

# FORMULA STUDENT INSPECTION SHEET

DRIVERLESS – copy for Formula Student Germany



UNIVERSITY:	Metropolis TU
VEHICLE NUMBER:	696
INSPECTION ORDER:	X01
SES PASSED:	✓
IADR PASSED:	✓
ASF PASSED:	-
ESF PASSED:	-
TS VOLTAGE:	600 V
BODY PROTECTION R:	15 kΩ

Present the vehicle for inspection in the following order:

- Pre-Inspection
- Accumulator Inspection\* Mon 04:00-05:45
- 1. Electrical Inspection\* } Mon 06:00-07:30
- Driverless Inspection\* }
- Mechanical Inspection\* Mon 08:00-09:15
- Driver Egress Mon 09:30-10:00
- 2. Tilt Test\*
- 3. Rain Test\*
- 4. Brake Test\*
- 5. Emergency Brake System Test\*

\* the vehicle is marked with a sticker if this part has been passed successfully.

## Used Symbols:

- Information
- ▶ Action
- △ Check in responsibility of the team
- Check

## NOTES:

- This form must stay with the vehicle at all times!
- Technical inspection approval voids if inspection sheet is lost.
- If there is a conflict between this form and the rules, the rules prevail.

## PART I: COMMENTS FROM DOCUMENT REVIEW

### ACCUMULATOR

- Accu Ok
- 

### ELECTRICAL

- ESF to be checked

### DRIVERLESS

- Driverless Ok

### MECHANICAL

- Mech Ok
- SES to be checked

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## PART II: PRE-INSPECTION

### TIS STATUS UPDATE

▶ Set online TIS status to *Present*

### TIRES

- |   |   |
|---|---|
| 1 <input type="radio"/> <b>DRY TIRES</b> - Make:<br>_____     | 4 <input type="radio"/> <b>RAIN TIRES</b> - Make:<br>_____                                      |
| 2 <input type="radio"/> <b>DRY TIRES</b> - Size:<br>_____     | 5 <input type="radio"/> <b>RAIN TIRES</b> - Size:<br>_____                                      |
| 3 <input type="radio"/> <b>DRY TIRES</b> - Compound:<br>_____ | 6 <input type="radio"/> <b>RAIN TIRES</b> - Compound:<br>_____                                  |
|   | 7 <input type="radio"/> <b>RAIN TIRES</b> - 2,4 mm min. tread depth molded by tire manufacturer |

### DRIVER GEAR & SAFETY

- |  |   |
|--|---|
| 8 <input type="radio"/> <b>UNDERWEAR</b> - Nomex or equivalent, fire resistant underwear (no cotton, no polyester, no bare skin). No holes.  | 41.1/2015, 41.1/2020 or newer FIA 8860-2010, FIA 8860-2018, FIA 8859-2015 (with SA 2015), FIA 8858-2010 (with SA(H) 2010) or newer. Closed Face, no Open Face, must have integrated shield (no dirtbike helmets). No camera mounts. |
| 9 <input type="radio"/> <b>SOCKS</b> - Nomex or equivalent, fire resistant socks (no cotton, no polyester, no bare skin). No holes.  |   |
| 10 <input type="radio"/> <b>GLOVES</b> - Fire resistant material. Leather allowed only over fire resistant material. No holes.   | 13 <input type="radio"/> <b>DRIVER SUITS</b> - Single piece SFI 3.2A/5 (or higher), SFI 3.4/5 (or higher), FIA 8856-2000/2018 (or higher), and LABELED AS SUCH. No holes.   |
| 11 <input type="radio"/> <b>ARM RESTRAINTS</b> - SFI Standard 3.3 or equivalent.   | 14 <input type="radio"/> <b>HAIR COVER</b> - Fire resistant (Nomex or equiv.) balaclava of full helmet skirt <b>REQUIRED FOR ALL DRIVERS</b> . No holes.  |
| 12 <input type="radio"/> <b>HELMETS</b> - Snell K2010, K2015, K2020, M2010, M2015, M2020, SA2010, SAH2010, SA2015, SA2020, EA2016 or newer.SFI 31.1/2010, 31.1/2015, 31.1/2020, 41.1/2010, | 15 <input type="radio"/> <b>SHOES</b> - SFI 3.3 or FIA 8856-2000/2018   |

### TIS STATUS UPDATE

▶ Set online TIS status to *Passed* or *Failed*

### NON-COMPLIANCE / COMMENTS

### APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____

## PART III: EGRESS TEST

### DRIVER POSITION

- 16  **ARM RESTRAINTS**- Must be installed so the driver can release them and exit unassisted regardless of vehicle's position.
- 17  **HEAD RESTRAINT**- Near vertical. Max. 25 mm from helmet. Helmet contact point 50 mm min. from any edge.
- 18  **MAIN HOOP & FRONT HOOP HEIGHTS** - Helmet of driver to be 50 mm below line between top of front and main roll hoop AND between top of main hoop to rear attachment point of main hoop bracing.
- 19  **LAP BELT MOUNTING** - Must pass over pelvic area between 45 - 65 deg. to horizontal for upright driver, 60-80 deg. for reclined. The lap belts must not be routed over the sides of the seat.
- 20  **SHOULDER HARNESS MOUNTING** - Angle from shoulder between 10 deg. up and 20 deg. down to horizontal.

### DRIVER EGRESS TEST

- All drivers must be able to exit the vehicle in less than 5s.
- Driver must be seated in ready to race condition.

### EGRESS PROCEDURE

- ▶ Both hands on the steering wheel. (in all possible steering positions)
- ▶ Pressing cockpit-mounted shutdown button.
- The egress time will stop when the driver has both feet on the ground

### DRIVER APPROVAL & RUN DOCUMENTATION

Driver Name	Wristband ID	Signatures when passed	Acc	Skid Pad	AutoX	Endurance
1. _____	_____	_____	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>
2. _____	_____	_____	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>
3. _____	_____	_____	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>
4. _____	_____	_____	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>
5. _____	_____	_____	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>
6. _____	_____	_____	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>

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## PART IV: ACCUMULATOR INSPECTION

The time limit for this part of the inspection is 105 minutes. Continuation of the inspection is possible after requeueing. During technical inspection all work carried out on the accumulator must be approved by a technical inspector.

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Present*

### COMMENTS

- ▶ Check comments from first page

### REQUIRED RESSOURCES

- 21  An ESO must attend.
  - All accumulator containers to be used during the event.
  - Accumulator Container Hand Cart.
  - Charger.
  - Tools needed for (dis-)assembly of Accumulator Container.
  - PDF or print-out of rule questions, if necessary.
  - Pictures of accumulator internals, if necessary.
  - Datasheets for used wiring, insulation materials, and TS components. (printed or properly sorted on one laptop, not on a cell phone)
- Samples of all wire types used inside the accumulator container.
- Samples of all used accumulator container material.
- Fully assembled spare boards of all inaccessible TS boards inside the accumulator
- Laptop and cables to display data of the AMS

### SAFETY BRIEFING

- no jewellery, no rings
- no cell phone
- no batch / no necklace
- no sources of distraction
- do not wear synthetic clothes
- wear safety glasses
- wear safety gloves

### BASIC SET OF HV-PROOF TOOLS

- 22  Insulated cable shear.
- 23  Insulated screw driver.
- 24  Insulated spanners (n/a if no screwed connections in TS).
- 25  Multimeter with protected probe tips
- 26  two 4mm banana plug test leads (1000V CAT III)

### SAFETY EQUIPMENT

- 27  Face shield.
- 28  Safety glasses (minimum three).
- 29  HV insulating gloves (minimum two pairs).
- 30  HV insulating blankets (two) (min  $1 m^2$ ) with label or serial number and datasheet.

### SELF DEVELOPED PCBs

- ▶ Ask for fully assembled spare PCB of self developed PCBs inside accumulator container.
- 31  Sufficient spacing regarding system voltage and implementation.
- 32  Sufficient insulation and temperature rating of coating if used, datasheet available.
- 33  Coating process according to datasheet

### CHARGER ASSEMBLY

- 34  Completely closed. Check opening in HV/TS enclosures, try to reach HV/TS potentials with insulated test probe (100 mm length, 6 mm diameter).
- 35  Interlock integrated.
- 36  TSMP integrated
- 37  Emergency shutdown button integrated.
- 38  Emergency shutdown button  $\geq 24$  mm diameter.
- 39  TS wiring is orange, marked with gauge, temperature rating  $>85^\circ C$  and voltage rating.
- 40  Conductive parts of charging equipment and accumulator are connected to protective earth (PE) while charging.

### DIS-CHARGE CIRCUIT AND BODY PROTECTION RESISTORS

- ▶ Switch off Charger. Measure resistance between TS+ and TS- measuring points.
- 41  Resistance is  $30 k\Omega^1$  + discharge resistor
- 42  Body protection resistor power rating is  $>6.0 W^2$

### INSULATION MEASUREMENT TEST

- ▶ Check low resistance connection between LV ground MP and PE/casing
- ▶ Choose test voltage to 500 V.<sup>3</sup>
- ▶ Connect insulation tester to charger TS+ and LV ground.
- ▶ Connect charger (do not activate charger) to accumulator, keep AIRs opened.

<sup>1</sup> 2 x Body Protection Resistor (BPR)

<sup>2</sup> sufficient to short circuit TS+ and TS-

<sup>3</sup>  $U_{max} \leq 250 V_{DC}$      $U_{max} > 250 V_{DC}$   
 $U_{Test} = 250 V_{DC}$      $U_{Test} = 500 V_{DC}$

<sup>4</sup> Minimal Resistance =  $500 \Omega/V \cdot U_{max} + BPR$

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- ▶ Measure resistance:  $R_{iso+} =$  k $\Omega$
- 43  Resistance is much higher than 315 k $\Omega$ <sup>4</sup>.
- ▶ Connect insulation tester to TS- and LV ground.
- ▶ Measure resistance:  $R_{iso-} =$  k $\Omega$
- 44  Resistance is much higher than 315 k $\Omega$ <sup>4</sup>.
- 45  Resistances are nearly equal.
- ▶ Open container housing, remove maintenance plugs.
- ▶ Check if no voltage is present.

## ASSEMBLY

- 46  All components and parts of the accumulator container need to be properly fixed.
- 47  All used fasteners must be secured by the use of positive locking except they are non-conductive and non-structural.
- 48  TS potentials are insulated against inner wall of accumulator container if container made from conductive material.
- 49  Tabs of pouch cells must not carry mechanical loads.
- 50  No soldering in high current path
- 51  Every container contains at least one appropriately sized and rated fuse.
  - ▶ Check datasheet of fuse, main wire and cells and compare to ESF.
- 52  Every container contains at least two appropriately sized and rated isolation relays (current and voltage).
- 53  Isolation relays and fuses are separated from cells by barrier according UL94-V0 or equivalent.
- 54  Pre-charge relay is of mechanical type with appropriate voltage rating.
- ▶ Check datasheet of pre-charge relay and compare to ESF
- 55  Maintenance plugs are located at both poles of each stack (including first and last stack).
- 56  Maintenance plugs removable without tools.
- 57  Maintenance plugs have positive locking mechanism.
- 58  Maintenance plugs must not be able to unintentionally create circuits or short circuits.
- 59  Stacks separated by Maintenance plugs  $\leq$  120 VDC.
- 60  Stacks separated by Maintenance plugs  $\leq$  6 MJ.
- 61  Stacks are insulated and separated by a fire resistant barrier according to UL94-V0 for min. used thickness or equivalent.
- 62  Holes in container only for wiring harness, ventilation, cooling or fasteners, if mechanical properties are not influenced.
  - ▶ Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100 mm length, 6 mm diameter).
- 63  If fully closed, equalizing valve implemented.
- 64  Spare accumulators of same size, weight and type.

## WIRING

- 65  All TS wires have proper overcurrent protection.
- 66  No other wires than TS wires are orange.
- 67  Securely anchored to withstand at least 200 N, if outside of enclosure.
- 68  Located out of the way of possible snagging or damage.
- 69  TS and LV wires separated (not valid for Interlock).
- 70  Every wire used in the Accumulator container (TS and LV) is rated for  $\geq$  600 V<sup>5</sup>.
- 71  Possible to clearly assign and prove gauge, temperature and voltage rating of TS wires.
- 72  Positive locking mechanism or if no positive locking possible, automotive certified components.
  - ▶ Check if insulated tools needed for the assembly of certified components are available
- 73  Insulation is not only insulating tape or rubber-like paint.

## CELL TEMPERATURE MONITORING DEVICE (CTMD)

- ▶ Install CTMD
- 74  CTMD sensor installed at negative cell tab as defined in the ESF or specified by the technical inspector.
- 75  Cooling at CTMD sensor positions not above-average.
  - ▶ Take a picture and upload it to competition server.

## INDICATOR LIGHT OR VOLTMETER

- 76  Red indicator light or voltmeter installed
- 77  Marked with "Voltage Indicator"
- 78  Visible while opening the battery connector.
- 79  Hard wired electronics, supplied by TS
- ▶ Connect power supply with 60 VDC<sup>6</sup> to accumulator TS connector.
- 80  Indicator light on or voltmeter showing present TS voltage.
- 81  Visible in bright sunlight.

## ACCUMULATOR MANAGEMENT SYSTEM

- 82  A minimum of 30 % of cells are monitored with temperature sensors.
- 83  Every temperature sensor placed on negativ terminal of monitored cell or in  $<$ 10mm distance on busbar.
  - ▶ Disconnect AMS current sensor connector
- 84  The AMS must open the shutdown circuit within 0.5 s.
  - ▶ Disconnect any other AMS internal connector
- 85  The AMS must open the shutdown circuit within 1 s.
  - ▶ Ask the team to connect their laptop to the AMS.
- ▶ Connect charger to battery/batteries, start charging process.
- 86  Cell voltages can be displayed.
- 87  Cell temperatures can be displayed.
- 88  Plausible accumulator current can be displayed.
  - ▶ Disconnect one SINGLE voltage sense wire, if any wires used.
- 89  The AMS must open the shutdown circuit within 0.5 s.
  - ▶ Disconnect one SINGLE temperature sense wire, if any wires used.
- 90  The AMS must open the shutdown circuit within 1 s.

## CHARGER SHUTDOWN CIRCUIT

- 91  IMD is integrated into the charging system
  - ▶ Connect charger to battery/batteries, start charging process
- 92  Voltage indicator shows that HV is present
  - ▶ Press shutdown button
- 93  AIRs open
- 94  Voltage indicator shows voltage  $<$ 60 V
  - ▶ Start charging, unplug TS accumulator connector
- 95  AIRs open.
- 96  Charger disabled, no voltage at charger connector

<sup>5</sup>max. TS voltage

<sup>6</sup>60 V or half the nominal tractive system voltage, whichever is lower

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## INSULATION MONITORING DEVICE

- 97  One IMD ground line is connected to the accumulator container and one ground line is connected to the charger casing by a separate wired connection
- ▶  $R_{Test} = 120 \text{ k}\Omega^7$
  - ▶ Activate charger output, connect  $R_{Test}$  between TS+ and LV GND.
- 98  Shutdown circuits opens within 30 s.
- 99  TS voltage decreases below 60 VDC within 5 s after shutdown
- 100  Reactivation of charger output is not possible.
- ▶ Push the reset button, if any.
- 101  Reactivation of charger output is not possible.
- ▶ Remove  $R_{Test}$ . Wait 40 s until IMD resets status output.
- 102  Reactivation of charger output is not possible.
- ▶ Activate TS, connect  $R_{Test}$  between TS- and LV GND.
- 103  Shutdown circuits opens within 30 s.

<sup>7</sup>  $R_{Test} = (\text{max. TS voltage} \cdot 250 \text{ Ohm/V}) - \text{BPR}$

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## ACCUMULATOR CONTAINER

- ▶ Team must show approved SES for accumulator container.
- ▶ Team must show SES test samples for accumulator container if alternative materials are used.
- 104  Accumulator container manufactured according to SES.
- 105  Internal vertical walls have to be rigidly fastened to the container. Minimum 75% of the height of the external walls. Divide the accumulator in sections of max. 12 kg.
- 106  Cells securely fastened towards all 3 directions.
- 107  Vehicle number, university name and ESO phone number(s) written on a high contrast background.
- 108  Roman Sans-Serif characters of at least 20 mm high are used.
- 109  Warning stickers with side length of  $\geq 100$  mm and text "Always Energized" and "High Voltage" (if TS >60 V) installed. (triangle with black lightning bolt on yellow background)
- 110  Check if all parts and the cover/lid of the housing are rigidly fastened.

## HANDCART

- 111  Handcart present with four wheels. Max. dimensions 1200 mm x 800 mm.
- 112  Handcart has always on type brake system.
- 113  The accumulator must be mechanically fixed to the handcart
- while on the handcart.
- 114  The accumulator must be protected from vibrations and shocks.
- 115  Label according to EV5.3.8 still visible while on handcart.

## WEIGHING OF ACCUMULATOR

- ▶ Weight of each used accumulator:

## SEALING OF COMPONENTS

- ▶ After all tests have been passed successfully seal the inspected TS housings:
- 116  Accumulator container(s) including spares
- 117  Charger
- 118  Additional Part:
- 119  Additional Part:

## TIS STATUS UPDATE

- ▶ Set online TIS status to *Passed* or *Failed*

## NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____/_____	_____	_____
2. _____/_____	_____	_____

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## PART V: ELECTRICAL INSPECTION

The time limit for this part of the inspection is 90 minutes. Continuation of the inspection is possible after requeueing. During technical inspection all work carried out on the vehicle must be approved by a technical inspector.

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Present*

### COMMENTS

- ▶ Check comments from first page

### REQUIRED RESSOURCES

- 120  An ESO must attend
- 121  An ASR must attend
  - RES remote control
  - Tools/equipment needed to arm the brake system
  - LV battery or cell datasheet
  - For self developed LV battery packs: an opened battery pack, laptop and cables to display data of the AMS
  - Datasheets for used wiring, insulation materials, and TS components. (printed or properly sorted on one laptop, not on a cell phone)
- At least all non-passed parts of the ESF. (printed or properly sorted on one laptop, not on a cell phone)
- At least all non-passed parts of the ASF. (printed or properly sorted on one laptop, not on a cell phone)
- Samples of all wire types used for the tractive system
- Fully assembled spare boards of all inaccessible TS boards outside the accumulator
- Photographs of all inaccessible TS connections

### LV BATTERY

- 122  Voltage  $\leq 60$  VDC
- 123  Rigid and sturdy casing
- 124  Only for wet-cell batteries: IPX7 rated and acid resistant casing if inside cockpit
- 125  Behind Firewall
- 126  Short circuit protection (e.g. fused)
- 127  Grounded to the chassis
- 128  Proper insulation of internal electrical connections
- 129  Proper mounting of cells
- 130  Complete battery pack inside rollover protection envelope
- Following checks only for Li-Ion batteries other than LiFePO<sub>4</sub>:
- 131  UL94-V0 for min. used thickness or equivalent casing
- 132  Overcurrent protection that trips below max. discharge current
- 133  Overtemperature protection of at least 30 % of the cells (max. 60°C or datasheet, whichever is lower)
- 134  Voltage protection of all cells
- 135  Signal failures electrically disconnect the LV battery (SCS)
  - ▶ Ask the team to connect their laptop to the AMS
- 136  Cell voltages can be displayed
- 137  Cell temperatures can be displayed

### SELF DEVELOPED PCBS

- ▶ Ask for fully assembled spare PCB of self developed PCBs
- 138  Sufficient spacing regarding system voltage and implementation
- 139  Sufficient insulation and temperature rating of coating if used,
- datasheet available
- 140  Coating process according to datasheet
- 141  BSPD PCB(s) is standalone with only minimum interface
- 142  BSPD PCB(s) are directly supplied from the LVMS

### MASTER SWITCHES

- 143  TSMS, ASMS & LVMS installed easily accessible on the right side of the vehicle and located next to each other
- 144  All master switches are located above 80% of shoulder height of Percy
- 145  Rigidly mounted and no need to be removed during maintenance
- 146  Rotary type with removable handle
- 147  Handle length  $\geq 50$  mm
- 148  "ON" position in horizontal
- 149  "ON" and "OFF" positions marked
- 150  TSMS and ASMS with locking mechanism for "OFF" position
- 151  LVMS marked with "LV" and symbol showing a red spark in a white edged blue triangle
- 152  LVMS mounted on an red circular area on high contrast background
- 153  Circular area diameter  $\geq 50$  mm
- 154  TSMS marked with "TS" and triangle with black lightning bolt on yellow background
- 155  TSMS mounted on an orange circular area on high contrast background
- 156  Circular area diameter  $\geq 50$  mm
- 157  ASMS marked with "AS"
- 158  ASMS mounted on an blue circular area on high contrast background
- 159  Circular area diameter  $\geq 50$  mm

### MEASURING POINTS

- 160  Two TS measuring points on exclusive orange background
- 161  A black LV ground measuring point installed
- 162  Next to the master switches
- 163  4 mm shrouded banana jacks
- 164  Non conductive cover
- 165  Cover removable without tools
- 166  Correctly marked ("TS+", "TS-", "GND")



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## TS SHUTDOWN DEVICES

- 167  Two shutdown buttons installed next to the main hoop, right and left on the vehicle at approx. height of drivers head. Push-Pull or Push-Rotate-Pull functionality
- 168  Marked with red sparked sticker
- 169  Diameter >39 mm
- 170  One cockpit shutdown button installed. Push-Pull or Push-Rotate-Pull functionality
- 171  Marked with red sparked sticker
- 172  Easy actuation by the driver
- 173  Diameter  $\geq$ 24 mm
- 174  Inertia switch rigidly mounted to the chassis and can be de-mounted for functionality test
- 175  Remote Emergency System installed
- 176  Rigidly mounted to the chassis
  - ▶ Check interlocks on ...
- 177  TS accumulator container(s)
- 178  Inverters
- 179  HVD
- 180  Power distribution boxes
- 181  Data Logger box
- 182  Outboard wheel motors. (Interlocks must act before a TS wiring failure.)

## TS VOLTAGE

- ▶ Measure voltage at TS measuring points
- 183  Equal or less than 60 VDC

## DIS-CHARGE CIRCUIT AND BODY PROTECTION RESISTORS

- ▶ Switch off LV. Measure resistance between TS+ and TS- measuring points
- 184  Resistance is 30 k $\Omega$ <sup>8</sup> + discharge resistor
- 185  Body protection resistor power rating is >6.0 W<sup>9</sup>
- 186  Dis-charge power rating is sufficient for continuous dis-charge

## TS WIRING

- 187  All TS wiring and components have to be in the envelope and behind the impact structures
- 188  TS connectors outside of enclosures cannot be physically connected other than the design intent configuration
- 189  TS wires of outboard wheel motors must not be able to reach the cockpit opening in case of a wire break. Wiring outside of impact structure is shortest possible distance.
- 190  All TS wires and connectors have proper overcurrent protection
- 191  TS wiring channels are orange
- 192  No other wires than TS wires are orange
- 193  TS wiring outside electrical enclosures in separate non-conductive conduit or orange shielded cable
- 194  Securely anchored to withstand at least 200 N, if outside of enclosure
- 195  Located out of the way of possible snagging or damage
- 196  Shielded against rotating/moving parts
- 197  No wire lower than the chassis
- 198  TS and LV wires separated (n/a for interlock)
- 199  Possible to clearly assign and prove gauge, temperature and voltage rating of TS wires
- 200  Suitable temperature rating for used position
- 201  Positive locking mechanism on every screwed connection. (Photographs for all inaccessible TS connections)
- 202  Insulation is not insulating tape or rubber-like paint

## HV WARNING STICKERS

- ▶ Check for warning stickers on TS containing enclosures. (triangle with black lightning bolt on yellow background)
- 203  Inverter(s)
- 204  Motor(s)
- 205  Power Distribution box(es)
- 206  Energy meter box
- 207  Other TS containing enclosures

## TRACTIVE SYSTEM PROTECTIONS

- ▶ Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100 mm length, 6 mm diameter)
- 208  Not possible to reach any TS potentials
- 209  TS components and containers protected from moisture

## HIGH VOLTAGE DISCONNECT

- 210  Clearly marked with "HVD"
- 211  Distance to ground greater than 350 mm
- 212  Inside roll-over protected envelope
- 213  Easily visible while standing behind the vehicle
- 214  No remote actuation (e.g. through wires)
- 215  Integrated interlock
  - ▶ Stand next to the vehicle, remove HVD
- 216  Removed within 10 s without tools
- 217  TS protection still given (insulated test probe). If dummy connector is used, it must be stored at the push-bar.

## TRACTIVE SYSTEM ACTIVE LIGHT

- 218  Mounted below highest point of the main roll hoop and within the roll-over protected envelope (including mounting)
- 219  Full illuminated surface visible by a person standing 3 m away from TSAL (1.6 m eye height)
- Cockpit indicator light ...
- 220  ... is inside the cockpit and marked with "TS off"
- 221  ... is green and visible in bright sunlight
- 222  ... is visible for the driver

<sup>8</sup>2 x Body Protection Resistor (BPR)

<sup>9</sup>sufficient to short circuit TS+ and TS-

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## DATA LOGGER

- 223  data logger is enclosed in a housing
- 224  All energy from accumulator flows through the data logger

## FIREWALLS

- Separates any point of the driver (less than 100 mm above the bottom of the helmet of the tallest driver) from any TS component (including TS wiring) . . .
- 225  . . . behind the driver's back
- 226  . . . at the sides of the driver
- 227  . . . at the front of the vehicle
- 228  First layer, facing TS must be made of Aluminum with a thickness of at least 0.5 mm
- 229  Second layer, facing driver must be made of electrically insulated material (no CFRP)
- 230  Material meets UL94-V0 for min. used thickness or equivalent

## ACCELERATOR PEDAL POSITION SENSOR (APPS)

- 231  Returns to original position if not actuated
- 232  At least two sensors with different transfer functions, each having a positive slope sense with either different gradients and/or offsets to the other(s) are installed. (For digital sensors, a checksum is necessary)
- 233  Sensors do not share supply or signal lines
- 234  Sensors are protected from being mechanically overstressed (positive stop of pedal)
- 235  Minimum two springs installed to return pedal
- 236  Each spring still returns pedal with the second one disconnected (springs in the torque encoders not counted)

## AUTONOMOUS SYSTEM STATUS INDICATORS

- 237  Both side ASSIs are mounted behind the driver's compartment, min 160 mm below the top of the main hoop and 600 mm above ground.
- 238  The rear ASSI is mounted on vehicle centerline, min 160 mm below the top of the main hoop and 100 mm above the brake light.
- 239  Round, triangle, or rectangular on black background
- 240   $15 \text{ cm}^2$  minimum illuminated area OR LED strips with a total length greater than 150 mm with elements <20 mm apart

## BRAKE LIGHT

- 241  Only one brakelight in red color
- 242  Located on vehicle centerline, height between wheel centerline and drivers shoulder
- 243  Round, triangle, or rectangular on black background
- 244   $15 \text{ cm}^2$  minimum illuminated area OR LED strips with a total length greater than 150 mm with elements <20 mm apart

## GROUNDING CHECKS

Measure resistance between any conductive parts of the vehicle within 100 mm around any TS component, the seat mounting points and the harness attachment points and the LV GND measuring point:

Part (if applicable)	Conductive (max. 300 mΩ @ 1 A)	May become conductive (max. 5 Ω @ 0 A)
Main Roll Hoop	<input type="checkbox"/>	
Frame / Monocoque	<input type="checkbox"/>	<input type="checkbox"/>
Driver harness mounting points	<input type="checkbox"/>	
Seat mounting points	<input type="checkbox"/>	
Firewall(s)	<input type="checkbox"/>	
Carbon fiber part within 10 cm around TS parts:		<input type="checkbox"/>
Suspension Front left or right if applicable	<input type="checkbox"/>	<input type="checkbox"/>
Suspension Rear left or right if applicable	<input type="checkbox"/>	<input type="checkbox"/>
Accumulator container	<input type="checkbox"/>	<input type="checkbox"/>
Accumulator Management System Data Connector	<input type="checkbox"/>	<input type="checkbox"/>
Conductive housings with TS parts inside	<input type="checkbox"/>	<input type="checkbox"/>
Additional Part:	<input type="checkbox"/>	<input type="checkbox"/>

## INSULATION MEASUREMENT TEST

- ▶ Choose test voltage to 500 V. <sup>10</sup>
  - ▶ Connect insulation tester to TS+ and LVMP
  - ▶ Measure resistance:  $R_{iso+} =$  kΩ
- 245  Resistance is much higher than 315 kΩ<sup>11</sup>
- ▶ Connect insulation tester to TS- and LVMP
  - ▶ Measure resistance:  $R_{iso-} =$  kΩ
- 246  Resistance is much higher than 315 kΩ<sup>11</sup>
- 247  Resistances are nearly equal

<sup>10</sup>  $\frac{U_{max}}{U_{Test}} \leq 250 \text{ V}_{DC}$      $\frac{U_{max}}{U_{Test}} > 250 \text{ V}_{DC}$   
 $\frac{U_{max}}{U_{Test}} = 250 \text{ V}_{DC}$      $\frac{U_{max}}{U_{Test}} = 500 \text{ V}_{DC}$

<sup>11</sup> Minimal Resistance = 500 ΩV · U<sub>max</sub> + BPR

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## !! TEST AT HIGH VOLTAGE !!

### TRACTIVE SYSTEM POWER-UP

- ▶ All driven wheels are off the ground, driven wheels removed
- ▶ Connect multimeter between TS+ and TS-
- ▶ Switch on TSMS with LVMS deactivated
- 248  Voltage at TS measurement points less or equal 60 VDC
  - ▶ Switch on LVMS with TSMS deactivated
- 249  IMD and AMS and TS and ASB Cockpit indicator light illuminate for 1 s to 3 s for visible check
- 250  Voltage at TS measurement points less or equal 60 VDC
  - ▶ ASMS deactivated, select mission "Manual driving"
  - ▶ Switch on TSMS and all shutdown buttons
  - ▶ Reset any IMD or AMS errors
- 251  TS still deactivated
  - ▶ Press external activation button next to the TSMS
- 252  TS still deactivated
  - ▶ Activate TS, measure TS voltage during TS power-up
- 253  System is precharged before second AIR closes
  - ▶ Switch off TSMS
- 254  TS voltage decreases below 60 VDC within 5 s
  - ▶ Try to power-up TS with switched off TSMS
- 255  TS still deactivated
  - ▶ Switch on TSMS
- 256  TS still deactivated

### TRACTIVE SYSTEM SHUTDOWN

- ▶ Connect multimeter between TS+ and TS-
- ▶ For every of the following switches, deactivation leads to TS shutdown, voltage decreases below 60 VDC within 5 s
- 257  LVMS
- 258  Shutdown button left
- 259  Shutdown button right
- 260  Cockpit shutdown button
- 261  Remote Emergency System
- 262  Inertia switch
- 263  Break-over-travel-switch
  - ▶ Show schematic of TS with all interlocks (ESF)
- 264  Interlocks

### TRACTIVE SYSTEM ACTIVE LIGHT

- ▶ Activate LVS
- 265  TSAL and Cockpit Indicator (CI) is green only
  - ▶ Activate TS
- 266  TSAL flashes red with freq 2 Hz - 5 Hz, and CI is off
- 267  TSAL is clearly visible (horizontal position, entire illuminated surface)
  - ▶ Disconnect TSAC state detection circuitry (disconnect data connection to accumulator container), activate LVS and TS
- 268  TSAL flashes red and CI is off
  - ▶ Deactivate TS, connect power supply >60 VDC<sup>12</sup> to TS<sup>13</sup>, activate LVS
- 269  TSAL is both green and red flashing simultaneously and CI is on
  - ▶ Disconnect power supply, remove HVD, override HVD interlock (!! cover TS potentials !!), activate LVS and TS
- 270  TSAL and CI is off

### INSULATION MONITORING DEVICE

- 271  One IMD ground line is connected to the accumulator container<sup>14</sup> and one ground line is connected to the main hoop by a separate wired connection
  - ▶  $R_{Test} = 120 \text{ k}\Omega$ <sup>15</sup>
    - IMD indicator light ...
- 272  ... is inside the cockpit and marked with "IMD"
- 273  ... is red and visible in bright sunlight, even from outside
- 274  ... is visible for the driver
  - ▶ Activate TS, connect  $R_{Test}$  between TS+ and LV GND
- 275  Shutdown circuits opens within 30 s
- 276  IMD indicator light illuminates
- 277  TS voltage decreases below 60 VDC within 5 s after shutdown circuit opens
  - ▶ Try to activate the TS by the required additional action (EV5.11.2)
- 278  Reactivation of TS is not possible
  - ▶ Push the reset button which is not accessible to the driver, if any and/or restart LVMS
- 279  Reactivation of TS is not possible
  - ▶ Remove  $R_{Test}$ . Wait 40 s until IMD resets status output
- 280  Reactivation of TS is not possible
  - ▶ Push all reset buttons in the cockpit, if any
- 281  Reactivation of TS is not possible
  - ▶ Push the IMD reset button which is not accessible to the driver, if any
- 282  Reactivation of TS is possible
  - ▶ Push *and hold* the reset button which is not accessible to the driver, if any. Connect  $R_{Test}$  between TS- and LV GND
- 283  Shutdown circuits opens within 30 s
- 284  IMD indicator light illuminates

### ACCUMULATOR MANAGEMENT SYSTEM

- AMS indicator light ...
- 285  ... is inside the cockpit and marked with "AMS"
  - ▶ Disconnect TS accumulator
- 286  ... is illuminated red and visible in bright sunlight, even from outside
- 287  ... is visible for the driver

<sup>12</sup>25 V<sub>AC</sub> equal 42.5 V<sub>DC</sub> when the signal is sinusoidal

<sup>13</sup>Do not use measuring points. The team needs to provide a method of connection which uses same receptacles as used for TSMP

<sup>14</sup>or the IMD's enclosure

<sup>15</sup> $R_{Test} = (\text{max. TS voltage} \cdot 250 \text{ Ohm/V}) \cdot \text{BPR}$

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## READY TO DRIVE ACTIVATION SEQUENCE

- ▶ Activate TS, press torque pedal
- 288  No turning of motors
- ▶ Let the team set the vehicle to ready to drive mode
- 289  Pressing brake pedal WHILE activating is necessary
- ▶ Repeat the activation sequence, but push the brake pedal only once before finally pushing the activation button
- 290  No ready to drive mode possible
- ▶ Disconnect the brake sensor
- 291  No ready to drive mode possible
- 292  Ready to drive sound duration is 1 s to 3 s continuously
- 293  Ready to drive sound is min 80 dBA (2 m around the vehicle)
- 294  Ready to drive sound is easy recognizable and no animal sound or song part

## APPS AND BSPD

- ▶ Set vehicle to ready to drive state
- ▶ Disconnect  $\geq 50\%$  of APPS
- 295  Motors do not turn
- ▶ Disconnect all APPS
- 296  Motors do not turn
- ▶ Team simulates 5 kW power (complete BSPD circuitry must be used), press brake representing hard braking ( $>0.5$  s)
- 297  TS shuts down
- ▶ Reactivate TS. Disconnect current sensor, press brake representing hard braking ( $>0.5$  s)
- 298  TS shuts down
- 299  Reactivation of TS is only possible after 10 s without implausibility

## SEALING OF COMPONENTS

- ▶ After all tests have been passed successfully seal the inspected TS housings:
- 300  Motor Controller housing
- 301  Energy Meter housing
- 302  IMD housing
- 303  TSAL circuitry housing
- 304  BSPD casing /BSPD calibration
- 305  Additional Part:
- 306  Additional Part:

## DATA LOGGER

- 307  Check data logger functionality and connectivity

## TIS STATUS UPDATE (ELECTRICAL PART)

- ▶ Set online TIS status to *Passed* or *Failed*

## REMOTE EMERGENCY SYSTEM BYPASS

- 308  RES bypass is implemented as described in the ASF.
- 309  Correct Safety relays is used.
- ▶ Let the teams explain their implementation.

## AUTONOMOUS SYSTEM BRAKE

- 310  Autonomous System Brake is identical to the system described in the ASF.
- 311  All parts of the Autonomous System Brake are properly mounted, no leaks.
- 312  No push-in fittings are used.
- 313  No more than two release points are used.
- 314  All release points are in proximity to each other and either be mounted in proximity to the ASMS or on the top side of the vehicle between front bulkhead and front hoop close to the vehicles center line.
- 315  The release points are operable by maximum two simple push/pull and/or turning actions, the order and direction of these actions must be shown next to the deactivation points.
- 316  Manual release points are marked with "brake release".

## AUTONOMOUS SYSTEM TEST

- ▶ Switch on the LVMS and select the inspection mission (AMI).
- 317  The ASSIs remains off.
- ▶ Switch on the ASMS and the TSMS.
- 318  Activating the TS using the cockpit activation button is not possible
- ▶ Activate the TS via the external activation button.
- 319  The ASSIs light up in yellow continuously after a self check ("AS Ready").
- ▶ Press RES "Go" button within 5 s after "AS Ready".
- 320  "AS Driving" (ASSIs flashing yellow ) has not been entered.
- 321  Vehicle is still not in R2D.
- 322  Check functionality and visibility of AMI.
- 323  All 3 ASSIs are clearly visible in very bright sunlight. At least one ASSI is visible from any angle of the vehicle.
- 324  Brakes are closed.
- ▶ Press the RES "Go" button.
- !! CAUTION WHEELS AND STEERING SYSTEM ARE MOVING !!**
- 325  The ASSIs start flashing yellow ("AS Driving").
- 326  Drivetrain is slowly spinning and steering system is moving.
- ▶ Wait for the transition from "AS Driving" to "AS Finished".
- 327  The ASSIs light up in blue continuously within 25 s to 30 s and brakes are engaged ("AS Finishes"). ASSIs must not start flashing.
- 328  ASSIs are clearly visible in very bright sunlight.
- 329  TS is deactivated.
- ▶ Turn off the ASMS and release the Brakes via the deactivation points.
- 330  Brakes are disengaged, manual steering is possible, ASSI is off.
- ▶ Try to activate TS again and enter "AS Ready" state.
- 331  TS stays disabled and system does not enter state "AS Ready".
- ▶ Powercycle LV system or press the reset button and re-enter

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"AS Ready" state.

- ▶ Press one shutdown button while autonomous state is "AS Ready".
- 332  ASSIs start flashing blue ("AS Emergency").
- 333  Brakes are closed.
- 334  Intermittent sound for 8 s to 10 s (1 Hz to 5 Hz, 50 % duty cycle).
- 335  ASB error indicator inside the cockpit is off.
- 336  TS is deactivated.
  - ▶ Turn of ASMS and reset the ASB (manual actions may be required).
  - ▶ Reset the ASB and re-enter "AS Driving" state with inspection mission selected, before each of the following tests.
  - ▶ 1. Press RES 2. Press any shutdown button 3. Switch off the

ASMS

- 337  TS is deactivated.
- 338  Transition to "AS Emergency", ASSI is blue flashing, brakes are closed and intermittent sound for 8 to 10 s.
- 339  ASB error indicator is off.
  - ▶ Test all operating errors (e. g. manual valves) and some (choose randomly 1 to 3) ASB failure modes (e.g. disconnect sensors/energy supply/pneumatics/hydraulics...).
- 340  System has detected a failure.
- 341  ASB indicator light illuminates.
- 342  When ASS is "AS Ready" or "AS Driving" state, the system has to enter "AS Emergency".
- 343  When ASS is "AS OFF" state no transition to "AS Ready" is possible when switching on ASMS and activating the TS (without LVMS power cycle).

## TIS STATUS UPDATE (DRIVERLESS)

- ▶ Set online TIS status to *Passed* or *Failed*

## NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____
2. _____ / _____	_____	_____

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## PART VI: MECHANICAL INSPECTION

The time limit for this part of the inspection is 75 minutes. Continuation of the inspection is possible after requeueing. During technical inspection all work carried out on the vehicle must be approved by a technical inspector.

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Present*

### COMMENTS

- ▶ Check comments from first page

### VEHICLE WITH TALLEST DRIVER READY TO RACE

- 344 ○ **FIRE EXTINGUISHERS** - Two (2) hand-held, 0.9 kg (2 lb.) minimum, dry chemical (10BC, 1A10BC, 34B, 5A 34B, 20BE or 1A 10BE), with pressure/charge gauge, Aqueous Film Forming Foam (AFFF) fire extinguishers are prohibited, 1 WITH VEHICLE securely installed on push-bar, 1 in paddock. (Must see BOTH at Tech.).
- 345 ○ **PUSH BAR (red color)** - With vehicle, securely attached to vehicle, detachable, push & pull function for 2 people. University must be written on. Two pair of HV gloves in protecting case and Multimeter must be installed.
- 346 △ **CAMERAS** - Must be secured by two points, see T13.5. No cameras mounted to helmet.
- 347 ○ **AUTONOMOUS SYSTEM SENSORS** - Sensors may not come into contact with the driver's helmet when normally seated.
- 348 ○ **VISIBILITY** - Minimum of 100 deg. field either side. Head rotation allowed or mirrors. If mirrors, must be firmly installed and adjusted
- 349 △ **VEHICLE CONTROLS** - All controls, including shifter, must be inside cockpit. No arms or elbows outside the SIS plane.
- 350 ○ **DRIVER FLUID PROTECTION** - A firewall (rigidly mounted cover plate for cooling systems using plain water) must extend sufficiently far upwards and/or rearwards such that any point, less than 100mm above the bottom of the helmet of the tallest driver, is not in direct line of sight with any of the following parts: cooling system and low voltage battery.
- 351 ○ **ROLL BAR PADDING** - Roll bar or bracing that could be hit by driver's helmet must be covered with 12mm thick, SFI spec 45.1 or FIA 8857-2001 padding.
- 352 △ **OTHER SIDE TUBES** - Design prevents driver's neck hitting bracing or other side tubes
- 353 ○ **HEAD RESTRAINT**- Near vertical. Must take 890N load. 40mm thick, SFI 45.2 standard. Max. 25mm from helmet. Helmet contact point 50mm min. from any edge. May be changed for different drivers. Minimum 150x150mm.
- 354 ○ **DRIVER RESTRAINT HARNESS** - SFI 16.1, SFI 16.5, SFI 16.6, FIA 8853/98 or FIA 8853/2016. 6- or 7-point system – Two-piece lap belt (min. width 50mm), two shoulder straps (min. width 75mm) and two leg or anti-submarine straps (min. width 50mm). (7-point system must have three anti-submarine straps). Must be securely attached to prim. structure (25.4 x 2.4mm or equal.)
- 355 ○ **LAP BELT MOUNTING** - Pivoting mounting with eye bolts or shoulder bolts attached securely to Primary Structure. Min. tab thickness 1.6mm. Attachment brackets to the monocoque must be steel, see T5.3.2.
- 356 ○ **SHOULDER HARNESS MOUNTING** - Mounting points 180 - 230mm apart (measured center to center). Angle from shoulder between 10 deg. up and 20 deg. down to horizontal. Attach to Primary Structure - 25.4 x 2.4mm or 25.0 x 2.5mm steel tube min. NOT to put bending loads into Main Hoop Bracing without extra bracing. Additional braces if not straight to main hoop. Cannot pass through a firewall. Attachment brackets to the monocoque must be steel.
- 357 ○ **SUSPENSION** - Fully operational with dampers front and rear; 50mm minimum wheel travel (minimum jounce of 25mm) with driver in vehicle.

### VEHICLE WITHOUT DRIVER

- 358 △ **TECH STICKER SPACE** - 45 mm x 175 mm on centerline of front of vehicle in front of the cockpit opening
- 359 △ **SCHOOL NAME & OTHER DECALS** - School Name, or recognized initials - min. 50mm tall (all letters). on both sides in Roman letters. Must be clearly visible.
- 360 △ **VEHICLE NUMBERS** - On front & both sides of vehicle, minimum 150mm tall, 20mm stroke & spacing, 25mm min. between number and background edge, Black on White, White on Black only, specified background shapes. Must be clearly visible, font: Roman Sans-Serif characters.
- 361 △ **BODYWORK EDGES** - edges that could contact a pedestrian must have a minimum radius of 1.0mm (safety requirement)
- 362 △ **BODY & STYLING** - Open wheeled, open cockpit, formula style body. Vertical keepout zones 75mm in front and behind tires (no aero exceptions), tires unobstructed from sides.
- 363 ○ **BODYWORK** - Min. 38mm radius on nose. No large openings in bodywork into driver compartment in front of or alongside driver, (except cockpit opening).
- 364 ○ **AERODYNAMIC DEVICES** - Securely mounted. The deflection may not exceed 10mm when a force of 200N is applied over a surface of 225 cm<sup>2</sup> and not more than 25mm when a point force of 50N is applied.
- 365 △ **AERODYNAMICS** - ALL aerodynamic devices maximum 250mm rearward of rear tires, maximum 700mm forward of front tires. Devices lower than 500mm from the ground rearward of the front axle must be no wider than vertical plane from the outside of the front and rear tires. Devices higher than 500mm behind the front axle must not be wider than the inside of the rear tires.
- 366 △ **AERO VERTICAL HEIGHT** - Devices forward of a vertical plane through the rearmost portion of the front face of the driver head restraint support, excluding any padding, set to its most rearward position, must be lower than 500mm from the ground. Rear device max 1.2 m above ground (incl. end plates); Front device max 250mm above ground outside of the inside plane of the front tires inside this plane max 500mm.
- 367 ○ **EDGES/RADII** - Edges that could contact a pedestrian must have a minimum radius of: horizontal leading edges min 5mm; vertical forward facing edges min 3mm. All other edges must have a minimum radius of 1.0mm
- 368 △ **SEAT** - Insulated against heat conduction, convection and radiation. Lowest point no lower than top of of the upper surface of the lowest SIS member OR must have longitudinal, 25.4 x 1.65mm steel tube underneath.
- 369 ○ **COCKPIT OPENING** - Fig. 11 (left) template passes down from above cockpit to below the upper side impact member. Steering wheel, seat & padding can be removed. No removing of firewall.
- 370 ○ **COCKPIT INTERNAL CROSS SECTION** - Fig. 11 (right) template passes from the cockpit opening to 100mm rear of rearmost pedal contact area (in most forward position). Steering wheel and paddings can be removed (without tools).

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- 371  **STEERING WHEEL** - Continuous perimeter, near round (no concave sections) with driver operable quick disconnect. 250mm max from front hoop.
- 372  **ROTATING PARTS** - Finger guards are required to cover any parts (e.g. fans) that spin while the vehicle is stationary. No holes >12mm dia.

## REMOVE BODY PANELS

- 373  **DRIVER'S LEG PROTECTION** - Covers inside of cockpit over any sharp edges or moving suspension / steering components.
- 374  **DRIVER'S FOOT PROTECTION** - Feet must be rearward of the Front Bulkhead and no part of shoes or legs above or outside the Major Structure (25x1.2 or equivalent) in side or front views when touching the pedals.
- 375  **PERCY** - Helmet of 95th percentile male (PERCY) to be 50mm below the lines between top of front and main roll hoops and between top of main hoop to rear attachment point of main hoop bracing. Center of bottom circle placed minimum 865mm from pedals.
- 376  **BRAKES** - Dual hydraulic system & reservoirs, operating on all four wheels, (one brake on limited slip differential is OK). System must be protected by structure or shields from drivetrain failure or minor collisions. No plastic brake lines. No brake-by-wire. No parts below chassis in side view. Brake pedal capable of 2000N, no failures if official exerts max force (seated normally in vehicle).
- 377  **BRAKE OVER TRAVEL SWITCH** - In the event of a failure in one or both of the brake circuits the brake pedal over travel will result in the shutdown circuit being opened.
- 378  **TUBING & MATERIALS** - Team must show an APPROVED SES. No Magnesium tubes in primary structure.
- 379  **MONOCOQUE** - Must see laminate test specimen. Steel backing plates ( $\geq 2$  mm thick) used at attachment points (must be fully supported).
- 380  **BOLTED JOINTS** in primary structure - Distance hole centerline to the nearest free edge > 1.5 x hole diameter.
- 381  **MAIN HOOP** - MUST BE STEEL. Check dimension as shown in approved SES. Must be made of one piece and extend to lowest frame member. Above Major Structure, must be within 10 deg. of vertical plane. Smooth bends without wrinkles.
- 382  **MAIN HOOP BRACING** - MUST BE STEEL. One straight brace on each side. Dimension as shown in the approved SES. Attached within 160mm from the top. Min. 30 deg. included angle with hoop. If main hoop is not vertical, bracing must not be on same side of the vertical plane as the main hoop. No bends. No rod-ends. Proper design for removable braces (capping etc.) on BOTH ENDS. Must take load back to bottom of main hoop and node of upper side impact tube through proper triangulated structure. (25.4 x 1.2mm or equivalent)
- 383  **FRONT HOOP** - Must be closed section metal tube. Can be multi-piece with gussets or additional attachments to the monocoque. Must extend down to lowest frame member. No lower than top of steering wheel. Max. 20 deg. to vertical. Check dimension as shown in approved SES.
- 384  **FRONT HOOP BRACING** - Two straight forward facing braces, 25.4 x 1.65mm or 25.0 x 1.75mm or 25.4 x 1.6mm wall steel or equivalent, attached within 50mm of top. Extra rearward bracing required if Front Hoop leans backwards more than 10 deg.
- 385  **SIDE IMPACT PROTECTION** - Min. of 2 tubes + diagonal must connect the main and front hoops in straight line. Upper tube between 240 - 320mm above lowest inside chassis point between FH and MH. Dimension as shown in approved SES.
- 386  **FRONT IMPACT PROTECTION** - No non-crushable objects forward of bulkhead. IMPACT ATTENUATOR forward of bulkhead, 200mm long x 200mm wide x 100mm high. No wing supports through the IA. IA must be securely fastened directly to AIP capable of taking transverse & vertical loads (no tape, etc.) Test piece presented and same as IA on vehicle. Standard IA: Requires diagonal brace if bulkhead >25.4mm from IA on any side.
- 387  **ANTI INTRUSION PLATE** - A 1.5mm solid steel or 4.0mm solid aluminium sheet. Must be welded (size: min. to centerlines) or min. 8 screws M8 Grade 8.8 (critical fasteners T10) (size: min. outside dimensions). CFRP plate is accepted if SES approved.
- 388  **FRONT BULKHEAD SUPPORT** - Support back to front roll hoop; 3 tubes per side, all 25mm x 1.5mm wall steel tube or equiv. 1 bottom; 1 top within 50mm of top of bulkhead, and connecting within 100mm above and 50mm below upper SIS tube; 1 or more node-to-node diagonal to completely triangulate connections to upper and lower SIS tubes.
- 389  **INSPECTION HOLES** - 4.5mm inspection holes required in non-critical areas of front & main hoops. Inspectors may ask for holes in other tube(s).
- 390  **QUICK JACK (red color)** - One device must be available to lift up all driven wheels min. 100mm above the ground. Lifting the car must be possible by one person. In lifted position the quick jack must be locked/secured and function without the support of a person or additional weights. University name must be written on.
- 391  **WHEELS** - 203.2mm (8") min. diam. No Aluminium or hollow wheel bolts. Single retaining nut must incorporate a device to retain the nut. Aluminum wheel nuts must be hard anodized.
- 392  **FIREWALL** - Fire resistant material; must separate driver compartment from cooling, oil system & LV battery. Pass-throughs OK with grommets. Multiple panels OK if gaps sealed. No gaps at sides or bottom. Must be rigidly mounted to the chassis. Material must meet UL94-V0, FAR25 or equivalent. On tractive side min. 0.5 mm aluminium plate grounded, on the driver side a rigid insulating layer (no CFRP) UL94-V0 or equivalent should be installed that can withstand a 250N 4mm screwdriver penetrating test.

## VEHICLE LIFTED AND WHEELS REMOVED

- 393  **SUSPENSION PICK-UP POINTS** - Inspected thoroughly for integrity.
- 394  **FASTENERS** - Steering, braking, harness and suspension systems must use SAE Grade 5 or Metric Grade M8.8 or higher specs (AN/MS) with visible positive locking mechanisms, no Loctite or lock washers. Minimum of 2 exposed threads with locking nuts. Rod ends in single shear are captured by a washer larger than the ball diameter. Adjustable tie-rod ends must have jam nuts to prevent loosening. No Nylon lock nuts for Brake calipers or Brake discs. No button head cap, pan head or round head screws in critical locations, e.g cage structure or harness mount. Primary structure e/D > 1.5.
- 395  **STEERING** - All steerable wheels must have positive stops placed on the rack to prevent linkage lock up or tires from contacting any part of the vehicle. 7 degrees max. free play at the steering wheel. NO STEER-BY-WIRE on front wheels. Rear wheel steering, max. 6 deg. and mechanical stops installed. No bonded joints in steering column.
- 396  The steering system has to be fully operational by a driver when ASMS is in "OFF"-Position.
- 397  **FLOOR CLOSEOUT PANEL** - Required from foot area to firewall; solid, non-brittle material; multiple panels are OK if gaps less than 3mm.
- 398  **GAS CYLINDERS LOCATION** - Axis not pointed at driver, within the rollover protection envelope, insulated from any heat source, must be shielded from the driver. The shields must be steel or aluminum with a minimum thickness of 1 mm.
- 399  **GAS CYLINDERS** - Proprietary manufacture & labeled, Non-flammable gas, regulator on tank, securely mounted, appro-

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- ropriate lines & fittings. Positively retained, i.e. no tie-wraps. Maximum of 10bar allowed, except cylinders/tanks with directly mounted pressure regulator (-> 10bar).
- 400 ○ **SCATTERSHIELDS INCL. MOUNTING** - Required for clutches, chains, belts, etc. No holes. 6mm diam. Grade 8.8 minimum. End parallel to lowest part of the sprocket/pulley in front and rear.
  - 401 △ **SCATTERSHIELD MATERIALS** - For chains, 2mm min. thick solid STEEL, 3 x chain width. For belts, 3mm min. thick Al 6061-T6, 3 x belt width. Finger guards: cover all drivetrain parts that spin while vehicle is stationary. No holes >12mm dia.
  - 402 ○ **LV BATTERY** - Attached securely to frame or chassis.
  - 403 ○ **HIGH PRESS HYDRAULICS** - Pumps and lines must have 1mm steel or aluminium shields protecting driver and workers.
  - 404 ○ Including all autonomous system high pressure hydraulics like the ASB.
  - 405 △ **COOLANT** - 100% water. NO ADDITIVES WHATSOEVER or oil for electric motors.
  - 406 ○ **CATCH TANKS** - Any coolant overflow or lube system vents must have separate catch tanks. 0.9 l minimum each, 100 deg. C material, behind firewall, below shoulder level. 3mm min. dia. vent away from driver down to the bottom level of frame. Trans or diff., cooling systems using plain water, unless sealed, require 100 ml catch tanks.
  - 407 △ **FLUID LEAKS** - Oil, grease, coolant, Brake fluid -> none permitted
  - 408 ○ **BELLYPANS** - In total minimum of two venting holes of at least 25mm diameter in the lowest part of the structure to prevent accumulation of liquids. One in each enclosed chassis structure. Additional holes are required when multiple local lowest parts exist in the structure.
  - 409 ○ **ACCUMULATOR CONTAINER POSITION** - All accumulator containers must lie within the primary structure of the frame lower than the top of the SIS. All accumulator containers must be protected from side or rear impact collisions. If an accumulator container or parts of it are mounted outside of the primary structure (EV.3.5.1, EV 3.5.3) an additional impact structure according to T3.2 must be built to protect the accumulator.
  - 410 ○ **ACCUMULATOR CONTAINER ATTACHMENT** - Accumulator container must be attached to the primary structure with fasteners min. Grade 8.8. Fasteners have to follow T10. Mounting as designed in SES. Brackets 1.6mm steel or 4mm aluminium with gussets to withstand bending loads. Monocoque needs 2mm steel backing plates or equivalent, mentioned in SES.
  - 411 ○ **PROTECTION OF TRACTIVE SYSTEM PARTS** - In side view no part of the tractive-system can project below the lower surface of the frame or the monocoque, whichever is applicable
  - 412 ○ **PROTECTION OF TRACTIVE SYSTEM PARTS** - All parts belonging to the tractive system including cables and wiring must be contained within the envelope of any part of the frame which is made from any regulated tubing defined in T3.2. If tractive system parts are mounted in a position where damage could occur from a rear or side impact (below 350mm from the ground), they have to be protected by a fully triangulated structure with tubes of a minimum outer diameter of 25.4mm and a minimum wall thickness of 1.25mm or equivalent
  - 413 ○ **MOTOR CASING** - 3mm Aluminium 6061-T6 or 2mm steel. If rotating around the stator or the motor case is perforated a scatter shield around the motor should be installed of 1mm 6061-T6 aluminium or steel.

## SENSORS FOR AUTONOMOUS SYSTEM

- 414 ○ **CHECK SENSORS** - Check if all Sensors are fulfilling the legal requirements (mainly radar and laser). The teams must provide the according certifications.
- 415 ○ **SENSOR POSITION** - Sensors must be positioned within the surface defined by the top of the main hoop and the outside edge of the four tires, with a maximum distance of 500mm above the ground and not further forward than 700mm forward of the front of the front tires. They must not exceed the width of the front axle.
- 416 ○ **SENSOR MOUNTING** - Sensors must be securely and rigidly mounted to the vehicle's structure.
- ▶ **SENSOR MARKING** - Mark all sensors.

## ACTUATORS FOR AUTONOMOUS SYSTEM

- 417 ○ **DECOUPLING** - Check if the team uses a decoupling mechanism for the brake/steering actuators.
- 418 ○ **PART REMOVAL** - parts like including bolts, clips, etc. must not be removed for disconnection i.e. they must never lose the physical contact to the disconnection mechanism
- 419 ○ **MANUAL OPERATION** - the disconnection mechanism must not block manual operation of steering/ braking in any position.
- 420 ○ **LOCKING** - the disconnection mechanism must be securely locked in both positions.

## TIS STATUS UPDATE

- ▶ Set online TIS status to *Passed* or *Failed*



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## NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____
2. _____ / _____	_____	_____

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## PART VII: TILT TEST

### TIS STATUS UPDATE

▶ Set online TIS status to *Present*

### COMMENTS

▶ Check comments from first page

### TILT TEST

421  **FLUID LEAKAGE** - No fluid spill permitted when vehicle is tilted to 60 degrees in the direction most likely to create spillage. Tanks must be filled to scribe line.

422  **VEHICLE STABILITY** - All wheels in contact with tilt table when tilted to 60 degrees to the horizontal.

423  **GROUND CLEARANCE** - At least 30 mm min. with driver.

### TIS STATUS UPDATE

▶ Set online TIS status to *Passed* or *Failed*

### NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____

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## PART VIII: RAIN TEST

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Present*

### COMMENTS

- ▶ Check comments from first page

### RAIN TEST

- ▶ The vehicle is lifted off the ground. Tractive system has to be active (TSAL ON)
- 424  Tractive system voltage is present at TSMPs
- ▶ **RAIN PROOF** - No driver is allowed to sit in the vehicle during the test. Water like rain will be sprayed at the vehicle for 120 sec. Another 120 sec. of waiting without water spary.
- 425  The Insulation Monitoring Device does not react and not shut down the tractive system.
- ▶ Connect  $R_{Test}$  between any TSMP and LVS GND.
- 426  Shutdown circuits opens within 30 s.

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Passed* or *Failed*

### NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____

## PART IX: BRAKE TEST

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Present*

### COMMENTS

- ▶ Check comments from first page

### BRAKE TEST

- 427  **BRAKING PERFORMANCE** - Must lock all four wheels and stop the vehicle in a straight line at the end of an acceleration run specified by the officials without electrical braking from motors. The tractive system has to be shut down by the driver before braking. The Tractive System Active Light has to be Green during breaking or shortly after the vehicle stopped (may take up to 5 sec. after shut down).
- 428  **BRAKE LIGHT** - has to be clearly visible even in bright sunlight.

### TIS STATUS UPDATE

- ▶ Set online TIS status to *Passed* or *Failed*

### NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____

## PART X: EMERGENCY BRAKE SYSTEM TEST

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## TIS STATUS UPDATE

- ▶ Set online TIS status to *Present*

## COMMENTS

- ▶ Check comments from first page

## EMERGENCY BRAKE SYSTEM TEST

- ▶ Use the RES dongle.
  - ▶ Apply EBS adapter device to team's RES sender, if available.
  - ▶ Switch on LVMS and select mission "EBS test".
- 429  AMI shows the correct mission.
- ▶ Switch on ASMS.
  - ▶ Activate TS
- 430  ASSI is yellow continuous.
- 431  TSAL is red flashing.
- ▶ Press RES "Go" button.
- 432  ASSI is yellow flashing and vehicle accelerates.
- ▶ EBS gets automatically triggered by the EBS adapter device at the brake point. If the EBS adapter device is not available press RES "stop button" when vehicle is at brake point.
- 433  Vehicle has to stop within 10m and has to stay stable.
- 434  Speed at brake point has to be around 40 km/h.
- 435  ASSI is blue flashing, intermittent sound is clearly noticeable for 8 - 10 s.
- 436  TSAL is green continuous.

## TIS STATUS UPDATE

- ▶ Set online TIS status to *Passed* or *Failed*

## NON-COMPLIANCE / COMMENTS

## APPROVAL

Inspector Names	Date, Time	Signatures when passed
1. _____ / _____	_____	_____