University:	Amet University
Vehicle number:	422
ESF Passed:	-
ASF Passed:	-
TS Voltage:	600 V

Present the vehicle for inspection in the following order
1. Pre-Inspection
2. Egress Test
3. Done simultaneously
    - 3.1 Accumulator Inspection
    - 3.2 Mechanical Inspection
4. LV Electrical Inspection
5. HV Electrical Inspection
6. Driverless Inspection
7. Vehicle Weighing
8. Tilt Test
9. Rain Test
10. Brake Test
11. EBS Test

INFORMATION

USED SYMBOLS

- ● Information
- ▲ Action
- △ Check is the responsibility of the team
- ○ Check

NOTES

- This sheet must always stay with the push bar. (Can be temporarily split for Accumulator inspection)
- Technical inspection approval voids if the inspection sheet is lost.
- If there is a conflict between this sheet and the rules, the rules prevail.

INSPECTION STATUS

Inspection	Pass	Inspector name	Inspector signature	Note
Pre-Inspection	☐			
Egress Test	☐			
Accumulator Inspection	☐			
Mechanical Inspection	☐			
LV Electrical Inspection	☐			
HV Electrical Inspection	☐			
Driverless Inspection	☐			
Tilt Test	☐			
Rain Test	☐			
Brake Test	☐			
EBS Test	☐			

KEY INSPECTION VALUES

- ● $U_{TSmax} = 600.4\,\text{V}$
- ● IMD $R_{Test} = 135\,\text{k}\Omega$

COMMENTS FROM DOCUMENT REVIEW

All comments from the document review must be checked and resolved during the relevant inspection. The team is responsible for notifying the inspectors about the comments. Inspectors shall place their initials and signatures next to the comments they have checked and resolved.

No comments from the review.

IMPORTANT NOTES

PART I: PRE-INSPECTION

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ TIRES

1 ○ **DRY TIRES** - Make

2 ○ **DRY TIRES** - Size

3 ○ **DRY TIRES** - Compound

4 ○ **WET TIRES** - Make

5 ○ **WET TIRES** - Size

6 ○ **WET TIRES** - Compound

7 ○ **WET TIRES** - 2.4 mm min. tread depth molded by tire manufacturer

○ DRIVER GEAR AND SAFETY

● Fire-resistant clothing must not be older than 10 years, recognizable since no FIA hologram label present.

8 ○ **FACE SHIELDS** - Made of impact resistant material.

9 ○ **UNDERWEAR** - Must be made from acceptable fire-resistant material as listed in T 13.3.13 and must cover the driver's body completely from neck down to ankles and wrists.

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

11 ○ **GLOVES** - Fire resistant material. No holes. Leather is allowed only over fire-resistant material.

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

13 ○ **HELMETS** - Snell SA2020, EA2016, SA2025 or newer, SFI 31.1/2015, 31.1/2020 or newer, FIA 8860-2010, FIA 8860-2018, FIA 8859-2015, 8859-2024 or newer. Closed Face, no Open Face, must have integrated shield (no dirt bike helmets). No camera mounts.

14 ○ **FRONTAL HEAD RESTRAINT** - If FHR/HANS is used, it must be certified to one of the following standards and be labelled as such - FIA 8858-2010, FIA 8860-2004, SFI 38.1.

15 ○ **DRIVER SUITS** - SFI 3.2A/5 (or higher), SFI 3.4/5 (or higher), FIA Standard 8856-2000 or FIA Standard 8856-2018.

16 ○ **HAIR COVER** - Fire resistant (Nomex or equiv.) balaclava of full helmet skirt REQUIRED FOR ALL DRIVERS.

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

NON-COMPLIANCE/COMMENTS

PART II: EGRESS TEST

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ DRIVER POSITION

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

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

20 ○ **MAIN HOOP AND FRONT HOOP HEIGHTS** - Helmet of driver to be 50 mm below the line between the top of the front and main roll hoop AND between the top of the main hoop to rear attachment point of main hoop bracing.

21 ○ **LAP BELT MOUNTING** - Must pass over pelvic area between 45° and 65° to horizontal for upright driver, 60° to 80° for reclined. The lap belts must not be routed over the sides of the seat.

22 ○ **SHOULDER HARNESS MOUNTING** - Angle from shoulder between 10° up and 20° down to horizontal.

○ DRIVER EGRESS TEST

- ● All drivers must be able to exit the vehicle in less than 5 s.
- ● 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.

NON-COMPLIANCE/COMMENTS

PART III: ACCUMULATOR INSPECTION

APPROVAL

Inspector Names	Date and Time	Signatures when passed

INSPECTION RULES

- The time limit for each attempt at this technical inspection is 120 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- The time limit for repair works is 15 min cumulative per one inspection attempt.

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

○ REQUIRED RESOURCES

23 ○ An ESO must attend.
- All accumulator containers to be used during the event.
- Accumulator Container Hand Cart.
- Charger.
- Tools needed for (dis)assembly of the Accumulator Container.
- Digital version or printout of ASES and 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

- All accumulator containers to be used during the event.
- No jewelry, no rings.
- No cell phone.
- No badge / no necklace.
- No other sources of distraction.
- Wear safety glasses.
- Wear safety gloves.

○ BASIC SET OF HV-PROOF TOOLS

24 ○ Insulated cable shears.
25 ○ Insulated screwdriver.
26 ○ Insulated spanners (n/a if no screwed connections in TS).
27 ○ Multimeter with protected probe tips.
28 ○ Two 4 mm banana plug test leads ($\geq$ 600 V CAT III).

○ SAFETY EQUIPMENT

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

○ SELF DEVELOPED PCBS

▲ Ask for fully assembled spares of self-developed PCBs inside the TSAC and the charger, where both TS and LVS parts are present.

33 ○ Sufficient TS to LVS clearance and creepage based on the system voltage and implementation (see EV 4.3.6 and table 5). Clearly marked and separated. Grooves and cut-outs must have a minimum width of 1.5 mm to influence the creepage path.

34 ○ The 1 min AC RMS isolation voltage of any component crossing the isolation barrier (TS to LVS) is $\geq 1800\,V_{DC}$ [1].

35 ○ The working voltage of any component crossing the isolation barrier (TS to LVS), if specified in the datasheet, is higher than the U_{TSmax}. The resistance is $\gg 315\,k\Omega$[2].

36 ○ Capacitors that bridge galvanic isolation must be class-Y capacitors.

37 ○ Sufficient insulation and temperature ($> 85\,°C$) rating of coating if used, datasheet available.

38 ○ Coating process (if applied) done properly and according to the datasheet. Check with UV light if necessary.

○ CHARGER ASSEMBLY

39 ○ Completely closed. Check openings in HV/TS enclosures, try to reach HV/TS potentials with an insulated test probe (100 mm length, 6 mm diameter).

40 ○ Interlock integrated.

41 ○ TSMP integrated, all electric connections secured by positive locking, no soldering (unless fulfilling EV4.5.15).

42 ○ Emergency shutdown button integrated.

43 △ Emergency shutdown button diameter $\geq 24\,mm$.

44 ○ TSAL green light integrated as an easily visible indicator.

45 ○ TS wiring is orange, ask team to prove temperature rating 85 °C and voltage rating.

46 ○ All exposed conductive parts of charging equipment and accumulator are connected to protective earth (PE) while charging. EV 3.1 applies: resistance to the LVS GND measuring point must be $\leq 100\,m\Omega$, measured at 1 A. The resistance between the (plugged-in) mains cable's PE and the charger's LVS GND measuring point is $\leq 100\,m\Omega$.

○ DISCHARGE CIRCUIT AND BODY PROTECTION RESISTORS

▲ Switch off Charger. Measure the resistance between TS+ and TS- measuring points (TSMPs): kΩ.

47 ○ Resistance is $30\,k\Omega$[3]$+R_{discharge}$. If not measurable, ask for an explanation and alternative measurement procedure.

48 ○ Body protection resistor power rating is sufficient.[4]

49 ○ Measure the resistance between TS+ TSMP and the charger's TS+ output connector. (should equal $15\,k\Omega$).

50 ○ Measure the resistance between TS- TSMP and the charger's TS- output connector. (should equal $15\,k\Omega$).

51 ○ Discharge power rating is sufficient for continuous discharge (if present).

○ INSULATION MEASUREMENT TEST

▲ Check low resistance connection between LVS ground MP and PE/casing.

▲ Set the test voltage to $500\,V_{DC}$. [5]

▲ Connect insulation tester to charger TS+ TSMP and LVS GND measuring point.

▲ Connect charger (do not activate charger) to accumulator, keep AIRs opened.

▲ Measure resistance: R_{iso+} = kΩ

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[1] $3 \times U_{TSmax}$ or $750\,V_{DC}$, whichever is higher.
[2] $500\,\Omega/V$, at a test voltage of maximum TS voltage or 250 V, whichever is higher.
[3] 2 x Body Protection Resistor (BPR). It is one of following:

$U_{TSmax} \leq 200\,V_{dc} : BPR = 5\,k\Omega$

$200\,V_{dc} \leq U_{TSmax} \leq 400\,V_{dc} : BPR = 10\,k\Omega$

$400\,V_{dc} \leq U_{TSmax} \leq 600\,V_{dc} : BPR = 15\,k\Omega$

[4] Sufficient to short circuit TS+ and TS-.
[5] IN 4.1.1:
$U_{TSmax} \leq 250\,V_{DC} : U_{Test} = 250\,V_{DC}$
$U_{TSmax} > 250\,V_{DC} : U_{Test} = 500\,V_{DC}$
[6] Minimal Resistance $= 500\,\Omega/V \times U_{TSmax} + R_{BPR}$

52 ○ Resistance is much higher than 315 kΩ[6].
▲ Connect insulation tester to charger TS- TSMP and LVS ground.
▲ Measure resistance: R_{iso-} = kΩ
53 ○ Resistance is much higher than 315 kΩ[6].
54 ○ Resistances are nearly equal.

○ TSAC ASSEMBLY

▲ Open TSAC housing, remove maintenance plugs.
▲ Check if no voltage is present.
● Maintenance plugs...
55 ○ ...allow electrical separation affecting both poles of each stack without tools (including the first and last stack),
56 ○ ...have a positive locking mechanism,
57 ○ ...must not be able to create short circuits or unintentional circuits,
58 ○ ...are not conductive on surfaces that do not provide any electric connection.
59 ○ All components and parts of the accumulator container are properly fixed.
60 ○ TS potentials are insulated against the inner wall of the accumulator container if the container is made from conductive materials.
61 ○ TS to LVS within the enclosure must be separated by barriers made of moisture-resistant insulating materials or maintain a 20 mm spacing through air or over a surface.
62 ○ All used fasteners must be secured by the use of positive locking except they are non-conductive and non-structural.
63 ○ Tabs of pouch cells do not carry mechanical loads. Pouch cells carry mechanical loads only on large surface areas.
64 ○ No soldering in the TS high current path (any path of a circuitry that, during normal operation, carries more than 1 A), unless fulfilling the exception criteria of EV 4.5.15.
65 ○ Every container contains at least one appropriately sized and rated fuse.
▲ Check the datasheet of fuse, main wire and cells and compare them to ESF.
66 ○ Every container contains at least two appropriately sized and rated isolation relays (current and voltage).
67 ○ Isolation relays and fuses are separated from cells by a barrier according to UL94-V0 or equivalent.
▲ Check the datasheet of the pre-charge relay and compare it to ESF.
68 ○ Pre-charge relay is of mechanical type with appropriate voltage rating.
69 ○ Stacks separated by Maintenance plugs $\leq$ 120 V_{DC}.
70 ○ Stacks separated by Maintenance plugs 6 MJ.
71 ○ Stacks are insulated and separated by a fire-resistant barrier according to UL94-V0 for min. used thickness or equivalent.
72 ○ Holes in the container only for the wiring harness, ventilation, cooling or fasteners, mechanical properties are not influenced.
73 ○ External openings for cooling or mounted connected cooling ducts are not pointing towards the driver, or if the accumulator is out of the car, towards the operator of the accumulator hand cart.
74 ○ Check openings in TS enclosures, try to reach TS potentials with an insulated test probe (100 mm length, 6 mm diameter).
75 ○ If fully closed, an equalizing valve is implemented.
76 ○ Spare accumulators of the same size, weight, and type.

○ WIRING

77 ○ All TS wires have proper overcurrent protection.
78 ○ No other wires than TS wires are orange.
79 ○ Securely anchored to withstand at least 200 N, if outside of enclosure.
80 ○ Located out of the way of possible snagging or damage.
81 ○ TS and LVS wires separated (n/a for Interlock).
82 ○ The temperature rating for TS connections and insulation must be appropriate for the expected surrounding temperatures but at least 85 °C.
83 ○ Every wire used in the TSAC (both TS and LVS) is rated for U_{TSmax} and > 85 °C - clear to assign and prove.
84 ○ Positive locking mechanism or automotive certified components if no positive locking is possible.
▲ Check if insulated tools needed for the assembly of certified components are available.
85 ○ Insulation is not only insulating tape or rubber-like paint.

○ INDICATOR LIGHT OR VOLTMETER

86 ○ Indicator light or voltmeter installed.
87 ○ Marked with "Voltage Indicator".
88 ○ Visible while opening the battery connector.
89 ○ Hard-wired electronics, supplied by TS.
90 ○ Verify that the indicator light or voltmeter (or its TS part) is galvanically isolated from the TSAC.
▲ Connect power supply with 60 V_{DC}[7] to the accumulator TS connector.
91 ○ Indicator light is on, or voltmeter is showing present TS voltage.
92 ○ Visible (and red, in case of indicator light) in bright sunlight.

○ CHARGER SHUTDOWN CIRCUIT

▲ Connect charger to the TSAC(s), start the charging process.
93 ○ Voltage indicator shows that HV is present.
▲ Connect multimeter between TS+ and TS- measuring points.
▲ Press the shutdown button: $t_{discharge} \approx$ s.
94 ○ AIRs open immediately.
95 ○ TS discharges below 60 V_{DC} within 5 s.
96 ○ Voltage indicator shows that HV is not present.
▲ Start charging, unplug TS accumulator connector.
97 ○ AIRs open.
98 ○ Charger is disabled, < 60 V measurable at TSMPs.
99 ○ If the SDC is opened the charging system must remain disabled until it is manually reset. Closing the SDC must not (re)activate charging.

○ ACCUMULATOR MANAGEMENT SYSTEM

100 ○ A minimum of 30 % of cells equally distributed within TSAC(s) are monitored with temperature sensors.
101 ○ Every temperature sensor is placed on the negative terminal of the monitored cell or in ≤ 10 mm distance on the busbar.
▲ Ask the team to connect their laptop to the AMS.
102 ○ Cell voltages can be displayed.
103 ○ Cell temperatures can be displayed.
▲ Start the charging process.
104 ○ Plausible accumulator current can be displayed.
▲ Disconnect AMS current sensor connector.
105 ○ AMS must open the shutdown circuit within 0.5 s.
▲ Start the charging process. Disconnect one SINGLE voltage sense wire, if any wires are used.
106 ○ AMS must open the shutdown circuit within 0.5 s.
▲ Start the charging process. Disconnect one SINGLE temperature sensor wire, if any wires are used.
107 ○ AMS must open the shutdown circuit within 1 s.
108 ○ Respective failed cell temperature measurement is displayed.
▲ Start the charging process. Disconnect one AMS communication connector (e.g. CAN, if applicable).
109 ○ AMS must open the shutdown circuit within 0.5 s.

○ INSULATION MONITORING DEVICE

110 ○ IMD is integrated into the charging system.
111 ○ 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.
▲ $R_{Test} = 135\,\text{k}\Omega$[8]
▲ Activate charger output, connect R_{Test} between TS+ TSMP and LVS GND.
112 ○ Shutdown circuits opens within 30 s.
113 ○ TS voltage decreases below 60 V_{DC} within 5 s after shutdown circuit opens.
114 ○ Reactivation of charger output is not possible.
▲ Push the reset button, if any.
115 ○ Reactivation of charger output is not possible.
▲ Remove R_{Test}. Wait 40 s until IMD resets status output.
116 ○ Reactivation of charger output is not possible.
▲ Ask the team to perform power cycle or push the IMD reset button to unlatch all faults.
▲ Activate TS, connect R_{Test} between TS- and LVS GND.
117 ○ Shutdown circuits opens within 30 s.

[7] 60 V or half the nominal tractive system voltage, whichever is lower.
[8] $R_{Test} = (U_{TSmax} \times 250\,\Omega/\text{V}) - R_{BPR}$

○ ACCUMULATOR CONTAINER

▲ Invite mechanical scrutineer for assistance with point 118.
▲ Team must show approved SES for the accumulator container.
▲ Team must show SES test samples for the accumulator container if alternative materials are used.
118 ○ Accumulator container manufactured according to ASES.
119 ○ Internal vertical walls have to be rigidly fastened to the container and extend upwards until the lid.
120 ○ Barriers do not divide any accumulator segment.
121 ○ Cells securely fastened towards all 3 directions.
122 ○ Vehicle number, university name and ESO phone number(s) written on a high contrast background.
123 △ Roman Sans-Serif characters of at least 20 mm high are used.
124 ○ Warning stickers with a side length of ≥ 100 mm and text "Always Energized" and "High Voltage" (if TS$>$ 60 V) installed (triangle with black lightning bolt on a yellow background).
125 ○ Check if all parts and the cover/lid of the housing are rigidly fastened.

○ HAND CART

126 ○ Hand cart present with four wheels. Max. dimensions 1200 $\times$ 800 mm.
127 ○ Hand cart has an always-on type brake system and is easily moved when the brake is released.
128 ○ Hand cart provides a firewall with the same width as the hand cart to protect the person while moving it, appropriately protects legs and body and is $>$ 30 cm higher than the handle and the TSAC.
129 ○ The firewall must be made from a rigid, fire retardant material (UL94-V0 or equivalent) and be transparent from 1.3 m above the ground.
130 ○ The TSAC must be mechanically fixed to the hand cart while on the hand cart.
131 ○ The TSAC must be protected from vibrations and shocks.
132 ○ The TSAC must not protrude the hand cart.
133 ○ The hand cart itself must have a label according to EV5.3.7 on its firewall maximum 1.3 m above the ground (the vehicle number, the university name, and the ESO phone number(s) must be displayed and written in Roman Sans-Serif characters of at least 20 mm high, clearly visible and placed on a high-contrast background).

○ SEALING OF COMPONENTS

▲ After all tests have been passed successfully seal the inspected TS housings:
134 ○ Accumulator container(s) including spares.
135 ○ Additional Parts:

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed
▲ Stop the timer
▲ Collect the timer

NON-COMPLIANCE/COMMENTS

PART IV: LV Electrical Inspection

APPROVAL

Inspector Names	Date and Time	Signatures when passed

INSPECTION RULES

- The time limit for each attempt at this technical inspection is 120 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- The time limit for repair works is 15 min cumulative per one inspection attempt.

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

○ REQUIRED RESOURCES

136 ○ An ESO must attend.
- TSAC mounted into the vehicle.
- LV battery or cell datasheet.
- For self-developed LV battery packs: an opened LV battery pack, laptop, and cables to display data of the LV battery 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.
- Samples of all wire types used for the tractive system.
- Photographs of all inaccessible TS connections.

○ LV BATTERY

137 ○ Voltage $\leq 60\,V_{DC}$.
138 ○ Rigid and sturdy casing.
139 ○ Only for wet-cell batteries: IPX7 rated and acid resistant casing if inside the cockpit.
140 ○ Behind Firewall.
141 ○ Short circuit protection (e.g., fused).
142 ○ Proper insulation of internal electrical connections.
143 ○ Proper mounting of cells.
144 ○ Complete battery pack inside rollover protection envelope.
145 ○ Has overpressure relief, gas vent behind a firewall (only applies to fully enclosed battery case).
▲ Following checks only for Li-Ion batteries other than LiFePO4:
146 ○ UL94-V0 for min. used thickness or equivalent casing.
147 ○ Overcurrent protection that trips below max. discharge current.
148 ○ Overtemperature protection of at least 30 % of the cells (max. 60 °C or datasheet, whichever is lower).
149 ○ Voltage protection of all cells.
150 ○ Signal failures electrically disconnect the LV battery (SCS) (check the schematics of LV battery AMS).
▲ Ask the team to connect their laptop to the AMS.
151 ○ Cell voltages can be displayed.
152 ○ Cell temperatures can be displayed.

○ SELF DEVELOPED PCBS

▲ Ask for fully assembled spares of self-developed PCBs where both TS and LVS parts are present (outside the TSAC) - i.e. discharge, TSMP, motor controller...

153 ○ Sufficient TS to LVS clearance and creepage based on the system voltage and implementation (see EV 4.3.6 and table 5). Clearly marked and separated. Grooves and cut-outs must have a minimum width of 1.5 mm to influence the creepage path.

154 ○ The 1 min AC RMS isolation voltage of any component crossing the isolation barrier (TS to LVS) is $\geq 1800\,V_{DC}$ [9].

155 ○ The working voltage of any component crossing the isolation barrier (TS to LVS), if specified in the datasheet, is higher than the U_{TSmax}. The resistance is $\gg 315\,k\Omega$[10].

156 ○ Capacitors that bridge galvanic isolation must be class-Y capacitors.

157 ○ Sufficient insulation and temperature ($> 85\,°C$) rating of coating if used, datasheet available.

158 ○ Coating process (if applied) done properly and according to the datasheet. Check with UV light if necessary.

▲ Ask for fully assembled PCB spare(s) and schematic of BSPD board(s).

159 ○ BSPD PCB(s) is standalone with only minimum interface.

160 △ BSPD PCB(s) are directly supplied from the LVMS.

○ MASTER SWITCHES

161 ○ TSMS, ASMS and LVMS installed easily accessible on the right side of the vehicle and located next to each other.

162 ○ ASMS is completely removed and kept by an ASR.

163 ○ Check the TSMS and ASMS for a lockout capability to prevent accidental activation of the TS.

164 △ All master switches are located above 80 % of shoulder height of Percy.

165 ○ Rigidly mounted and no need to be removed during maintenance.

166 ○ Rotary type with removable handle.

167 △ Handle length $\geq 50\,mm$.

168 ○ "ON" position in horizontal.

169 ○ "ON" and "OFF" positions marked.

170 ○ TSMS with a locking mechanism for "OFF" position.

171 ○ LVMS marked with "LV" and a symbol showing a red spark in a white-edged blue triangle.

172 ○ LVMS mounted on a red circular area on a high contrast background.

173 △ Circular area diameter $\geq 50\,mm$.

174 ○ TSMS marked with "TS" and triangle with a black lightning bolt on a yellow background.

175 ○ TSMS mounted on an orange circular area on a high contrast background.

176 △ Circular area diameter $\geq 50\,mm$.

177 ○ ASMS marked with "AS".

178 ○ ASMS mounted on a blue circular area on a high contrast background.

179 △ Circular area diameter $\geq 50\,mm$.

○ MEASURING POINTS

180 ○ Two TS measuring points on exclusive orange background.

181 ○ A black LV ground measuring point installed.

182 ○ Next to the master switches.

183 ○ 4 mm shrouded banana jacks.

184 ○ Non-conductive cover.

185 ○ Cover removable without tools.

186 ○ Correctly marked ("TS+", "TS-", "GND").

○ TS SHUTDOWN DEVICES

187 ○ 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.

188 ○ Marked with red sparked sticker.

189 △ Diameter $> 39\,mm$.

190 ○ One cockpit shutdown button installed. Push-Pull or Push Rotate-Pull functionality.

191 ○ Marked with red sparked sticker.

192 ○ Easy actuation by the driver.

193 △ Diameter $\geq 24\,mm$.

194 ○ Inertia switch rigidly mounted to the chassis with correct orientation (according to datasheet) and can be unmounted for functionality test.

● Check interlocks on ...

195 ○ TS accumulator container(s).

[9] $3 \times U_{TSmax}$ or $750\,V_{DC}$, whichever is higher.
[10] $500\,\Omega/V$, at a test voltage of maximum TS voltage or 250 V, whichever is higher.

196 ○ Inverters.
197 ○ HVD.
198 ○ Power distribution boxes.
199 ○ Data Logger box.

● If outboard wheel motors are used:
200 ○ Outboard wheel motors - interlocks must act before a TS wiring failure.
201 ○ Suspension member - interlock must act in case of suspension failure.

○ TS VOLTAGE

▲ Measure voltage at TS measuring points.
202 ○ Equal or less than 60 V_{DC}.

○ DISCHARGE CIRCUIT AND BODY PROTECTION RESISTORS

▲ Switch off LVMS. Measure resistance between TS+ and TS- measuring points: kΩ.
203 ○ Resistance is 30 kΩ[11]+$R_{discharge}$. If not measurable, ask for an explanation and alternative measurement procedure.
204 ○ Body protection resistor power rating is sufficient.[12]
205 ○ Discharge power rating is sufficient for continuous discharge.

○ TS WIRING

206 ○ All TS wiring and components have to be in the envelope and behind the impact structures.
207 ○ TS wires of outboard wheel motors must not be able to reach the cockpit opening in case of a wire break. Any wiring outside 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 a separate non-conductive enclosure 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 LVS wires separated (n/a for interlockc).
217 ○ Ask team to prove that TS wires fulfill temperature rating $> 85\,°C$ and voltage rating.
218 ○ Suitable temperature rating for the used position.
219 ○ Positive locking mechanism on every screwed connection, photographs of all inaccessible TS connections.
220 ○ Positive locking mechanism on every TSMP connection, no soldering (unless fulfilling EV4.5.15), photographs of all inaccessible connections.
221 ○ TSMP connections sufficiently insulated or separated from LVS / chassis.
222 ○ Insulation is not only insulating tape or rubber-like paint.

○ HV WARNING STICKERS

▲ Check for warning stickers on TS containing enclosures - triangle with a black lightning bolt on yellow background.
223 ○ Inverter(s).
224 ○ Motor(s).
225 ○ Power Distribution box(es).
226 ○ Data logger box.
227 ○ Other TS containing enclosures.

[11] 2 x Body Protection Resistor (BPR). It is one of following:

$$U_{TSmax} \leq 200\,V_{dc} : BPR = 5\,k\Omega$$
$$200\,V_{dc} \leq U_{TSmax} \leq 400\,V_{dc} : BPR = 10\,k\Omega$$
$$400\,V_{dc} \leq U_{TSmax} \leq 600\,V_{dc} : BPR = 15\,k\Omega$$

[12] Sufficient to short circuit TS+ and TS-.

○ TRACTIVE SYSTEM PROTECTIONS

▲ Check opening in TS enclosures, try to reach TS potentials with insulated test probe (100 mm length, 6 mm diameter).

228 ○ Not possible to reach any TS potentials.
229 ○ TS components and containers protected from moisture.

○ HIGH VOLTAGE DISCONNECT

230 ○ Clearly marked with "HVD".
231 △ Distance to ground greater than 350 mm.
232 ○ Inside roll-over protected envelope.
233 ○ No remote actuation (e.g., through wires).
234 ○ Integrated interlock.

▲ Ask ESO to remove HVD and document the process (video).
235 ○ Removed within 10 s without tools.
236 ○ 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

237 ○ Mounted below the highest point of the main roll hoop (no lower than 75 mm) and within the roll-over protected envelope (including mounting).
● Cockpit indicator light...

238 ○ ... is inside the cockpit and marked with "TS off",
239 ○ ... is illuminated green and visible, even in bright sunlight and from outside the cockpit,
240 ○ ... is easily visible for the driver.

○ DATA LOGGER

241 ○ Data logger is fully enclosed in a housing.
242 ○ Data logger is properly mounted.

243 ○ All TS current flowing from/to accumulator flows through the data logger.

○ ACCUMULATOR MANAGEMENT SYSTEM

▲ Disconnect AMS signal(s) from the TS accumulator.
● AMS indicator light...
244 ○ ... is inside the cockpit and marked with "AMS",

245 ○ ... is illuminated red and visible, even in bright sunlight and from outside the cockpit,
246 ○ ... is easily visible for the driver.

○ 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)...
247 ○ ... behind the driver's back,
248 ○ ... at the sides of the driver,
249 ○ ... at the front of the vehicle.

250 ○ First layer, facing TS must be made of Aluminium with a thickness of at least 0.5 mm.
251 ○ Second layer, facing driver must be made of electrically insulated material (no CFRP).
252 ○ Material meets UL94-V0 for min. used thickness or equivalent.

○ ACCELERATOR PEDAL POSITION SENSOR (APPS)

253 ○ Returns to the original position if not actuated.
254 ○ 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.
255 ○ Sensors do not share supply or signal lines.

256 ○ Sensors are protected from being mechanically overstressed (positive stop of the pedal).
257 ○ Minimum two springs installed to return pedal.
258 ○ Each spring still returns the pedal with the second one disconnected (springs in the torque encoders not counted).

○ AUTONOMOUS SYSTEM STATUS INDICATORS (ASSI)

259 ○ The rear ASSI is mounted on vehicle centerline, $\geq$ 160 mm below the top of the main hoop and $\geq$ 100 mm above the brake light.
260 ○ Both ASSIs, mounted on the left and right sides, are located behind the driver's compartment, $\geq$ 160 mm below the top of the main hoop and $\geq$ 600 mm above ground.
261 ○ At least one ASSI visible from any angle from a point 160 cm above the ground within 3 m radius from main hoop.
262 ○ Round, triangle, or rectangular on dark background.
263 △ 15 cm^2 minimum illuminated area, or LED strip with a total length greater than 150 mm with elements $<$ 20 mm apart.

○ BRAKE LIGHT

264 ○ Only one brake light.
265 ○ Located on vehicle centerline, height between wheel center line and driver's shoulder.
266 ○ Round, triangle, or rectangular on black background.
267 ○ Must be clearly visible even in bright sunlight, if and only if a brake system is actuated.
268 △ 15 cm^2 minimum illuminated area, or LED strips with a total length greater than 150 mm with elements <20 mm apart.

○ INSULATION MEASUREMENT TEST

▲ Set the test voltage to 500 V_{DC}. [13]
▲ Connect insulation tester to TS+ TSMP and LVS GND measuring point.
▲ Measure resistance: R_{iso+} = kΩ
269 ○ Resistance is much higher than 315 kΩ[14].
▲ Connect insulation tester to TS- TSMP and LVS ground.
▲ Measure resistance: R_{iso-} = kΩ
270 ○ Resistance is much higher than 315 kΩ[14].
271 ○ Resistances are nearly equal.

GROUNDING CHECKS

● An electrically conductive part is considered grounded, if its resistance to the LVS ground is $\leq$ 100 mΩ measured at 1 A. Other parts (which are, or may become electrically conductive) within 100 mm of any TS component must have a $\leq$ 100 Ω resistance to the LVS ground.
● Conductive seat, driver harness, firewall mountings and TS firewall must be properly grounded.
● 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.
▲ Verify that all TS enclosures are constructed by exactly one of the following:...
272 ○ ...Each material used to build a TS enclosure has a resistance of $\geq$ 2 MΩ @ 500 V, except protruding electrically conductive parts - i.e. screws, (shielded) connectors, which need to be properly grounded.
273 ○ ...Enclosure is made of a solid grounded layer of at least 0.5 mm thick electrically conductive material - aluminium or better. $\geq$ 0.9 mm thick steel layer might be used for the TSAC as the grounded layer.

● Each $\leq$ 100 mΩ grounding must be able to carry $\geq$ 10 % of TS main fuse - measure if needed / in doubts.
● N/A: Not applicable - not conductive, or not closer to TS components than 100 mm.
▲ Measure resistance between LVS GND measuring point and...

[13] IN 4.1.1:
$U_{TSmax} \leq 250\,V_{DC}$: $U_{Test} = 250\,V_{DC}$
$U_{TSmax} > 250\,V_{DC}$: $U_{Test} = 500\,V_{DC}$
[14] Minimal Resistance = $500\,\Omega/V \times U_{TSmax} + R_{BPR}$

Part	N/A	$< 100\,m\Omega$@1 A	$< 100\,\Omega$
Main Roll Hoop		○	
Driver harness mounting points		○	
Seat and seat mounting points (N/A if not conductive)	○	○	
Firewall(s) mounting points and aluminium layer		○	
Accumulator container and/or protruding parts (fasteners, connectors)	○	○	
TS enclosures and/or protruding parts (fasteners, connectors)	○	○	
TS connectors (shells) (N/A if not conductive)	○	○	
TS motor(s) startionary part (N/A if fully enclosed/unreachable)	○	○	
Suspension Front left (N/A e.g. if RWD)	○		○
Suspension Front right (N/A e.g. if RWD)	○		○
Suspension Rear left (N/A e.g. if FWD)	○		○
Suspension Rear right (N/A e.g. if FWD)	○		○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed

▲ Stop the timer

▲ Collect the timer

NON-COMPLIANCE/COMMENTS

PART V: MECHANICAL INSPECTION

APPROVAL

Inspector Names	Date and Time	Signatures when passed

INSPECTION RULES

- The time limit for each attempt at this technical inspection is 75 min. Continuation of the inspection is possible after requeuing.
- During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- Only tools needed for the (dis)assembly of parts for mechanical inspection.

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

○ VEHICLE WITH TALLEST DRIVER SEATED

274 ○ **FIRE EXTINGUISHERS** - Two foam type (of at least 34B or 5A 34B rating), with valid inspection tag, one in the team's paddock area (except for the inspection).

275 ○ **PUSH BAR** - Red color with university name. Securely attached to the vehicle, push and pull function. Operable by 2 people.

276 ○ **CAMERAS AND SENSORS** - Must be securely mounted. Must not come into contact with the driver's helmet under any circumstances. No cameras mounted to helmet.

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

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

279 ○ **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 100 mm above the bottom of the helmet of the tallest driver, is not in a straight line of sight with any of the following parts: fuel supply system, hydraulic fluid (except brake system and dampers), flammable liquids and low voltage battery.

280 ○ **ROLL BAR PADDING** - Roll bar or bracing that could be hit by the driver's helmet must be covered with 12 mm thick, SFI spec 45.1 or FIA 8857-2001 padding. Design prevents driver's neck hitting bracing or other side tubes.

281 ○ **HEAD RESTRAINT** - Near vertical. Must withstand 890 N load. 40 mm thick, SFI 45.2 standard or FIA technical list n°17 type B. Max. 25 mm from helmet. Helmet contact point 50 mm min. from any edge. May be changed for different drivers. Minimum 150 × 150 mm.

282 ○ **DRIVER RESTRAINT HARNESS** - SFI 16.1, SFI 16.5, SFI 16.6, or 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). Shoulder harness straps must have angle from shoulder between 10° up and 20° down to horizontal in side view. Belts must not pass through a firewall.

283 ○ **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

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

285 △ **SCHOOL NAME AND OTHER DECALS** - School Name, or recognized initials - min. 50 mm tall (all letters). on both sides in Roman letters. Must be clearly visible.

286 △ **VEHICLE NUMBERS** - On front and both sides of vehicle, minimum 150 mm tall, 20 mm stroke and spacing, 25 mm min. between number and

background edge, Black on White, White on Black only, and specified background shapes. Must be clearly visible, font: Roman Sans-Serif characters, horizontally aligned.

287 △ **LOW VOLTAGE MASTER SWITCH** - Must be located on the right side of the vehicle, in proximity to the main hoop, at the 95th percentile male driver's shoulder height, in the middle of a completely red circular area of ≥ 50 mm diameter. Marked with LV and international symbol. Level horizontal when in ON position.

288 △ **BODYWORK/AERODYNAMIC DEVICES EDGES** - Edges that could contact with any standing pedestrian without reaching to the vehicle must have a minimum radius of 3.0 mm for all forward-facing edges and 1.0 mm for all other edges (safety requirement).

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

290 ○ **BODYWORK** - Min. 38 mm radius on nose. No large openings in bodywork into the driver compartment in front of or alongside the driver, (except cockpit opening). Any gaps between bodywork and other parts must be reduced to a minimum. No external concave radii of curvatures in front of the cockpit opening and T 8.2 (in side view).

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

292 ○ **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.

293 △ **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.

294 △ **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.

295 △ **SEAT** - Insulated against heat conduction, convection and radiation. The lowest point no lower than the top of the upper surface of the lowest SIS member OR must have a longitudinal, 25.4×1.65 mm steel tube underneath.

296 ○ **COCKPIT OPENING** - Cockpit opening template (T 4.1) passes down from above the cockpit to below the upper side impact member. The steering wheel, seat and padding can be removed. No removing of firewall.

297 ○ **COCKPIT INTERNAL CROSS SECTION** - Cross section template (T 4.1) template passes from the cockpit opening to 100 mm rear of the rearmost pedal contact area (in most forward position). The steering wheel and paddings can be removed (without tools).

298 ○ **STEERING WHEEL** - Continuous perimeter with no concave sections. Driver operable quick disconnect. Max. 250 mm from the front hoop. In any steering angle, steering wheel must be below top most point of front hoop.

○ REMOVE BODY PANELS

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

300 ○ **DRIVER'S FOOT PROTECTION** - Feet must be rearward of the Front Bulkhead and no part of shoes or legs above or outside the primary structure in side or front views when touching the pedals.

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

302 ○ **PERCY** - Helmet of 95th percentile male (PERCY) to be 50 mm below the lines between the top of the front and main roll hoops and between the top of the main hoop to rear attachment point of main hoop bracing. Center of bottom circle placed minimum 915 mm from pedals.

303 ○ **BRAKES** - Dual hydraulic system and 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. Any part of the brake system must be within the surface envelope. Brake pedal capable of 2000 N, no failures if official exerts max force (seated normally in the vehicle). Check attachment of brake pedal to chassis, critical fasteners - min. 4 mm metric grade 8.8, positive locking.

304 △ **BRAKE OVER TRAVEL SWITCH** - In the event of a failure in one or both brake circuits the brake pedal over travel will result in the shutdown circuit being opened.

305 ○ **CHASSIS AND MATERIALS** - Team must show an APPROVED SES. Monocoque: Team must present laminate test specimens. All samples must be marked with information about laminated structure and date of testing.

306 ○ **BOLTED JOINTS** - Bolted joints in Primary Structure are consider as critical fasteners (T 10). Must be positively locked, distance hole centerline to the nearest free edge $>$ 1.5 x hole diameter. Manufactured according to SES. Monocoque: All attachments between monocoque and other primary structures (e.g. hoops, removable TSAC imapact protection) must use $\geq$ 2 mm thick steel backing plates (T 3.15.6). Backing plates must not have concave section.

307 ○ **INSPECTION HOLES** - 4.5 mm inspection holes required in non-critical areas of front and main hoops. Inspectors may ask for holes in other tube(s).

308 ○ **MAIN HOOP** - Must be made of one piece steel tube. Check tube dimensions and geometry in the approved SES. Monocoque: Each attachment point requires a minimum of two 8 mm metric grade 8.8 bolts and steel backing plates with a minimum thickness of 2 mm. Tabs or brackets must have an edge distance ratio "e/D" of 1.5 or greater. Design in accordance with SES.

309 ○ **MAIN HOOP BRACING** - Must be steel. One straight brace on each side. Tube dimension as specified in the approved SES. Attached within 160 mm from the top of MH. Min. 30° included angle with hoop. Proper design for removable braces (capping,...). Monocoque: Each brace attached with min. one 10 mm metric grade 8.8 bolt and min. 2 mm steel backing plate. Design in accordance with SES.

310 ○ **FRONT HOOP** - Must be closed section metal tube with dimension and geometry as specified in SES. Check dimension of tube through inspection hole. Monocoque: Laminated front hoop must have sufficient layer overlap and be manufactured according to good engineering practices.

311 ○ **FRONT HOOP BRACING** - Two straight forward-facing braces, attached within 50 mm of top and must have a minimum distance of 100 mm between each other at the front hoop. Tube dimensions and geometry same as specified in SES. Monocoque: See material specimens and test result in SES. Any holes or cutouts dimensions (eg. service windows) must not be larger than specified in SES.

312 ○ **SIDE IMPACT PROTECTION** - Three tubes must connect the main and front hoops, 2 horizontal and 1 diagonal bracing. The upper tube must be between 240 mm to 320 mm above the lowest inside chassis point between FH and MH. Check tube dimensions and geometry as shown in the approved SES. Monocoque: See material specimens and test results in SES. Check that dimensions match specification in SES.

313 ○ **FRONT BULKHEAD SUPPORT** - Support front bulkhead to front hoop. Min. 3 tubes on each side, tube dimensions and design according to SES specification. Monocoque: See material specimens and test result in SES. Any holes or cutouts (eg. for suspension) must not be larger than specified in SES.

314 ○ **FRONT BULKHEAD** - No non-crushable objects forward of bulkhead. No non-crushable object 25 mm behind the AIP. Front bulkhead manufactured according to SES specification. Requires diagonal bracing if larger than 400 $\times$ 350 mm. Monocoque: cutout dimension and material thickness match SES specification. See material sample and test resuls in SES.

315 ○ **IMPACT ATTENUATOR** - No portion of the required 100 $\times$ 200 $\times$ 200 mm volume of the IA can be positioned more than 350 mm above the ground. No wing supports through the IA. Must be securely fastened directly to AIP. Adhesive used to mount standard IA to AIP must have a shear strength of at least 24 MPa. Manufactured in accordance with IAD form. Test piece presented and same as IA on vehicle.

316 ○ **ANTI INTRUSION PLATE** - A 1.5 mm solid steel or 4.0 mm solid aluminium sheet. Must be welded (size: min. to centerlines) or min. 8 bolts M8 Grade 8.8 critical fasteners with 2 mm thick steel backing plates (size: min. outside dimensions). Alternative materials allowed if tested and approved in SES and IAD.

317 ○ **REMOVABLE TRACTIVE SYSTEM PROTECTION** - i.e. rear bulkhead. Fasteners, their spacing and any brackets in accordance with SES. Monocoque: For each 200 mm of reference perimeter a minimum of one 8 mm metric grade 8.8 bolts must be used. See material sample.

318 ○ **ACCUMULATOR ATTACHMENTS** - Min. 2 attachment points. Any brackets used to mount the TSAC must be made of steel 1.6 mm thick or aluminium 4 mm thick and must have gussets to carry bending loads. Bolted joint using either tabs or brackets must have an edge distance ratio "e/D" of 1.5 or greater. Manufactured in accordance with SES.

319 ○ **LAP BELT MOUNTING** - Pivoting mounting with eye bolts or shoulder bolts attached securely to Primary Structure. Min. tab thickness 1.6 mm. Attachments to the monocoque must use one M10 8.8 or two M8 8.8 bolts and $\geq$ 2 mm thick steel backing plates (T 4.5.1). See test specimen and compare with actual design and SES.

320 ○ **SHOULDER HARNESS MOUNTING** - Mounting points 180 mm to 230 mm apart (measured center to center). Must not exert bending loads into the Main Hoop Bracing without extra bracing. Additional braces if not straight to the main hoop. Monocoque: Attached to Primary Structure as specified in SES using one M10 8.8 or two M8 8.8 bolts and $\geq$ 2 mm thick steel backing plates. See test specimen and compare with actual design.

321 ○ **FIREWALL** - Fire resistant material; must separate driver compartment from cooling, oil system and LV battery. Passthroughs are OK with grommets. Multiple panels are OK if gaps are sealed. No gaps at the sides or bottom. Must be rigidly mounted to the chassis. Material must meet UL94-V0 (or UL94 HF-1 / UL94 VTM-0 for foams), FAR 25.853(a)(1)(i) or equivalent (check if a minimum thickness is required in the datasheet).

322 ○ **JACKS** - One or two devices that must be available to safely lift and hold all driven wheels min. 100 mm above the ground. In lifted position the jack (s) must be locked/secured and function without the support of a person or additional weights. It must be safe for the driver to enter and exit the vehicle without additional devices. The device must not extend out of the vehicle's projected surface area. Device pick-up points must be indicated by orange triangles on both sides. University name on it.

323 ○ **RIM CLEARANCE** - The radial clearance between any non-rotating part and the inside of the rim must be at least 5 mm in static condition at any steering angle and any ride height.

○ VEHICLE LIFTED AND WHEELS REMOVED

324 ○ **WHEELS** - 203.2 mm (8") min. diameter. No Aluminium or hollow wheel bolts. Single retaining nut must incorporate a device to retain the nut. Aluminium wheel nuts must be hard anodized.

325 ○ **SUSPENSION PICK-UP POINTS** - Inspected thoroughly for integrity.

326 ○ **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. Alternative fasteners allowed for steering and suspension if equivalency can be shown. Snap rings allowed for brake floaters, groove must be manufacture according to standart and in pristine condition.

327 ○ **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° max. free play at the steering wheel. NO STEER-BY-WIRE on front wheels. Rear wheel steering, max. 6° and mechanical stops installed.

328 ○ **GAS CYLINDERS** - Nonflammable gas, max. pressure 10 bar, may exceed 10 bar if directly mounted regulator limits output to 10 bar. All parts designed for max. pressure. Proprietary manufacturer, certified and labeled. All parts inside rollover protection envelope. Must be shielded from driver by min. 1 mm aluminium. Insulated from heat sources. Mounting must withstand 40g in lateral and longitudinal direction and 20g in vertical direction.

329 ○ **SCATTERSHIELDS INCL. MOUNTING** - Required for clutches, chains, belts, etc. No holes. Attached by M6 grade 8.8 bolts minimum. Must start and end parallel to the lowest point of the driven sprocket / chain wheel / belt or pulley.

330 ○ **SCATTERSHIELD MATERIALS** - $\geq$ 2 mm thick solid steel $\geq$ 3 mm thick Al 6061-T6. Min. 3 times chain/belt width. Finger guards: cover all drivetrain parts that spin while the vehicle is stationary. No holes $>$ 12 mm dia.

331 △ **FANS AND TURBINES** - Combined rated power of all active devices designed to move air is $\leq$500 W. This includes cooling fans but does not apply to turbochargers and superchargers according to CV 1.8.

332 ○ **LV BATTERY** - Rigid and sturdy casing and attached securely to frame or chassis. Behind a firewall, within the rollover protection envelope.

333 ○ **HIGH PRESS HYDRAULICS** - Pumps and lines must have 1 mm steel or aluminium shields protecting driver and workers. Including all autonomous system high pressure hydraulics like the ASB.

334 △ **COOLANT** - 100 percent water. NO ADDITIVES WHATSOEVER.

335 ○ **CATCH TANKS** - Rigidly mounted to chassis, rearward of firewall below shoulder level. Vents for water cooling system must have catch-can min. 100 mL or 10 % of fluid volume. All parts rated above 120 °C. Separate catch-can for fluids other than water, each 0.9 L or 10 percent of the fluid volume each, whichever is greater. Any catch can must vent through 3 mm hose down to the bottom of the chassis outside the bodywork.

336 ○ **BELLYPANS** - In a 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.

337 △ **FLUID LEAKS** - Oil, grease, coolant, Brake fluid → none permitted

○ SENSORS FOR AUTONOMOUS SYSTEM

338 ○ **CHECK SENSORS** - Check if all Sensors are fulfilling the legal requirements (mainly radar and laser). The teams must provide the according certifications.

339 ○ **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 500 mm above the ground and not further forward than 700 mm forward of the front of the front tires. They must not exceed the width of the front axle.

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

341 ▲ **SENSOR MARKING** - Mark all sensors.

○ ACTUATORS FOR AUTONOMOUS SYSTEM

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

▲ If yes, check next items:

343 ○ **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.

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

345 ○ **LOCKING** - The disconnection mechanism must be securely locked in both positions.

○ AUTONOMOUS SYSTEM BRAKE (ASB)

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

347 △ **LEAKS** - No leaks in pneumatic/hydraulic circuit.

348 ○ **PUSH-IN FITTINGS** - None used.

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

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed

▲ Stop the timer

▲ Collect the timer

NON-COMPLIANCE/COMMENTS

PART VI: HV Electrical Inspection

APPROVAL

Inspector Names	Date and Time	Signatures when passed

INSPECTION RULES

- ● The time limit for each attempt at this technical inspection is 120 min. Continuation of the inspection is possible after requeuing.
- ● During technical inspection all work carried out on the vehicle must be approved by a technical inspector.
- ● The time limit for repair works is 15 min cumulative per one inspection attempt.

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

○ SAFETY BRIEFING

- ● No badge / no necklace.
- ● No cell phone nor radio - do your calls outside.
- ● No other sources of distraction.
- ● One team member at SDC button when TS ON.
- ● Wear safety gloves when touching TS components.

○ TRACTIVE SYSTEM POWER-UP

- ▲ Recommend the team to lower the maximum motor speed for the upcoming inspection.
- ▲ All driven wheels are off the ground, driven wheels are removed.
- ▲ Connect multimeter between TS+ and TS- measuring points.
- ▲ Switch on TSMS with LVMS deactivated.

350 ○ Voltage at TS measurement points less or equal 60 V_{DC}.

- ▲ Switch on LVMS with TSMS deactivated.

351 ○ IMD and AMS cockpit indicator lights illuminate for 1 s to 3 s for visible check.

352 ○ IMD and AMS cockpit indicator lights are clearly visible in very bright sunlight.

353 ○ Voltage at TS measurement points less or equal 60 V_{DC}.

- ▲ Switch on TSMS and all shutdown buttons.
- ▲ Reset any IMD or AMS errors.

354 ○ TS still deactivated.

- ▲ Activate TS, measure TS voltage during TS power-up.

355 ○ System is pre-charged before the second AIR closes.

- ▲ Switch off TSMS: $t_{discharge} \approx$ s.

356 ○ TS discharges below 60 V_{DC} within 5 s.

- ▲ Try to power up TS with switched off TSMS.

357 ○ TS still deactivated.

- ▲ Switch on TSMS.

358 ○ TS still deactivated.

○ TRACTIVE SYSTEM SHUTDOWN

- ▲ Connect multimeter between TS+ and TS- measuring points.
- ▲ For each of the following switches, deactivation leads to TS shutdown, voltage decreases below 60 V_{DC} within 5 s.

359 ○ LVMS.

360 ○ Shutdown button left.

361 ○ Shutdown button right.

362 ○ Cockpit shutdown button.

363 ○ Inertia switch.

364 ○ Break-over-travel-switch.

- ▲ Show schematic of TS with all interlocks (ESF).

365 ○ Interlocks.

○ TRACTIVE SYSTEM ACTIVE LIGHT

▲ Activate LVS.
366 ○ TSAL and "TS Off" Cockpit Indicator (CI) is green only, visible in bright sunlight.
▲ Activate TS.
367 ○ TSAL flashes red with a frequency of 2 Hz to 5 Hz, and CI is off.
368 ○ Entire illuminated surface of the TSAL is visible in bright sunlight.
369 ○ TSAL has a fully illuminated surface visible by a person standing 3 m away from TSAL (1.6 m eye height) - use a dedicated tool.
370 ○ Less than 10° is blocked by the main hoop.
▲ Deactivate TS, disconnect TSAC state detection circuitry connector if applicable[15], activate LVS and TS.
371 ○ TSAL flashes red and CI is off.
▲ Deactivate TS, reconnect TSAC state detection, connect power supply $> 60\,V_{DC}$ to TS[16], activate LVS.
372 ○ TSAL is green and simultaneously is flashing red, CI is on.
▲ Disconnect power supply, remove HVD, override HVD interlock (!! cover TS potentials !!), activate LVS and TS.
373 ○ TSAL and CI is completely off (no red nor green light).
▲ Deactivate TS, reconnect HVD, activate LVS. Ask the team to demonstrate the safe state of TSAL by disconnecting any signal influencing the green light.
374 ○ TSAL and CI is completely off (no red nor green light).

○ INSULATION MONITORING DEVICE

375 ○ One IMD ground line is connected to the accumulator container and one ground line is connected to the main hoop by a separate wired connection.
▲ $R_{Test} = 135\,k\Omega$[17]
● IMD indicator light...
376 ○ ... is inside the cockpit and marked with "IMD",
377 ○ ... is illuminated red and visible, even in bright sunlight and from outside the cockpit (check during power-on self-test),
378 ○ ... is easily visible for the driver.
▲ Activate TS, connect R_{Test} between TS+ and LVS GND.
379 ○ Shutdown circuits opens within 30 s.
380 ○ IMD indicator light illuminates.
381 ○ TS voltage decreases below $60\,V_{DC}$ within 5 s after shutdown circuit opens.
382 ○ Reactivation of TS is not possible.
▲ Push the reset button which is not accessible to the driver, if any and/or restart LVMS.
383 ○ Reactivation of TS is not possible.
▲ Remove R_{Test}. Wait 40 s until IMD resets the status output.
384 ○ Reactivation of TS is not possible.
▲ Push all reset buttons in the cockpit if any.
385 ○ Reactivation of TS is not possible.
▲ Push the IMD reset button, which is not accessible to the driver, if any.
386 ○ 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 LVS GND measuring points.
387 ○ Shutdown circuits opens within 30 s.
388 ○ IMD indicator light illuminates.

○ MOTOR(S) SPINNING SAFETY RULES

● Clean up unnecessary equipment from car surroundings.
● All team members in inspection slot are aware of upcoming actions.
● Don't stand in spinning parts scatter areas (even the SDC button responsible team member if possible).

[15] Skip test if disconnecting the connector also opens the interlock or stops LVS supply.
[16] Do not use measuring points.
[17] $R_{Test} = (U_{TSmax} \times 250\,\Omega/V) - R_{BPR}$

○ READY-TO-DRIVE ACTIVATION SEQUENCE

▲ Activate TS, press the torque pedal.
389 ○ Motors are not spinning.
▲ Let the team set the vehicle to ready-to-drive mode.
390 ○ Pressing brake pedal WHILE activating is necessary.
391 ○ Brake light in red color.
392 ○ Verify that motors respond to the torque pedal and spin.
▲ Repeat the activation sequence, but push the brake pedal only once before finally pushing the activation button.
393 ○ No ready-to-drive mode possible.
▲ Disconnect the brake sensor.
394 ○ No ready-to-drive mode possible.
▲ Set vehicle to ready-to-drive state.
395 ○ Ready-to-drive sound duration is 1 s to 3 s continuously.
396 △ Ready-to-drive sound is min 80 dBA (2 m around the vehicle).
397 ○ Ready-to-drive sound is easily recognizable and no animal sound or song part.

○ APPS AND BSPD

▲ Set vehicle to ready-to-drive state.
398 ○ Verify that motors respond to the torque pedal and spin.
▲ Disconnect $\geq 50\,\%$ of APPS.
▲ Move the accelerator pedal over the entire pedal travel range.
399 ○ Motors do not spin.
▲ Disconnect all APPS.
▲ Move the accelerator pedal over the entire pedal travel range.
400 ○ Motors do not spin.
▲ Team simulates 5 kW power (complete BSPD circuitry must be used), press brake representing hard braking ($> 0.5\,\mathrm{s}$).
401 ○ TS shuts down.
▲ Reactivate TS. Disconnect the current sensor, and press the brake representing hard braking ($> 0.5\,\mathrm{s}$).
402 ○ TS shuts down.
403 ○ Reactivation of TS is only possible after 10 s without implausibility.

○ DATA LOGGER

▲ Check data logger functionality and connectivity.

○ SEALING OF COMPONENTS

▲ After all tests have been passed successfully seal the inspected TS housings:
404 ○ Data logger housing
405 ○ Additional Parts:

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed
▲ Stop the timer
▲ Collect the timer

NON-COMPLIANCE/COMMENTS

PART VII: DRIVERLESS INSPECTION

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Present ▲ Atach/place the timer ▲ Start the timer

○ REMOTE EMERGENCY SYSTEM BYPASS

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

406 ○ RES bypass is implemented as described in the ASF.

407 ○ Correct safety relay is used.

○ AUTONOMOUS SYSTEM BRAKE

▲ Compare implementation in vehicle to ASF (Forms: "EBS Concept Overview" OR "EBS Mechnical System").

408 ○ Autonomous System Brake is identical to the system described in the ASF and located within the rollover protection, except the brake system (T6) and deactivation points. No leaks.

409 ○ No more than two deactivation points are used.

410 ○ All parts using compressed gas must be designed for the maximum possible operating pressure.

411 ○ If the pressure regulator is adjustable and its maximum range exceeds the maximum operating pressure, it must be set to the pressure specified in the ASF.

▲ The team must demonstrate the pressure regulator setting.

▲ Seal the pressure regulator.

▲ Note the pressure regulator setting to the first page of inspection sheet.

412 ○ All deactivation points are mounted in the surface envelope (T 1.1.18) and 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.

413 ○ All deactivation points are protected against unintended actuation (e.g. by being hit by a cone while driving) and 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.

414 ○ All deactivation points have a red handle and are marked with "Brake release".

○ AUTONOMOUS SYSTEM TEST

▲ Switch on the LVMS and select the inspection mission (AMI).

415 ○ Misson must be selected without use of an external device.

416 ○ The ASSIs remains off.

▲ Switch on the ASMS and the TSMS.

417 ○ Activating the TS using the cockpit activation button is not possible

▲ Activate the TS via the external activation button.

418 ○ The ASSIs light up in yellow continuously after a self check ("AS Ready").

▲ Press RES "Go" button within 5 s after "AS Ready".

419 ○ "AS Driving" (ASSIs flashing yellow) has not been entered

420 ○ Vehicle is still not in R2D.

421 ○ Check functionality and visibility of AMI.

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

423 ○ Brakes are engaged at least on one axle. Check the brake light as well.

▲ Press the RES "Go" button.

!! CAUTION WHEELS AND STEERING SYSTEM ARE MOVING !!

424 ○ The ASSIs start flashing yellow ("AS Driving").

425 ○ Drivetrain is slowly spinning and steering system is moving.

▲ Wait for the transition from "AS Driving" to "AS Finished".

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

427 ○ All 3 (blue) ASSIs are clearly visible in very bright sunlight.

428 ○ TS is deactivated.

▲ Turn off the ASMS and release the Brakes via the deactivation points.

429 ○ Brakes are disengaged, manual steering is possible, ASSI is off.

▲ Re-enter "AS Ready" state.

▲ Press one shutdown button.

430 ○ ASSIs start flashing blue ("AS Emergency").

431 ○ Brakes are engaged.

432 ○ Intermittent sound for 8 s to 10 s (1 Hz to 5 Hz, 50 % duty cycle).

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

434 ○ TS is deactivated.

▲ Turn off ASMS and release brakes (by operating the deactivation points).

▲ Every following test, re-enter "AS Driving" state with inspection mission selected.

▲ For each of the following tests, deactivation leads to TS shutdown and transition to "AS Emergency".

435 ○ Press RES.

436 ○ Switch off ASMS.

▲ For following tests, system is able to detect a failure and enters "AS Emergency" when in "AS Ready" or "AS Driving" state.

437 ○ Test all operating errors (e. g. manual valves).

438 ○ Choose randomly 1 to 3: Test ASB failure modes (e.g. disconnect sensors/energy supply/pneumatics/hydraulics. . .).

439 ○ System has detected a failure.

▲ Re-enter "AS Driving" state with inspection mission selected.

▲ Wait till "AS Finished". Then open SDC by pressing RES emergency button.

440 ○ Vehicle transitioned to "AS Emergency" (ASSIs flashing blue).

○ TIS STATUS UPDATE/TIMER

▲ Set online TIS to Passed or Failed

▲ Stop the timer

▲ Collect the timer

NON-COMPLIANCE/COMMENTS

PART VIII: TILT TEST

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ TILT TEST

441 ○ **FLUID LEAKAGE** - No fluid spill permitted when the vehicle is tilted to 60° in the direction most likely to create spillage. Tanks must be filled to the scribe line with non-moveable fuel level line 12-25 mm below the top of the sight tube.

442 ○ **VEHICLE STABILITY** - All wheels in contact with tilt table when tilted to 60° to the horizontal.

443 △ **GROUND CLEARANCE** - At least 30 mm with driver. If an active suspension is installed, the static ground clearance is measured in the lowest adjustable position

NON-COMPLIANCE/COMMENTS

PART IX: RAIN TEST

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ RAIN TEST

- ▲ Lift the vehicle using the jacks. No driver is allowed to sit in the vehicle during the test.
- ▲ Remove all driven wheels from the vehicle.
- ▲ Activate TS, measure TS voltage during TS power-up.

444 ○ Plausible TS voltage is measured and TSAL is flashing red.

- ▲ Disconnect the multimeter from the car and cover TSMPs.
- ▲ Spray rain-like water at the vehicle for 120 s.
- ▲ Wait another 120 s without spraying.

445 ○ The IMD does not react and does not shut down the TS (TSAL is flashing red).

- ▲ $R_{Test} = 135\,\text{k}\Omega$[18]
- ▲ Connect R_{Test} between any TSMP and LVS ground.

446 ○ Within 30 s the IMD reacts and opens the SDC (TSAL is green continuous), IMD dashboard indicator is illuminated.

NON-COMPLIANCE/COMMENTS

If the team fails the rain test, follow the procedures described in the handbook.

[18] $R_{Test} = (U_{TSmax} \times 250\,\Omega/\text{V}) - R_{BPR}$

PART X: BRAKE TEST

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ R2D TEST

447 ○ Ready-to-drive sound is at least 80 dBA (2 m around the vehicle, fast weighting).

○ BRAKE TEST

448 ○ **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.

449 ○ **BRAKE LIGHT** - Must be clearly visible even in bright sunlight.

450 ○ **TSAL** - Must be clearly visible even in bright sunlight.

451 ○ After accelerating, the TS must be switched off by the driver, using the cockpit shutdown button. The driver must brake using only the mechanical brakes.

452 ○ After the brake test, the vehicle must be able to continue driving under its own power without external assistance.

NON-COMPLIANCE/COMMENTS

PART XI: EMERGENCY BRAKE SYSTEM TEST

APPROVAL

Inspector Names	Date and Time	Signatures when passed

○ EMERGENCY BRAKE SYSTEM TEST

▲ Switch on LVMS and select mission "EBS test".
453 △ AMI shows the correct mission.
▲ Switch on ASMS.
▲ Activate TS.
454 ○ ASSI is yellow continuous.
455 ○ TSAL is red flashing.
▲ Press RES "Go" button.
456 ○ ASSI is yellow flashing and vehicle accelerates.
▲ Press RES "stop button" when vehicle is at brake point.
457 ○ Vehicle has to stop within 10 m and has to stay stable.
458 ○ Speed at brake point has to be around 40 km/h.
459 ○ ASSI is blue flashing, intermittent sound is clearly noticeable for 8 s to 10 s.
460 ○ TSAL is green continuous.

NON-COMPLIANCE/COMMENTS