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:	604.8 V
BODY PROTECTION R:	15 kΩ

Used Symbols:

- ● Information
- ▶ Action
- △ Check in responsibility of the team
- ◯ Check
- ⊙ Check optional, if Mechanical Inspection at FSA, FSCH, FSN, FSPT is passed

NOTES:

- This form must stay with the push bar 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.

Present the vehicle for inspection in the following order:

	Pre-Inspection	
	Accumulator Inspection*	Mon 04:00-05:45
1.	Electrical Inspection* / Driverless Inspection*	Mon 06:00-07:40
	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.

PART I: COMMENTS FROM DOCUMENT REVIEW

ACCUMULATOR

- Accu Ok
-

ELECTRICAL

- ESF to be checked

DRIVERLESS

- Driverless Ok

MECHANICAL

- Mech Ok
- SES to be checked

PART II: PRE-INSPECTION

☐ TIS STATUS UPDATE

► Set online TIS status to *Present*

► Write down inspector names legibly, sign only when passed

☐ TIRES

1 ◯ **DRY TIRES** - Make: _____

2 ◯ **DRY TIRES** - Size: _____

3 ◯ **DRY TIRES** - Compound: _____

4 ◯ **RAIN TIRES** - Make: _____

5 ◯ **RAIN TIRES** - Size: _____

6 ◯ **RAIN TIRES** - Compound: _____

7 ◯ **RAIN TIRES** - 2,4 mm min. tread depth molded by tire manufacturer

☐ DRIVER GEAR & SAFETY

8 ◯ **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 inspection.).

9 ◯ **UNDERWEAR** - Nomex or equivalent, fire resistant underwear (no cotton, no polyester, no bare skin). No holes.

10 ◯ **SOCKS** - Nomex or equivalent, fire resistant socks (no cotton, no polyester, no bare skin). No holes.

11 ◯ **GLOVES** - Fire resistant material. Leather allowed only over fire resistant material. FIA hologram present. No holes.

12 ◯ **ARM RESTRAINTS** - SFI Standard 3.3 or equivalent.

13 ◯ **HELMETS** - Snell K2015, K2020, M2015, M2020, SA2020, EA2016 or newer. 31.1/2015, 31.1/2020, 41.1/2015, 41.1/2020 or newer. FIA 8860-2010, FIA 8860-2018, FIA 8859-2015 or newer. Closed Face, no Open Face, must have integrated shield (no dirtbike helmets). No camera mounts.

14 ◯ **FHR/HANS** - If used, must be certified to one of these standards: FIA 8858-2010, FIA 8860-2004, SFI 38.1.

15 ◯ **DRIVER SUITS** - Single piece SFI 3.2A/5 (or higher), SFI 3.4/5 (or higher), FIA 8856-2000/2018 (or higher), and LABELED AS SUCH. FIA hologram present. No holes.

16 ◯ **HAIR COVER** - Fire resistant (Nomex or equiv.) balaclava of full helmet skirt REQUIRED FOR ALL DRIVERS. No holes.

17 ◯ **SHOES** - SFI 3.3 or FIA 8856-2000/2018

18 ◯ **SEWING OR STITCHING** - Teams must show compliance to T13.3 if driver's clothing is embroidered. Fire resistant material must be used, examples: Nomex, Aramid, Belcotex and Indura.

☐ 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

19 ◯ **ARM RESTRAINTS**- Must be installed so the driver can release them and exit unassisted regardless of vehicle's position.

20 ◯ **HEAD RESTRAINT**- Near vertical. Max. 25 mm from helmet. Helmet contact point 50 mm min. from any edge.

21 ◯ **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.

22 ◯ **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.

23 ◯ **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's Name	Wristband ID	Signature Inspector - when passed	Acc	Skid Pad	AutoX	Endurance
1.				☐☐	☐☐	☐☐	☐
2.				☐☐	☐☐	☐☐	☐
3.				☐☐	☐☐	☐☐	☐
4.				☐☐	☐☐	☐☐	☐

Checked by officials only after a dynamic run!

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*
- ► Write down inspector names legibly, sign only when passed

☐ COMMENTS

- ► Check comments from first page

☐ REQUIRED RESSOURCES

24 ◯ 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

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

☐ SAFETY EQUIPMENT

30 ◯ Face shield.
31 ◯ Safety glasses (minimum three).
32 ◯ HV insulating gloves (minimum two pairs).
33 ◯ 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.

34 ◯ Sufficient spacing regarding system voltage and implementation.
35 ◯ Sufficient insulation and temperature rating of coating if used, datasheet available.
36 ◯ Coating process according to datasheet

☐ CHARGER ASSEMBLY

37 ◯ Completely closed. Check opening in HV/TS enclosures, try to reach HV/TS potentials with insulated test probe (100 mm length, 6 mm diameter).
38 ◯ Interlock integrated.
39 ◯ TSMP integrated
40 ◯ Emergency shutdown button integrated.
41 △ Emergency shutdown button $\geq$24 mm diameter.
42 ◯ TS wiring is orange, marked with gauge, temperature rating >85°C and voltage rating.
43 ◯ Conductive parts of charging equipment and accumulator are connected to protective earth (PE) while charging. Mind new groundign rules, see EV 3.1
44 ◯ Switches, plugs and indicators must be labeled.

☐ DIS-CHARGE CIRCUIT AND BODY PROTECTION RESISTORS

- ► Switch off Charger. Measure resistance between TS+ and TS- measuring points.

45 ◯ Resistance is 30 kΩ [1] + discharge resistor
46 ◯ Body protection resistor power rating is >6.1 W [2]

[1] 2 x Body Protection Resistor (BPR)

[2] sufficient to short circuit TS+ and TS-

☐ INSULATION MEASUREMENT TEST

- ▶ Check low resistance connection between LV ground MP and PE/casing
- ▶ Choose test voltage to 500 V. [3]
- ▶ Connect insulation tester to charger TS+ and LV ground.
- ▶ Connect charger (do not activate charger) to accumulator, keep AIRs opened.
- ▶ Measure resistance: R_{iso+} = kΩ

47 ◯ Resistance is much higher than 315 kΩ [4].

- ▶ Connect insulation tester to TS- and LV ground.
- ▶ Measure resistance: R_{iso-} = kΩ

48 ◯ Resistance is much higher than 315 kΩ[4].

49 ◯ Resistances are nearly equal.

- ▶ Open container housing, remove maintenance plugs.
- ▶ Check if no voltage is present.

☐ ASSEMBLY

50 ◯ All components and parts of the accumulator container need to be properly fixed.

51 ◯ All used fasteners must be secured by the use of positive locking except they are non-conductive and non-structural.

52 ◯ TS potentials are insulated against inner wall of accumulator container if container made from conductive material.

53 ◯ Tabs of pouch cells must not carry mechanical loads.

54 ◯ No cells are damaged or can be damaged by the segment structures.

55 ◯ No soldering in high current path

56 ◯ Every container contains at least one appropriately sized and rated fuse.

- ▶ Check datasheet of fuse, main wire and cells and compare to ESF.

57 ◯ Every container contains at least two appropriately sized and rated isolation relays (current and voltage).

58 ◯ Isolation relays and fuses are separated from cells by barrier according UL94-V0 or equivalent.

59 ◯ Pre-charge relay is of mechanical type with appropriate voltage rating.

- ▶ Check datasheet of pre-charge relay and compare to ESF

60 ◯ Maintenance plugs are located at both poles of each stack (including first and last stack).

61 ◯ Maintenance plugs removable without tools.

62 ◯ Maintenance plugs have positive locking mechanism.

63 ◯ Maintenance plugs must not be able to unintentionally create circuits or short circuits.

64 ◯ Stacks separated by Maintenance plugs $\leq$ 120 VDC.

65 ◯ Stacks separated by Maintenance plugs $\leq$ 6 MJ.

66 ◯ Stacks are insulated and separated by a fire resistant barrier according to UL94-V0 for min. used thickness or equivalent.

67 ◯ 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).

68 ◯ If fully closed, equalizing valve implemented.

69 ◯ Spare accumulators of same size, weight and type.

☐ WIRING

70 ◯ All TS wires have proper overcurrent protection.

71 ◯ No other wires than TS wires are orange.

72 ◯ Securely anchored to withstand at least 200 N, if outside of enclosure.

73 ◯ Located out of the way of possible snagging or damage.

74 ◯ TS and LV wires separated (not valid for Interlock).

75 ◯ Every wire used in the Accumulator container (TS and LV) is rated for $\geq$604.8 V [5].

76 ◯ Possible to clearly assign and prove gauge, temperature and voltage rating of TS wires.

77 ◯ 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

78 ◯ Insulation is not only insulating tape or rubber-like paint.

☐ CELL TEMPERATURE MONITORING DEVICE (CTMD)

- ▶ Install CTMD

79 ◯ CTMD sensor installed at negative cell tab as defined in the ESF or specified by the technical inspector.

80 ◯ Cooling at CTMD sensor positions not above-average.

- ▶ Take a picture and upload it to competition server.

☐ INDICATOR LIGHT OR VOLTMETER

81 ◯ Red indicator light or voltmeter installed

82 ◯ Marked with “Voltage Indicator”

83 ◯ Visible while opening the battery connector.

84 ◯ Hard wired electronics, supplied by TS

- ▶ Connect power supply with 60 VDC[6] to accumulator TS connector. Use proper plugs, no measuring probes.

85 ◯ Indicator light on or voltmeter showing present TS voltage.

86 ◯ Visible in bright sunlight.

☐ ACCUMULATOR MANAGEMENT SYSTEM

87 ◯ A minimum of 30 % of cells are monitored with temperature sensors.

88 ◯ Every temperature sensor placed on negativ terminal of monitored cell or in <10mm distance on busbar.

- ▶ Disconnect AMS current sensor connector

89 ◯ The AMS must open the shutdown circuit within 0.5 s.

- ▶ Disconnect any other AMS internal connector

90 ◯ 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.

91 ◯ Cell voltages can be displayed.

92 ◯ Cell temperatures can be displayed.

93 ◯ Plausible accumulator current can be displayed.

- ▶ Disconnect one SINGLE voltage sense wire, if any wires used.

94 ◯ The AMS must open the shutdown circuit within 0.5 s.

- ▶ Disconnect one SINGLE temperature sense wire, if any wires used.

95 ◯ The AMS must open the shutdown circuit within 1 s.

3 $U_{max} \leq 250\,V_{DC}$ U_{Test} = 250 V_{DC} $U_{max} > 250\,V_{DC}$ U_{Test} = 500 V_{DC}

4 Minimal Resistance = 500 Ω/V · U_{max} + BPR

5 max. TS voltage

6 60 V or half the nominal tractive system voltage, whichever is lower

☐ CHARGER SHUTDOWN CIRCUIT

96 ◯ IMD is integrated into the charging system

▶ Connect charger to battery/batteries, start charging process

97 ◯ Voltage indicator shows that HV is present

▶ Press shutdown button

98 ◯ AIRs open

99 ◯ Voltage indicator shows voltage <60 V

▶ Start charging, unplug TS accumulator connector

100 ◯ AIRs open.

101 ◯ Charger disabled, no voltage at charger connector

☐ INSULATION MONITORING DEVICE

102 ◯ 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 kΩ[7]

▶ Activate charger output, connect R_{Test} between TS+ and LV GND.

103 ◯ Shutdown circuits opens within 30 s.

104 ◯ TS voltage decreases below 60 VDC within 5 s after shutdown circuit opens.

105 ◯ Reactivation of charger output is not possible.

▶ Push the reset button, if any.

106 ◯ Reactivation of charger output is not possible.

▶ Remove R_{Test}. Wait 40 s until IMD resets status output.

107 ◯ Reactivation of charger output is not possible.

▶ Activate TS, connect R_{Test} between TS- and LV GND.

108 ◯ Shutdown circuits opens within 30 s.

☐ ACCUMULATOR CONTAINER

▶ Team must show approved SES for accumulator container.

▶ Team must show SES test samples for accumulator container if alternative materials are used.

109 ◯ Accumulator container manufactured according to SES.

110 ◯ 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.

111 ◯ Cells securely fastened towards all 3 directions.

112 ◯ All parts carrying cells and loads: UL94-V0 certified materials.

113 ◯ External openings not pointing towards driver or hand cart operator.

114 ◯ Vehicle number, university name and ESO phone number(s) written on a high contrast background.

115 △ Roman Sans-Serif characters of at least 20 mm high are used.

116 ◯ Warning stickers with side length of ≥100 mm and text "Always Energized" and "High Voltage" (if TS >60 V) installed. (triangle with black lightning bolt on yellow background)

117 ◯ Check if all parts and the cover/lid of the housing are rigidly fastened.

☐ HAND CART

118 ◯ Hand cart present with four wheels. Max. dimensions 1200 mm x 800 mm.

119 ◯ Hand cart has always on type brake system.

120 ◯ The accumulator must be mechanically fixed to the handcart while on the handcart.

121 ◯ The accumulator must be protected from vibrations and shocks.

122 ◯ Firewall (same width as hand cart, from lowest point to 30 cm above TSAC/handle) must protect operator.

123 ◯ Label according to EV5.3.8 on hand cart firewall below handle.

☐ SEALING OF COMPONENTS

▶ After all tests have been passed successfully seal the inspected TS housings:

124 ◯ Accumulator container(s) including spares

125 ◯ Charger

126 ◯ Additional Part:

127 ◯ Additional Part:

☐ TIS STATUS UPDATE

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

NON-COMPLIANCE / COMMENTS

APPROVAL

[7] R_{Test} = (max. TS voltage · 250 Ohm/V) - BPR

FORMULA STUDENT INSPECTION SHEET

DRIVERLESS – copy for Formula Student Germany

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

PART V: ELECTRICAL 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 vehicle must be approved by a technical inspector.

☐ TIS STATUS UPDATE (E-INSPECTION)

- ▶ Set online TIS status (E-Inspection) to *Present*
- ▶ Write down inspector names legibly, sign only when passed

☐ COMMENTS

- ▶ Check comments (Electrical) from first page

☐ REQUIRED RESSOURCES

128 ◯ An ESO must attend
129 ◯ 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
- Laptop and cables to display data of the TS accumulator 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
- The connector to safely close the SDC while the HVD is removed
- The connector to safely supply the TS using shrouded receptacles when the TS accumulator is unconnected
- Photographs of all inaccessible TS connections
- “TSAL green” sign

☐ LV BATTERY

130 ⊙ Voltage $\leq$60 VDC
131 ⊙ Rigid and sturdy casing
132 ⊙ Only for wet-cell batteries: IPX7 rated and acid resistant casing if inside cockpit
133 ⊙ Behind Firewall
134 ⊙ Short circuit protection (e.g. fused)
135 ⊙ Grounded to the chassis
136 ⊙ Proper insulation of internal electrical connections
137 ⊙ Proper mounting of cells
138 ⊙ Complete battery pack inside rollover protection envelope
139 ⊙ Following checks only for Li-Ion batteries other than $LiFePO_4$:
140 ⊙ UL94-V0 for min. used thickness or equivalent casing
141 ⊙ Overcurrent protection that trips below max. discharge current
142 ⊙ Overtemperature protection of at least 30 % of the cells (max. 60 °C or datasheet, whichever is lower)
143 ⊙ Voltage protection of all cells
144 ⊙ Signal failures electrically disconnect the LV battery (SCS)
- ▶ Ask the team to connect their laptop to the AMS

145 ◯ Cell voltages can be displayed
146 ◯ Cell temperatures can be displayed

☐ SELF DEVELOPED PCBS

- ▶ Ask for fully assembled spare PCB of self-developed PCBs

147 ⊙ Sufficient spacing regarding system voltage and implementation
148 ⊙ Sufficient insulation and temperature rating of coating if used, datasheet available
149 ⊙ Coating process according to datasheet
150 ⊙ BSPD PCB(s) is standalone with only minimum interface
151 ⊙ BSPD PCB(s) are directly supplied from the LVMS
152 ⊙ Ends of a BSPD current transducer’s auxiliary winding must be insulated.

☐ MASTER SWITCHES

153 ◯ TSMS, ASMS & LVMS installed easily accessible on the right side of the vehicle and located next to each other
154 △ All master switches are located above 80% of shoulder height of percy
155 ⊙ Rigidly mounted and no need to be removed during maintenance
156 ⊙ Rotary type with removable handle
157 △ Handle length $\geq$50 mm
158 ⊙ "ON" position in horizontal
159 ⊙ "ON" and "OFF" positions marked
160 ⊙ TSMS and ASMS with locking mechanism for “OFF” position
161 ⊙ LVMS marked with “LV” and a symbol showing a red spark in a white-edged blue triangle
162 ⊙ LVMS mounted on a red circular area on high contrast background
163 △ Circular area diameter $\geq$ 50 mm
164 ⊙ TSMS marked with “TS” and triangle with black lightning bolt on yellow background
165 ⊙ TSMS mounted on an orange circular area on high contrast background
166 △ Circular area diameter $\geq$ 50 mm
167 ⊙ ASMS marked with “AS”
168 ⊙ ASMS mounted on a blue circular area on high contrast background
169 △ Circular area diameter $\geq$ 50 mm

☐ MEASURING POINTS

170 ◯ Two TS measuring points on exclusive orange background
171 ◯ A black LV ground measuring point installed
172 ⊙ Next to the master switches
173 ⊙ 4 mm shrouded banana jacks
174 ⊙ Non conductive cover
175 ⊙ Cover removable without tools
176 ⊙ Correctly marked (“TS+”, “TS-”, “GND”)

☐ TS SHUTDOWN DEVICES

177 ◯ Two shutdown buttons installed next to the main hoop, right and left on the vehicle at approx. height of the driver's head. Push-Pull or Push-Rotate-Pull functionality. Must be red
178 ⊙ Marked with red sparked sticker
179 △ Diameter >39 mm
180 ◯ One cockpit shutdown button installed. Push-Pull or Push-Rotate-Pull functionality. Must be red
181 ⊙ Marked with red sparked sticker
182 ⊙ Easy actuation by the driver
183 △ Diameter ≥24 mm
184 ◯ Inertia switch upright and rigidly mounted to the chassis and can be demounted for functionality test
185 ◯ Remote Emergency System installed
186 ◯ Rigidly mounted to the chassis
► Check interlocks on . . .
187 ⊙ TS accumulator container(s)
188 ⊙ Inverters
189 ⊙ HVD
190 ⊙ Power distribution boxes
191 ⊙ Data Logger box
● Outboard wheel motors . . .
192 ◯ . . . have a dedicated interlock wire routed along the TS wiring, must act before the TS wiring or its clamping fails
193 ◯ . . . have a dedicated interlock wire routed along a suspension member, must act if the suspension fails
194 ◯ . . . interlock(s) can opened for demonstration

☐ COCKPIT INDICATORS

● AMS indicator light . . .
195 ◯ . . . is inside the cockpit and marked with "AMS"
196 ⊙ . . . is illuminated red and visible in bright sunlight, even from outside
197 ⊙ . . . is visible for the driver
● IMD indicator light . . .
198 ◯ . . . is inside the cockpit and marked with "IMD"
199 ⊙ . . . is red and visible in bright sunlight, even from outside
200 ⊙ . . . is visible for the driver
● TS off indicator light . . .
201 ◯ . . . is inside the cockpit and marked with "TS off"
202 ⊙ . . . is green and visible in bright sunlight
203 ⊙ . . . is visible for the driver

☐ TS VOLTAGE

► Measure voltage at TS measuring points
204 ◯ Equal or less than 60 VDC

☐ TS WIRING

205 ⊙ All TS wiring and components have to be in the envelope and behind the impact structures
206 ⊙ TS cannot be activated if TS connectors outside of enclosures are connected other than the design intent configuration
207 ⊙ TS wires of outboard wheel motors must not be able to reach the cockpit opening in case of a wire break. The wiring outside of the impact structure is the shortest possible distance.
208 ⊙ All TS wires and connectors have proper overcurrent protection
209 ⊙ TS wiring channels are orange
210 ⊙ No other wires than TS wires are orange
211 ⊙ TS wiring outside electrical enclosures in separate non-conductive conduit or orange shielded cable
212 ⊙ Securely anchored to withstand at least 200 N, if outside of enclosure
213 ⊙ Located out of the way of possible snagging or damage
214 ⊙ Shielded against rotating/moving parts
215 ⊙ No wire lower than the chassis
216 ⊙ TS and LV wires separated (n/a for interlock)
217 ⊙ Possible to clearly assign and prove gauge, temperature, and voltage rating of TS wires
218 ⊙ Suitable temperature rating for used position
219 ⊙ Positive locking mechanism on every screwed connection. (Photographs for all inaccessible TS connections)
220 ⊙ TSMPs: positive locking mechanism on every connection. (Photographs for all inaccessible TS connections)
221 ◯ Insulation is not insulating tape or rubber-like paint

☐ DATA LOGGER

222 ◯ Data logger is fully enclosed in a housing
223 ◯ Data logger is rigidly mounted
224 ◯ Only the two preapplied 3M™ Dual Lock™ strips on the bottom side of the data logger are used
225 ◯ All energy from accumulator flows through the data logger

☐ TRACTIVE SYSTEM PROTECTIONS

► Check openings in TS enclosures, try to reach TS potentials with insulated test probe (100 mm length, 6 mm diameter)
226 ◯ Not possible to reach any TS potentials
227 ◯ TS components and containers protected from moisture

☐ HV WARNING STICKERS

► Check for warning stickers on TS containing enclosures. (triangle with a black lightning bolt on yellow background)
228 ⊙ Inverter(s)
229 ⊙ Motor(s)
230 ⊙ Power Distribution box(es)
231 ⊙ Energy meter box
232 ⊙ Other TS containing enclosures

☐ HIGH VOLTAGE DISCONNECT

233 ◯ Clearly marked with "HVD"

234 △ Distance to ground greater than 350 mm

235 ⊙ Inside roll-over protected envelope

236 ⊙ No remote actuation (e.g. through wires)

237 ⊙ Integrated interlock

► Stand next to the vehicle, remove HVD

238 ⊙ Removed within 10 s without tools

239 ◯ TS protection still given (insulated test probe). If a dummy connector is used, it must be stored at the push bar.

☐ TRACTIVE SYSTEM ACTIVE LIGHT

240 ◯ Max. 75 mm below the highest point of the main hoop and within the roll-over protected envelope (including mounting)

241 △ Full illuminated surface visible by a person standing 3 m away from TSAL (1.6 m eye height)

242 △ $\leq 10°$ blocked by main hoop

☐ 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) ...

243 ⊙ ... behind the driver's back

244 ⊙ ... at the sides of the driver

245 ⊙ ... at the front of the vehicle

246 ⊙ First layer, facing TS must be made of Aluminum with a thickness of at least 0.5 mm

247 ⊙ Second layer, facing driver must be made of electrically insulated material (no CFRP)

248 ⊙ Material meets UL94-V0 for min. used thickness or equivalent

249 ⊙ TSAC cooling duct openings do not point towards the driver, although if behind a firewall

☐ ACCELERATOR PEDAL POSITION SENSOR (APPS)

250 ◯ Returns to the original position if not actuated

251 ⊙ At least two sensors with different, non-intersecting transfer functions, with either different gradients and/or offsets to the other(s) are installed. (For digital sensors, a checksum is necessary)

252 ⊙ Sensors are protected from being mechanically overstressed (positive stop of the pedal)

253 ⊙ Minimum two springs installed to return pedal

254 ⊙ Each spring still returns pedal with the second one disconnected (springs in the torque encoders not counted)

☐ AUTONOMOUS SYSTEM STATUS INDICATORS

255 ◯ 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.

256 ◯ 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.

257 ◯ Round, triangle, or rectangular on dark background

258 △ $15\,cm^2$ minimum illuminated area *OR* LED strips with a total length greater than 150 mm with elements <20 mm apart

☐ BRAKE LIGHT

259 ◯ Only one brake light in red color

260 ⊙ Located on vehicle centerline, height between wheel centerline and drivers shoulder

261 ⊙ Round, triangle, or rectangular on black background

262 △ $15\,cm^2$ minimum illuminated area *OR* LED strips with a total length greater than 150 mm with elements <20 mm apart

☐ ACCUMULATOR MANAGEMENT SYSTEM

► Disconnect TS accumulator

263 ◯ AMS indicator light is illuminated red

► Ask the team to connect their laptop to the AMS

264 ◯ AMS data can be displayed

☐ GROUNDING CHECKS

- EV 3.1 has been fully revised. Each TS enclosure must either contain a $\geq$0.5 mm properly grounded conductive layer or all materials must be electrically isolating for each own. Conductive seat, driver harness, and firewall mountings, as well as TS firewalls and conductive parts protruding through TS enclosures, must be properly grounded. A conductive part having $\leq$300 mΩ measured at 1 A and being able to continuously carry $\geq$10 % of the TS main fuse to LVS ground is properly grounded. Other conductive parts within 100 mm of any TS component must be $\leq$100 Ω to LVS ground.
- It is possible to join two TS enclosures one following EV 3.1.1 point 1 and the other one following EV 3.1.1 point 2 if each individual TS enclosure is fully closed.

▶ Check for each TS enclosure . . .

265 ◯ . . . all materials used to build a TS enclosure separately have a resistance $\geq$2 MΩ @ 500 V $\Rightarrow$ fully isolated TS enclose, no grounded layer needed

266 ◯ . . . expect e.g. screws, (shielded) connectors, backing plates isolating materials used $\Rightarrow$ fully isolated TS enclose, no grounded layer needed but protruding elements must be properly grounded

267 ◯ . . . at least one material has $<$2 MΩ $\Rightarrow$ $\geq$0.5 mm thick solid grounded layer made of aluminium or better required and properly grounded

268 ◯ . . . a $\geq$0.9 mm thick steal layer might be used for TSAC as the grounded layer

▶ Measure resistance of conductive parts to LVS ground next to TSMPs (max. 300 mΩ @ 1 A) . . .

269 ◯ . . . main hoop

270 ◯ . . . seat mounting points

271 ◯ . . . driver harness mounting points

272 ◯ . . . firewall mounting points, also if not protruding through the firewall

273 ◯ . . . TS firewall

274 ◯ . . . TS accumulator container

275 ◯ . . . TS enclosures if applicable

276 ◯ . . . TS enclosure protruding parts if applicable

277 ◯ Each grounding is able to carry $\geq$10 % of TS main fuse

▶ Measure resistance of conductive parts to LVS ground (max. 100 Ω @ 0 A) . . .

278 ◯ . . . carbon fiber part within 10 cm around TS part

279 ◯ . . . suspension front left or right if applicable

280 ◯ . . . suspension rear left or right if applicable

☐ DIS-CHARGE CIRCUIT AND BODY PROTECTION RESISTORS

▶ Switch off LV. Measure resistance between TS+ and TS- measuring points

281 ◯ Resistance is 30 kΩ [8] + discharge resistor

282 ⊙ Body protection resistor power rating is >6.1 W [9]

283 ⊙ Dis-charge power rating is sufficient for continuous dis-charge

☐ INSULATION MEASUREMENT TEST

▶ Choose test voltage to 500 V. [10]

▶ Connect insulation tester to TS+ and LVMP

▶ Measure resistance: R_{iso+} = kΩ

284 ◯ Resistance is much higher than 315 kΩ[11]

▶ Connect insulation tester to TS- and LVMP

▶ Measure resistance: R_{iso-} = kΩ

285 ◯ Resistance is much higher than 315 kΩ[11]

286 ◯ Resistances are nearly equal

[8] 2 x Body Protection Resistor (BPR)

[9] sufficient to short circuit TS+ and TS-

[10] $U_{max} \leq 250\,V_{DC}$ U_{Test} = 250 V_{DC} ; $U_{max} > 250\,V_{DC}$ U_{Test} = 500 V_{DC}

[11] Minimal Resistance = 500 Ω/V · U_{max} + BPR

!! 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

287 ◯ Voltage at TS measurement points less or equal 60 VDC

- ▶ Switch on LVMS with TSMS deactivated

288 ◯ IMD and AMS and TS Cockpit indicator light illuminate for 1 s to 3 s for visible check

289 ◯ 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

290 ◯ TS still deactivated

- ▶ Press external activation button next to the TSMS

291 ◯ TS still deactivated

- ▶ Activate TS, measure TS voltage during TS power-up. Use the team's multimeter and test leads. Set multimeter into manual range

292 ◯ System is precharged before second AIR closes

- ▶ Switch off TSMS

293 ◯ TS voltage decreases below 60 VDC within 5 s

- ▶ Try to power-up TS with switched off TSMS

294 ◯ TS still deactivated

- ▶ Switch on TSMS

295 ◯ TS still deactivated

☐ TRACTIVE SYSTEM SHUTDOWN

- ▶ Connect multimeter between TS+ and TS-
- ▶ For each of the following switches, deactivation leads to TS shutdown, the voltage decreases below 60 VDC within 5 s

296 ◯ LVMS

297 ◯ Shutdown button left

298 ◯ Shutdown button right

299 ◯ Cockpit shutdown button

300 ◯ Remote Emergency System (Switch on ASMS)

301 ◯ Inertia switch

302 ◯ Break-over-travel-switch

- ▶ Show schematic of TS with all interlocks (ESF)

303 ◯ Interlocks

☐ TRACTIVE SYSTEM ACTIVE LIGHT

- ▶ Activate LVS

304 ◯ TSAL and Cockpit Indicator (CI) is green only

- ▶ Activate TS

305 ◯ TSAL flashes red with freq 2 Hz - 5 Hz, and CI is off

306 ◯ TSAL is clearly visible (horizontal position, entire illuminated surface)

- ▶ Deactivate TS, disconnect TSAC state detection circuitry connector if applicable[12], activate LVS and TS

307 ◯ TSAL flashes red and CI is off

- ▶ Deactivate TS, reconnect TSAC state detection, connect power supply >60 VDC[13] to TS[14], activate LVS

308 ◯ 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

309 ◯ TSAL and CI is off

☐ INSULATION MONITORING DEVICE

310 ◯ One IMD ground line is connected to the accumulator container[15] and one ground line is connected to the main hoop by a separate wired connection

- ▶ R_{Test} = 135 kΩ[16]
- ▶ Activate TS, connect R_{Test} between TS+ and LV GND

311 ◯ Shutdown circuits opens within 30 s

312 ◯ IMD indicator light illuminates

313 ◯ 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)

314 ◯ Reactivation of TS is not possible

- ▶ Push the reset button which is not accessible to the driver, if any and/or restart LVMS

315 ◯ Reactivation of TS is not possible

- ▶ Remove R_{Test}. Wait for 40 s until IMD resets status output

316 ◯ Reactivation of TS is not possible

- ▶ Push all reset buttons in the cockpit, if any

317 ◯ Reactivation of TS is not possible

- ▶ Push the IMD reset button which is not accessible to the driver, if any

318 ◯ 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

319 ◯ Shutdown circuits opens within 30 s

320 ◯ IMD indicator light illuminates

[12] Skip test if disconnecting the connector also opens the interlock and/or stops LVS supply
[13] 25 V_{AC} equal 42.5 V_{DC} when the signal is sinusoidal
[14] Do not use measuring points. The team needs to provide a method of connection that uses the same receptacles as used for TSMP
[15] or the IMD's enclosure
[16] R_{Test} = (max. TS voltage · 250 Ohm/V) - BPR

☐ READY TO DRIVE ACTIVATION SEQUENCE

- ▶ Activate TS, press torque pedal

321 ◯ No turning of motors

- ▶ Let the team set the vehicle to ready-to-drive mode

322 ◯ Pressing brake pedal WHILE activating is necessary

- ▶ Repeat the activation sequence, but push the brake pedal only once before finally pushing the activation button

323 ◯ No ready-to-drive mode possible

- ▶ Disconnect the brake sensor

324 ◯ No ready-to-drive mode possible

325 ◯ Ready to drive sound duration is 1 s to 3 s continuously

326 △ Ready to drive sound is min 80 dBA (2 m around the vehicle)

327 ◯ Ready to drive sound is easily recognizable and no animal sound or song part

☐ APPS AND BSPD

- ▶ Set vehicle to ready to drive state
- ▶ Disconnect $\geq$ 50 % of APPS
- ▶ Move the accelerator pedal over the entire pedal travel

328 ◯ Motors do not turn

- ▶ Disconnect all APPS
- ▶ Move the accelerator pedal over the entire pedal travel

329 ◯ Motors do not turn

- ▶ Team simulates 5 kW power (complete BSPD circuitry must be used), press brake representing hard braking (>0.5 s)

330 ◯ TS shuts down

- ▶ Reactivate TS. Disconnect the current sensor, press brake representing hard braking (>0.5 s)

331 ◯ TS shuts down

332 ◯ 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:

333 ◯ Motor Controller housing

334 ◯ Energy Meter housing

335 ◯ IMD housing

336 ◯ TSAL circuitry housing

337 ◯ BSPD casing /BSPD calibration

338 ◯ Additional Part:

339 ◯ Additional Part:

☐ DATA LOGGER

340 △ Check data logger functionality and connectivity

☐ TIS STATUS UPDATE (E-INSPECTION)

- ▶ Set online TIS status (E-Inspection) to *Passed* or *Failed*

☐ TIS STATUS UPDATE (D-INSPECTION)

► Set online TIS status (D-Inspection) to *Present*

☐ COMMENTS

► Check comments (Driverless) from first page

☐ REMOTE EMERGENCY SYSTEM BYPASS

► Check, if RES bypass is implemented correctly (as per ASF-Form "Actuator Power Supply")

341 ◯ RES bypass is implemented as described in the ASF

342 ◯ Correct safety relay is used

☐ AUTONOMOUS SYSTEM BRAKE

► Compare implementation in vehicle to ASF (Forms: "EBS Concept Overview" OR "EBS Machnical System")

343 ◯ Autonomous System Brake is identical to the system described in the ASF

344 ◯ No more than two release points are used

345 ◯ All release points are in proximity to each other and are either 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

346 ◯ The release points are operable by maximum two simple push/pull and/or turning actions, the order and direction of these actions are shown next to the deactivation points

347 ◯ The release points are marked with "brake release"

☐ AUTONOMOUS SYSTEM TEST

► Switch on the LVMS and select the inspection mission

► Disable Race E-Key frequency of RES (Set race mode switch next to master switches to position opposite to "R")

348 ◯ The ASSIs remains off

► Switch on the ASMS and the TSMS

349 ◯ Activating the TS using the cockpit activation button is not possible

► Activate the TS via the external activation button

350 ◯ The ASSIs light up in yellow continuously after a self check ("AS Ready")

► Press RES "Go" button within 5 s after "AS Ready"

351 ◯ "AS Driving" (ASSIs flashing yellow) has not been entered

352 ◯ Vehicle is still not in R2D

353 △ Autonomous Mission Indicator (AMI) is easily readable and shows the correct mission

354 ◯ All 3 ASSIs are clearly visible in very bright sunlight. At least one ASSI is visible from any angle of the vehicle

355 ◯ Brakes are closed at least on one axle

► Press the RES "Go" button.
!! CAUTION WHEELS AND STEERING SYSTEM ARE MOVING !!

356 ◯ The ASSIs start flashing yellow ("AS Driving")

357 ◯ Drivetrain is slowly spinning and steering system is moving

► Wait for the transition from "AS Driving" to “AS Finished”

358 ◯ The ASSIs light up in blue continuously within 25 s to 30 s and brakes are engaged ("AS Finishes"). ASSIs must not start flashing

359 ◯ ASSIs are clearly visible in very bright sunlight

360 ◯ TS is deactivated

► Turn off the ASMS and release the Brakes via the deactivation points

361 ◯ Brakes are disengaged, manual steering is possible, ASSI is off

► Re-enter "AS Ready" state

► Press one shutdown button

362 ◯ ASSIs start flashing blue ("AS Emergency")

363 ◯ Brakes are closed

364 ◯ Intermittent sound for 8 s to 10 s (1 Hz to 5 Hz, 50 % duty cycle)

365 △ Sound level is min 80 dBA (2 m around the vehicle)

366 ◯ TS is deactivated

► Turn off ASMS and release brakes (manual actions may be required)

► Re-enter "AS Driving" state with inspection mission selected, before each of the following tests

► 1. Press RES 2. Switch off the ASMS

367 ◯ TS is deactivated

368 ◯ Transition to "AS Emergency", ASSI is blue flashing, brakes are closed and intermittent sound for 8 to 10 s

► 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. . .)

369 ◯ System has detected a failure

370 ◯ When ASSI is "AS Ready" or "AS Driving" state, the system enters "AS Emergency"

► Enable Race E-Key frequency (Set race mode switch to position "R")

► Try to enter "AS Ready" state

371 ◯ Activating the TS is not possible, "AS Ready" state is not entered

☐ TIS STATUS UPDATE (D-INSPECTION)

► If **ALL driverless checks from mechanical inspection** (page 18) are passed as well: Set online TIS status (D-Inspection) to *Passed* or *Failed*

NON-COMPLIANCE / COMMENTS

APPROVAL

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

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 (M-INSPECTION)

► Set online TIS status (M-Inspection) to *Present*

► Write down inspector names legibly, sign only when passed

☐ COMMENTS

► Check comments from first page

☐ VEHICLE WITH TALLEST DRIVER READY TO RACE

372 ○ **PUSH BAR (red color)** - 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. The inspection sheet must always stay with the push bar.

373 △ **CAMERAS** - Must be secured by two points, see T13.5. No cameras mounted to helmet.

374 ○ **AUTONOMOUS SYSTEM SENSORS** - Sensors may not come into contact with the driver's helmet when normally seated.

375 ○ **VISIBILITY** - Minimum of 100 deg. field either side. Head rotation allowed or mirrors. If mirrors, must be firmly installed and adjusted.

376 △ **VEHICLE CONTROLS** - All controls, including shifter, must be inside cockpit. No arms or elbows outside the SIS plane.

377 ○ **DRIVER FLUID PROTECTION** - A firewall (or heat resistant cover plate for cooling systems using plain water (except wheel motors and their cooling hoses)) must be rigidly mounted and extend sufficiently far upwards and/or rearwards such that any point, less than 100 mm 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.

378 ○ **ROLL BAR PADDING** - Roll bar or bracing that could be hit by driver's helmet must be covered with 12 mm thick, SFI spec 45.1 or FIA 8857-2001 padding.

379 △ **OTHER SIDE TUBES** - Design prevents driver's neck hitting bracing or other side tubes.

380 ○ **HEAD RESTRAINT**- Near vertical. Must take 890 N load. 40 mm thick, SFI 45.2 standard. Max. 25 mm from helmet. Helmet contact point 50 mm min. from any edge. May be changed for different drivers. Minimum 150x150 mm.

381 ○ **DRIVER RESTRAINT HARNESS** - SFI 16.1, SFI 16.5, SFI 16.6, FIA 8853/2016. 6- or 7-point system – Two-piece lap belt (min. width 50 mm), two shoulder straps (min. width 75 mm) and two leg or anti-submarine straps (min. width 50 mm). (7-point system must have three anti-submarine straps). Must be securely attached to prim. structure (25.4 x 2.4 mm or equal.).

382 ○ **LAP BELT MOUNTING** - Pivoting mounting with eye bolts or shoulder bolts attached securely to primary structure. Min. tab thickness 1.6 mm. Attachment brackets to the monocoque must be steel, see T5.3.2.

383 ○ **SHOULDER HARNESS MOUNTING** - Mounting points 180 - 230 mm apart (measured center to center). Attach to primary structure - 25.4 x 2.4 mm or 25.0 x 2.5 mm 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.

384 △ **SUSPENSION** - Fully operational with dampers front and rear; 50 mm minimum wheel travel (minimum jounce of 25 mm) with driver in vehicle.

☐ VEHICLE WITHOUT DRIVER

385 △ **TECH STICKER SPACE** - 45 mm x 175 mm on centerline of front of vehicle in front of the cockpit opening

386 △ **SCHOOL NAME & OTHER DECALS** - School name, or recognized initials - min. 50 mm tall (all letters). on both sides in roman letters. Must be clearly visible.

387 △ **VEHICLE NUMBERS** - On front & both sides of vehicle, minimum 150 mm tall, 20 mm stroke & spacing, 25 mm 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.

388 △ **BODYWORK EDGES** - edges that could contact a pedestrian must have a minimum radius of 1.0 mm (safety requirement).

389 △ **BODY & STYLING** - Open wheeled, open cockpit, formula style body. Vertical keepout zones 75 mm in front and behind tires (no aero exceptions), tires unobstructed from sides.

390 ○ **BODYWORK** - Min. 38 mm radius on nose. No large openings in bodywork into driver compartment in front of or alongside driver, (except cockpit opening). In any side view in front of the cockpit opening no external concave radii (exception T8.2).

391 ○ **AERODYNAMIC DEVICES** - Securely mounted. The deflection may not exceed 10 mm when a force of 200 N is applied over a surface of 225 cm^2 and not more than 25 mm when a point force of 50 N is applied.

392 △ **AERODYNAMICS** - ALL aerodynamic devices maximum 250 mm rearward of rear tires, maximum 700 mm forward of front tires. Devices lower than 500 mm 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 500 mm behind the front axle must not be wider than the inside of the rear tires.

393 △ **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 500 mm from the ground. Rear device max 1.2 m above ground (incl. end plates); Front device max 250 mm above ground outside of the inside plane of the front tires inside this plane max 500 mm.

394 ○ **EDGES/RADII** - Edges that could contact a pedestrian must have a minimum radius of: forward facing edges min 3 mm; all other edges min. 1 mm.

395 △ **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 1.65 mm steel tube underneath.

396 ⊙ **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.

397 ○ **COCKPIT INTERNAL CROSS SECTION** - Fig. 11 (right) template passes from the cockpit opening to 100 mm rear of rearmost pedal contact area (in most forward position). Steering wheel and paddings can be removed (without tools).

398 △ **STEERING WHEEL** - Continuous perimeter, near round (no concave sections) with driver operable quick disconnect. 250

mm max from front hoop.

399 ◯ **ROTATING PARTS** - Finger guards are required to cover any parts (e.g. fans) that spin while the vehicle is stationary. No holes >12 mm dia.

☐ REMOVE BODY PANELS

400 ◯ **JACKS** - Up to two devices that lift up all driven wheels min. 100 mm above the ground. In lifted position it is safe to enter and exit the vehicle and the devices must not extend out of the vehicles projected surface area. University name must be written on. Vehicle pickup points must be indicated by orange triangles.

401 ◯ **DRIVER'S LEG PROTECTION** - Covers inside of cockpit over any sharp edges or moving suspension / steering components.

402 ⊙ **DRIVER'S FOOT PROTECTION** - Feet must be rearward of the front bulkhead. The front bulkhead, together with the AIP, must cover the driver's feet in front view. No part of shoes or legs above or outside the primary structure (25x1.2 or equivalent) in side or front views when touching the pedals.

403 ⊙ **PERCY** - Helmet of 95th percentile male (PERCY) including 50 mm clearance must be 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 865 mm from pedals.

404 ◯ **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 driv-etrain failure or minor collisions. No plastic brake lines. No brake-by-wire. No parts below chassis in side view. Brake pedal capable of 2000 N, no failures if official exerts max force (seated normally in vehicle).

405 △ **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.

406 ◯ **WHEELS** - 203.2 mm (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.

407 ◯ **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 250 N 4 mm screwdriver penetrating test.

☐ SES, IAD & REQUIRED TESTS PRESENTED

408 ◯ **SES TUBING & MATERIALS** - Team must show an APPROVED SES. No magnesium tubes in primary structure.

409 ⊙ **SES TEST SPECIMEN** - Team must show all relevant test specimen. Labled (non-removable) with structure acronym and date. Speciment width, skin & core thickness according to SES.

410 ⊙ **INSPECTION HOLES** - 4.5 mm inspection holes required in non-critical areas of front & main hoops. Must be accessible with standard calliper. Inspectors may ask for holes in other tubes and/or structures.

411 ⊙ **SES DIMENSIONS & THICKNESSES** - All chassis dimensions according to SES: tube diameter and wall thickness; laminate skin thickness, core thickness, panel height.

412 ◯ **HOLES & CUTOUTS** - All holes/cutouts in primary structure < 60 mm² or deducted from panel height.

413 ⊙ **LAMINATE ORIENTATION** - Tested structures must be correctly oriented or quasi-isotropic (T3.5.4, especially MHBS).

414 ⊙ **BOLTED JOINTS/ATTACHMENTS** in primary structure - Distance hole centerline to the nearest free edge > 1.5 x hole diameter. Steel backing plates (≥2 mm thick) with perimeter near circular or oval used at attachment points (must be fully supported). According to SES (T3.16.6) if two panels are bolted together.

415 ⊙ **HARNESS ATTACHMENTS** for shoulder harness, lap belt and anti-submarine belt according to SES calculation, simulation and/or physical test. Test/calculation conducted according to realistic belt angle.

416 ⊙ **MAIN HOOP** - 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, not oval after bending.

417 ⊙ **MAIN HOOP BRACING** - Same material as main hoop (both (non) magnetic). One straight brace on each side. Attached within 160 mm from the top. Min. 30 deg. included angle with main hoop. No bends. No rod-ends. Proper design for removable braces (capping etc.) on both ends.

418 ⊙ **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.

419 ⊙ **FRONT HOOP BRACING** - Two straight forward facing braces, attached within 50 mm of top. Extra rearward bracing required if front hoop leans backwards more than 10 deg.

420 ⊙ **FRONT BULKHEAD SUPPORT** - Upper tube connecting within 50 mm of top of bulkhead, and connecting within 100 mm above and 50 mm below upper SIS tube.

421 ⊙ **SIDE IMPACT PROTECTION** - Upper tube between 240 - 320 mm above lowest inside chassis point between FH and MH.

422 ◯ **SUSPENSION PICK-UP POINTS** - Inspected thoroughly for integrity. No crushed core, no skin detacted from core.

423 ⊙ **FRONT IMPACT PROTECTION** - Team must show an APPROVED IAD and test piece (if applicable), which both must reflect status on the car. IMPACT ATTENUATOR forward of bulkhead. IA must be securely fastened directly to AIP capable of taking transverse & vertical loads (no tape, etc.). Non-crushable objects forward of bulkhead must have been evaluated in IAD. No wing supports through the IA.

424 ⊙ **IAD DIMENSIONS** - IA min. 200 mm long x 200 mm wide x 100 mm high. AIP solid sheet metal, min. 1.5 mm steel or 4.0 mm aluminium; alternative design accepted, if SES/IAD approved. Standard IA: Requires diagonal or X-brace if FBH dimensions larger than 400 mm width and/or 350 mm height.

425 △ **IA POSITION** - The minimum volume dimensions cannot not be more than 350 mm above ground (measured with driver seated).

426 ⊙ **AIP ATTACHMENT** - Standard: must be welded (full perimeter, size: min. to centerlines) or min. 8 screws M8 grade 8.8 (critical fasteners T10) (size: min. outside dimensions). Non-standard: Must follow T3.16.6.

☐ VEHICLE LIFTED AND WHEELS REMOVED

427 ◯ **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 adhesive or lock washers. Minimum of 2 exposed threads with lock 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. Snap or re-

taining rings must not bear any load in non-OEM application (e.g. not for brake disc floaters).

428 ⊙ **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. Stationary parts within rollover protection envelope. 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. Bonded joints in accordance with T3.2.8.

429 ○ The steering system has to be fully operational by a driver when ASMS is in “OFF”-Position.

430 △ **FLOOR CLOSEOUT PANEL** - Required from foot area to firewall; solid, non-brittle material; multiple panels are OK if gaps less than 3 mm.

431 ○ **GAS CYLINDERS LOCATION** - Axis not pointed at driver, within the rollover protection envelope (see FIGURE 2), 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.

432 ○ **GAS CYLINDERS** - Proprietary manufacture & labeled, nonflammable gas, regulator on tank, securely mounted, appropriate lines & fittings. Positively retained, i.e. no tie-wraps. Maximum of 10 bar allowed, except cylinders/tanks with directly mounted pressure regulator (-> 10 bar).

433 ○ **SCATTERSHIELDS INCL. MOUNTING** - Required for clutches, chains, belts, etc. No holes. 6 mm diam. grade 8.8 minimum. End parallel to lowest part of the sprocket/pulley in front and rear.

434 △ **SCATTERSHIELD MATERIALS** - For chains, 2 mm min. thick solid STEEL, 3 x chain width. For belts, 3 mm min. thick Al 6061-T6, 3 x belt width. Finger guards: cover all drivetrain parts that spin while vehicle is stationary. No holes >12 mm dia.

435 ○ **LV BATTERY** - Attached securely to frame or chassis.

436 ○ **HIGH PRESS HYDRAULICS** - Pumps and lines must have 1 mm steel or aluminium shields protecting driver and workers.

437 ○ Including all autonomous system high pressure hydraulics like the ASB.

438 △ **COOLANT** - 100% water. NO ADDITIVES WHATSOEVER or oil for electric motors.

439 ○ **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. 3 mm min. dia. vent away from driver down to the bottom level of frame. Cooling systems using plain water, unless sealed, require 100 ml catch tanks.

440 △ **FLUID LEAKS** - Oil, grease, coolant,Brake fluid -> none permitted

441 ⊙ **BELLYPANS** - In total minimum of two venting holes of at least 25 mm 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.

442 ⊙ **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, rear and front 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 T3.15 must be build to protect the accumulator.

443 ⊙ **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 1.6 mm steel or 4 mm aluminium with gussets to withstand bending loads. Monocoque needs 2 mm steel backing plates with perimeter near circular or oval. Equivalent attachment may be according to SES.

444 ⊙ **POSITION OF TRACTIVE SYSTEM PARTS** - All parts belonging to the tractive system must be located within the rollover protection envelope, excluding outboard motors.

445 ⊙ **PROTECTION OF TRACTIVE SYSTEM PARTS** - If tractive system parts are mounted in a position where damage could occur from a rear or side impact (below 350 mm from the ground), they have to be protected by a fully triangulated structure with tubes of a minimum outer diameter of 25.4 mm and a minimum wall thickness of 1.25 mm or equivalent.

446 ⊙ **MOTOR CASING** - Min. 2 mm aluminium 6061-T6. May be split into two equal sections. If motor casing is rotating around the stator or is perforated an additional 1 mm aluminium 6061-T6 scatter shield around the motor should be installed.

☐ TIS STATUS UPDATE (M-INSPECTION)

► Set online TIS status (M-Inspection) to *Passed* or *Failed*

☐ SENSORS FOR AUTONOMOUS SYSTEM

447 ○ **CHECK SENSORS** - Check if all Sensors are fulfilling the legal requirements (mainly radar and laser, e.g. Class 1 Laser Product acc. to **IEC 60825-1**). The teams must provide the according certifications.

448 ○ **SENSOR POSITION** - Sensors must be positioned within the surface envelope or the envelope for aerodynamic devices.

449 ○ **SENSOR MOUNTING** - Sensors must be securely and rigidly mounted to the vehicle’s structure.

► **SENSOR MARKING** - Mark all sensors.

☐ ACTUATORS FOR AUTONOMOUS SYSTEM

450 ○ **DECOUPLING** - Check if the team uses a decoupling mechanism for the brake/steering actuators.

451 ○ **PART REMOVAL** - parts like including bolts, clips, etc. must not be removed for disconnection i.e. they must never loose the physical contact to the disconnection mechanism

452 ○ **MANUAL OPERATION** - the disconnection mechanism must not block manual operation of steering/ braking in any position.

453 ○ **LOCKING** - the disconnection mechanism must be securely locked in both positions.

☐ AUTONOMOUS SYSTEM BRAKE (ASB)

454 ○ **MOUNTING** - All parts are properly mounted. No lateral forces acting on the pistons of pneumatic/hydraulic actuators.

455 ○ **LEAKS** - No leaks in pneumatic/hydraulic circuit

456 ○ **PUSH-IN FITTINGS** - None used

457 ○ **OVERPRESSURE PROTECTION** - Must have overpressure protection in function critical pneumatic circuits, if parts of the circuit exceed 10 bar.

☐ TIS STATUS UPDATE (D-INSPECTION)

► If **ALL** **driverless checks** **from eletrical inspection** (page 14) are passed as well: Set online TIS status (D-Inspection) to *Passed* or *Failed*

NON-COMPLIANCE / COMMENTS

APPROVAL

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

PART VII: TILT TEST

☐ TIS STATUS UPDATE

► Set online TIS status to *Present*

► Write down inspector names legibly, sign only when passed

☐ COMMENTS

► Check comments from first page

☐ TILT TEST

458 ◯ **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.

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

460 △ **GROUND CLEARANCE** - At least 30 mm min. with driver. Active suspension in lowest position.

☐ TIS STATUS UPDATE

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

NON-COMPLIANCE / COMMENTS

APPROVAL

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

PART VIII: RAIN TEST

☐ TIS STATUS UPDATE

- ► Set online TIS status to *Present*
- ► Write down inspector names legibly, sign only when passed

☐ COMMENTS

- ► Check comments from first page

☐ RAIN TEST

- ► Apply seal sticker to all additional sealing material, that can be removed (e.g. tape, as not mentioned in IN1.5.1).
- ► The vehicle is lifted off the ground. Tractive system has to be active (TSAL ON)

461 ○ 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 waitng without water spary.

462 ○ The Insulation Monitoring Device does not react and not shut down the tractive system.

- ► Connect R_{Test} between any TSMP and LVS GND.

463 ○ 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*
- ► Write down inspector names legibly, sign only when passed

☐ COMMENTS

- ► Check comments from first page

☐ BRAKE TEST

464 ○ **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).

465 ○ **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

☐ TIS STATUS UPDATE

- ► Set online TIS status to *Present*
- ► Write down legibly inspector name

☐ 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".

466 △ AMI shows the correct mission.

- ► Switch on ASMS.
- ► Activate TS

467 ○ ASSI is yellow continuous.

468 ○ TSAL is red flashing.

- ► Press RES "Go" button.

469 ○ 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.

470 ○ Vehicle has to stop within 10m and has to stay stable.

471 ○ Speed at brake point has to be around 40 km/h.

472 ○ ASSI is blue flashing, intermittent sound is clearly noticeable for 8 - 10 s.

473 ○ 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.	_____/_____	_____	_____