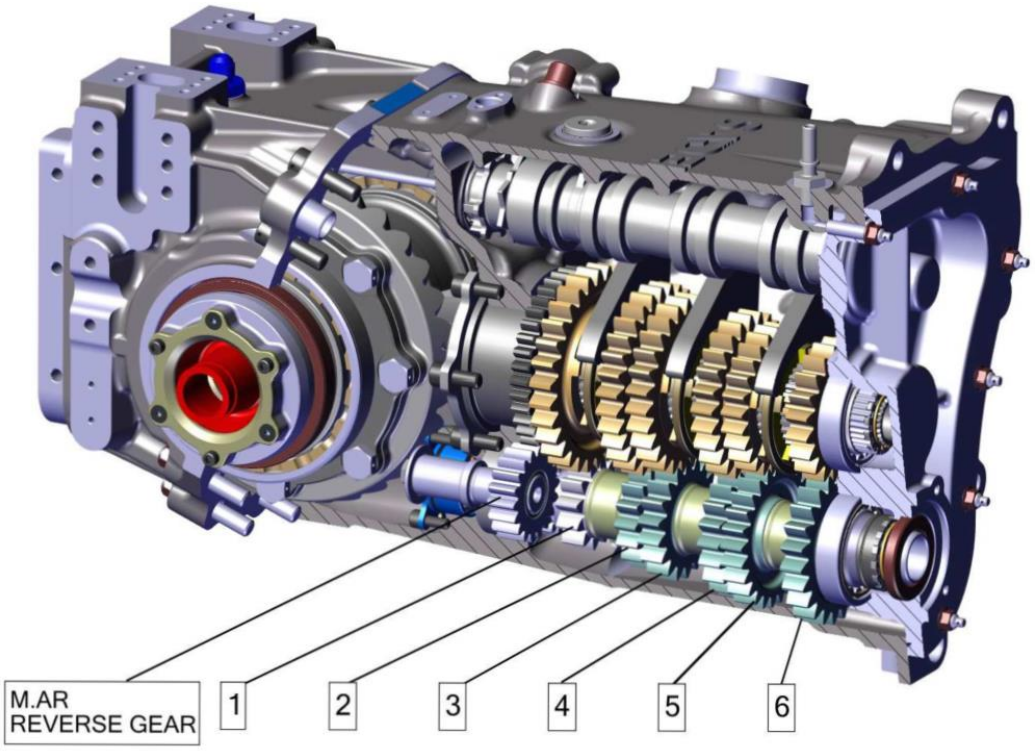
F4-21 car is equipped with a 6 gears sequential gearbox, not limited slip differential:
the SADEV SLR75-14

13.2 RATIO CHART

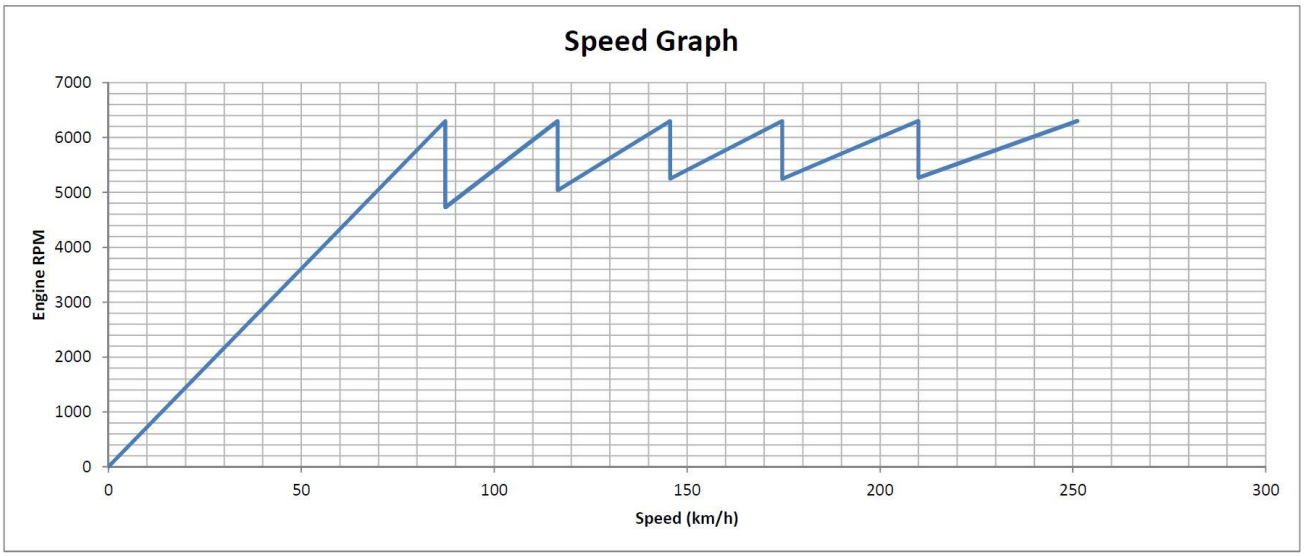
Final drive Ref.	
Secondary shaft	10
Crown wheel	31

Reverse gear	
Primary shaft	18
Idler	14
Secondary shaft	40

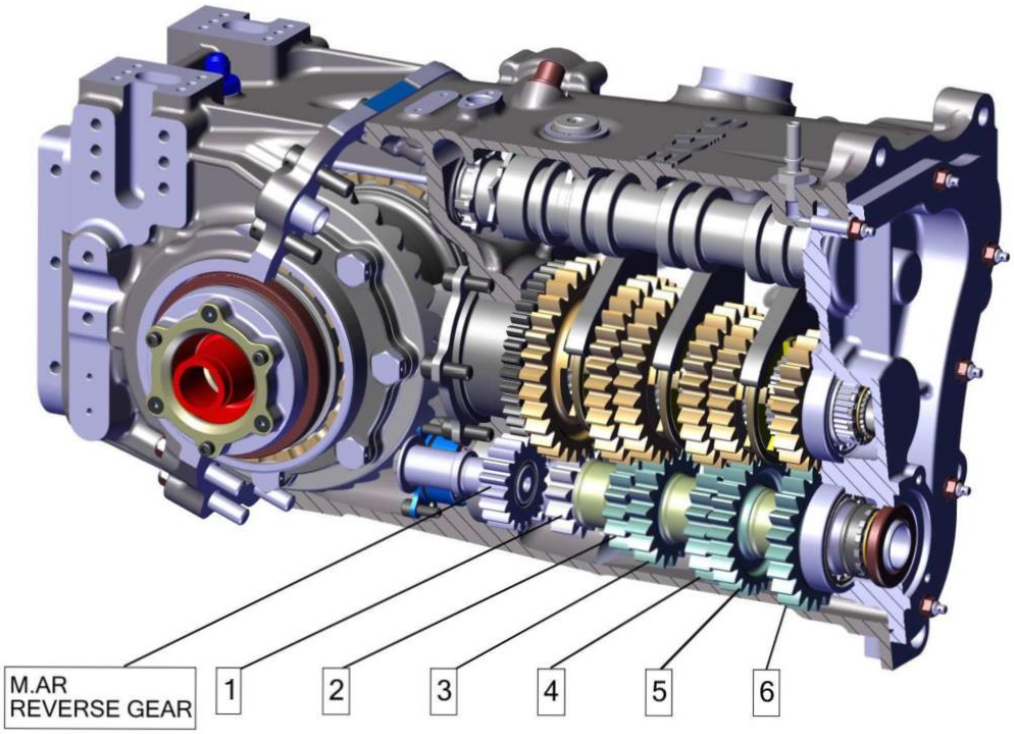
13.3 STANDARD STAGES CHART



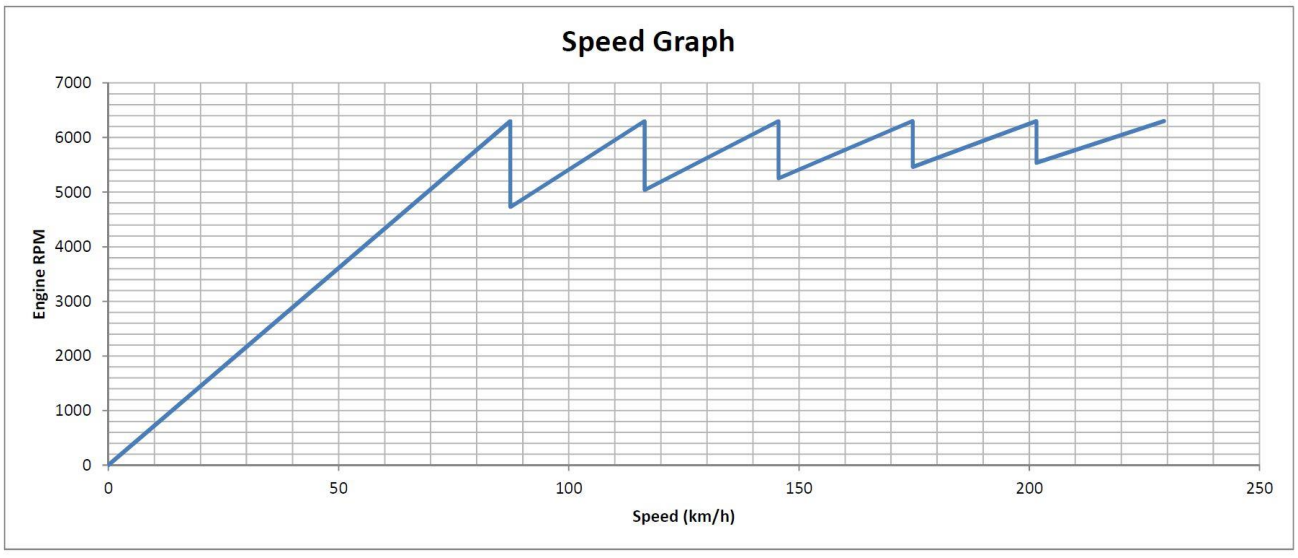
Gear	Ratio	
1st	12/30	2.50
2nd	16/30	1.88
3rd	18/27	1.50
4th	20/25	1.25
5th	25/26	1.04
6th	23/20	0.87



13.4 Optional Stages Chart



Gear	Ratio	
1st	12/30	2.50
2nd	16/30	1.88
3rd	18/27	1.50
4th	20/25	1.25
5th	24/26	1.08
6th	21/20	0.952



13.5 LUBRICATION

13.5.1 Particular Precautions

No additives should be added to the oil. The resulting consequences are not in any circumstances covered by SADEV.
When topping up the rear differential oil, do not mix any other oil with that already in the box.

13.5.2 Storage And Use

Be particularly careful with any oil bottles which are open when used:

- Close the bottle again properly after use to prevent the introduction of water or dirt.
- Store bottles horizontally, protected from severe weather.
- Do not store bottles close to a washing station.
- Do not decant the oil into larger containers.

13.5.3 Washing Under Pressure

When the rear differential is removed, seal all openings correctly to prevent the ingress of water into the rear differential.

13.5.4 Gearbox Temperature

SADEV recommends use in operation between **100°C - 110°C**, above this temperature, the life of the gearbox parts may be affected.

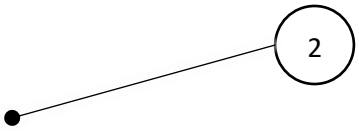
13.5.5 Gearbox Oil

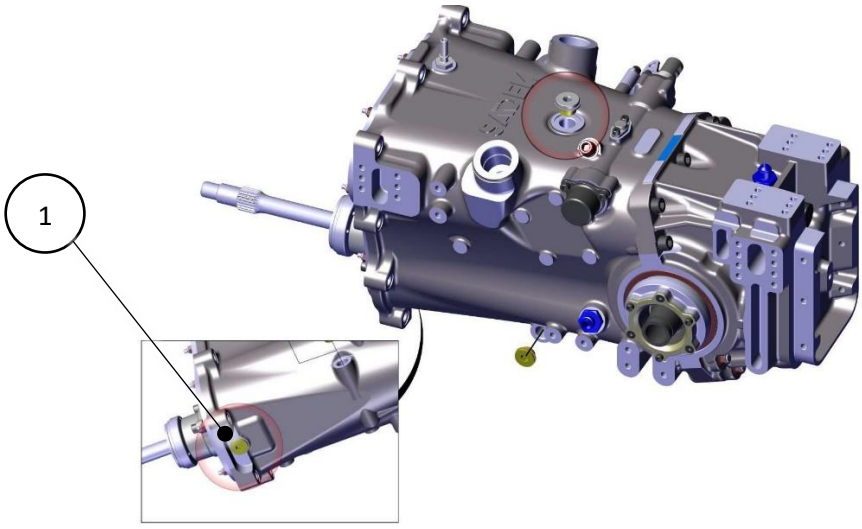
Oil capacity: 1.5 L

1st oil change	Oil change	Viscosity
After a 50 Km running-in	After each meeting or 150 km or special stage	75w140

13.5.6 Drain the gearbox:

- Disassemble the drain magnet plug (1), and clean it up.
- Filler cap (2)

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13.6 SADEV FACTORY REBUILD

- The gearboxes are delivered plumbed and numbered.
- SADEV will adopt a careful attitude when receiving a gearbox without any 'SADEV 'seals. This will also be valid if the gearbox shows minor or major damages.

13.6.1 Returning Gearboxes For Servicing

At the time the gearboxes return to SADEV, follow the Receiving procedure as described below:

- Gear box drained and cleaned.
- Release bearing in place
- Oil pump in place.
- Lubrication ports closed with the proper plugs.
- Shifters and reverse gears locking, in place.
- Drain plug and drain plug seal in place.
- Differential in place
- A card specifying the kilometers of the special stages and road stages since the last service, available at the end of the technical manual.

13.7 SERVICE PLANNING

The service plan of the gearbox is based on SADEV experiences. The information given about service plan can be updated in the near future.

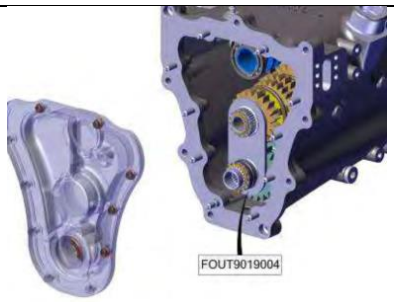
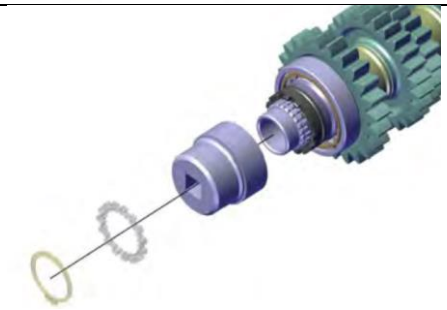
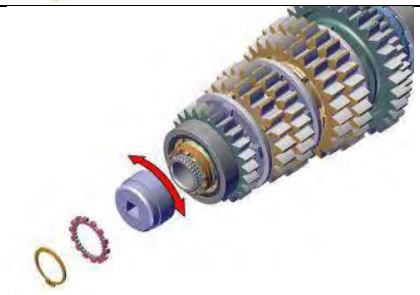
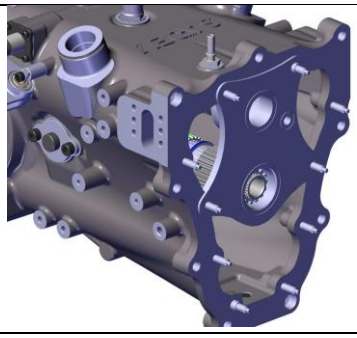
ELEMENT	PART NUMBER	ACTION	FREQUENCY
Gearbox check-up	all	Complete rebuilding in order to check all the gears and the differential	2'000 km

13.8 GLUED COMPONENTS

Glued components and tightening torque are shown in the 3D exploded view, refer to paragraph 13.12.

WARNING:
Glue components have been chosen during tests sessions. Only 'Loctite' brand components must be used. Sadev can't ensure consequences of false glue component choice.

13.9 SPECIAL TOOLS

IMAGE	*PN.*	*DESCRIPTION*	
	FOUT9019004	Anti-splay plate	
	FOUT1910110	Primary nut sleeve	
	FOUT9003276	Secondary nut socket	
	FOUT9072007	Fork adjustment	

13.10 INFORMATION ABOUT DISASSEMBLY

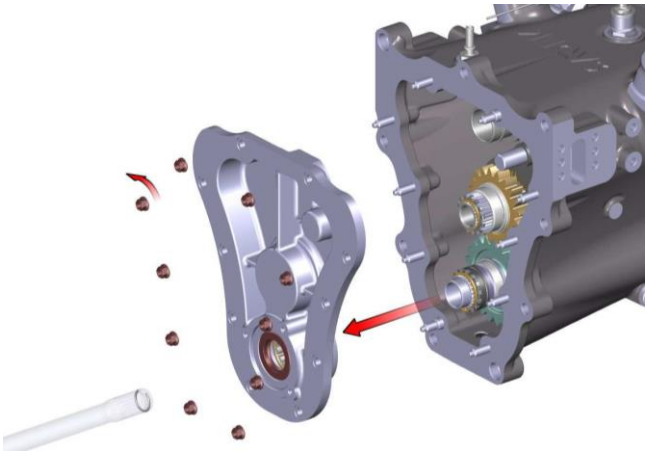
Before any intervention

Unless otherwise stated, all interventions are done with gearbox in neutral, drained and disassembled of the car.
Arrange you a clean and large enough surface to put parts during disassembly.
It is very important to mark the mounting direction of each part during disassembly. When they were run in a direction of rotation, reusing them in the opposite direction may cause premature damage.
For the same reason, sets of Fork/Dog ring/Dog ring hub, must always be kept together.
During each disassembly, remove the oil and grease, clean and check the state of each part; replace it if necessary.
During assembly, lightly lubricate the bearings, needle bearings with gearbox oil.

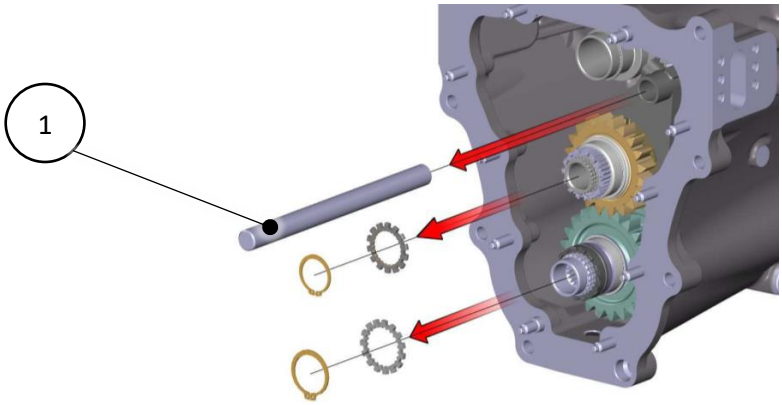
13.11 ASSEMBLY /DISASSEMBLY

13.11.1 Gears disassembly

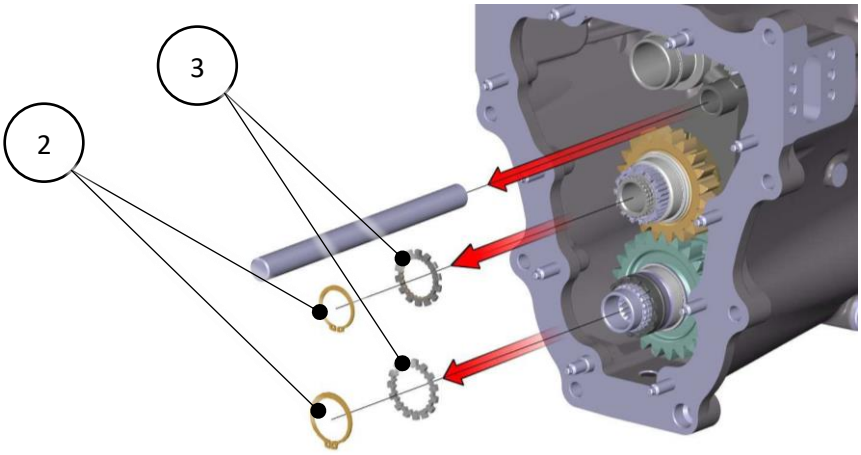
- Drain the gearbox thought lower drain plug.
- Remove the clutch shaft and the retaining ring.
- Loosen the 10 nuts M8; and remove the cover plate.



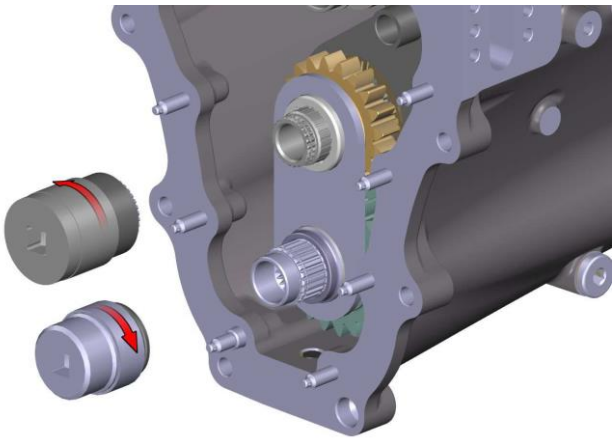
- Remove the fork shaft (1).



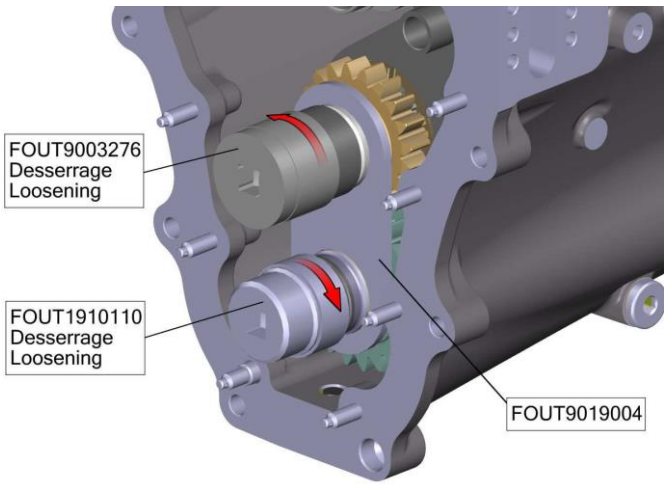
- Remove the circlips ② and the nut stopping washers ③ from the primary and secondary shafts, then engage two gears.



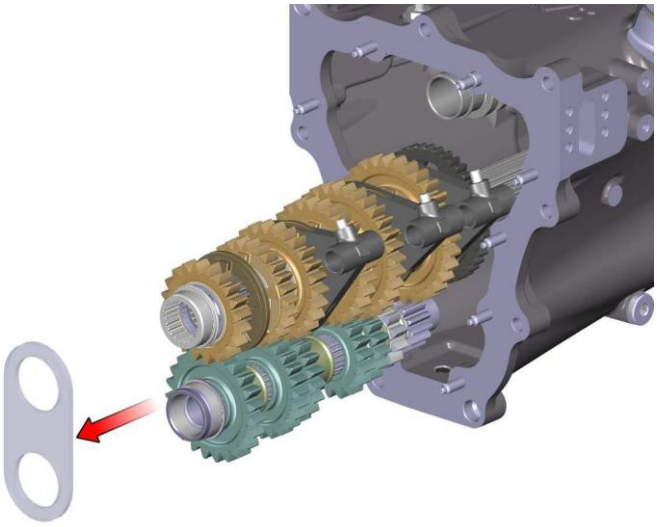
- Mount the anti-splay plate FOUT9019004 on the primary and secondary shafts.



- Loosen the 2 nuts:
  use FOUT1910110 tool for the primary shaft
  use FOUT9003276 tool for the secondary shaft.

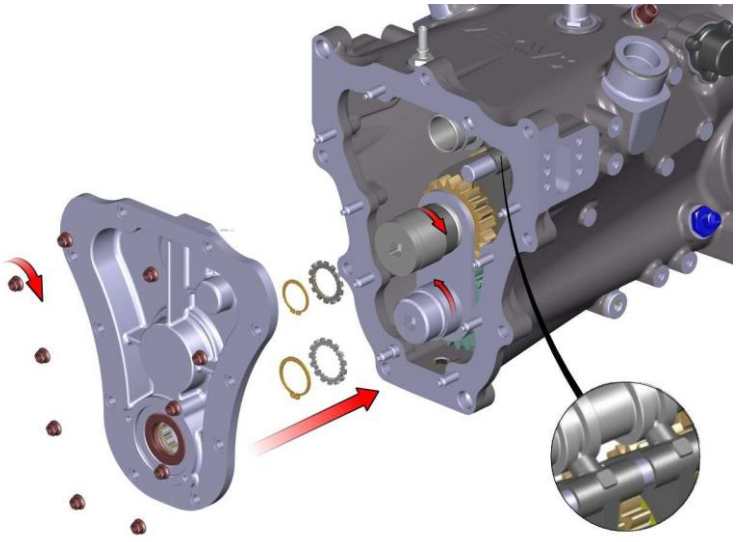


- Remove the anti-splay plate, then remove each component, noting the order of assembly.



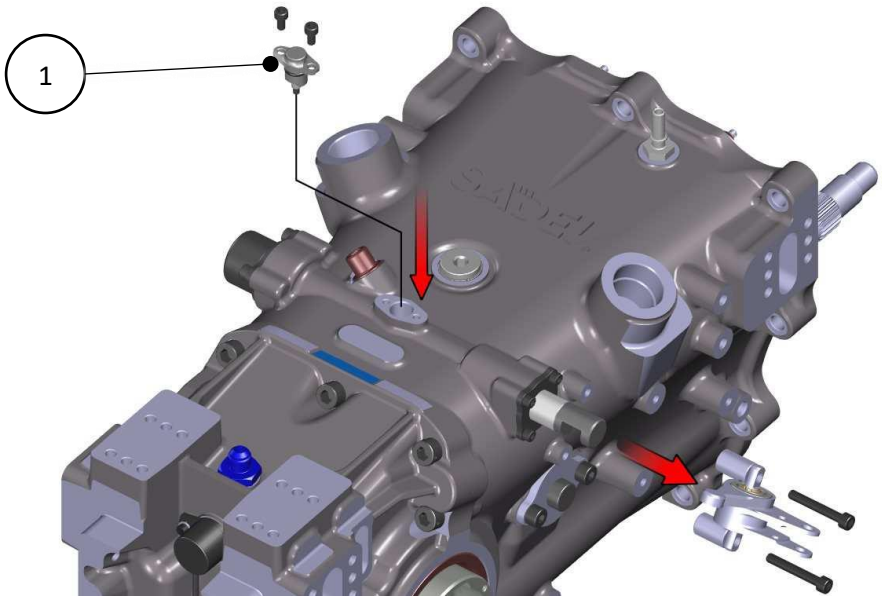
13.11.2 Gears refitting

- Clean and check the condition of parts.
- Lightly lubricate the forks and the needle roller bearing cages using gearbox oil.
- Replace each gears in the reverse order from removal. For new gears, put the reference of the gears of the primary shaft towards the operator.
- Then shift into two gears.
- Mount the Anti-splay plate "FOUT9019004".
- Clean and degrease the threads of the shafts and their nuts, for assembly use copper grease.
- Primary nut, copper grease tightening torque 150N.m.
- Secondary nut, copper grease, tightening torque 180N.m.
- Reinstall the splined washers and the circlips.
- Remove the Anti-splay plate.
- Fit the fork shaft. Be careful that the control fingers of the 4 forks are in initial locations.
- Replace the closing plate and tighten the M8 nuts (25N.m).

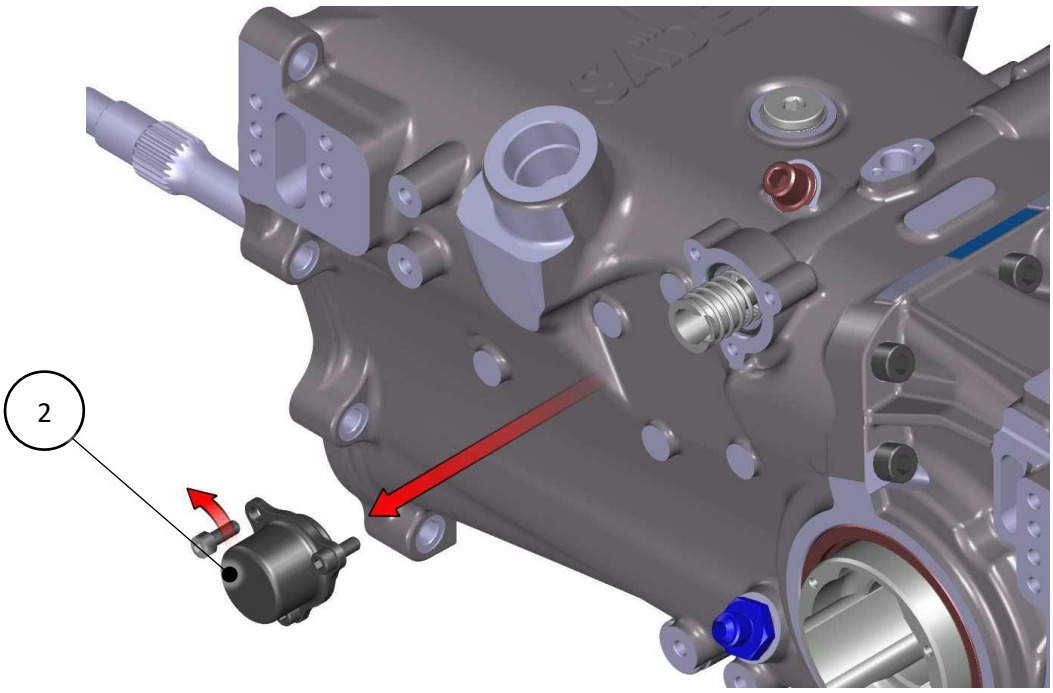


13.11.3 Selector shaft disassembly

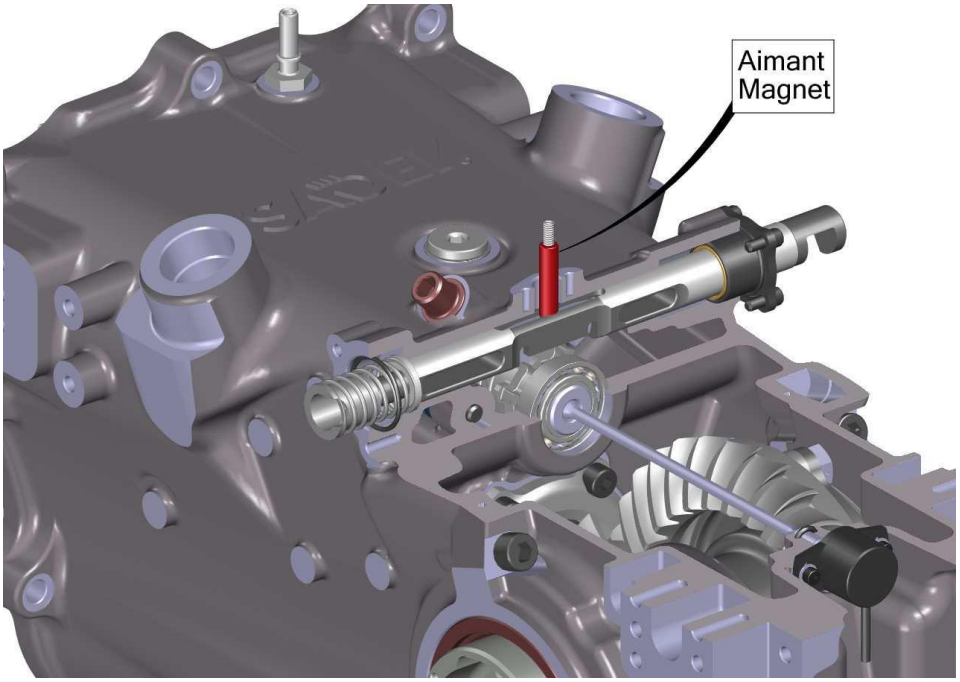
- Engage reverse gear.
- Remove the push pin of the selector ratchet ①.



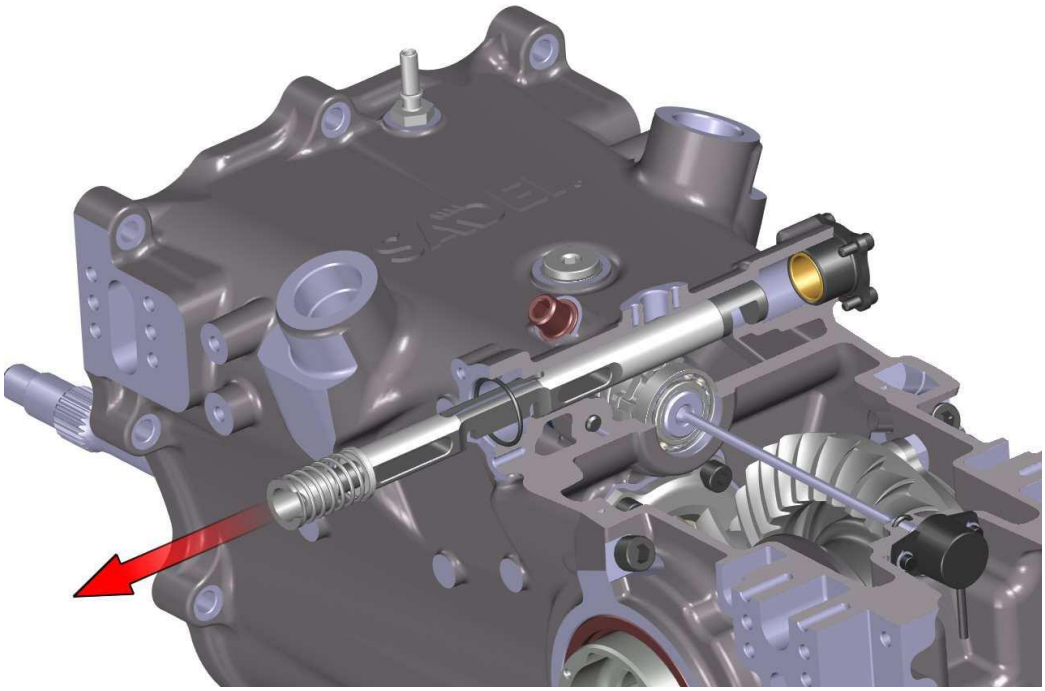
- Unscrew the 3 M6 screws then remove the selector closing block ②.



- Hold the selector shaft rachet with a magnet (Facom tool ref.827.1).

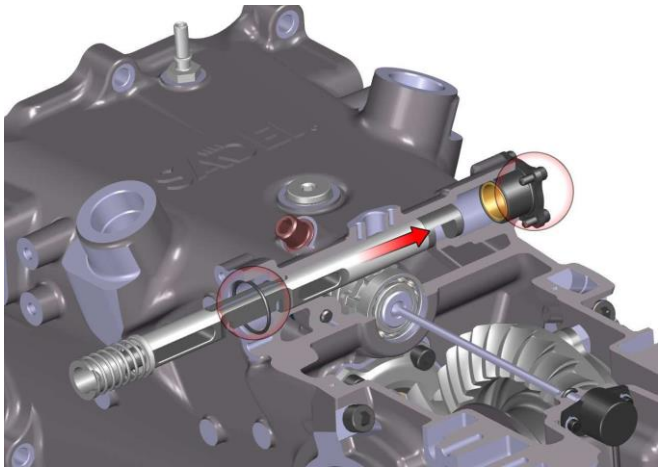


- Remove the selector assembly. Check the components.

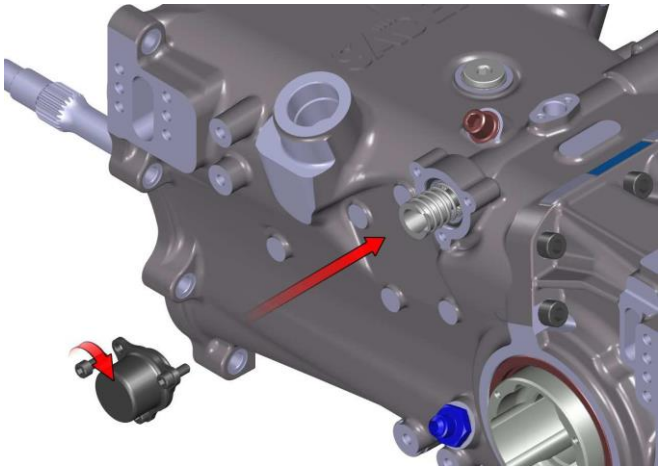


13.11.4 Selector shaft refitting

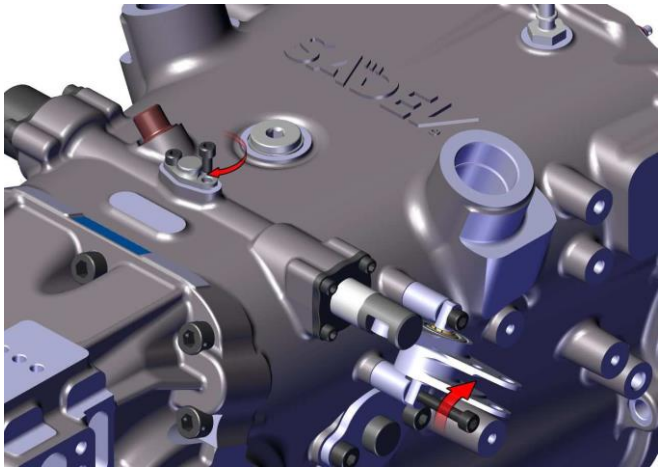
- Engage the reverse gear. Check the O'ring.
- Set in place the rachet into the selector axle.
- Insert the selector axle assembly in the main housing.



- Refit the selector closing block with the 3 M6 screws (loctite 243; torque 15N.m).

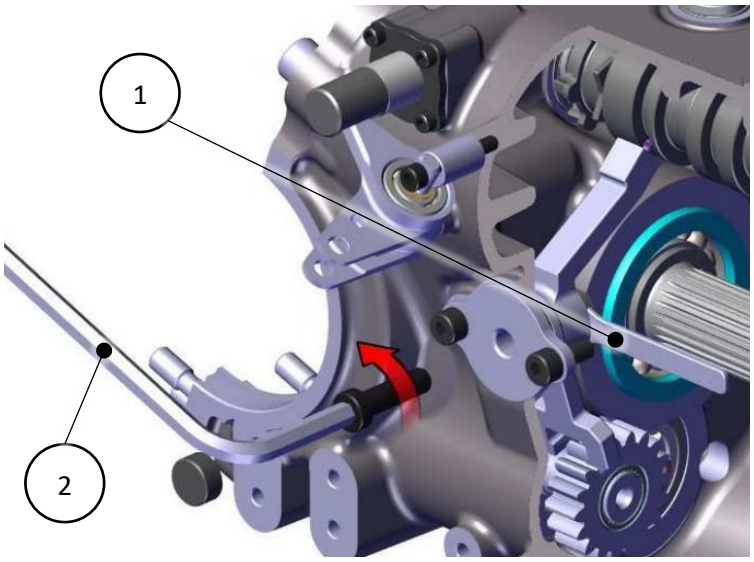


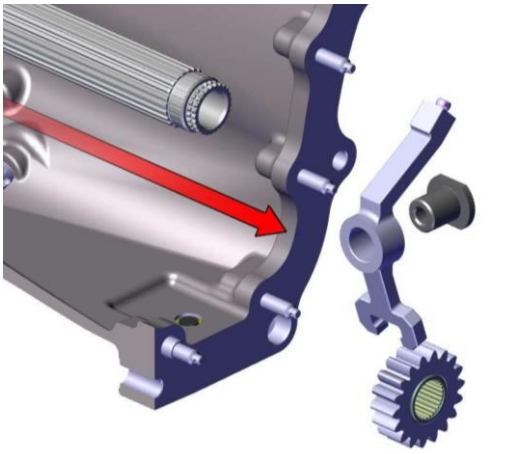
- Refit the push pin, screw the 2 M5 (loctite 222; torque 8N.m).



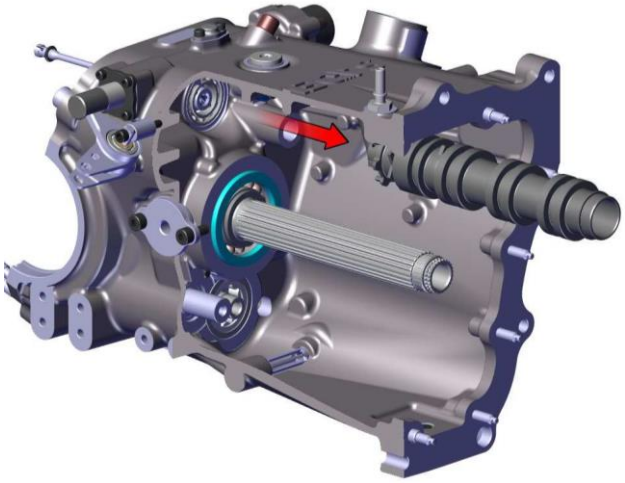
13.11.5 Barrel and reverse gear rocker removal

- Remove all gears. "see paragraph 13.11.1" and the primary shaft.
- Remove the reverse gear rocker: hold the special nut with a flat wrench ①, loosen the external pin bolt with an Allen key ②.





- Remove the barrel.

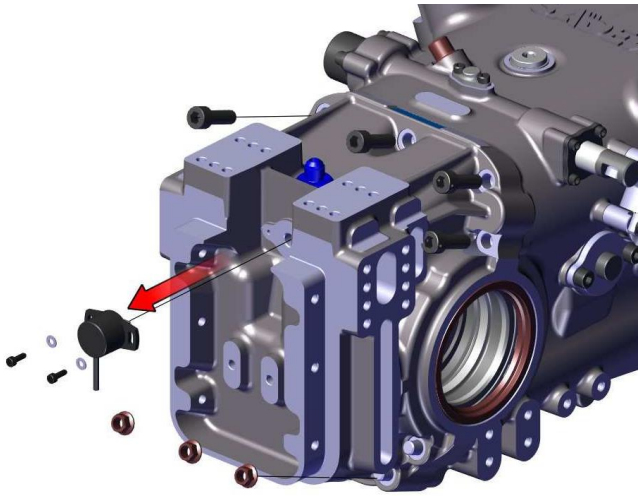


13.11.6 Barrel and reverse gear rocker refitting

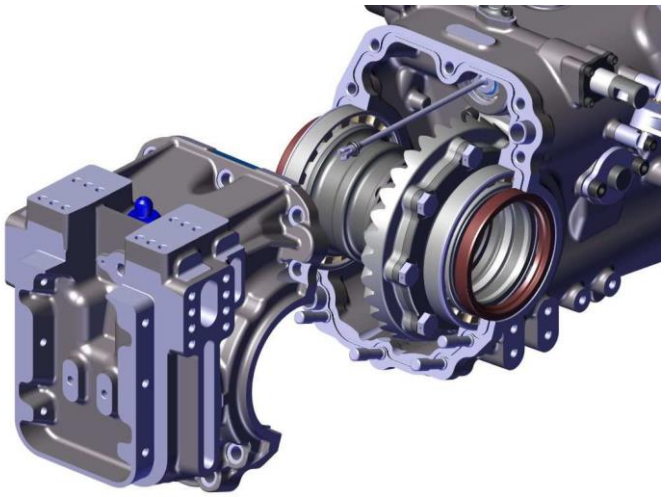
- Fit the barrel.
- Fit the reverse pinion gear in the fork of the reverse gear rocker.
- Insert the rocker control finger in the barrel groove.
- Refit the external pin bolt and the inner special nut.
- Tighten the external pin bolt (Loctite 270, torque 55 N.m).

13.11.7 Differential removal

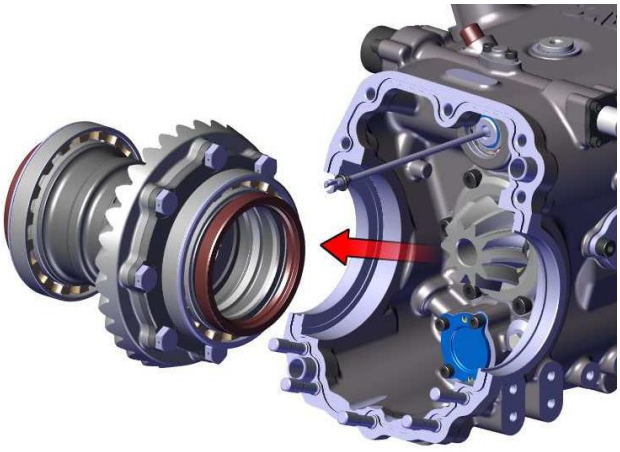
- Drain the gearbox.
- Disconnect the sensor and unscrew the 5 M10 nuts and the 5CHC M10x30 screws.



- Remove the rear housing.

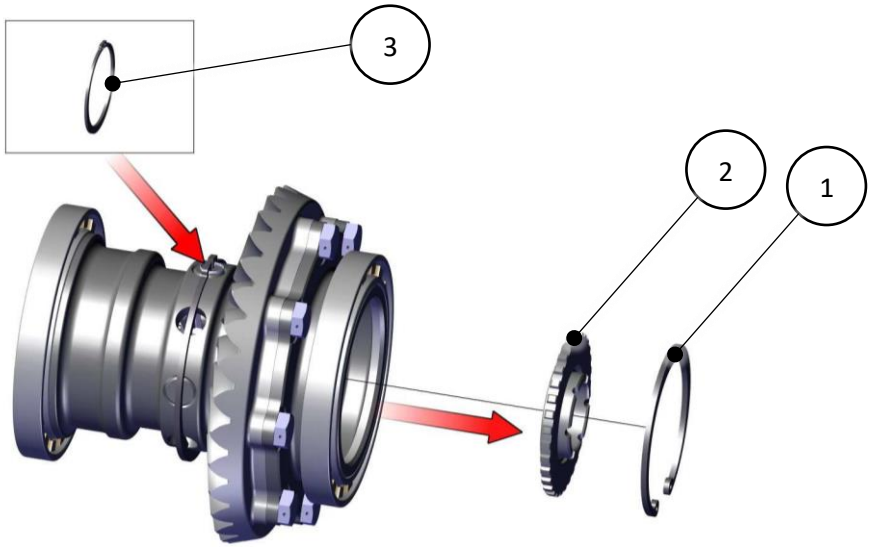


- Extract the differential.

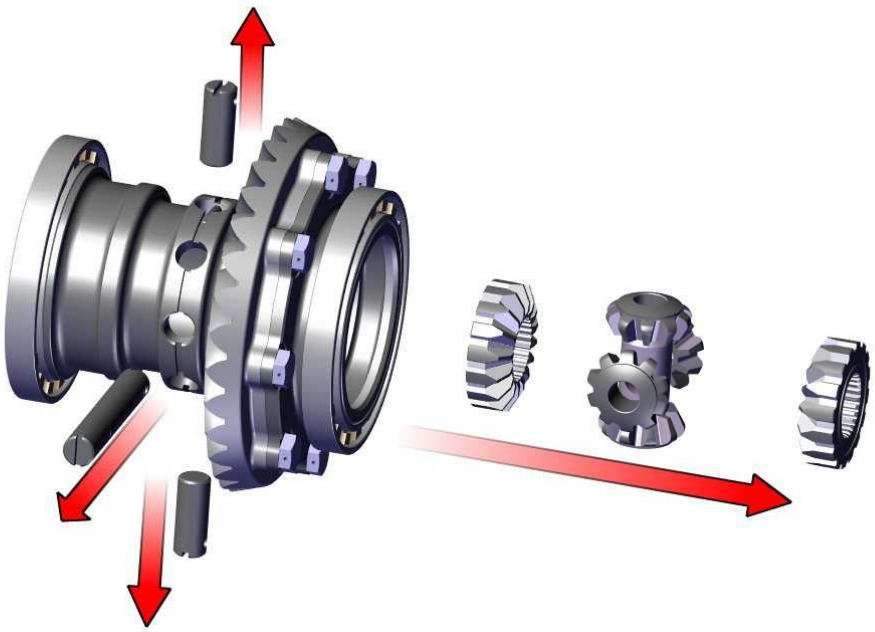


13.11.8 Differential block disassembly

- Remove the circlips ①.
- Remove the cover ②.
- Remove the outside circlip "wire locking" ③.

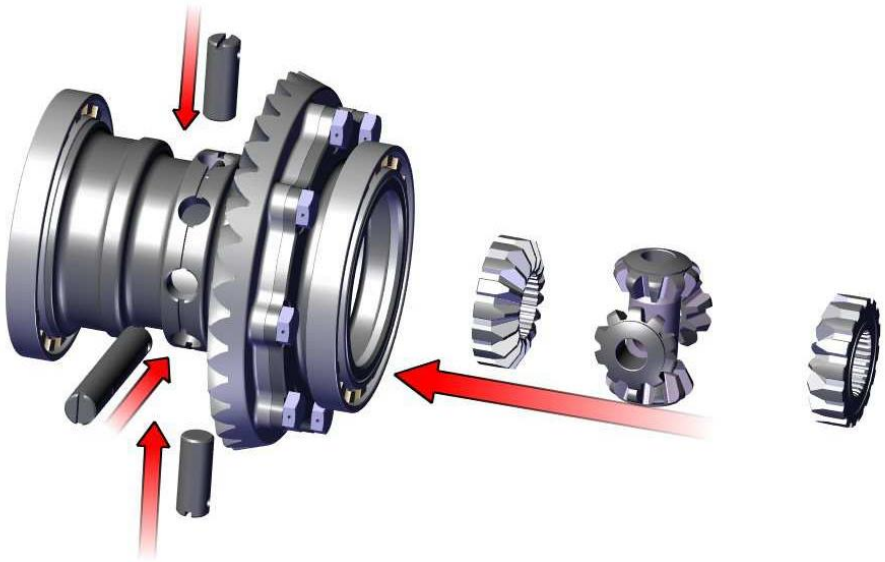


- Remove the gear axles from the case, extract the planet gears and the sun gears from the cage.

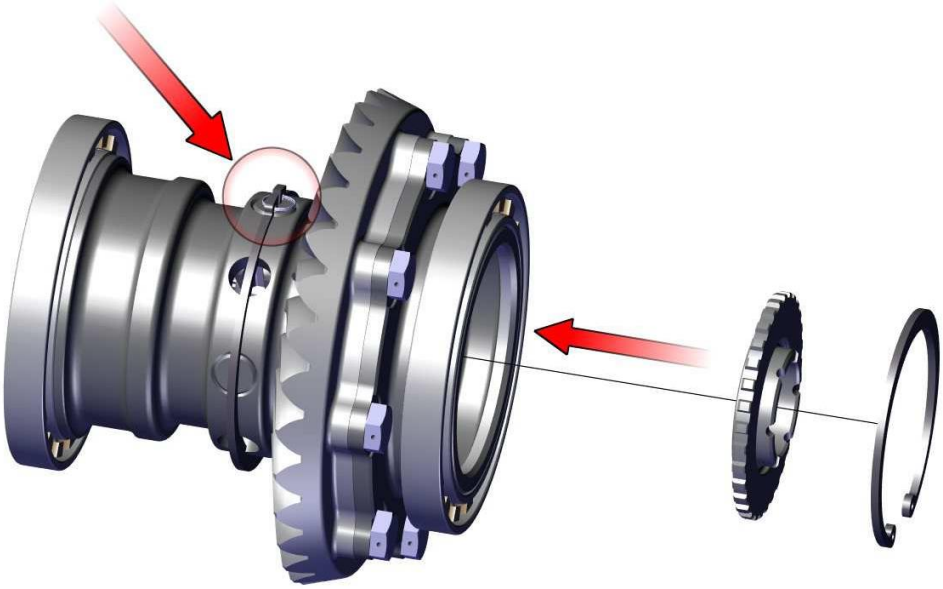


13.11.9 Differential block reassembly

- Clean and degrease the parts, check their wear and replace if necessary.
- Reassemble the parts, use gearbox oil to lubricate, respect the reverse order of disassembly.

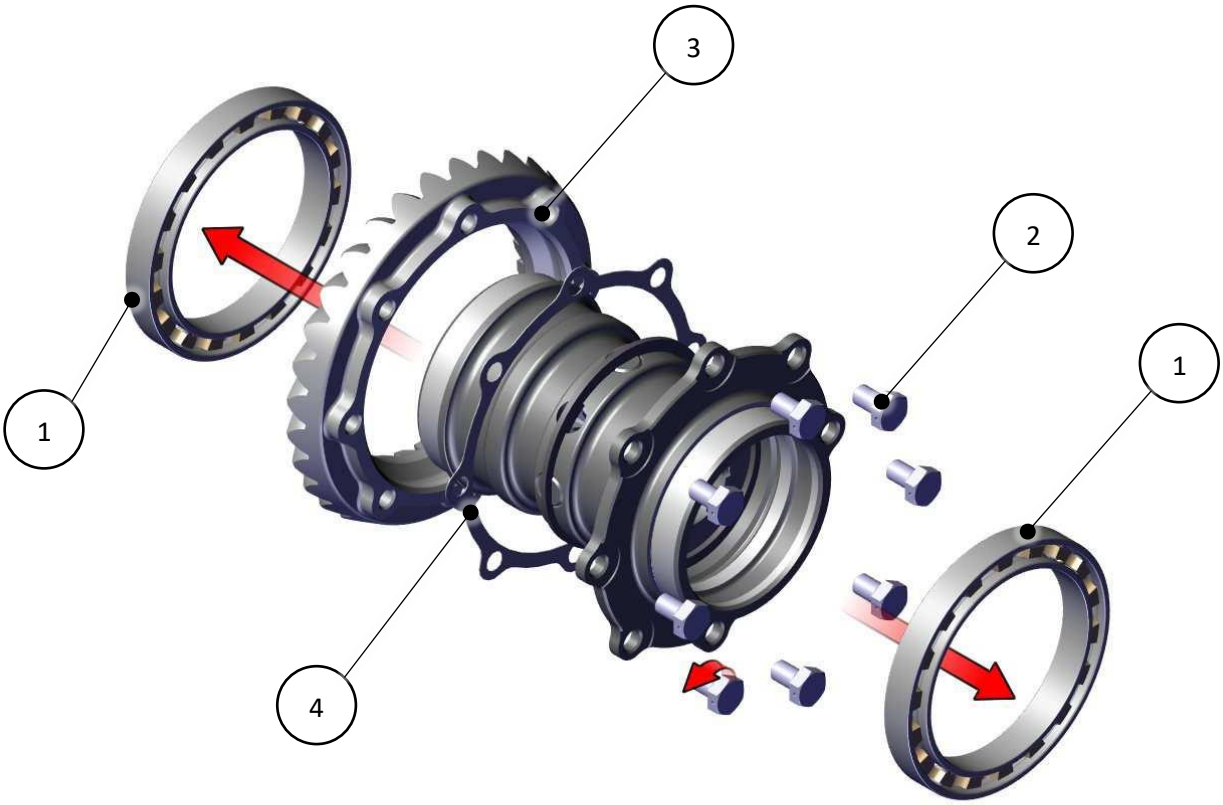


- Use safety wire to secure the circlip.



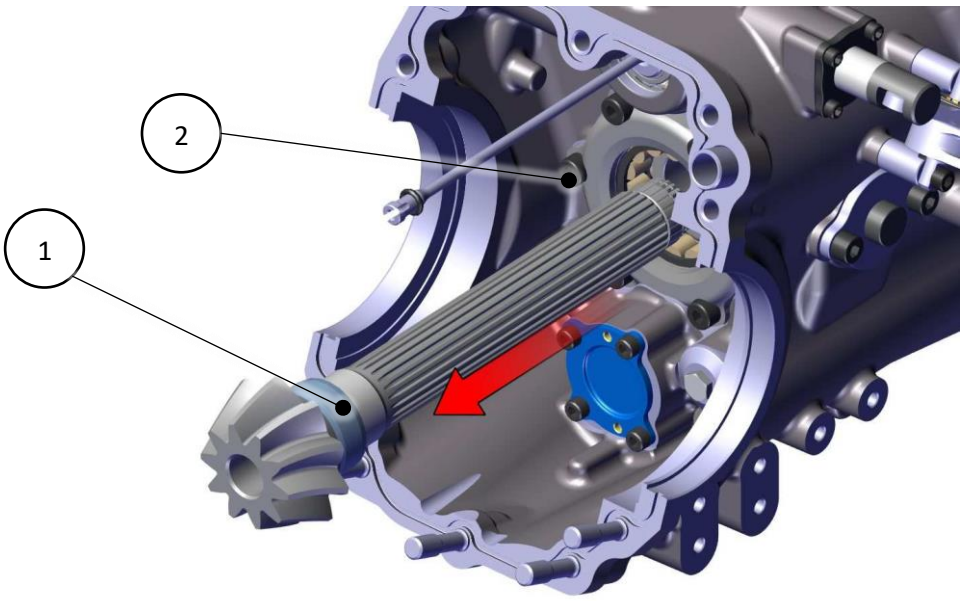
13.11.10 Crown wheel and differential bearings replacement

- Remove the bearings (extractor needed)①.
- Untighten the M10x1.00 bolts ② (heat if necessary). Remove the crown wheel ③
- Remove the EKAGRIP wedge ④.
- Clean and degrease the wheel crown, use an M10 x 1.0 tap drill.
- Refit the wheel crown, the new EKAGRIP wedge, use new bolts (loctite 648, torque 90 N.m).
- Assemble the bearings.

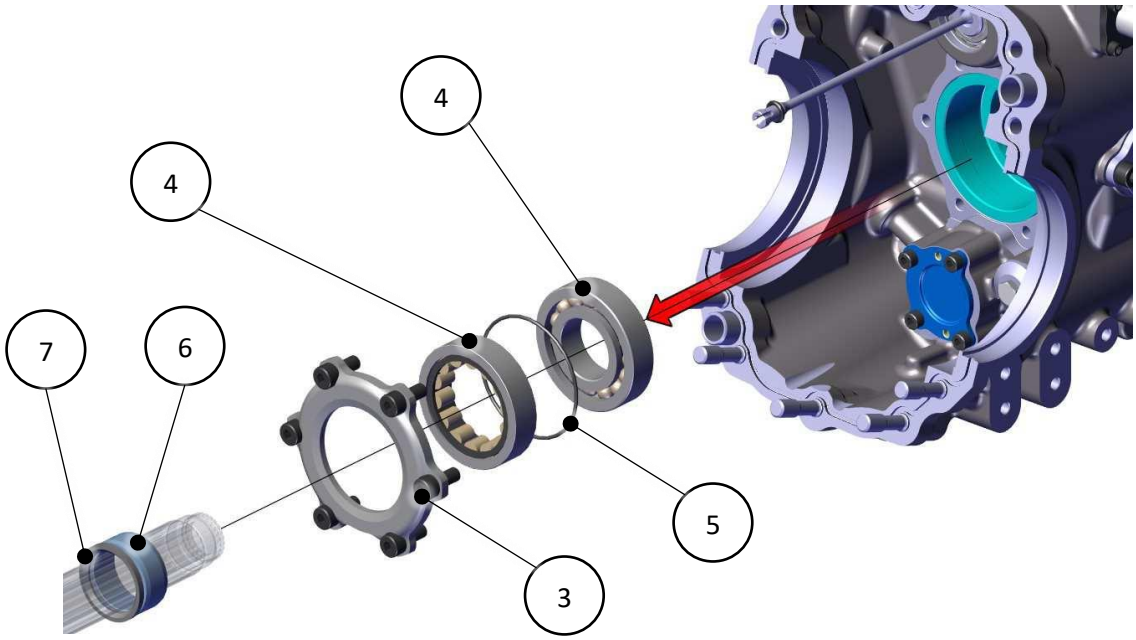


13.11.11 Remove the secondary shaft

- Drain the gearbox through the lower drain plug. (see paragraph 13.5.6).
- Remove the primary gears and secondary gears (see paragraph 13.11.1).
- Remove the differential case (see paragraph 13.11.7).
- Using a mallet, remove the secondary shaft ①.
- Remove the 6 M8x18 bolts. (heat if necessary) ②.

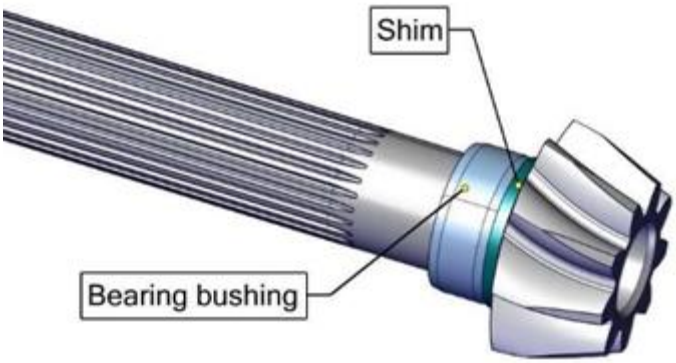


- Remove the flange bearing NU207 ③.
- Remove the 2 bearings ④, and the o-ring Ø 68x2 ⑤.
- Remove the inner bearing ring ⑥ (extractor needed), finally remove the shim ⑦.

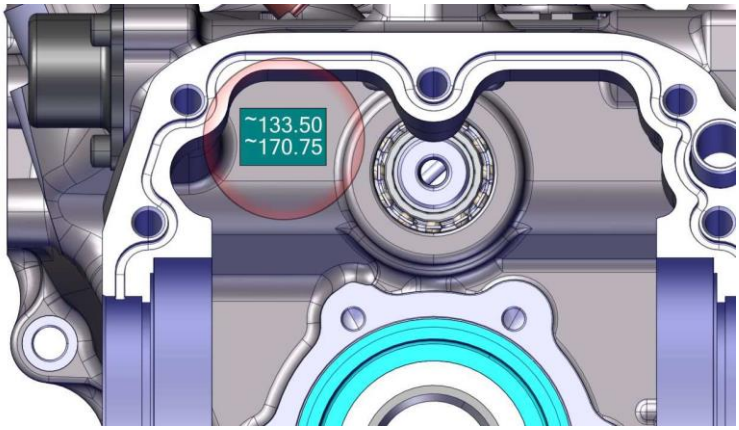


13.11.12 Secondary shaft advancement, shim calculation.

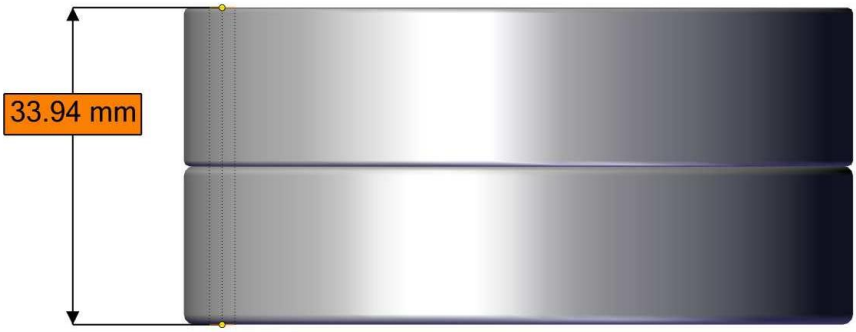
Operation to find the thickness (**D**) of the advancement shim on the secondary shaft:



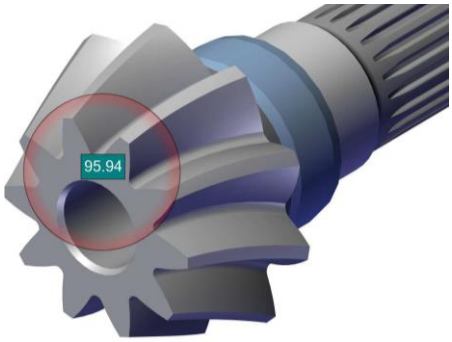
- Note the smallest dimension marked in the main housing (**A**) (ex 133.50).



- Note the thickness of the two secondary shaft bearings (**B**) (ex 33.94).



- Note the value engraved on the secondary shaft (**C**) (ex 95.94)



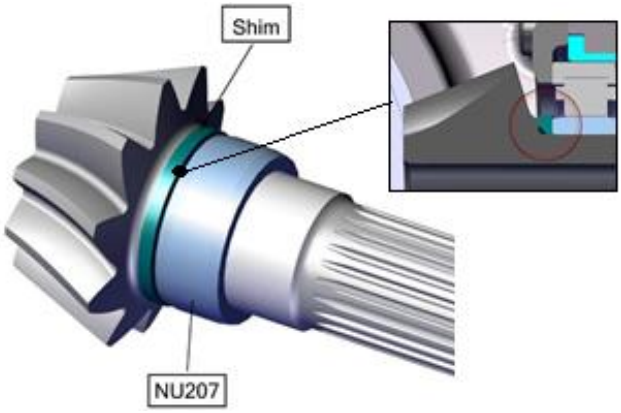
$$A - (B + C) = D$$

Ex: 133.50 - (33.94 + 95.94) = 3.62

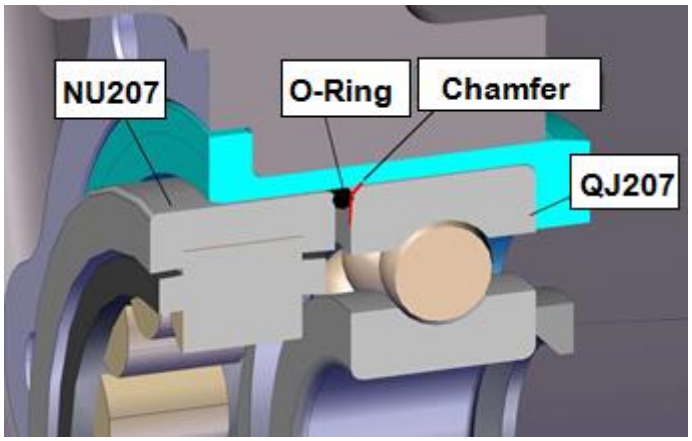
Choose the shim from the F19102051 set, assemble the shim being the closest as possible to the calculated thickness (ex 3.60mm).

13.11.13 Secondary shaft reassembly

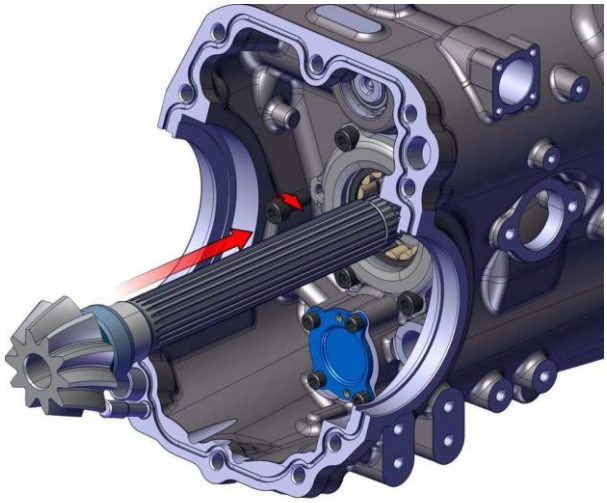
- Assemble the correct thickness F1910205 shim, press the bearing inner ring NU207 on the secondary shaft. **Warning**: Shim mounting direction.



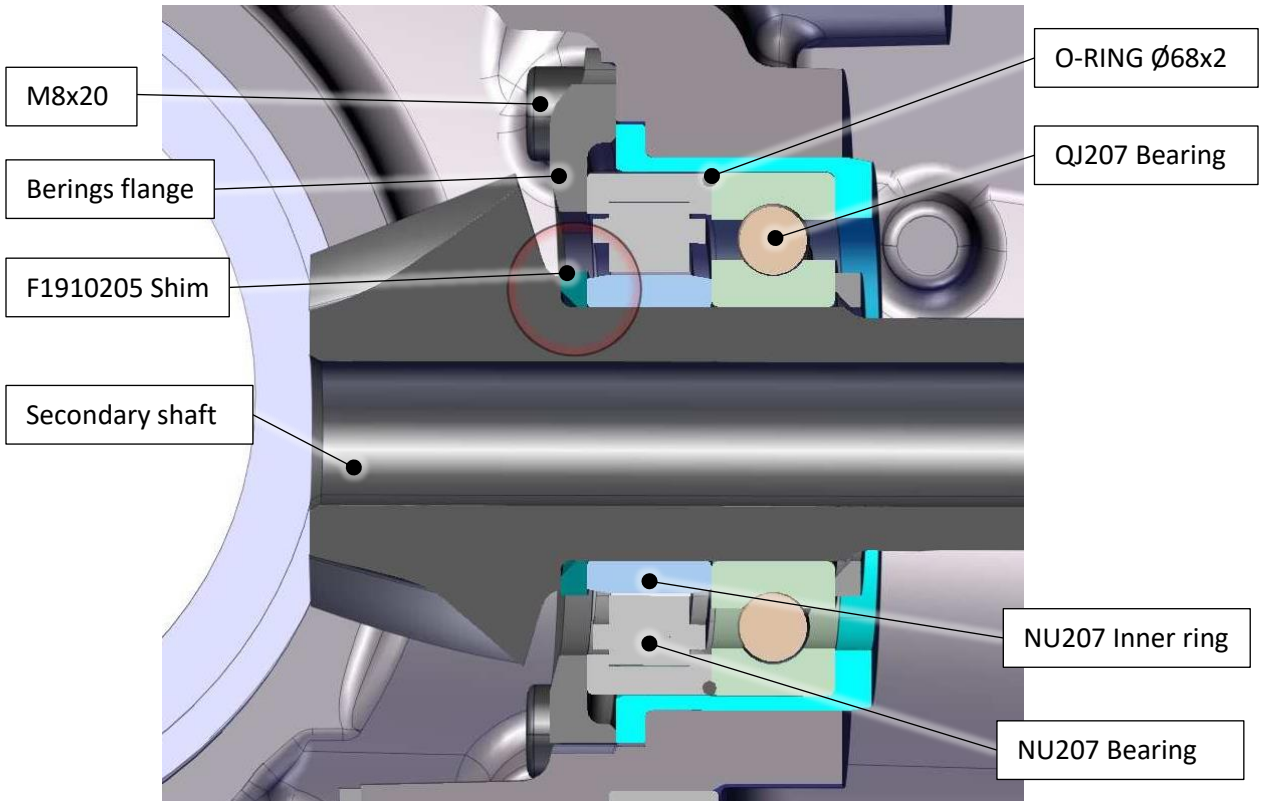
- Refit the bearing QJ207. **Warning**: chamfer on differential side. Set in place a new o-ring on the chamfer of the external race of the QJ207 bearing. Refit the NU207 bearing.



- Refit the bearings flange on the housing, tighten the 6 M8 bolts (Loctite 270; torque 25N.m).



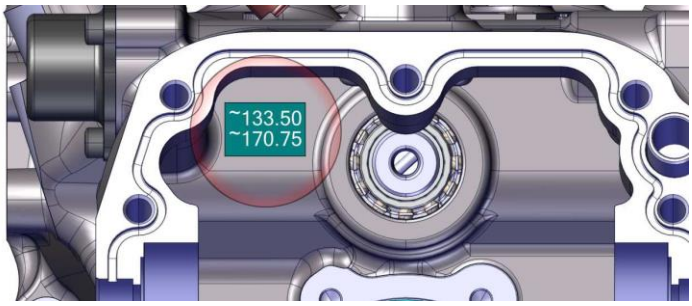
- Set it in place the secondary shaft through the bearings using a plastic mallet.



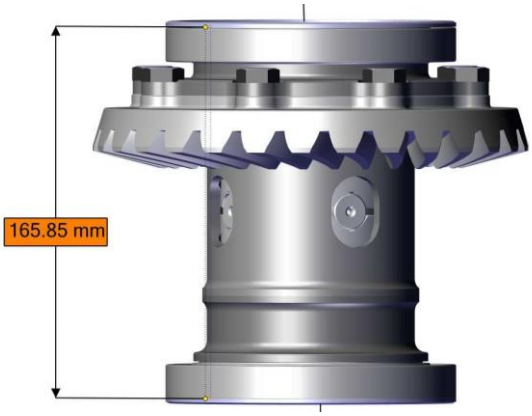
13.11.14 Differential centering, shim calculation

Operation to find the total thickness (**Z**) of the shims to centering the differential case and the crown wheel.

- Note the highest dimension marked in the main housing (**X**) (ex. 170.75).



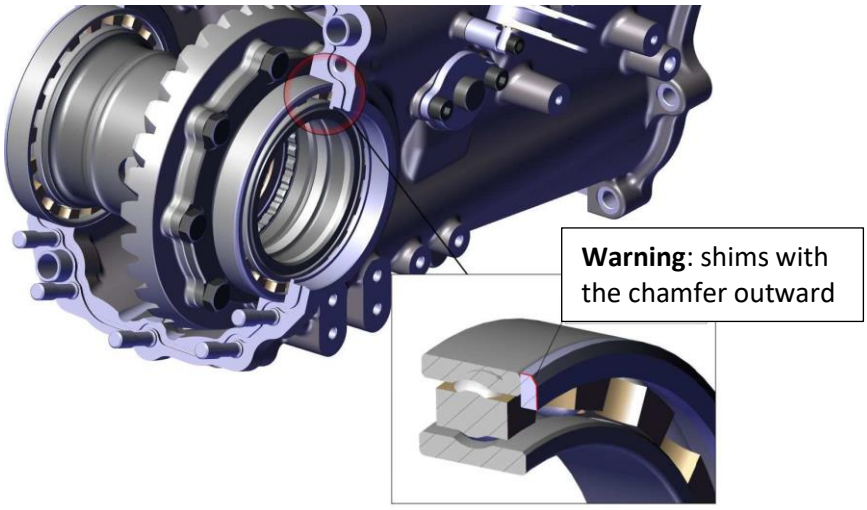
- Note the highest distance between the external races of the bearings assembled on the differential case (**Y**) (ex.165.85).



$$X + 0.1 - Y = Z$$

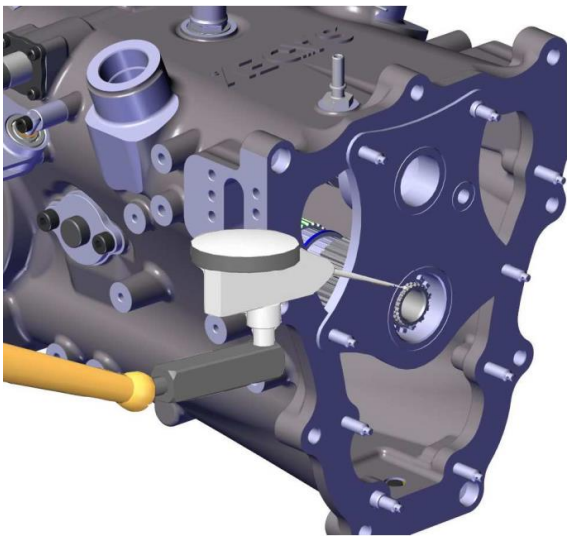
Ex: 170.75 + 0.1 – 165.85 = 5.05

- Choose the shims from the F19103201 set, assemble the shims being as closest as possible to the calculated total thickness.
  NOTE: At the first attempt, use two shims of similar thicknesses (ex 2.50mm).



13.11.15 Differential centering, final drive backlash

- Mount all parts except the stages, keep the reverse gear on the secondary shaft. Tighten the secure nut on the secondary shaft (180 N.m).
- Check the gear backlash using a dial indicator placed on the secure nut (F9072203).

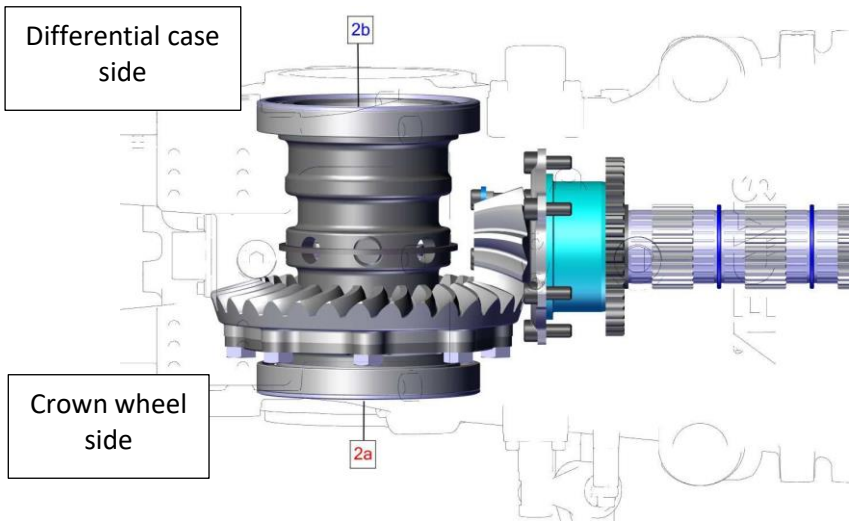


- Measure the backlash in many positions of the nut (between 5 and 10 measurements on several turns of the secondary shaft). The correct clearance must be between **0.08mm** and **0.15mm**.

If the backlash is not correct, remove the differential housing, remove the shims behind the differential case and proceed as follows:

- **If the play is excessive**: move the crown wheel closer to the pinion by increasing the thickness of the shim (crown side) and reducing the thickness of the shim (differential case side) accordingly.
- **If the play is insufficient**: move the crown wheel away from the pinion by reducing the thickness of shim (crown side) and increasing the thickness of the shim (differential case side) accordingly.

NOTE: keep the total thickness of the two shims constant so as not to affect the preload on the bearings.

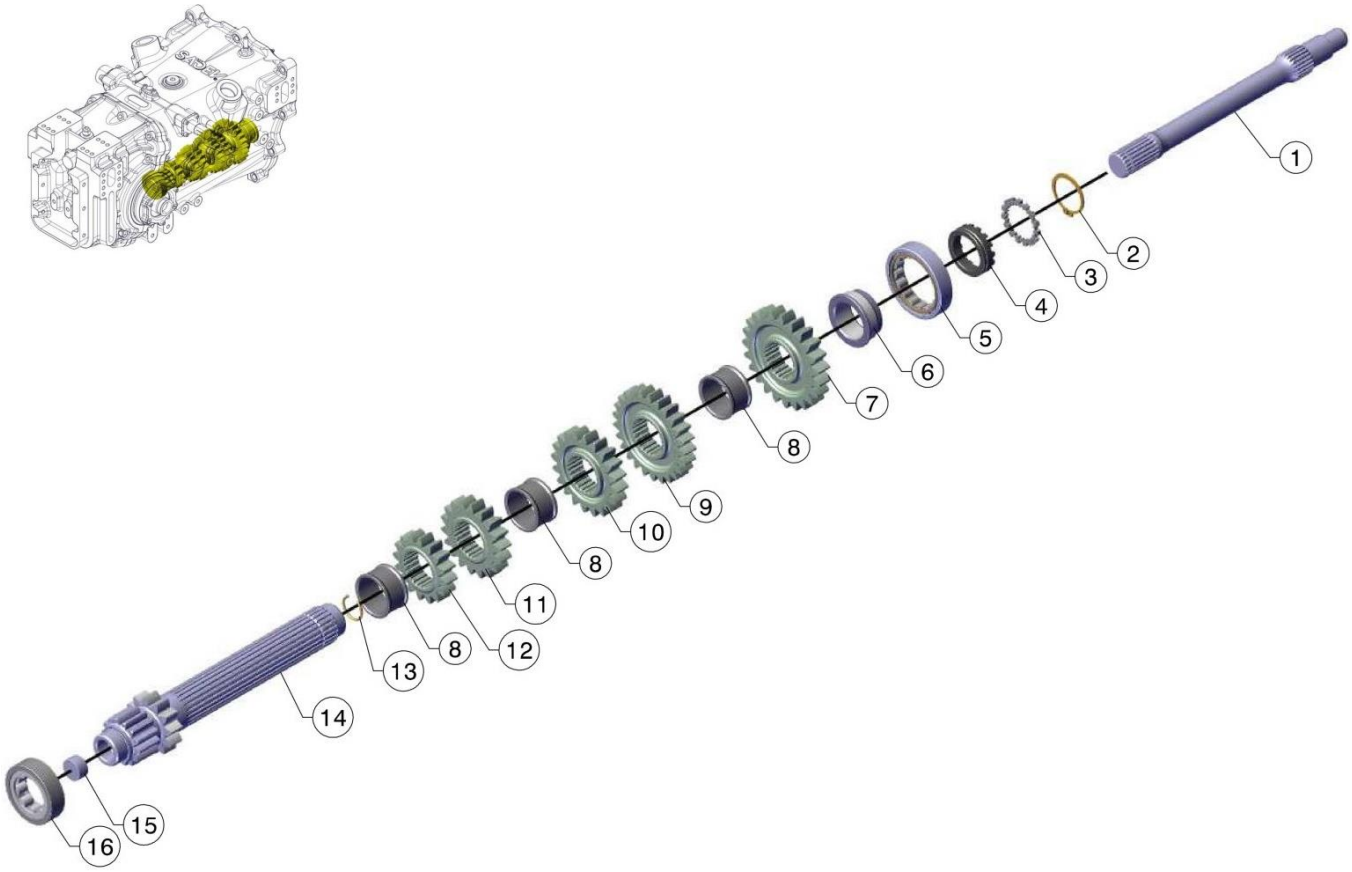


Check clearance after each operation.
Once the clearance has been checked, refit the differential and gears

13.12 EXPLODED VIEWS

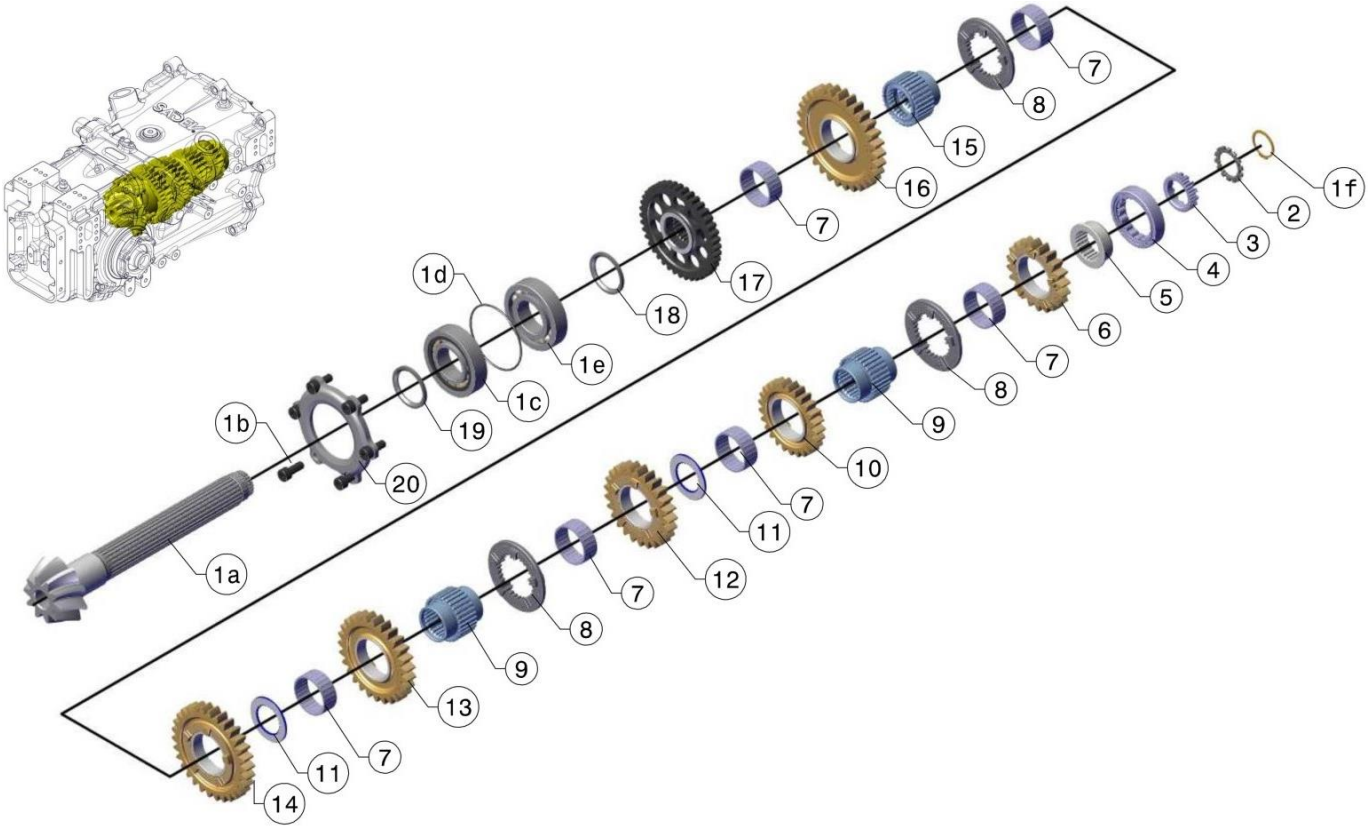
Refer to spare catalogue for part numbers

13.12.1 Primary Shaft



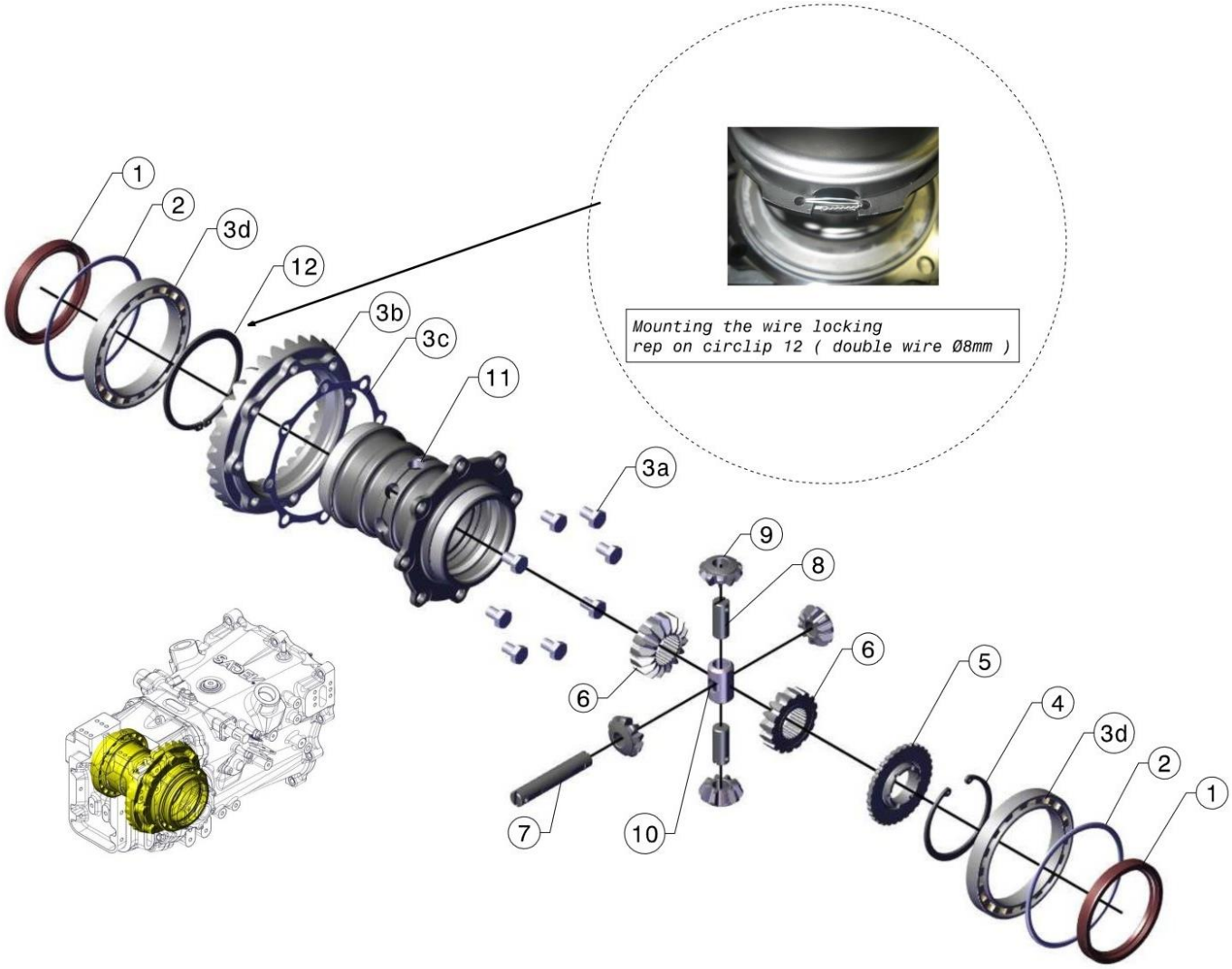
Item	Part number	Description	Glue	Torque (daN*m)
4	F1910108	Nut	G.C.	15,0
5	0103012	NU 1007 ECP Bearing	518	
15	F9072103	Plug	518	
16	0103015	NU 304 ECP Bearing	518	

13.12.2 Secondary Shaft



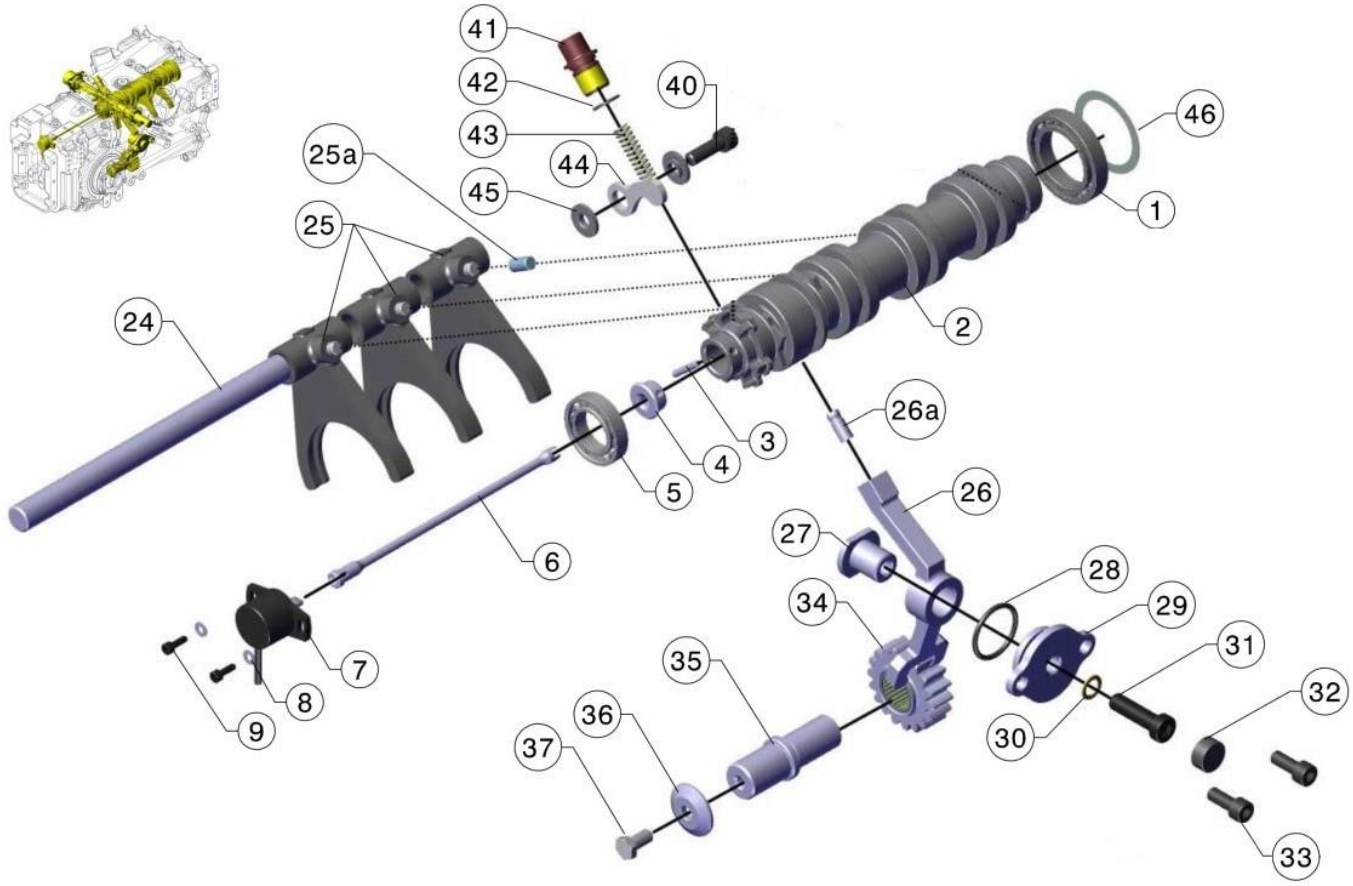
Item	Part number	Description	Glue	Torque (daN*m)
1b	0301561	CHC M8x18 bolt	270	2,5
3	F9072208	Secondary nut	C.G.	18,0
4	0103012	NU 1007 ECP Bearing	518	

13.12.3 Differential



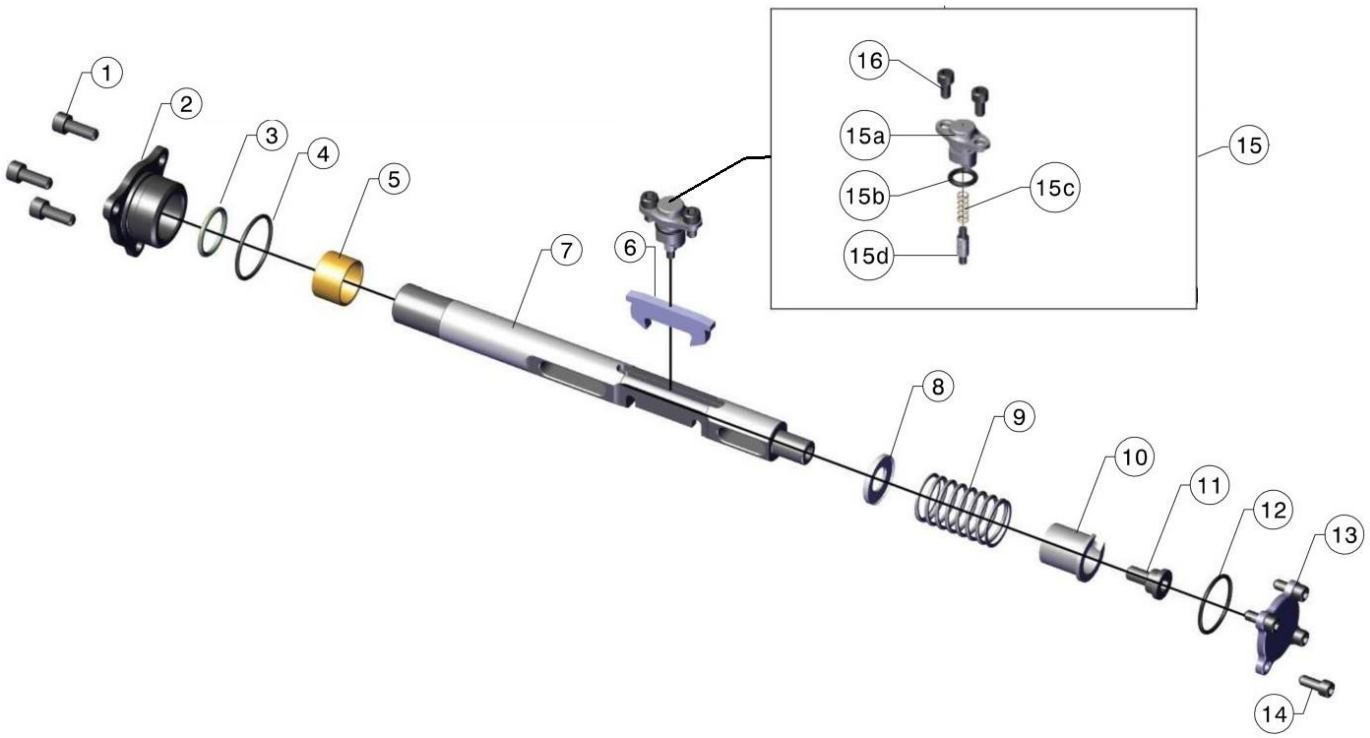
Item	Part number	Description	Glue	Torque (daN*m)
3a	F0085941	Crown screw	648	9,0

13.12.4 Selector



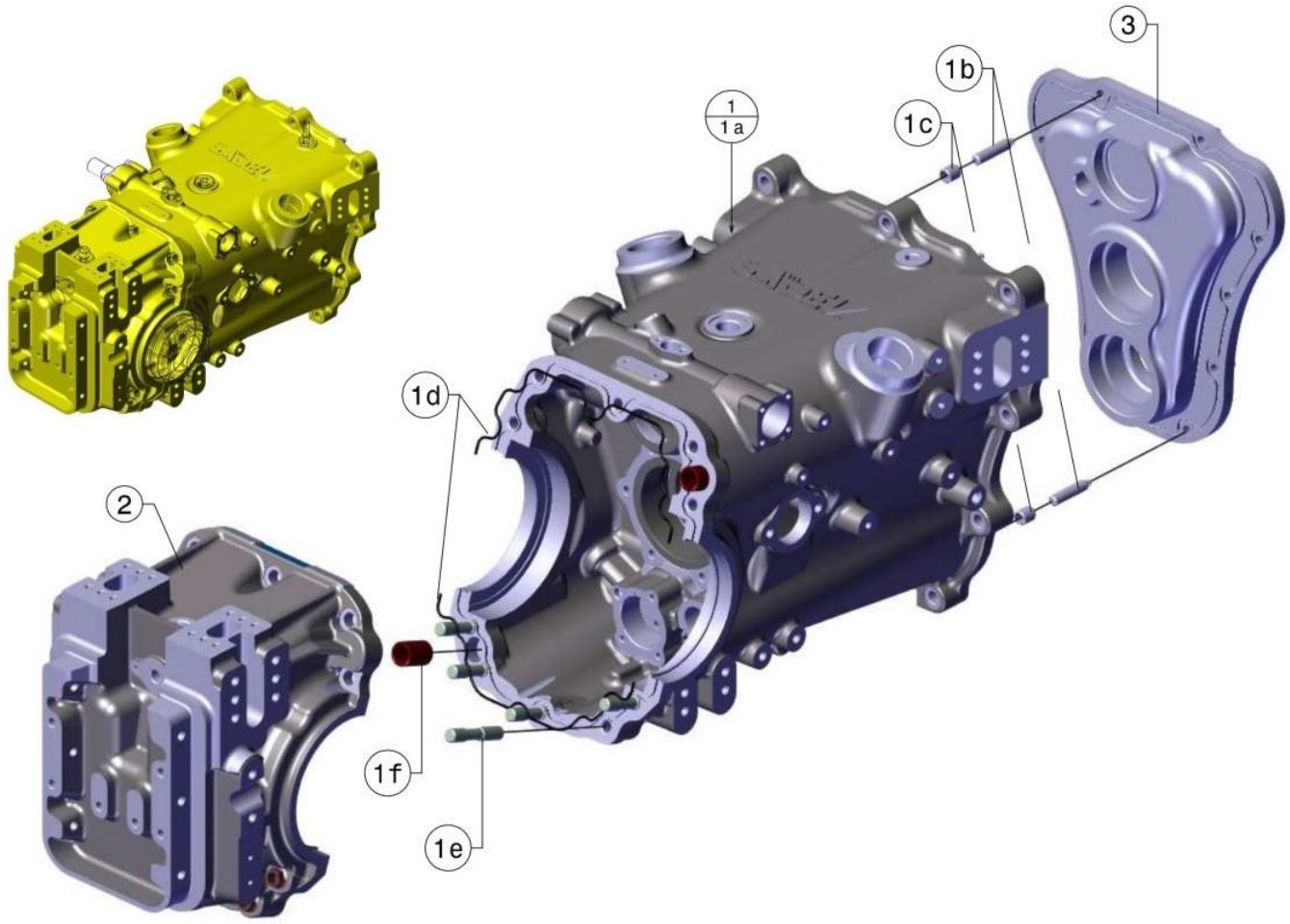
Item	Part number	Description	Glue	Torque (DaN m)
1	0101088	61907 Bearing	648	
5	0101128	61905 Bearing	648	
26a	F0077108	Reverse gear pin	648	
31	0304006	CZHC M10x35 Bolt	270	5,5
33	0301421	CHC M8x20 Bolt	270	3,2
37	F0085135	Reverse gear screw	648	3,5
40	0301169	CHC M8x25 Bolt	243	2,5

13.12.5 Selector Axle



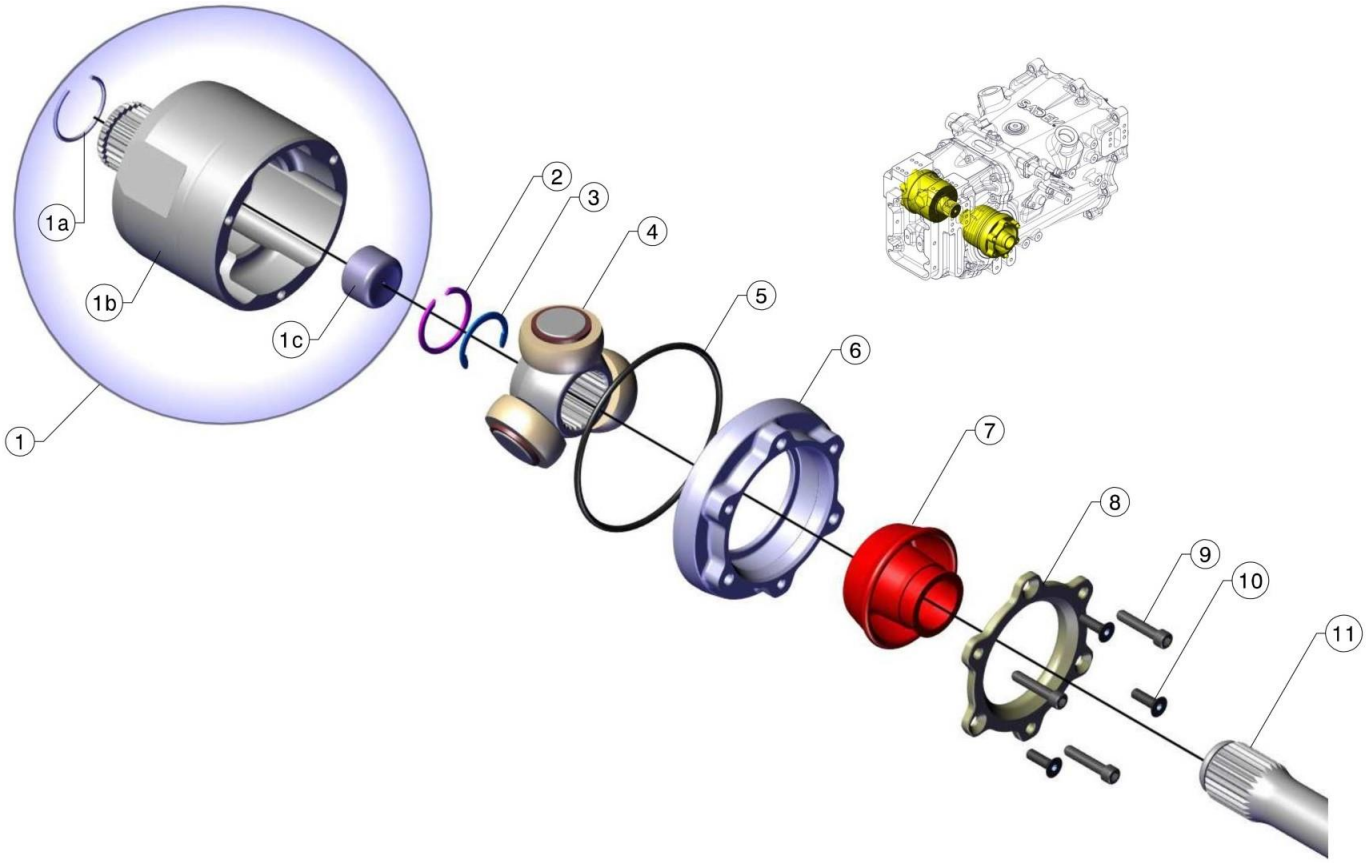
Item	Part number	Description	Glue	Torque (DaN m)
1	0301422	CHC M16x16 Bolt	243	1,5
11	F0059021	Shoulder screw	243	2,5
14	0301138	CHC M5x12 Bolt	222	0,8

13.12.6 Housing



Item	Part number	Description	Glue	Torque (DaN m)
1a	F90570000	Bearing casing	12867	
	F0085126	Revere axle	12867	
	F0085135	Free wheel nut	648	3,5
1b	F9047008	Stud closing plate	648	
1e	F9047030	Stud	648	

13.12.7 Transmission



Item	Part number	Description	Glue	Torque (DaN m)
1c	F1910706	Drive shaft stop	518	
9	0301490	CHC M5x25 Bolt	243	0,8

14 SHIFT SYSTEM

14.1 SYSTEM OVERVIEW

The T421 is equipped with a semi-automatic shift system. Here below a quick overview:

- GCU (Gear Control Unit): embedded in the ECU.
- GCC (Gearshift Current Controller): Marelli GCC, this unit manage the actuator (ESA) control
- ESA II (Electric Shift Actuator): Marelli ESA II, this unit driven by the GCC perform the physical shift, ESA II is a position-controlled unit, refer to the chapter 13.1.2 for its setting and maintenance.

14.1.1 Gearshift Control

The semi-automatic gearshift is controlled by several parameters of the vehicle, critical sensors are:

- Paddle sensors
- RPM
- Throttle position
- Barrel position
- REV button
- ACK button

Upshift

- 1st to 6th gear: right paddle
- N to 1st gear: ACK button + right paddle
- R to N: ACK button + right paddle

Downshift

- 6th to 1st gear: left paddle (if over-revs threshold is respected)
- 1st to N: ACK button + left paddle
- N to R: (car steady): ACK button + REV button

The downshift is allowed only if the lower gear (to be engaged) will not results in an overrevs. If an overrev is expected the shift will be skipped and driver must repeat the request.

14.1.2 Gear State values explanation

In the logged data is available the channel:

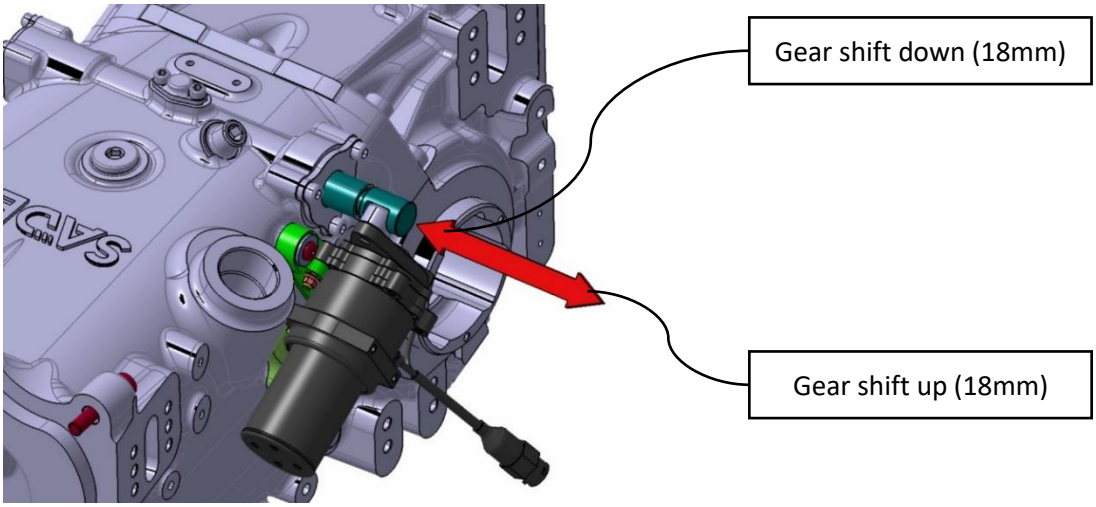
- GearState: the reported value describes the actuation status.

Please refer to the table below showing the configurations for the channel:

Enum	0	3	4	5	6	8	10	15	19	20	21	22	24	26	31
Gear State	Idle	Upshift Extract Timeout	Upshift Extract	Upshift Engage Timeout	Upshift Engage	Upshift Lock	Upshift Re-center	Upshift Failed	Downshift Extract Timeout	Downshift Extract	Downshift Engage Timeout	Downshift Engage	Downshift Lock	Downshift Re-center	Downshift Failed

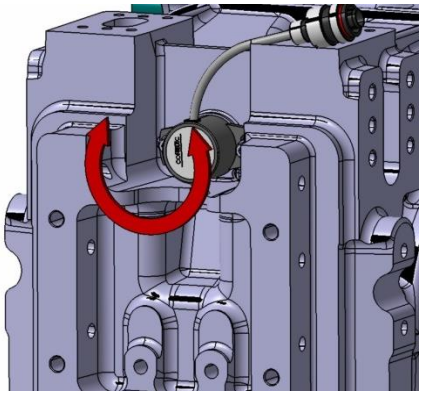
14.1.3 ESA settings

- Engage the 1st gear by acting manually on the selector axle of the gearbox



- Go to the page #2 of the dash display: **Setting page.**
  Check the **Gear Pot** (gear barrel absolute position) value is **1630mV +/- 10mV**

P Brake F	P Brake R	Brake Bias	Steer Pot
bar	bar	%	mV
TPS1	TPS2	Pedal 1	Pedal 2
mV	mV	mV	mV
	Gear Pot	ESAP	E-Throttle
			Not Active
	mV	mm	Setup



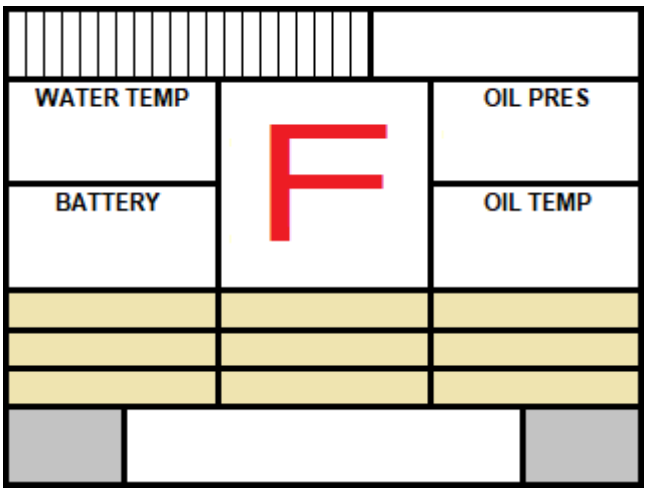
- Check the **ESAP**: absolute actuator position [mV], the value should be **0 +/-30mV** when actuator is not operational.

P Brake F	P Brake R	Brake Bias	Steer Pot
bar	bar	%	mV
TPS1	TPS2	Pedal 1	Pedal 2
mV	mV	mV	mV
	Gear Pot	ESAP	E-Throttle
			Not Active
	mV	mm	Setup

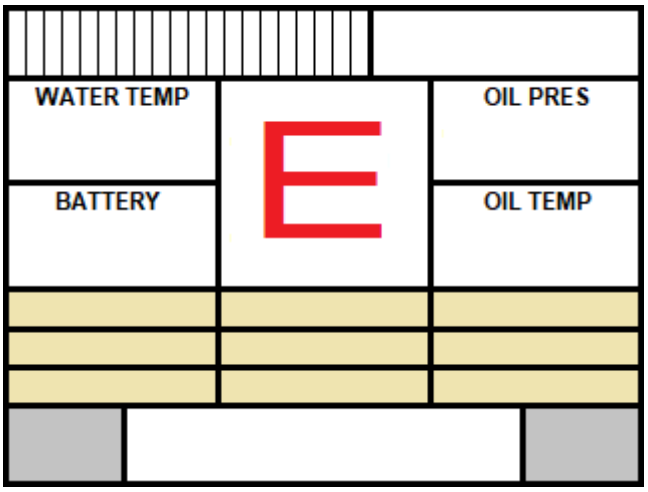
14.1.4 ESA Warnings

In the first page of the display are shown also the following warning messages related to the barrel sensor:

- **F**: barrel sensor position out of mechanical range. The barrel is stuck in a not engaged position between two gears.



- **E**: barrel sensor position out of electrical range. The electrical output of the barrel sensor is: **< 500 mV or >4500 mV**.

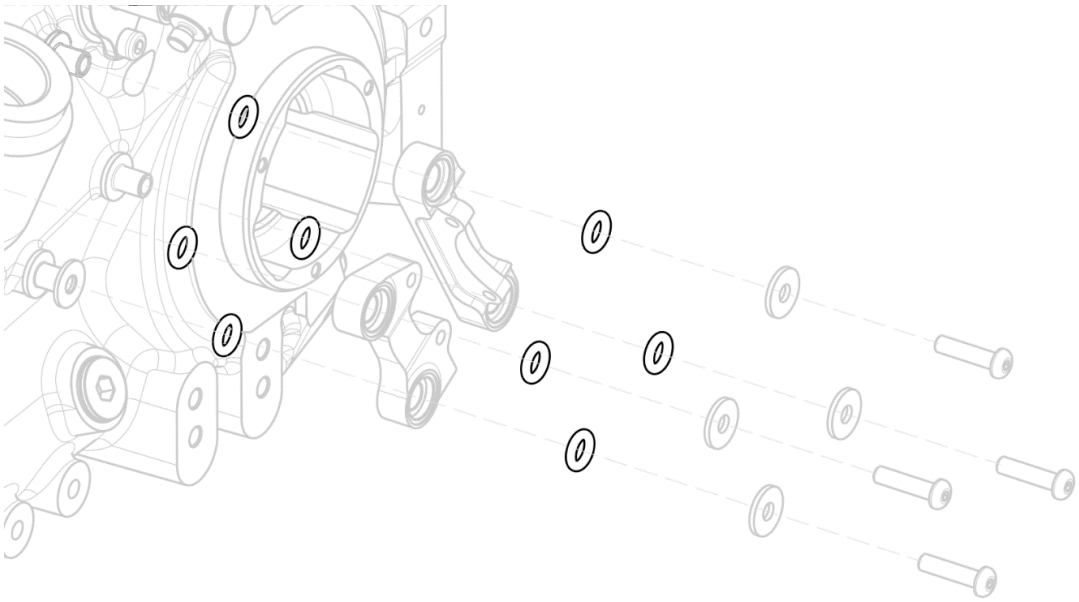


Potential causes:

- Barrel sensor faulty or disconnected.
- Short circuit on harness.

14.1.5 ESA Maintenance

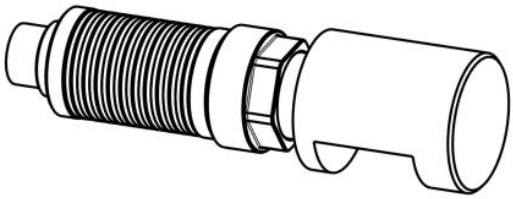
It is reminded to regularly check the AV mounting of the ESA:



The rubber ring (pn. ORN08x3,5) should be inspected each 1’000 km and must be replaced before 3’000 km.

14.1.6 Damped Shaft Assy

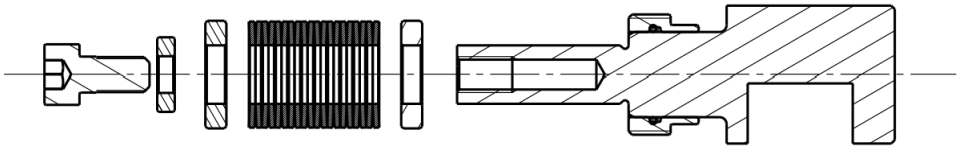
Eighteen Belleville washer are included in the damped shaft assy (pn. 3322012).



The Belleville washers must follow the stacking order:

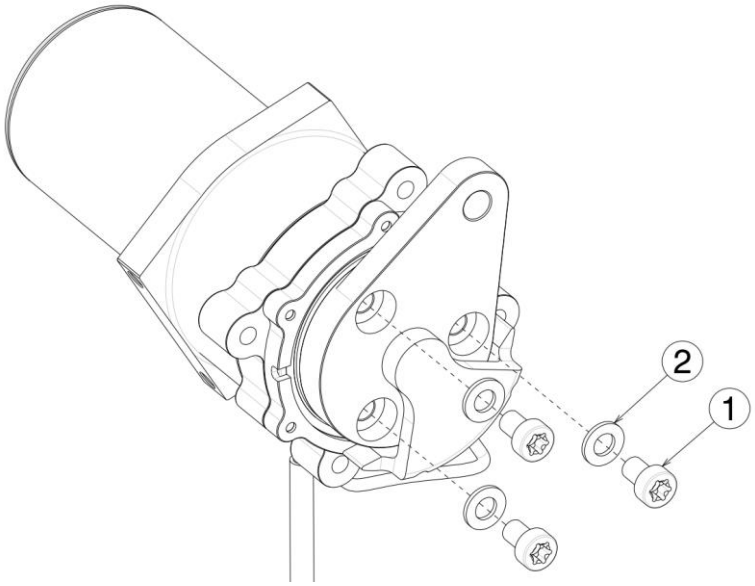
> < > < > < > < > < > < > < > < > <

Insert shoulder ring, Belleville springs (prescribed stack) and the M5 screw. After reaching the mechanical stop, tight at 4 Nm, apply Loctite 243.



14.1.7 ESA rocker bolts

Please find below specification for ESA rocker bolts, tightening torque and prescription for installation



Item	p/n	Description	Qty
1	ISO14580-M5X8-CL 12.9	Hexalobular socket screws M5, length 8 mm, grade 12.9	3
2	ISO7089-5	Washer 5.3x10x1	3

Bolts should be fitted with Loctite 270, applying a tightening torque of 4.5 Nm.

If bolts are removed for maintenance please make sure of cleaning them with isopropyl alcohol before applying Loctite.

15 ELECTRONIC & SOFTWARE

Refer to engine supplier docs.

16 ANNEXES

16.1 TIGHTENING TORQUE

		8.8 grade		10.9 grade	
Thread [mm]	**Pitch [mm]**	**Torque [Nm]**	**Torque [Lbs ft]**	**Torque [Nm]**	**Torque [Lbs ft]**
3	0,5	1,2	0,92	1,8	1,3
4	0,7	2,8	2,08	4,0	2,9
5	0,8	5,8	4,26	8,1	6,0
6	1	9,7	7,13	13,6	10,0
8	1,25	23,7	17,45	33,3	24,5
8	1	26,4	19,50	37,2	27,4
10	1,5	47,0	34,70	66,2	48,8
10	1,25	51,4	37,91	72,3	53,3
12	1,75	81,0	59,72	113,9	84,0
12	1,25	93,4	68,90	131,4	96,9
14	2	129,9	95,85	182,7	134,8
14	1,5	146,9	108,34	206,6	152,3
16	2	206,5	152,30	290,4	214,2
16	1,5	229,0	168,90	322,0	237,5

		Grade 5	Grade 8
Thread [Inch]	**Pitch [TPI]**	**Torque [Lbs-ft]**	**Torque [Lbs-ft]**
1/4	28	7	10
5/16	24	14	20
3/8	24	25	35
7/16	20	40	55
1/2	20	60	85
9/16	18	85	120
5/8	18	120	170