

PAS 1884:2021

Safety operators in automated vehicle testing and trialling – Guide



Centre for Connected
& Autonomous Vehicles



bsi
Documents
Document Sharing Hub

Publishing and copyright information

The BSI copyright notice displayed in this document indicates when the document was last issued.

© The British Standards Institution 2021.

Published by BSI Standards Limited 2021.

ISBN 978 0 539 15147 3

ICS 03.220.20, 43.020

No copying without BSI permission except as permitted by copyright law.

Publication history

First published November 2021

Contents

Foreword	ii
0 Introduction	iv
1 Scope	1
2 Normative references	2
3 Terms, definitions and abbreviations	3
4 Responsibilities of the trialling organization and safety operator	8
5 Safety operator selection, fitness to drive and experience	11
6 Safety operator training	14
7 Safety operator skills testing and refresher training	24
8 Training and performance records	26
Bibliography	28

Foreword

This PAS was sponsored by the Centre for Connected and Autonomous Vehicles (CCAV). Its development was facilitated by BSI Standards Limited and it was published under licence from The British Standards Institution. It came into effect on 30 November 2021.

Acknowledgement is given to Chris Fordham of TRL and Tony Pipe, as the technical authors, and the following organizations that were involved in the development of this PAS as members of the steering group:

- Altelium Ltd
- Arrival Ltd
- Burges Salmon LLP
- CAT Driver Training Ltd
- Centre for Connected and Autonomous Vehicles (CCAV)
- Co-opted Member
- DG Cities Ltd
- Driver and Vehicle Standards Agency (DVSA)
- FirstGroup Plc
- Fusion Processing Ltd
- Horiba MIRA
- JC Bamford Ltd
- Metropolitan Police Service
- Millbrook
- Oxbotica Ltd
- Oxford Bus Company
- Oxfordshire County Council
- Pinsent Masons
- Stagecoach Group
- StreetDrone Ltd
- Thatcham
- Transport for Greater Manchester
- TRL
- Vehicle Certification Agency (VCA)
- Wayve Technologies Ltd
- WMG, University of Warwick

Acknowledgement is also given to the members of a wider review panel who were consulted in the development of this PAS.

The British Standards Institution retains ownership and copyright of this PAS. BSI Standards Limited as the publisher of the PAS reserves the right to withdraw or amend this PAS on receipt of authoritative advice that it is appropriate to do so. This PAS will be reviewed at intervals not exceeding two years.

This PAS is not to be regarded as a British Standard. It will be withdrawn upon publication of its content in, or as, a British Standard.

The PAS process enables a guide to be rapidly developed in order to fulfil an immediate need in industry. A PAS can be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

Relationship with other publications

PAS 1884 has been developed as part of a wider programme sponsored by CCAV in conjunction with the Department for Transport (DfT), Innovate UK and Zenic to develop a suite of standardization products to promote the safe testing and deployment of automated vehicles in the UK and inform wider international standardization activity.

PAS 1884 is intended to be read in conjunction with:

- the related BSI PAS Connected and Automated Vehicles (CAV) series (PAS 1880, PAS 1881, PAS 1882, PAS 1883 and BSI Flex 1890) and the UK Government Code of Practice for automated vehicle training [N1];
- existing legislation for UK vehicles and roads.

Information about this document

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

The cover image of PAS 1884 is a modified version of an image on which copyright is claimed. Copyright owner of this image is Oxbotica Ltd.

Use of this document

As a Guide, this PAS takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice.

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The guidance in this PAS is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. "organization" rather than "organisation").

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

Compliance with a Publicly Available Specification cannot confer immunity from legal obligations.

In particular, attention is drawn to the following non-exhaustive list of specific regulations:

- The Automated and Electric Vehicles Act 2018 [1];
- The Data Protection Act 2018 [2];
- EU Regulation 2019/2144 [3];
- EU Directive 2010/40 [4];
- The Road Traffic Act 1988 [5];
- The Motor Vehicles (Driving Licences) Regulations 1999 [6];
- Rehabilitation of Offenders Act 1974 [7];
- The Public Service Vehicles (Conduct of Drivers, Inspectors, Conductors and Passengers) Regulations 1990 [8];
- Equality Act 2010 [9];
- Health and Safety at Work etc. Act 1974 [10];
- The Management of Health and Safety at Work Regulations 1999 [11].

0 Introduction

The UK Government is committed to investing in automated vehicle technology, research and innovation to explore the potential benefits these technologies could bring to industry and society. Testing and trialling automated vehicle technologies in a scenario or set of scenarios is therefore a crucial step to achieve this objective.

The use of a suitably licenced and trained safety operator is a widely-used means to manage risks within automated vehicle tests or trials on public or private roads or land. The safety operator is responsible for the safe operation of the subject vehicle, either from inside or in visual line of sight, and is required to continuously supervise the subject vehicle during automated vehicle tests or trials. It is therefore critical to have a standardized approach to safety operator selection and training to ensure a consistent level of safety. It is also noteworthy that some elements of safety operator training can be done in-house but it is important to have test or trial-specific training on the subject vehicle and route. Good practice is for trialling organizations to also implement regular refresher training so that the safety operator is always fully aware of the limitations and capabilities of the subject vehicle and automated driving system (ADS).

PAS 1884 has been developed to provide guidance to any trialling organization that trains or utilizes safety operators engaged in automated vehicle tests and trials. It might also be of use to road authorities, local authorities, testbeds, vehicle agencies, insurers and legal organizations.

PAS 1884 provides guidance on the factors to be considered in selecting and training safety operators and recommends the key responsibilities of the trialling organization in ensuring that a safety operator is in possession of appropriate skills and knowledge to enable them to act competently at all times during tests or trials and in the event of an incident or emergency. PAS 1884 also provides guidance on how skills testing and refresher training can be used to maintain the competence of safety operators for the role, but it does not provide guidance on their real-time monitoring or supervision during tests or trials. Additional safety operator controls and training might be required that are specific to a given test or trial, or to a specific subject vehicle, or as technology evolves.

Whilst it is acknowledged that many tests or trials will make use of engineers from the ADS development team to fulfil the safety operator role, it might be necessary to consider increasing the number and range of personnel able and qualified to perform the role. This PAS therefore aims to support selection, training and performance of safety operators either within or outside of the ADS development team.

PAS 1884 does not provide guidance on the responsibilities, selection and training of safety operators that are not in visual line of sight of the subject vehicle (i.e. beyond the visual line of sight where the safety operator is unable to continually maintain direct unaided visual contact with the subject vehicle that is under their control). This is due to the fact that, at the time of writing, the technology to enable safe, reliable remote operation of automated vehicles on public or private roads is in a highly immature state and the requirements placed on remote operators, particularly regarding expected situational awareness, remain ill-defined.

Although it is outside the scope of this PAS, guidance for remote operators who are beyond the visual line of sight of the subject vehicle might be an outcome for future standardization work.

1 Scope

This PAS gives guidance for organizations engaged in automated vehicle trialling and developmental testing that utilize safety operators who are either inside the subject vehicle or are outside of it with the subject vehicle always remaining in visual line of sight.

The PAS covers:

- a) responsibilities of the trialling organization and safety operator;
- b) safety operator selection, fitness to drive and experience;
- c) training of the safety operator on:
 - 1) general skills and knowledge required to drive the base subject vehicle;
 - 2) test or trial-specific topics;
 - 3) visual line of sight remote operation;
 - 4) expected subject vehicle behaviour and unexpected subject vehicle behaviour;
 - 5) minimal risk conditions and minimal risk locations;
 - 6) the subject vehicle's relevant operational design domain (ODD) and its attributes;
 - 7) the test or trial route;
 - 8) eligibility criteria and abort criteria;
 - 9) hazards and mitigations;
 - 10) safety protocols;
 - 11) handover points;
 - 12) safety and welfare of passengers; and
 - 13) management of freight;
- d) safety operator skills testing and refresher training; and
- e) training and performance records.

The PAS applies to both trials and developmental testing, including trials of prototype vehicles, passenger and freight carrying services on both public and private roads or land, as bound by and proportionate to the relevant ODD.

This PAS reflects existing good practice, but it is not exhaustive. Some additional guidelines, relevant to specific vehicle types, use cases and trials, are also provided as good practice.

The PAS does not cover:

- a) endorsement of specific safety operator training courses;
- b) guidelines for automated supervision of the subject vehicle;
- c) when the safety operator is not in visual line of sight of the subject vehicle; or
- d) the role of the in-vehicle or remote test engineer.

This PAS is not intended to provide an accreditation or certification system.

PAS 1884 is of use to any trialling organization that trains or utilizes safety operators.

The PAS might also be of use to safety operators, road authorities, local authorities, testbeds, vehicle agencies, insurers and legal organizations.

2 Normative references

For dated references, only the edition cited applies.

For undated references, the latest edition of the referenced document (including any amendments) applies.

[N1] UK GOVERNMENT. *Code of Practice: Automated Vehicle Trialling*. CCAV/DfT. Available at <https://www.gov.uk/government/publications/trialling-automated-vehicle-technologies-in-public/code-of-practice-automated-vehicle-trialling>

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purpose of this PAS the following terms and definitions apply.

3.1.1 abort criteria

criteria that would cause an immediate end to a test (3.1.34) or trial (3.1.36) before it has been completed

[SOURCE: Oxford English Dictionary [12], modified]

NOTE For context in which this term is used, an abort decision is especially likely because failure is imminent.

3.1.2 advanced driver assistance system (ADAS)

system consisting of interdependent components that supports human drivers by performing a part of the dynamic driving task (3.1.8) or providing safety relevant information

NOTE Examples include adaptive cruise control, lane departure correction and automatic emergency braking.

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.3]

3.1.3 automated driving

situation where the full function of the dynamic driving task (3.1.8) is performed by the automated driving system (3.1.4) within its operational design domain (3.1.22)

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.4]

3.1.4 automated driving system (ADS)

hardware and software that are collectively capable of performing the dynamic driving task (3.1.8) on a sustained basis, regardless of whether it is limited to a specific operational design domain (3.1.22)

NOTE 1 This definition is adapted from SAE J3016 (2018) [13] and is used specifically for driving automation systems that can deliver SAE level 3, 4, or 5 driving.

NOTE 2 An automated driving system differs from a driving automation system in that the former enables the subject vehicle to deliver the full function of the dynamic driving task within the defined operational design domain whereas the latter covers systems that partially or fully cover the dynamic driving task.

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.5]

3.1.5 automated vehicle

vehicle fitted with an automated driving system (3.1.4) that uses both hardware and software to perform dynamic driving tasks (3.1.8) associated with moving the vehicle within a defined operational design domain (3.1.22)

[SOURCE: PAS 1883:2020, 3.1.2]

3.1.6 base subject vehicle

vehicle category, make and model to be used in a test (3.1.34), trial (3.1.36) or operational scenario (3.1.30)

3.1.7 blind spot monitoring

vehicle system that warns of the presence of other vehicles or objects in areas that a human driver might have difficulty observing and that could present a hazard if the subject vehicle (3.1.32) were to execute a lane change or sudden turn

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.12, modified]

3.1.8 dynamic driving task (DDT)

real-time operational and tactical functions required to operate a vehicle safely in on-road traffic

[SOURCE: PAS 1881:2020, 3.5]

3.1.9 eligibility criteria

criteria that is to be met before a test (3.1.34) or trial (3.1.36) can commence

NOTE Eligibility might include specific operational design domain attributes.

3.1.10 expected subject vehicle behaviour

subject vehicle (3.1.32) behaviour that is based on the expected performance and intended functionality of the automated driving system (3.1.4) and/or advanced driver assistance system (3.1.2) that remain within the definition of the operational design domain (3.1.22)

3.1.11 fault injection testing

method to evaluate the effect of a fault within an element by inserting faults, errors, or failures in order to observe the safety operator (3.1.28) and/or automated driving system (3.1.4) response

[SOURCE: BS ISO 26262-1:2018, 3.57, modified]

3.1.12 handover

process by which the sustained dynamic driving task (3.1.8) function transitions either from a human driver to an automated driving system (3.1.4) or from an automated driving system to a human driver

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.31]

3.1.13 human-machine interface (HMI)

hardware and software that allow users to interact with machines, translating their inputs into signals and providing feedback

[SOURCE: PAS 1881:2020, 3.9]

NOTE Typically information to be conveyed from the machine to the human is displayed using a graphical user interface (GUI).

3.1.14 incident

event or illegal vehicle behaviour which results in injury, ill health, damage or loss

[SOURCE: PAS 1881:2020, 3.10, modified]

3.1.15 intervention

action or set of actions initiated by the safety operator (3.1.28) to override automated operation and take control of the subject vehicle (3.1.32)

3.1.16 investigation

process conducted to gather and analyse information and data to identify the cause(s) of an incident (3.1.14) that occurred previously, where the findings might be used as part of a record of the test (3.1.34) or trial (3.1.36) safety and to inform updates to systems or processes to prevent recurrence

NOTE "Cause(s)" refers to the actions, omissions, events or conditions, or a combination thereof, which led to an incident.

3.1.17 method statement

description in logical sequence of how a task is carried out in a safe manner

[SOURCE: PAS 1881:2020, 3.12]

3.1.18 minimal risk condition (MRC)

condition to which a human driver or automated driving system (3.1.4) brings a vehicle after performing the dynamic driving task (3.1.8) fallback in order to reduce the risk of a crash when a given trip cannot be continued

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.40, modified]

3.1.19 minimal risk manoeuvre (MRM)

tactical or operational manoeuvre triggered and executed by the automated driving system (3.1.4) or a human driver to achieve the minimal risk condition (3.1.18)

[SOURCE: PAS 1883:2020, 3.1.8, modified]

3.1.20 near miss

unplanned event that did not result in injury, illness, loss or damage, but has the potential to do so if it were not for safety operator (3.1.28) intervention (3.1.15)

[SOURCE: PAS 1881:2020, 3.25]

3.1.21 object and event detection and response (OEDR)

subtasks of the dynamic driving task (3.1.8) that include monitoring the driving environment and executing an appropriate response to such objects and events

NOTE Monitoring the driving environment might include detecting, recognizing, and classifying objects and events and preparing to respond as needed. Responses to objects and events might be completing the DDT and/or the DDT fallback.

[SOURCE: SAE J3016, *International Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*, 3.20 [13], modified].

3.1.22 operational design domain (ODD)

operating conditions and defined environment under which a given automated driving system (3.1.4) or feature thereof is specifically designed to function

NOTE 1 Operating conditions include, but are not limited to, meteorological or environmental conditions whilst a defined environment includes, but is not limited to, geographical and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or road characteristics.

NOTE 2 For further information refer to PAS 1883.

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.43, modified]

3.1.23 passenger carrying vehicle (PCV)

subject vehicle (3.1.32) that carries passengers

NOTE A PCV might be a service that follows a specified route with stopping points for passengers to get on or off. PCVs include public service vehicles (PSVs) which are vehicles that are used to carry passengers for hire or payment.

[SOURCE: <https://www.gov.uk/drivers-hours/passenger-carrying-vehicles>, modified]

3.1.24 place of relative safety

location that puts an effective safety clearance between the subject vehicle (3.1.32), safety operator (3.1.28), other in-vehicle occupants or freight and the risks presented by hazards in the surrounding environment, that minimizes hazards to other users

NOTE Places of relative safety might include a side road, rest or service area, lay-by, hard shoulder or emergency refuge area. The relative safety of a location, or locations, will vary depending on the test or trial environment and hazards presented by the road and road traffic. Dynamic risk assessment can be used to determine the safest location at a given point in time.

3.1.25 platoon

linking of two or more vehicles in a convoy using connectivity technology and automated driving support systems which allow the vehicles to maintain automatically a set, close distance between each other when connected for certain parts of a journey and to adapt to changes in the movement of the lead vehicle with little to no action from the safety operators (3.1.28)

[SOURCE: EU Regulation 2019/2144, modified [3]]

3.1.26 remote operator

safety operator (3.1.28) who oversees the operation of an automated vehicle (3.1.5) from a remote location

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.48]

3.1.27 safety case

structured argument, supported by evidence, intended to justify that a system and activity is acceptably safe for a specific application in a specific operational design domain (3.1.22)

NOTE For further information refer to PAS 1881.

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.49, modified]

3.1.28 safety operator

person who is trained and able to supervise the function of an automated vehicle (3.1.5) either at the controls within the subject vehicle (3.1.32) or remote with continuous direct, unaided visual line of sight (3.1.41) of the subject vehicle (3.1.32)

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.50, modified]

NOTE 1 "Safety operator" is used to describe a safety driver or remote operator. A safety driver is a safety operator who is situated within the vehicle itself to oversee its operation. A remote operator is a safety operator who oversees the operation of the vehicle from a remote location.

NOTE 2 The safety operator might also be referred to as a "fallback-ready user", i.e. the user of a vehicle equipped with an engaged ADS feature who is able to operate the vehicle, is receptive to ADS-issued requests to intervene, and to react appropriately to DDT performance-relevant system failures in the vehicle – see SAE J3016, International Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles [13].

3.1.29 safety operator training programme

package of training designed in a series of modules to provide a safety operator (3.1.28) with the skills, understanding and competencies required to perform the role safely during a test (3.1.34) or trial (3.1.36) of an automated vehicle (3.1.5)

3.1.30 scenario

description of a driving situation that includes the safety operator (3.1.28), subject vehicle's relevant operational design domain (3.1.22), test (3.1.34) or trial (3.1.36) objectives and activities

[SOURCE: BSI Flex 1890:2020-10, 2.1.53, modified]

3.1.31 simulation

environment or situation, often computer-generated, used for testing components, systems or human behaviours

NOTE Simulation in the CAV domain can refer to a wide range of topics from microsimulation of traffic to simulation of CAV sensors and components to human-in-the-loop simulations of CAVs.

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.55]

3.1.32 subject vehicle

automated vehicle (3.1.5), the behaviour of which is of primary interest in a test (3.1.34), trial (3.1.36) or operational scenario (3.1.30)

NOTE The term “subject vehicle” can be used interchangeably with the terms “ego vehicle” and “vehicle under test (VUT)”.

[SOURCE: PAS 1883:2020, 3.1.12, modified]

3.1.33 telematics

collection and communication of vehicle operational and status data

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.57]

3.1.34 test

experimental evaluation or assessment of performance

3.1.35 test engineer

person who is trained and able to monitor the performance of the automated driving system (3.1.4) and communicate with the safety operator (3.1.28) as required during the dynamic driving task (3.1.8)

NOTE The test engineer might be in-vehicle or remote. In-vehicle test engineers might be sitting in the cab of a freight-carrying vehicle or anywhere in the passenger compartment of a passenger vehicle.

3.1.36 trial

series of tests (3.1.34) or assessments of performance

[SOURCE: PAS 1881:2020, 3.42]

3.1.37 trialling organization

organization responsible for the automated vehicle test (3.1.34), trial (3.1.36) or service being provided

NOTE Trialling organizations might be research organizations, autonomous vehicle manufacturers, software development companies, sensor manufacturers or transport operators. In a consortium, the lead partner might assume the role of trialling organization.

[SOURCE: PAS 1881:2020, 3.25, modified]

3.1.38 unexpected subject vehicle behaviour

subject vehicle (3.1.32) behaviour resulting from performance that is unplanned or unintended, and can be hazardous or unsafe

NOTE Unexpected behaviour outside of the operational design domain can result in the automated driving system and/or advanced driving system being unable to negotiate or manage to control the subject vehicle in a safe manner. Such unexpected behaviour can also arise as a result of internally or externally generated security or malicious threats.

3.1.39 vehicle-to-everything (V2X)

uni-directional or bi-directional sharing of data between vehicles and other vehicles, infrastructure, other road users or any other communications system

NOTE The definition is not intended to indicate that a vehicle is necessarily connected to everything but reflects that vehicles can be connected to a broad spectrum of systems of which vehicle-to-vehicle (3.1.41), vehicle-to-infrastructure, and vehicle-to-grid communications are examples.

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.62]

3.1.40 vehicle-to-vehicle (V2V)

vehicles sharing data with other vehicles

[SOURCE: BSI Flex 1890 v.3.0:2020-10, 2.1.65]

3.1.41 visual line of sight (VLOS)

continuous maintenance of direct unaided visual contact of the subject vehicle (3.1.32) that is under safety operator (3.1.28) control throughout a test (3.1.34) or trial (3.1.36), and a clear view of the road ahead in the foreseeable path of the automated vehicle (3.1.5) in order to detect objects, threats and other road users at a distance that would allow the safety operator to intervene in time to avoid hazards

[SOURCE: Civil Aviation Authority, <https://www.caa.co.uk/Consumers/Unmanned-aircraft/Our-role/An-introduction-to-unmanned-aircraft-systems/>, modified]

3.1.42 vulnerable road user

road user who is at a higher risk of physical injury in the event of a collision, relative to typical car occupants

NOTE Vulnerable road users includes pedestrians, cyclists, motorcyclists, horse riders, users of mobility scooters or e-scooters.

[SOURCE: EU Directive 2010/40 [4], modified]