FORMULA STUDENT AI 2024 RULES

INTRODUCTION

Formula Student UK (FS) is an educational challenge organised by the Institution of Mechanical Engineers (IMechE) for the purpose of educating and preparing students of engineering and other disciplines for their future careers.

The Formula Student Artificial Intelligence (FS-AI) event will challenge university teams comprising of engineering, computer science and other students (teams) to develop the AI computer hardware and produce the software for an Automated Driving System (ADS) that can complete the Dynamic Driving Task (DDT) enabling a full-size Formula Student Vehicle to complete typical Formula Student dynamic events.

Wherever possible, the terminology used in this document follows that defined in SAE J3016 – "Taxonomy and Definitions for Terms Related to Driving Automation Systems". A list of the abbreviations used can be found below.

As with all Formula Student competitions, there will be both static and dynamic events to test the knowledge and skills of the students.

The FS-AI competition will run in parallel with the manual Formula Student event.

This year we will continue to merge the two classes **Automated Driving System (ADS) entries and Dynamic Driving Task (DDT) into one class, FS-AI.**

This means all teams can enter one event through three vehicle entry options:

Automated Driving System (ADS) follows the FS Driverless technical regulations which allow teams to adapt an existing Formula Student vehicle to create their own Automated Driving System - Equipped Vehicle (ADS-EqV). The cars will not be driven manually at any time.

Dynamic Driving Task (DDT) uses the IMechE Automated Driving System Dedicated Vehicle (ADS-DV), a Formula Student style vehicle (without driver accommodation) with an electric powertrain and drive-by-wire controls. Teams will integrate an AI (artificial intelligence) computer and sensors and develop the software for the AI computer in order that the car may complete its defined missions by executing the Dynamic Driving Task. Teams intending to compete in this entry for 2024 will have the opportunity to share one of the two IMechE ADS DVs or use their own previously purchased vehicle. There may be a limit applied to the number of teams that can share the IMechE ADS-DVs.

Dynamic Driving Task (DDT) with the team using their own ADS-DV.

These vehicles will compete against each other on track and one winner trophy will be awarded.

These rules reflect the philosophy of the use of the ADS-DV. This vehicle is designed to be an easy to use platform to encourage new teams into FS-AI. Teams are encouraged to use the shared vehicle as a testing ground for their software, while they move towards building their own ADS entry vehicle.

Merging the classes into one makes the competition easier to enter and will encourage international teams to enter FS-AI.

Specific rules will apply to those teams sharing an IMechE ADS-DV to ensure a fair competition.

The static events for both entry types will cover the design of the AI system that the teams have produced and the team's understanding of the software design, development and validation. The

static events will also include determination of the team's understanding of the design and operational challenges for an ADS to drive in the real world and the requirements for functional safety. As per the manual Formula Student event there will also be a Business Plan Presentation.

In the dynamic events, the vehicles in both entry types will complete Skidpad, Acceleration, Autocross / Sprint and 10-lap Trackdrive missions on event specific courses using cones for demarcation.

AUTOMATED DRIVING SYSTEM (ADS) INTRODUCTION

ADS vehicles must be built to the rules for Formula Student Driverless Vehicles defined in the main Formula Student UK 2024 Rules and follow all technical regulations from Sections T, CV / EV / AFV (as applicable) and IN.

Teams competing with an ADS entry must follow all regulations from Section A of the main Formula Student UK 2024 Rules, unless deleted or superceded according to Section A of this rules document.

The FS-AI ADS entries will have Static and Dynamic events as detailed in sections S and D of this document, competing against FS-AI DDT entries.

The Cost & Manufacturing event will be replaced with a Real World AI event. For the dynamic events, there will be no Efficiency event as part of the Trackdrive.

Points for the ADS entries will be awarded as follows:

Static Events:	
Business Plan Presentation	100
Real World AI	100
Engineering Design	150
Simulation Development	100
Dynamic Events:	
Skid Pad	100
Acceleration	100
Autocross/Sprint	100
Trackdrive	250
Total Points	**1000**

Table 1: Maximum Points Awarded ADS entries

Ref. rule T14.4.1 'Every vehicle must be equipped with a standard RES specified on the Formula Student Website' the relevant information is unchanged from previous years as follows:

The RES that has to be used for the competition is a GF2000i-codec / T53R98 combination from Gross-Funk GmbH11.

- SIL3 (EN61508) certified
- EMV certified
- communication in 430MHz to 440MHz band
- increased signal strength of 88mW
- 12V to 24V supply voltage (0:26A @12 V)
- 450 g, 173mm_113mm_35mm
- IP20 (receiver) / IP65 (sender)

The hardware revision may be 2023 (with eKey, compatible with Formula Student Germany Rules) or an earlier revision.

Further information about the RES can be found in the document 'FS-AI Remote Emergency Stop' available on the IMechE Formula Student Website.

All documents required by the Formula Student rules for the ADS entries must be submitted by the deadlines in the Key Dates document published on the Formula Student Website.

Note that the ASF for the ADS entries is not subject to the 8-page restriction applied to the DDT entries and must contain full details of the EBS including all applicable FMEAs.

DYNAMIC DRIVING TASK (DDT) INTRODUCTION

Teams competing with a DDT entry will have the opportunity to share one of the two IMechE ADS DVs or use their own previously purchased vehicle.

Teams competing with a DDT entry must follow all regulations from Section A of the main Formula Student UK Rules, unless deleted or superceded according to Section A of this rules document.

There may be a limit applied to the number of teams that can share the two IMechE ADS-DVs.

The ADS-DV consists of:

- Formula Student style chassis and suspension
- Electric drivetrain with 4-wheel drive
- Drive-by-wire steering system
- Drive-by-wire brakes
- Emergency brake system
- Vehicle Control Unit (VCU) which controls the motors, brakes and steering

The shared IMechE ADS-DV vehicle(s) are fitted with a standard AI computer and ZED stereo camera sensor, additional information is provided here:

https://github.com/FS-AI/FS-AI_Compute

Teams may apply to add their own additional AI computer and / or sensors subject to IMechE approval. The approval process for additional hardware is detailed on the IMechE Formula Student website and further information on the approval requirements is available here:

https://github.com/FS-AI/FS-AI_ADS-DV_CAD

Teams that have previously purchased an ADS-DV should select, procure and fit their own AI computer and sensors required to run the vehicle.

All teams must develop software to perform the following functions:

- Event mission selection and initiation
- Object and Event Detection and Response (OEDR) by interpreting the signals from the fitted sensors to determine the location of the cones on the track boundary
- Path planning to determine the route through the cones
- Vehicle position and motion control in both the lateral and longitudinal directions to navigate around the course whilst respecting the track limits
- Event mission tracking including safely completing the mission by stopping the vehicle under full control

Vehicle control is effected through a standard CAN bus interface between the AI computer and the ADS-DV VCU to provide the target settings for the steering, electric motor torque and the braking system. This interface also enables the AI computer to receive information about the vehicle state.

The FS-AI DDT entries will have Static and Dynamic events as detailed in sections S and D of this document, competing against FS-AI ADS entries.

Points for the DDT entries will be awarded as follows:

Static Events:	
Business Plan Presentation	100
Real World AI	100
Engineering Design	150
Simulation Development	100
Dynamic Events:	
Skid Pad	100
Acceleration	100
Autocross/Sprint	100
Trackdrive	250
Total Points	**1000**

Table 2: Maximum Points Awarded DDT entries

CHANGELOG

Document	Version	Change
FS-AI 2024 Rules	V1.0	Document updated from 2023 rules to 2024 rules baseline.

ABBREVIATIONS

ADR	Autonomous Design Report		**DV**	Driverless
AIP	Anti-Intrusion Plate		**EAIR**	ESF Add Item Request
AIR	Accumulator Isolation Relay		**EBS**	Emergency Brake System
AMI	Autonomous Mission Indicator		**ECU**	Electronic Control Unit
AMS	Accumulator Management System		**EDR**	Engineering Design Report
APPS	Accelerator Pedal Position Sensor		**EI**	Flexural Rigidity
AS	Autonomous System		**ESF**	Electrical System Form
ASB	Autonomous System Brake		**ESO**	Electrical System Officer
			ESO	
ASF	Autonomous System Form		**Q**	Electrical System Officer Qualification
ASMS	Autonomous System Master Switch		**ETC**	Electronic Throttle Control
ASR	Autonomous System Responsible		**EV**	Electric Vehicle
ASRQ	ASR Qualification		**FTO**	Fuel Type Order
ASSI	Autonomous System Status Indicator		**HPI**	High Pressure Injection
BOM	Bill of Material		**HV**	High Voltage
BOTS	Brake Over-Travel Switch		**HVD**	High Voltage Disconnect
BPP	Business Plan Presentation Event		**IA**	Impact Attenuator
BPPV	Business Plan Pitch Video		**IAD**	Impact Attenuator Data
BSPD	Brake System Plausibility Device		**IMD**	Insulation Monitoring Device
CBOM	Costed Bill of Material		**LPI**	Low Pressure Injection
CRD	Cost Report Documents		**LV**	Low Voltage
			LVM	
CV	Internal Combustion Engine Vehicle		**S**	Low Voltage Master Switch
DBOM	Detailed Bill of Material		**LVS**	Low Voltage System
DC	Driverless Cup		**MU**	Magazine Uploads
DI	Direct Injection		**OC**	Off-course
DNA	Did Not Attempt		**OEM**	Original Equipment Manufacturer
DNF	Did Not Finish		**PCB**	Printed Circuit Board
DOO	Down or Out		**R2D**	Ready-to-drive
DQ	Disqualified		**RES**	Remote Emergency System
DSS	Design Spec Sheet		**RMS**	Root Mean Square
SCS	System Critical Signal		**TS**	Tractive System
SDC	Shutdown Circuit		**TSAC**	Tractive System Accumulator Container
SES	Structural Equivalency Spreadsheet		**TSAL**	Tractive System Active Light
			TSM	
TMD	Team Member Designation		**P**	Tractive System Measuring Point
			TSM	
TPS	Throttle Position Sensor		**S**	Tractive System Master Switch
			USS	Unsafe Stop
			VSR	Vehicle Status Report

SECTION A – ADMINISTRATIVE REGULATIONS

Teams competing in the ADS or DDT entries must follow all regulations from Section A of the main Formula Student UK 2024 Rules, unless defined 'Not Applicable' or superceded by the text below.

ADS entries (ONLY) ADMINISTRATIVE REGULATIONS

A1   All rules apply with the following exceptions:

      A1.2.4   Superceded by Sections S & D of the FS-AI 2024 Rules.

      A1.2.5   Superceded by Sections S & D of the FS-AI 2024 Rules.

      A1.2.6   Superceded by Sections S & D of the FS-AI 2024 Rules.

      A1.2.7   Superceded by Sections S & D of the FS-AI 2024 Rules.

A6   All rules apply with the following exception:

      A6.3.1   Substitute 'ASR' for 'drivers'.

DDT entries (ONLY) ADMINISTRATIVE REGULATIONS

A1   All rules apply with the following exceptions:

      A1.2.2   Superceded by Section T of the FS-AI 2024 Rules (DDT Section).

      A1.2.3   Superceded by Section IN of the FS-AI 2024 Rules (DDT Section).

      A1.2.4   Superceded by Sections S & D of the FS-AI 2024 Rules.

      A1.2.5   Superceded by Sections S & D of the FS-AI 2024 Rules.

      A1.2.6   Superceded by Sections S & D of the FS-AI 2024 Rules.

      A1.2.7   Superceded by Sections S & D of the FS-AI 2024 Rules.

A2   Not Applicable.

A3   All rules apply.

A4   All rules apply with the following exceptions:

      A4.3   Not Applicable.

      A4.6   Not Applicable.

A5   All rules apply with the following exceptions:

      A5.2.6   Not Applicable.

      A5.5   Not Applicable.

A6   All rules apply with the following exceptions:

      A6.3.1   Substitute 'ASR' for 'drivers'.

      A6.4   Not Applicable.

      A6.7.2   Not Applicable.

      A6.7.3   Not Applicable.

A6.7.4　Outside of the dynamic areas the ADS-DV must be moved with only the steering system activated and must be pushed using the provided pushbar.

A6.7.6　Not Applicable.

A6.7.8　Not Applicable.

A6.8　　Not Applicable.

A6.9　　Not Applicable.

A6.10　Not Applicable.

A6.11　Not Applicable.

A6.12　The ADS-DV must be charged according to the user manual.

SECTION T – GENERAL TECHNICAL REQUIREMENTS

ADS entries VEHICLES

ADS entries vehicles must follow the Formula Student UK 2024 Technical Rules (Section T) in their entirety, with the following addition:

T14.14 Wireless Communications

T14.14.1 During dynamic events, wireless communication may be limited, and the organisers cannot guarantee interference free, reliable wireless connection.

T14.4.2 (D)GPS may be used but there will be no space to securely build up base stations on the competition site.

DDT entries TECHNICAL REGULATIONS

As an unmanned vehicle built to a standard specification, the Formula Student UK 2024 Technical Rules (Section T) do not apply to the ADS-DV used by the DDT entries. The applicable technical regulations for the DDT entries are listed below.

The DDT entries will use a standard ADS-DV, which will include a chassis, electric drivetrain and Vehicle Control Unit (VCU) controlling the autonomous vehicle actuators (motors, steering and brakes).

Teams using the shared IMechE ADV-DV vehicle(s) must produce the complete software to create the AI driver. They may also select, supply and fit additional sensors (subject to prior IMechE approval). The software must communicate with the VCU in order to complete the dynamic driving task required to complete the driving missions.

T1 [DDT entries Only] VEHICLE DESIGN & MODIFICATION

T1.1 Baseline Vehicle

T1.1.1 The baseline vehicle will be homologated and built to the specification as defined in the ADS-DV Vehicle Specification.

T1.1.2 No modifications to the vehicle are allowed whatsoever except as follows:

- Mounting and installation of the sensors
- Mounting and installation of the AI computer

T1.1.3 In all cases, mounting and installation of the sensors and AI computer must not affect any of the vehicle's electrical components or the any of the vehicle's moving components.

T1.1.4 The vehicle will contain an umbilical connector that will include CANbus communication to the VCU and power for the AI computer and sensors. The umbilical specification including CANBus communication protocol is defined in the ADS-DV Vehicle Specification.

T1.1.5 The team must provide and develop the AI system for the vehicle which includes:

- [Teams that have previously purchased an ADS-DV Only] An AI compute platform.
- [Teams that have previously purchased an ADS-DV Only] Suitable sensors.
- The software to execute the DDT required to complete the Dynamic Events driving missions.

T1.1.6 [Teams using a Shared IMechE ADS-DV Only] As well as using the provided stereo camera, teams may select, supply and fit additional sensors, subject to prior IMechE approval. See Sections T1.3 & T1.4 and the FS-AI Github CAD repository 'README.md':

https://github.com/FS-AI/FS-AI_ADS-DV_CAD

T1.1.7 The developed AI system must command the VCU to control the vehicle actuators using the specified CANBus communication protocol in order to complete the DDT required for each mission. In all cases any requirements for the communications protocol as defined by the vehicle specification must be respected.

T1.1.8 The communication between the VCU and the AI computer will include a handshake, which is initiated by the VCU. The VCU must always receive the correct response from the AI computer within 50ms else the Emergency Braking System (EBS) will be triggered.

T1.2 Data Logger

T1.2.1 The vehicle will be fitted with a standardized data logger so that the AI steering and torque targets and other parameters can be monitored. The officials and the team will have access to the recorded data.

T1.3 Sensors Mounting

T1.3.1 All sensors must be securely mounted.

T1.3.2 For all sensors and mounts, any edge that could come into contact with a pedestrian must have a minimum radius of 1mm.

T1.3.3 All sensors must be positioned within the surface defined by the top of the TSAL mounted on the main 'sharks fin' and the outside edges of the four tyres (see Figure 1) or within 100mm of the original ADS-DV bodywork. CAD data is available of this envelope at:

https://github.com/FS-AI/FS-AI_ADS-DV_CAD

T1.3.4 [Teams that have previously purchased an ADS-DV Only] Additionally, sensors may be mounted with a maximum distance of 500mm above the ground and less than 700mm forward of the front of the front tyres (see Figure 1). They must not exceed the width of the front axle (measured at the height of the hubs). (Teams using a shared IMechE ADS-DV will not be permitted to mount sensors in this zone).

T1.4 Sensors Legal and Work Safety

T1.4.1 All sensors must fulfil the local legislative specifications (i.e. eye-protection for laser sensors, power limitation for radar sensors, etc.) in the country of competition.

T1.4.2 Compliance with Legal and Safety requirements must be demonstrated by submitting the datasheets for the implemented sensors prior to the competition in the ASF.
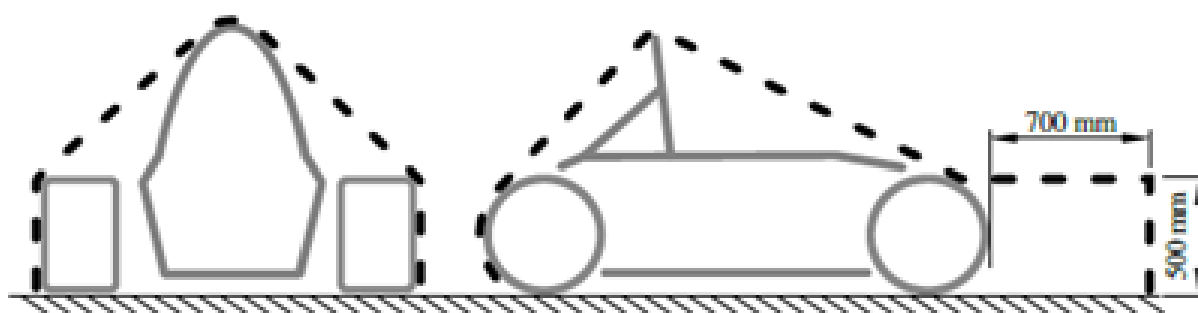
Figure 1

T2 [DDT entries Only] VEHICLE IDENTIFICATION

T2.1 Vehicle Number

T2.1.1 [Teams that have previously purchased an ADS-DV Only] Each team will select an available number at the time of its entry into Formula Student.

T2.2 Formula Student Logo

T2.2.1 [Teams that have previously purchased an ADS-DV Only] Each car will be required to append three (3) Formula Student logos, 20 cm x 15 cm. One (1) marking to the front end of the nose of the car and one (1) on each side panel, ideally above the race number plate or within the top third of the side panels, (these will be supplied by the organisers). No sponsor or other markings will be permitted to encroach on these areas. A document showing the requirements can be found here:

https://www.imeche.org/events/formula-student/team-information/logo-usage

T2.2.2 [Teams that have previously purchased an ADS-DV Only] Alternatively, teams may incorporate the Formula Student logo into their own colour / graphics schemes, in any of the permitted colour options, providing the logo meets the size and location requirements above and does not breach the Institution Brand Guidelines – see the Formula Student Website. The logo is available in various formats on the Use of Logos webpage.

T2.2.3 [Teams that have previously purchased an ADS-DV Only] In addition to the Formula Student logos and numbers, Formula Student will retain rights to 50% of the remaining area of the vehicle for logos for official FS-AI event partners.

T3 [DDT entries Only] VEHICLE EQUIPMENT

The IMechE shared ADS-DV vehicle(s) will be provided with the equipment listed below, which must remain with the vehicle(s) at all times.

T3.1 Pushbar

T3.1.1 Each team must use the removable device (called the pushbar) that attaches to the rear of the vehicle and allows two people to push and pull the vehicle while standing behind the vehicle.

T3.1.2 [Teams that have previously purchased an ADS-DV Only] The pushbar must be presented during technical inspection.

T3.2 Fire Extinguishers

T3.2.1 [Teams that have previously purchased an ADS-DV Only] Each team must have at least two dry chemical/dry powder fire extinguishers with a minimum firefighting agent capacity of 0.9 kg.

T3.2.2 The following are the minimum accepted ratings:

- USA, Canada and Brazil: 10BC or 1A 10BC
- Europe: 34B or 5A 34B
- Australia: 20BE or 1A 10BE

Extinguishers of larger capacity (higher numerical ratings) are acceptable.

T3.2.3 Aqueous Film Forming Foam (AFFF) fire extinguishers are prohibited. Halon extinguishers and systems are prohibited.

T3.2.4 All extinguishers must be equipped with a manufacturer installed pressure / charge gauge.

T3.2.5 [Teams that have previously purchased an ADS-DV Only] Except for the initial inspection, one extinguisher must readily be available in the team's paddock area, and the second must accompany the vehicle wherever the vehicle is moved. Both extinguishers must be presented with the vehicle at technical inspection.

T3.2.6 Hand-held fire extinguishers are not permitted to be mounted on or in the vehicle.

T3.3 Electrical Safety Equipment

T3.3.1 [Teams that have previously purchased an ADS-DV Only] Two pairs of high-voltage (HV) insulating gloves (not expired) and a multimeter must be kept with the vehicle at all times. The HV gloves must be protected from mechanical damage, humidity and sunlight by a case or similar means. It must be possible to open the case without using tools.

T4 [DDT entries Only] AUTONOMOUS SYSTEM

T4.1 Emergency Braking System (EBS)

T4.1.1 The vehicle will have an Emergency Braking System (EBS) and the AI computer must be able to trigger the EBS.

T4.2 Functional Safety

T4.2.1 Requests from the AI computer need to be plausible. For example, if the AI computer requests for the brakes to be applied and the vehicle to accelerate at the same time, then the software must stop the vehicle with the EBS and the run will be aborted. A list of conditions that are regarded as implausible will be published in the ADS-DV Software Interface API available from:

https://github.com/FS-AI/FS-AI_API

T4.2.2 The AI Computer must request EBS activation if an error is detected, for example if the signal from a sensor is lost.

T4.2.3 Teams must make their software source code available for inspection if required to verify compliance with T4.2.1 and T4.2.2. Alternatively, functional tests may be conducted.

T4.3 Autonomous Missions

T4.3.1 The software developed for the AI computer must implement the following missions:

- Acceleration

- Skidpad
- Autocross/Sprint
- Trackdrive
- Static Inspection A and B (see IN6.2)
- Autonomous Demonstration (see IN6.3)

T4.3.2 The ADS-DV will have an Autonomous Mission Indicator (AMI) which will be checked before every dynamic discipline. The team must ensure that the AI computer reads the AMI state correctly from the VCU.

T4.4 Autonomous System Form (ASF)

T4.4.1 Prior to the competition, all teams must submit a clearly structured documentation of their AI computer and sensors called ASF.

T4.4.2 The ASF must contain as a minimum the following items:

- AI computer platform description
- High level description of the software structure
- Details on all sensors selected (see also T1.5.2)
- A description of how learned data is removed for each autocross run

T4.4.3 [Teams using a Shared IMechE ADS-DV Only] The ASF must also contain any requests to fit additional sensors to the vehicle, which will be approved or denied on a case by case basis.

T4.4.4 The body of the ASF must be a maximum of 8 pages long. Appendices for datasheets do not count towards the 8 pages.

T4.5 Wireless Communications

T4.5.1 During dynamic events, wireless communication may be limited, and the organisers cannot guarantee interference free, reliable wireless connection.

T4.5.2 (D)GPS may be used but there will be no space to securely build up base stations on the competition site.

SECTION IN – TECHNICAL INSPECTIONS

ADS entries TECHNICAL INSPECTIONS

The ADS entries must follow the Formula Student UK 2024 Inspection Rules (Section IN) in their entirety.

DDT entries TECHNICAL INSPECTIONS

The main Formula Student UK 2024 Inspection Rules (Section IN) do not apply to the ADS-DV used by the DDT entries. The complete inspection regulations for the DDT entries are listed below.

IN1 [DDT entries Only] VEHICLE INSPECTION

IN1.1 Static Inspection

IN1.1.1 [Teams that have previously purchased an ADS-DV Only] Teams bringing their own ADS-DV to an event must demonstrate that the ADS-DV remains unmodified from the standard specification.

IN1.1.2 [Teams that have previously purchased an ADS-DV Only] The following items will be inspected to ensure everything is to standard specification to maintain operational safety:

- Chassis and bodywork.
- Battery and powertrain.
- Software spec for BMS and VCU.
- Mechanical checks will be made to ensure all components are correctly fitted.
- RES Remote Control.
- Pushbar.
- Joystick.
- ASSI.
- AMI.
- TSAL.
- R2D.
- Data logger.

IN1.1.3 [Teams that have previously purchased an ADS-DV Only] In case of an issue with the vehicle when marshals are not available, the team is expected to have at least the following basic tools available at all times during the event. These must be in good condition, and must be presented for inspection:

- Insulated cable shears.
- Insulated screw drivers.
- Multimeter with protected probe tips.
- Insulated tools for removing bodywork.
- Face shield.
- The two pairs of HV insulating gloves (not expired), in their protective case, as detailed in Section T.
- The two fire extinguishers as detailed in Section T.
- Safety glasses with side shields.

IN2 [DDT entries Only] AUTONOMOUS SYSTEM INSPECTION

IN2.1 AI Computer and Sensor Installation Inspection

IN2.1.1 Each DDT entries Team must demonstrate that their AI computer and sensor installation is compliant with the rules defined by Section T – DDT entries Technical Regulations.

IN2.1.2 [Teams that have previously purchased an ADS-DV Only] The Team must present their ADS-DV for inspection with their AI Computer installed and their sensors fitted.

IN2.1.3 [Teams using a Shared IMechE ADS-DV Only] If the Team have requested to use additional sensors, they will be asked to fit their sensor assembly to one of the IMechE vehicles for inspection.

IN2.1.4 The following items are required for the static inspection:

- One ASF present – the report (8 pages max) must be in paper format, datasheets may be electronic format.
- Data sheets for all perception sensors.
- Documents which prove that all perception sensors meet local legislation.
- Print-outs of rule questions (if applicable).

IN2.2 Static Inspection Mission

IN2.2.1 Each DDT entries Team must demonstrate that their software is capable of completing a Static Inspection Mission to the satisfaction of a Formula Student Scrutineer before attempting the dynamic Autonomous Demonstration Mission Inspection.

IN2.2.2 The AI Computer control of the vehicle will be checked with the following procedure:

- [Teams using a Shared IMechE ADS-DV Only] The Team will load their software onto the ADS-DV AI computer and, if they have requested to use additional sensors, fit their approved sensor assembly.
- The vehicle will be raised off the ground, the wheels may or may not be removed at the discretion of the officials.
- Mission Type 'Static Inspection A' will be selected and executed using the RES 'Go' signal.
- The vehicle must sweep through the full range of steering angles finishing in the straight ahead position.
- The vehicle must ramp up the drivetrain speed to 200 rpm in 10 seconds and then stop within 5 seconds, followed by correctly setting the VCU state to 'AS Finished'.
- The vehicle will be power-cycled to reset the Autonomous System.
- Mission Type 'Static Inspection B' will be selected and executed using the RES 'Go' signal.
- The vehicle must spin up the drivetrain to 50 rpm, then trigger the EBS system thus setting the VCU state to 'AS Emergency'.

IN2.3 Autonomous Demonstration Mission Inspection

IN2.3.1 Each DDT entries Team must demonstrate that their software is capable of completing an Autonomous Demonstration Mission to the satisfaction of a Formula Student Scrutineer before completing any dynamic events.

IN2.3.2 The Autonomous Demonstration Mission Inspection is completed as follows:

- The Team will load their software onto the ADS-DV AI computer and, if they have requested to use additional sensors, fit their approved sensor assembly.
- The vehicle will be placed between a series of cones similar to the acceleration event.

- The Mission Type 'Autonomous Demo' will be selected and executed using the RES 'Go' signal.
- The vehicle must sweep the steering left and right and return to straight.
- The vehicle must accelerate for 10m to at least 15kph.
- The vehicle must stop within a further 10m.
- The vehicle must accelerate for a further 10m to at least 15kph.
- The vehicle must deploy the EBS.
- The vehicle must stay within the cones.

SECTION S – STATIC EVENTS

Section S of the main Formula Student UK 2024 rules does not apply to Teams competing in the FS-AI competition. This Static Events rule set will be employed for both ADS and DDT entries.

S1 STATIC EVENT NO-SHOW PENALTY

S1.1.1 Where a team fails to notify officials by the date and time specified in the competition handbook that they are unable to attend their scheduled static event session the organisers may apply a points penalty of a maximum of (negative) 100 points per absent notification. This will be applied to a team's overall event score. For the avoidance of doubt this is additional to any specified penalty applicable for non-attendance at a scheduled static event session.

S2 BUSINESS PLAN PRESENTATION EVENT – ADS entries AND DDT entries

S2.1 Business Plan Presentation Event Objective

S2.1.1 The objective of the Business Plan Presentation (BPP) event is to evaluate the team's ability to develop and deliver a comprehensive business case that meets the brief as described below.

S2.1.2 The event is a role play and teams should present themselves as employees of a company rather than as students.

S2.1.3 The judges should be treated as if they were potential investors or partners for the presented business model. Teams should assume that the "executives" represent different areas of a corporate organisation, including engineering, production, marketing and finance, and thus may not all be engineers.

S2.1.4 FS-AI teams must assume that they have been approached to tender for an AI system which is to go into production within 24 months. The AI system is for a new Autonomous Driving System Vehicle which operates at SAE level 4 in a city centre environment moving people from the outskirts of the city centre into the heart of the city centre on defined routes.

S2.1.5 Teams must present a BPP which covers

a) The development of a suitable AI system (computer, sensors and software) including costs, timing and resources to fulfil the objective.
b) Development of the production process and production line to produce AI systems which are mechanically configured to be fitted directly to the vehicle.
c) Details on the final production AI system delivered to the vehicle assembly plant at a production rate that the team may select but it must be >50 units per year and include any key information to enable your team to win the tender.

S2.2 Business Plan Presentation Schedule

S2.2.1 Judging of Business Plan Presentations will be made on the static events days. Presentation times will be published in the event schedule. Teams are reminded that the BPP judging will be held in the BPP judging rooms, NOT at your display area.

S2.2.2 Teams arriving more than eleven (11) minutes late to their assigned BPP judging slot will be deemed to have missed their assigned time period and will receive zero (0) points for the event.

S2.3 Business Plan Presentation Format

S2.3.1 One or more team members will present to the judges.

S2.3.2 All team members who will deliver any part of the presentation, or who will respond to the judges' questions, must be present when the presentation starts and must be introduced to the judges. Team members present for the Business Plan Presentation may answer questions even if they did not speak during the presentation itself.

S2.3.3 Presentations are limited to a maximum of ten (10) minutes. Penalties will be imposed if the presentation is less than nine (9) minutes or exceeds eleven (11) minutes. Teams will be asked to rapidly conclude their presentation if they overrun significantly.

S2.3.4 The presentation itself will not be interrupted by questions. Immediately following the presentation there will be a question and answer session of up to five (5) minutes.

S2.3.5 Only judges may ask questions. Only team members present for the Business Plan Presentation may answer the judges' questions.

S2.3.6 Teams giving a PowerPoint or similar style presentation are required to provide an electronic copy of their slides using a USB drive provided by the judges at the time of the BPP.

S2.3.7 Access to an internet connection during the initial or final judging cannot be guaranteed.

S2.3.8 The judging sessions may be filmed by BPP judges.

S2.3.9 LCD / Plasma TV-style screens or video projectors will be provided by the organisers but teams should bring their own laptop computers and may use their own projectors if they wish. The screens / projectors will have HDMI and VGA Input Connectors. Teams are responsible for the compatibility of their computer equipment and setting up of the screens. Overseas teams should ensure they have UK compatible power leads / adaptors.

S2.4 Business Plan Presentation Evaluation Criteria

S2.4.1 The presentation will be evaluated against the following categories:

- Content
- Visual Aids
- Delivery
- Q&A

S2.4.2 The criteria are applied only to the team's presentation itself. The team that makes the best presentation, regardless of the quality of their entry, will win the event.

S2.4.3 Content marks will only be awarded for the information presented to the judges. Printed material to support this is allowable but must:

- Be referred to within the presentation.
- Be limited to a maximum of eight (8) sides of A4 paper. Decorative covers are excluded from this page count.

S2.5 Business Plan Presentation Scoring Formula

S2.5.1 The maximum points from the Business Plan Presentation event is 100.

S2.5.2 The Business Plan Presentation scores will be normalised such that the highest scoring presentation scores 100 points towards the overall competition score, all other teams will be awarded points on a pro-rata basis.

BUSINESS PLAN PRESENTATION SCORE = (100) x Pyour / Pmax

Where:

- "Pmax" is the highest score awarded to any team
- "Pyour" is the score awarded to your team

S3 AUTONOMOUS DESIGN EVENT - ADS entries AND DDT entries

S3.1 Autonomous Design Event Objective

S3.1.1 The concept of the design event is to evaluate the student's engineering process and effort that went into the design and development of the AI system, its vehicle integration and [ADS entries Only] Autonomous Driving System (ADS), meeting the intent of the competition.

S3.1.2 The design event will focus on what the team have achieved, but some evaluation will be made on the team's understanding of the vehicle and the algorithms deployed in their software.

S3.2 [ADS entries Only] Engineering Design Report (EDR) and Design Spec Sheet (DSS)

S3.2.1 ADS entries teams should refer to the main Formula Student UK 2024 Rules Sections S5.2 and S5.3 for details of the EDR and DSS documents.

S3.3 Autonomous Design Report (ADR)

S3.3.1 The ADR will be used to sort the teams into appropriate design queues, based on the quality of its review.

S3.3.2 The ADR should contain a description of the AI computer, the selected sensors and the software developed to perform the Dynamic Driving Task. A high level diagram explaining the software structure should be included. Any information to scope, explain or highlight design features, concepts, methods or objectives to express the value and performance of the autonomous system to the judges shall be included at the team's discretion.

S3.3.3 Evidence of information mentioned in the ADR should be brought to the competition and be available, on request, for review by the judges.

S3.3.4 The ADR must not exceed five pages of content (text, which may include pictures and graphs).

S3.3.5 Any portions of the ADR that exceeds five pages of content will not be evaluated.

S3.3.6 The ADR must be written as a scientific paper.

S3.3.7 The ADR must be submitted by the deadline defined in the Key Dates Document.

S3.4 Autonomous Design Judging Procedure

S3.5.1 [ADS entries Only] Teams will present their vehicle to the judges. The judges shall inspect the vehicle and discuss the vehicle design with the team to determine if the design concepts are adequate and appropriate for the application.

S3.5.2 [DDT entries Only] Teams will have a presentation room with LCD display available. They may present a fifteen (15) minute presentation at the start of the event or present posters of their software design and simulation. There will be a further fifteen (15) minutes to discuss the content of their presentation.

S3.5.3 Teams need to show some simulation test data, where the judges can see how the algorithms work and access to the software and algorithms must be provided.

Hint. IPG Automotive's CarMaker is available to all teams for FREE (virtual test driving software widely used by industry leaders), a model package has been specifically developed for the FSAI competition.

S2.5.4 Some teams may be chosen to participate in the Design Finals to determine the engineering design event winner. The design finals will be held separately from the initial judging and teams will be informed about their participation during the event. Teams are not required to prepare any material for the Design Finals and are not permitted to bring any materials to present.

S2.5.5 For the Design Finals, ADS entries are required to bring along their vehicle. For DDT entries, an FS-AI DDT vehicle will be present.

S3.5.6 Teams may bring any photographs, drawings, charts, spare parts or other material that they believe are supportive to the design event, but the space provided for design judging may be limited.

S3.6 Autonomous Design Judging Criteria

S3.6.1 The judges will evaluate the engineering effort based upon the team's ADR, the engineering presentation and responses to questions.

S3.6.2 The judges will review the software and AI system to determine if the design concepts are adequate and appropriate for the application. The judges are looking for detailed understanding in areas such as the following topics: design of their software, integration of compute platform and sensors, design of any scale vehicles they have built, and topics such as functional safety as required to develop the software for an autonomous vehicle.

S3.6.3 The judges may deduct points if the team cannot adequately explain the engineering of the AI system.

S3.6.4 Teams are encouraged to not spend much time discussing simulation, as this is discussed in detail in their Simulation Development presentations. It may be mentioned as part of the discussion of the integration and development process of their system.

S3.7 Autonomous Design Scoring

AUTONOMOUS DESIGN SCORE = (150) x Pyour / Pmax

Where:

- "Pmax" is the highest score awarded to any team
- "Pyour" is the score awarded to your team

S4 REAL WORLD AI EVENT - ADS entries AND DDT entries

S4.1 Real World AI Event Objective

S4.1.2 The Real World AI event is predominantly a technical event and will focus primarily on the team's understanding of the real world challenges for autonomous vehicles.

S4.1.1 The objective of the Real World AI event is to evaluate the team's understanding of the challenges to be overcome in order that an autonomous vehicle may operate on existing and future road networks, and present a creative analysis of how the current and future industry is looking to solve these problems.

S4.1.2 Half of the Real World AI presentation marks will be awarded for analysis on a minimum of 3 topics such as (but not limited to):

- Other road users including vehicles and pedestrians and other obstacles
- Inclement weather (snow, rain, ice etc)
- Any aspects of connectivity including V2V and V2I technology.
- Functional safety requirements for autonomous vehicles
- The wider philosophy and socioeconomic consequences of a driverless world including ethical and legal issues
- Sensor suite option evaluations

The other half of the presentation marks will be awarded for a detailed analysis of a specific case study. This case study topic for 2024 is **'Is the world ready for Level 4 autonomous vehicles deployed on public roads?'**

Teams must analyse two or more **countries** around the world and critically evaluate their **legislation, society and technology readiness for driver-out vehicles** to be deployed on public roads. Marks will be awarded for analysing the challenges facing the industry and society.

S4.1.3 The team should focus on the challenges that would be faced for the ADS vehicle to meet SAE Level 4 and can comment on the additional challenges in order to achieve Level 5.

S4.1.4 Presentations will be evaluated on content, organisation and visual aids as well as the presenters' delivery and the team's overall knowledge and response to questions.

S4.2 Real World AI Presentation Schedule

S4.2.1 Judging of the Real World AI presentation will be made on the static events days. Presentation times will be published in the event schedule. Teams are reminded that the Real World AI judging will be held in a designated area, NOT at your display area.

S4.2.2 Teams arriving more than eleven (11) minutes late to their assigned Real World AI judging slot will be deemed to have missed their assigned time period and will receive zero (0) points for the event.

S4.3 Real World AI Presentation Format

S4.3.1 One or more team members will give the presentation to the judges.

S4.3.2 All team members who will deliver any part of the presentation, or who will respond to the judges' questions, must be present when the presentation starts and must be introduced to the judges. Team members present for the Real World AI event may answer questions even if they did not speak during the presentation itself.

S4.3.3 Presentations are limited to a maximum of fifteen (15) minutes. Penalties will be imposed if the presentation exceeds sixteen (16) minutes. Teams will be asked to rapidly conclude their presentation if they overrun significantly.

S4.3.4 The presentation itself will not be interrupted by questions. Immediately following the presentation there will be a question and answer session of up to fifteen (15) minutes.

S4.3.5 Only judges may ask questions. Only team members present for the Real World AI events may answer questions.

S4.3.6 Teams giving a PowerPoint or similar style presentation are required to provide an electronic copy of their slides using a USB drive provided by the judges at the time of the Real World AI event.

S4.3.7 Access to an internet connection during the initial or final judging cannot be guaranteed.

S4.3.8 The judging sessions may be filmed by Real World AI judges.

S4.3.9 There will be no 'Final' for the Real World AI event.

S4.3.10 LCD / Plasma TV-style screens or video projectors will be provided by the organisers, but teams should bring their own laptop computers and may use their own projectors if they wish. The screens / projectors will have HDMI and VGA Input Connectors. Teams are responsible for the compatibility of their computer equipment and setting up of the screens. Overseas teams should ensure they have UK compatible power leads / adaptors.

S4.4 Real World AI Evaluation Criteria

S4.4.1 Forty (40) % of the marks are allocated to content, twenty (20) % of the marks are allocated to organisation, visual aids, delivery and forty (40) % of the marks are allocated to the Q&A session.

S4.4.2 The criteria are applied to the team's presentation and the team's understanding of the subject material.

S4.5 Real World AI Scoring Formula

S4.5.1 The maximum points from the Real World AI event is 100.

S4.5.2 The Real World AI scores will be normalised such that the highest scoring presentation scores 100 points towards the overall competition score, all other teams will be awarded points on a pro rata basis.

REAL WORLD AI SCORE = (100) x Pyour/Pmax

Where:

- "Pmax" is the highest score awarded to any team
- "Pyour" is the score awarded to your team

S5 SIMULATION DEVELOPMENT EVENT - ADS entries AND DDT entries

S5.1 Simulation Development Event Objective

S5.1.1 The purpose of this event is to evaluate the student's understanding of simulation within the autonomous vehicle development workflow, and demonstrate their self-driving algorithms in detail, especially while teams cannot access physical hardware.

S5.1.2 The teams are required to simulate at least 1 dynamic event out of the Acceleration, Skidpad and Track Drive events with a virtual vehicle, either the IMechE ADS-DV or the team's own Formula Student ADS entries vehicle.

S5.1.3 Teams are free to use whatever simulation software they choose. Development of their own sensor models, environments and vehicle models will be rewarded. Detailed understanding of pre-made or open-source models and environments will also be rewarded. Simulating more than one dynamic event will be rewarded. Vehicle performance (i.e. laptime) won't be directly rewarded or compared.

Hint. IPG Automotive's CarMaker is available to all teams for FREE (virtual test driving software widely used by industry leaders), a model package has been specifically developed for the FSAI competition.

Topics judges would like to see covered include, but are not limited to:

- Digital twin environments and environmental factors (i.e. weather)
- Perception and localisation algorithm development

- Vehicle models and dynamics analysis
- FS-AI Mission Control implementation
- Further software stack development, including path planning and vehicle controls (driver models)
- Debugging and visualisation tools
- Integration of the vehicle interface with simulated vehicle actuator controller(s)
- Correlation and validation methodologies (noise factors, etc)
- Data analysis methodologies
- How does simulation development inform real-world testing?

Teams of all levels of simulation development are encouraged to enter. To help get teams started, Edinburgh University Formula Student Team have kindly open-sourced their Gazebo simulator here:

https://gitlab.com/eufs/eufs_sim

S5.2 Simulation Development Presentation Schedule

S5.2.1 Judging of Simulation Development Presentations will be made on the static events days. Presentation times will be published in the event schedule.

S5.2.2 Teams arriving more than eleven (11) minutes late to their assigned Simulation Development judging slot will be deemed to have missed their assigned time period and will receive zero (0) points for the event.

S5.3 Simulation Development Presentation Format

S5.3.1 One or more team members will present to the judges.

S5.3.2 All team members who will deliver any part of the presentation, or who will respond to the judges' questions, must be present when the presentation starts and must be introduced to the judges. Team members present for the Simulation Development Presentation may answer questions even if they did not speak during the presentation itself.

S5.3.3 Presentations are limited to a maximum of fifteen (15) minutes. Penalties will be imposed if the presentation exceeds sixteen (16) minutes. Teams will be asked to rapidly conclude their presentation if they overrun significantly.

S5.3.4 The presentation itself will not be interrupted by questions. Immediately following the presentation there will be a question and answer session of up to fifteen (15) minutes.

S5.3.5 Only judges may ask questions. Only team members present for the Simulation Development Presentation may answer the judges' questions.

S5.3.6 Teams giving a PowerPoint or similar style presentation are required to provide an electronic copy of their slides using a USB drive provided by the judges at the time of the Simulation Development event.

S5.3.7 Access to an internet connection during the initial or final judging cannot be guaranteed.

S5.3.8 The judging sessions may be filmed by Simulation Development judges.

S5.3.9 LCD / Plasma TV-style screens or video projectors will be provided by the organisers but teams should bring their own laptop computers and may use their own projectors if they wish. The screens / projectors will have HDMI and VGA Input Connectors. Teams are responsible for the compatibility of their computer equipment and setting up of the screens. Overseas teams should ensure they have UK compatible power leads / adaptors.

S5.4 Simulation Development Evaluation Criteria

S5.4.1 The presentation will be evaluated against the following categories:

- Content
- Visual Aids
- Delivery
- Q&A

S5.5 Simulation Development Scoring Formula

S5.5.1 The maximum points from the Simulation Development Presentation event is 100.

S5.5.2 The Simulation Development Presentation scores will be normalised such that the highest scoring presentation scores 100 points towards the overall competition score, all other teams will be awarded points on a pro-rata basis.

SIMULATION DEVELOPMENT PRESENTATION SCORE = (100) x Pyour/Pmax

Where:

- "Pmax" is the highest score awarded to any team
- "Pyour" is the score awarded to your team

SECTION D – DYNAMIC EVENTS

Section D of the main Formula Student UK 2024 rules does not apply to Teams competing in the FS-AI competition. However, where possible common rules have been adopted and therefore have been numbered accordingly. This Dynamic Events rule set will be employed for both ADS and DDT entries.

D1 DYNAMIC EVENTS GENERAL

The Dynamic Section Rules have been made in collaboration with Motorsport UK Yearbook and in compliance with their issued permit for the FSUK Event.

D1.1 [DDT entries Only] IMechE ADS-DV Sharing Protocol

D1.1.1 Where Teams are sharing the IMechE ADS-DV vehicle they will be expected to comply with the Shared ADS-DV Protocol document published separately on the Formula Student website. This document outlines changeover procedures, responsibilities and penalties for impeding other teams' use of the vehicle.

D1.1.2 Should it be deemed necessary, the Event Captain may amend the Sharing Protocol at any time during the competition to deal with operational situations such as weather or mechanical breakdowns.

D1.2 Dynamic Area and Dynamic Vests

D1.2.1 The definition of the Dynamic Area and the allocation and usage of the Dynamic Vests (including the specific ASR vest) will be communicated by the Event Captain during each Event Briefing. Unless advised otherwise by the Event Captain only the ASR shall be allowed in the dynamics event area while a vehicle is in autonomous mode.

D1.3 Presentation at the Event Start Area

D1.3.1 When driving autonomously, an ASR must introduce themselves to the officials and be present at the event start area with the Remote Emergency System (RES). Additionally, one single monitoring device (laptop, tablet, ...) may be brought. This device will not be permitted to transmit commands or data to the vehicle and the officials may request that any devices are disabled during an Autonomous Driving event.

D2 AUTONOMOUS DRIVING RULES

D2.4 Practice Track

D2.4.1 A practice track for testing and tuning vehicles will be available. Track opening times will be subject to operational constraints such as availability of officials and marshals.

D2.4.2 To use the practice track, vehicles must have passed all technical inspections.

D2.4.3 For the duration of the event, practice or testing at any location other than the practice track is absolutely forbidden.

D2.5 Cones & Markings

D2.5.1 Details of the cones used, and more detailed track layout figures, can be found in a specific document 'FS-AI Dynamic Events Setup and Cones Specification' available on the IMechE Formula Student website.

D2.6 Start-up Procedure DV Running

D2.6.1 No additional equipment (e.g. laptop, jack-up device, pressure tank, etc.) is allowed to start up the vehicle at the staging / starting line.

D2.6.2 If the vehicle does not enter "AS Ready" state within 1 minute after being staged, the team may be sent back to the preparation area by the officials.

D2.6.3 The vehicle may only be staged with the steering system in straight position.

D2.6.4 The vehicle may be pushed from the preparation area to the start line with activated LVS.

D2.6.5 The EBS and / or ASB may be energised / armed already in the preparation area.

D2.6.6 The ASMS may only be switched on by the ASR after approval from an official at the starting line.

D2.6.7 There will be a time limit for the run to start after the "Go" signal is sent, communicated to the teams by the Event Captain.

D2.7 Vehicle Break Downs and Usage of RES during DV Running

D2.7.1 [ADS entries Only] Stalling the engine or deactivating the Tractive System (TS) for any reason during a dynamic event will result in Did Not Finish (DNF) as the autonomous system is not allowed to restart the engine / reactivate the TS.

D2.7.1 [DDT entries Only] Deactivating the TS by the AI computer during a dynamic event will result in DNF as the autonomous system is not capable of reactivating the TS.

D2.7.2 If a vehicle comes to a standstill for any reason, it may have up to 30s to attempt to continue to drive. If the vehicle doesn't restart within 30s, it will be deactivated using the RES, deemed disabled and scored as DNF for the run.

D2.7.3 When the vehicle is driving in autonomous mode, one ASR must be present with the Event Captain to operate the RES remote control.

D2.7.4 The ASR or the officials may stop the vehicle using the RES in any of the following cases:

- Its behaviour seems to be uncontrolled (e.g. driving off-course).
- It is mechanically or electrically damaged.
- It is driving too slowly.
- To ensure safe conditions on the track (e.g. persons or animals on the track). In this case the team will be given a re-run.

D2.7.5 If a vehicle breaks down or is stopped by the use of the RES it will be removed from the track, will not be able to re-enter the track and scored DNF. [DDT entries Only] In the event of a fault with a shared IMechE ADS-DV a re-run may be permitted at the discretion of the Event Captain, dependent upon the nature of the break down.

D2.7.6 If a traceable signal loss of the RES appears and doubtless proof can be brought by the team that it is was not self-inflicted, a re-run may be granted.

D2.7.7 At the direction of the officials, team members may be instructed to retrieve broken-down vehicles. This recovery may only be done under the control of the officials.

D2.8 Procedure After Completing a DV Dynamic Event

D2.8.1 [ADS entries Only] The vehicle must be collected by the ASR and an additional team member immediately after approval from the officials.

D2.8.1 [DDT entries Only] The officials will deal with recovery of the vehicle. The ASR may be requested to assist.

D3 WEATHER CONDITIONS

D3.1 Operating Conditions

D3.1.1 The following track conditions are recognised:

- Dry
- Damp
- Wet

D3.1.2 The operating condition is decided by the officials and may change at any time.

D3.1.3 [ADS entries Only] The current operating condition will be communicated to the ASR by the Event Captain and events may be postponed, re-scheduled or cancelled dependent upon the vehicle capability to operate safely in Damp or Wet conditions.

D3.1.4 [DDT entries Only] Shared IMechE ADS-DVs will not be permitted to run in conditions of falling rain or standing water sufficient to generate spray from the tyres. The Event Captain may postpone, re-schedule or cancel events as required.

D4 SKIDPAD EVENT

D4.1 Skidpad Track Layout

D4.1.1 The Skidpad track consists of two pairs of concentric circles in a figure of eight pattern.

D4.1.2 The centres of these circles are 18.25 m apart. The inner circles are 15.25 m in diameter and the outer circles are 21.25 m in diameter.

D4.1.3 16 cones are placed around the inside of each inner circle. 13 cones are positioned around the outside of each outer circle, in the pattern shown in the Skidpad layout diagram.

D4.1.4 Each circle is marked with a line, outside the inner circle and inside the outer circle.

D4.1.5 The driving path is the 3 m wide path between the inner and outer circles. The vehicles enter and exit through gates on a 3 m wide path that is tangent to the circles where they meet.

D4.1.6 The line between the centres of the circles defines the start / finish line. A lap is defined as traveling around one of the circles, starting and ending at the start / finish line.

D4.3 Skidpad Procedure

D4.3.1 Each team has at least two runs. The procedure for any additional runs beyond 2 will be communicated by the Event Captain at the Event Briefing.

D4.3.2 Running order is based upon time of arrival and [DDT entries Only] the most efficient use of IMechE Shared vehicles, at the discretion of the Event Captain. Teams on their first run will usually receive priority. Priority will be given to the team with fewer runs.

D4.3.3 Staging - The foremost part of the vehicle is staged 15m before the timekeeping line.

D4.3.4 Starting - A Go-signal from the RES is used to indicate the approval to begin, timing starts only after the foremost part of the vehicle crosses the starting line and stops after the foremost part of the vehicle crosses the finish line.

D4.3.5 The vehicle will enter perpendicular to the figure eight and will take one full lap on the right circle to establish the turn. The next lap will be on the right circle and will be timed. Immediately following the second lap, the vehicle will enter the left circle for the third lap. The fourth lap will be on the left circle and will be timed. Immediately upon finishing the fourth lap, the vehicle will exit the track.

D4.3.6 The vehicle will exit at the intersection moving in the same direction as entered and must come to a full stop within 25m after crossing the timekeeping line, inside the marked exit lane and enter the 'AS Finished' state.

D4.3.7 Penalties will be recorded according to section D9 from the Go signal until the vehicle either enters the 'AS Finished' state or is stopped using the RES.

D4.4 Skidpad Scoring

D4.4.1 The run time is the average time of the timed left and the timed right circle plus penalties which are added after the averaging.

D4.4.2 25 points are awarded to every team that finishes at least one run without a DNF.

D4.4.4 If a team's run time including penalties is below Tmax, additional points based on the following formula are given:

$$SKIDPADSCORE = 75\left(\frac{\left(\frac{T_{max}}{T_{team}}\right)^2 - 1}{\left(\frac{T_{max}}{T_{min}}\right)^2 - 1}\right)$$

T_{team} is the team's best run time including penalties.
T_{min} is the fastest vehicle run time including penalties.
T_{max} is 200% of the fastest vehicle time including penalties.

D5 ACCELERATION EVENT

D5.1 Acceleration Track Layout

D5.1.1 The acceleration track is a straight line with a length of 75m from starting line to finish line. The track is at least 3m wide. Cones are placed along the track at intervals of about 5m. Cone locations are not marked on the pavement.

D5.3 Acceleration Procedure

D5.3.1 Each team has at least two runs. The procedure for any additional runs beyond 2 will be communicated by the Event Captain at the Event Briefing.

D5.3.2 Running order is based upon time of arrival and [DDT entries Only] the most efficient use of IMechE Shared vehicles, at the discretion of the Event Captain. Teams on their first run will usually receive priority. Priority will be given to the team with fewer runs.

D5.3.3 Staging - The foremost part of the vehicle is staged at 0.30m before the starting line. Vehicles will accelerate from a standing start.

D5.3.4 Starting - A Go-signal from the RES is used to indicate the approval to begin, timing starts only after the foremost part of the vehicle crosses the starting line and stops after the foremost part of the vehicle crosses the finish line.

D5.3.5 If the vehicle has gone off-course it will be allowed to continue until such point as the ASR or the Event Captain or supervising Formula Student Official deems the situation to be beyond recovery or dangerous.

D5.3.6 After crossing the finish line, the vehicle must come to a full stop within 100m inside the marked exit lane and enter the 'AS Finished' state.

D4.3.7 Penalties will be recorded according to section D9 from the Go signal until the vehicle either enters the 'AS Finished' state or is stopped using the RES.

D5.4 Acceleration Scoring

D5.4.1 25 points are awarded to every team that finishes at least one run without a DNF.

D5.4.3 If a team's best time including penalties is below Tmax additional points based on the following formula are given:

$$ACCELERATION\ SCORE = 75\left(\frac{\frac{T_{max}}{T_{team}} - 1}{\frac{T_{max}}{T_{min}} - 1}\right)$$

T_{team} is the team's best time including penalties.
T_{min} is the fastest vehicle time.
T_{max} is 200% of the fastest vehicle time.

D6 AUTOCROSS / SPRINT

D6.1 Autocross Track Layout

D6.1.1 The Autocross track layout for DDT and ADS entries is a handling track built to the following guidelines:

- Straights: No longer than 80m
- Constant Turns: up to 50m diameter
- Hairpin Turns: Minimum of 9m outside diameter (of the turn)
- Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc.
- The minimum track width is 3m

D6.3 Autocross Procedure

D6.3.1 There will be a track walk prior to the Autocross. During the track walk no equipment (e.g. antennas, sensors, cameras, GPS loggers, etc) other than analogue measurement devices (i.e. measurement wheel or measurement tape) is allowed.

D6.3.2 Using data collected in a previous run is not permitted for the autocross event. The teams may be asked to prove to a scrutineer or official that any collected data has been deleted before a new run is staged.

D6.3.3 Each team has at least two runs consisting of one single lap. The procedure for any additional runs beyond 2 will be communicated by the Event Captain at the Event Briefing.

D6.3.4 Running order is based upon time of arrival and [DDT entries Only] the most efficient use of IMechE Shared vehicles, at the discretion of the Event Captain. Teams on their first run will usually receive priority. Priority will be given to the team with fewer runs.

D6.3.5 Staging - The vehicle is staged such that the front wheels are 6m before the starting line on the track.

D6.3.6 Starting - A Go-signal from the RES is used to indicate the approval to begin. Timing starts after the foremost part of the vehicle crosses the starting line and stops after the foremost part of the vehicle crosses the finish line.

D6.3.7 After the run the vehicle must come to a full stop within 30m after the finish line on the track and enter the 'AS Finished' state.

D6.3.8 Penalties will be recorded according to section D9 from the Go signal until the vehicle either enters the 'AS Finished' state or is stopped using the RES.

D6.5 Autocross Scoring

D6.5.1 25 points are awarded to every team that finishes at least one run without DNF or DQ.

D6.5.2 If a team's best time including penalties is below Tmax, additional points based on the following formula are given:

$$AUTOCROSSSCORE = 75 \left(\frac{\frac{T_{max}}{T_{team}} - 1}{\frac{T_{max}}{T_{min}} - 1} \right)$$

T_{team} is the team's best time including penalties.
T_{min} is the fastest vehicle time.
T_{max} is 200% of the fastest vehicle time.

D8 TRACKDRIVE

D8.1 Trackdrive Track layout

D8.1.1 The Trackdrive layout for DDT and ADS entries is a closed loop circuit built to the following guidelines:

- Straights: No longer than 80m
- Constant Turns: up to 50m diameter
- Hairpin Turns: Minimum of 9m outside diameter (of the turn)
- Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc.
- The minimum track width is 3m

D8.1.2 The Trackdrive circuit may not be the same layout as the Autocross / Sprint circuit, at the discretion of the Event Captain or Formula Student UK Committee.

D8.2 Trackdrive Procedure

D8.2.1 There will be a track walk prior to the trackdrive. During the track walk no equipment (e.g. antennas, sensors, cameras, GPS loggers, etc) other than analogue measurement devices (i.e. measurement wheel or measurement tape) is allowed.

D8.2.2 Running order is set at the Event Captain's discretion, considering the most efficient use of shared vehicles and previous performance results for Autocross / Sprint.

D8.2.3 There is no requirement for the fuel level to be set before the event.

D8.2.4 There will be at least one run consisting of ten laps. The number of runs and the starting order procedure will be announced before the start of the event. Any further runs must not use data stored, track or dynamic performance information gathered from a previous run and evidence may be requested that previous information has been deleted.

D8.2.5 Staging - The vehicle is staged such that the front wheels are 6m before the starting line on the track.

D8.2.6 Starting - A Go-signal from the RES is used to indicate the approval to begin. Timing starts after the foremost part of the vehicle crosses the starting line and stops after the foremost part of the vehicle crosses the finish line on the last lap.

D8.2.7 After ten laps the vehicle must come to a full stop within 30m after crossing the finish line on the track and enter the 'AS Finished' state.

D8.2.8 There will be no last lap signal sent to the vehicle, the vehicle should count laps itself autonomously.

D8.2.9 Cones that are Down or Out (DOO) are not replaced / reset during the run. There will be no re-run due to cones in the driving path or disorientation due to missing cones.

D8.2.10 Penalties will be recorded according to section D9 from the Go signal until the vehicle either enters the 'AS Finished' state or is stopped using the RES.

D8.4 Trackdrive Scoring

D8.4.1 Each lap of the Trackdrive event is individually timed. The corrected elapsed time is determined by adding any penalty times.

D8.4.3 Ten (10) points are awarded for every completed lap, independent of the corrected elapsed time. This is also applied for teams that do not finish the Trackdrive i.e. get a DNF.

D8.4.5 If a team's best time including penalties is below Tmax additional points based on the following formula are given:

$$TRACKDRIVE\ SCORE = 150\left(\frac{\frac{T_{max}}{T_{team}} - 1}{\frac{T_{max}}{T_{min}} - 1}\right)$$

T$_{team}$ is the team's best time including penalties.
T$_{min}$ is the fastest vehicle time.
T$_{max}$ is 200% of the fastest vehicle time.

D9 DYNAMIC EVENTS PENALTIES

D9.1 General Penalties

D9.1.1 Penalties will not be assessed for accident avoidance or other reasons deemed sufficient by the officials.

D9.1.2 A cone is Down or Out (DOO) if the cone has been knocked over or the entire base of the cone lies outside the box marked around the cone in its undisturbed position.

D9.1.3 Cones that are DOO are not replaced / reset during a run. There will be no re-run due to cones in the driving path or disorientation due to missing cones.

D9.1.4 The DOO penalty (see D9.1.7) is added for each DOO including entry and exit gate cones before the start and after the finish line, that occur on that particular run.

D9.1.5 An Off-course (OC) occurs when the vehicle has all four wheels outside the track boundary as indicated by the perimeter cones.

D9.1.6 An Unsafe Stop (USS) is defined as not stopping within the specified area and / or not entering the 'AS Finished' state. In this case only points for lap completions will be awarded.

D9.1.7 Penalty table:

	Acceleration	Skidpad	Autocross	Trackdrive
DOO	2s	0.2s	2s	2s
OC	DNF	DNF	10s	10s
USS	DNF	DNF	DNF	−50 points

D9.1.8 DNF equals zero points for that run.

D9.1.9 DQ equals zero points for that run.

D9.1.10 If a team Did Not Attempt (DNA) an event the score is zero points.

D9.1.11 Each run with an incorrect number of laps at Skidpad is classed as DNF.