AC 139-7-7 (Rev 0)
10 May 2023

Civil Aviation Authority of Singapore

Advisory Circular

GUIDANCE ON THE USE OF AUTONOMOUS VEHICLES AT THE AIRSIDE

GENERAL

Advisory Circulars (ACs) are issued by the Director-General of Civil Aviation (DGCA) from time to time to provide practical guidance or certainty in respect of the statutory requirements for aviation safety. ACs contain information about standards, practices and procedures acceptable to CAAS. An AC may be used, in accordance with section 11 of the Air Navigation Act 1966 (ANA), to demonstrate compliance with a statutory requirement. The revision number of the AC is indicated in parenthesis in the suffix of the AC number.

PURPOSE

This AC provides the guidance and information for the experimentation and use of autonomous vehicle (AV) technology at the airside.

APPLICABILITY

This AC applies to an operator who intends to or holds an aerodrome certificate or heliport certificate (also known as an “aerodrome operator”).

RELATED REGULATIONS

This AC relates specifically to Regulation 34 of the Air Navigation (139 – Aerodromes) Regulations (ANR-139).

RELATED ADVISORY CIRCULARS

- AC 139-7-2 Guidance on movement in airside
- AC 139-3-2 Guidance on inspection, monitoring and reporting

CANCELLATION
This is the first AC issued on the subject.

EFFECTIVE DATE
This AC is effective from 10 May 2023.

OTHER REFERENCES
- Technical Reference 68 – Autonomous Vehicles issued by the Singapore Standards Council

1 USE OF AUTONOMOUS VEHICLES AT THE AIRSIDE

1.1 Autonomous vehicle (AV) technologies are evolving rapidly and are expected to be increasingly adopted at the airside due to potential benefits such as increased efficiency, security and safety.

1.2 The use of AV at the airside may impact the existing measures for safe movement of persons and vehicles, as well as aerodrome operations or maintenance procedures. As with any new equipment, vehicle or process at the aerodrome, the aerodrome operator must ensure that AV operations are implemented in accordance with the applicable regulations in the ANR-139. Besides the guidance in AC 139-7-2, the aerodrome operator should also follow the guidance and information in this AC for the experimentation and use of AV technology at the airside.

1.3 In this AC, "AV system" refers to the vehicle and various associated systems (such as those for obstacle detection, navigation, communication, or surveillance), and the procedures to support the operation of the AV.

2 ESTABLISHMENT OF AV OPERATIONS FRAMEWORK AT THE AIRSIDE

2.1 The aerodrome operator should establish an AV operations framework at the airside for ensuring the safe operation of AV at the airside. The framework should consist of –

(a) Evaluation and approval of proposed AV operations, including the safety assessment of the AV system;

(b) Training and competency requirements for the personnel involved in AV operations;

(c) Coordination with the airside community;

(d) Maintenance of the AV system;

(e) Monitoring and reviewing of safety performance of each type of AV and its impact on airside operations;

(f) Documentation; and

(g) Means to ensure that the AV operations are performed safely, in compliance with requirements and take correction actions when necessary.

2.2 The framework should complement the application of the Airport By-Laws and other rules that may also be applicable on the AV operations.

3 EVALUATION AND APPROVAL OF AV OPERATIONS

3.1 The aerodrome operator should have a review process to evaluate whether a proposed AV operation can be conducted safely at the airside. The aerodrome operator should allow the AV operation only if the aerodrome operator is satisfied that the AV operation can be conducted safely.

3.2 For the purpose of evaluating the AV operation, the aerodrome operator should gather information such as:

(a) scope of work (e.g. objectives of trial/deployment, proposed area/travel routes of the AV, number and type of AVs);

(b) proposed plan (e.g., timeline and milestones, details on charging of AV, maintenance of AV);

(c) capabilities of the AV system;

(d) technical competencies of the personnel involved (e.g., list of personnel operating the AVs, their training and competency assessment records);

(e) technical specifications and certifications of the AV system that includes:

(i) vehicle safety inspection certificate of the AV from an accredited assessment body;

(ii) technical specifications (i.e. description of the industry standards for the AV technologies, systems and/or solutions used, basic design and components of the AV, basic design and function of the software in the AV, and modifications made to the AV);

(iii) documentation detailing the tests carried out either by the manufacturer or an accredited assessment body to determine that the safety and security features of the AV are safe for use at the airside, including the charging of the AV;

(iv) documentation detailing contingency plans in the event when the AV malfunctions;

(v) documentation that the systems used to guide and control the AV would not interfere with radio communications and air navigation systems;

(vi) information on the communication protocols used by the AV and its systems (as coordinated with the air navigation service provider) to ensure that communication systems of the AV would not interfere with radio communications and air navigation systems;

(Refer to **Appendix A** for the list of industry standards and certification for AVs.)

(f) risk assessment conducted in accordance with the aerodrome operator's safety management system.

3.3 The review process stated in paragraph 3.1 should include the following aspects:

(a) the design and construction of the AV system such that the AV is being operated safely, particularly when it is experiencing:

(i) fault-free conditions;
(ii) random hardware or technical faults; and
(iii) various environmental conditions and traffic scenarios (e.g. heavy rain, hot climate, road user behaviour).

(b) the proposed areas and travel routes for AV trial or deployment, and taking the following factors into consideration:

(i) Vehicular traffic volume;
(ii) Complexity of the aerodrome operations;
(iii) Weather condition (e.g., rain and visibility);
(iv) Size of AV;
(v) Type/complexity of AV operations; and
(vi) AV trial test parameters
(vii) Sufficient power and charging points for the AVs;
(viii) Adequate wireless data network; and
(ix) Adequate infrastructure to enable AVs to access the identified areas or facilities.

(c) the ability of the AV in performing the operations as stated in **Appendix B**. The aerodrome operator should justify the setting of the applicable safety distances to be maintained and collision avoidance manoeuvres for the performance of the operations listed in **Appendix B**.

(d) the necessity of an onboard AV driver or remote AV driver during the AV trial/operation.

(e) the contingency plan to address situations where the driving or detection systems on the AV malfunction, or if the AV encounters environments beyond expected operating conditions, or other failure modes.

3.4 The aerodrome operator should determine considerations (e.g. changes to airside driving rules, airside layout, operating locations, etc.) that might impact the earlier safety risk assessment to ensure that the safety assessment continues to be valid.

3.5 The aerodrome operator should ensure that the mitigating measures as identified in the safety risk assessment are carried out.

4 TRAINING AND COMPETENCY REQUIREMENTS OF PERSONNEL INVOLVED IN AV OPERATIONS

4.1 The aerodrome operator should ensure the personnel involved in AV operations (i.e. onboard or remote AV driver) has the ability to control or intervene the AV operations at the airside. The aerodrome operator should also ensure that such a person, before he/she is involved in the AV trial and operation, has met the following training and competency requirements:

(a) He/she possessed a valid an Airfield Driving Permit issued by the aerodrome operator;

(b) He/she has undergone a training programme by the manufacturer/company to operate the AV; and

(c) He/she has been assessed to be competent to operate the AV by the developer of the AV.

5 COORDINATION WITH RELEVANT PARTIES

5.1 The aerodrome operator should inform the airside community on trials and deployment of AVs at the airport for the community's overall awareness.

5.2 The information to share with the airside community should include:

(a) time and location of trial or deployment of AV;

(b) description of the AV operation;

(c) presence of AV driver (onboard or remote);

(d) pictorial/photograph of AV; and

(e) emergency number to contact during an accident or malfunction of AV.

5.3 The aerodrome operator should also establish appropriate communication channels for the airside community to provide feedback on the AV operations.

6 MAINTENANCE OF AV

6.1 The aerodrome operator should make arrangements to ensure that the AV systems are maintained in a good condition and are always functioning properly.

7 SAFETY PERFORMANCE MONITORING AND DATA RECORDING

7.1 The aerodrome operator should establish a process to monitor the AV operations at the airside. This process should include:

(a) monitoring of AV trial progress;

(b) monitoring the safety performance of AV and impact on airside operations;

(c) reviewing the safety performance of each type of AV at least quarterly and revise the approval whenever necessary;

(d) reporting of any malfunctioning of AV; and

(e) reporting of any incidents involving the AV.

7.2 To facilitate the safety performance monitoring, the aerodrome operator should ensure that a data recorder is installed in each AV to store information when the AV is in operation. The data recorder should always be in operation when the AV is in use and

captures information at a frequency of at least 2Hz. The data recorder should capture the following information:

(a) date and time;

(b) vehicle location (in latitude and longitude);

(c) speed of the vehicle;

(d) status of the vehicle, including whether the vehicle is operating in manual mode, autonomous mode, teleoperation mode, or a mixture of modes;

(e) occurrences where the AV driver (may be onboard or remote) overrides the autonomous mode, including the types of override;

(f) steering, braking, acceleration, force of impact etc. from various sensors on the AV;

(g) camera or video footage captured by –

(i) an internal facing camera (capturing the inputs to the AV, controls, and partial part of front windscreen);

(ii) an external front and rear facing camera; and

(h) weather condition (such as precipitation, etc.).

7.3 The aerodrome operator should specify the data types and format for the stored information so as to be able to read and store the data collected.

7.4 The aerodrome operator should determine the duration for the storage of the data collected from the AV data recorder to facilitate effective review of AV operations at the airside.

8 REPORTING AND INVESTIGATION OF AN INCIDENT OR ACCIDENT INVOLVING AV

8.1 As with other vehicle operations at the airside, AV operations are also subject to the reporting requirements in the ANR-139. The aerodrome operator must notify CAAS and carry out an investigation of any accident or incident involving:

(a) an AV and aircraft; or

(b) an AV which causes or may cause a danger to persons or property.

8.2 Examples of such incidents may include:

(a) Collision involving the AV and people, other vehicles, airside infrastructure, ground handling equipment, or any other objects;

(b) Deviation outside of the AV’s planned route.

8.3 The aerodrome operator should immediately make an assessment to determine if the AV trial or AV operation is safe to continue or should be suspended after every incident or accident.

8.4 For any AV trials that were suspended due to an incident or accident, the aerodrome operator should carry out an investigation and only restart the AV trial or operation after all the safety issues have been resolved.

8.5 The aerodrome operator should refer to AC 139-3-2 for further guidance on the reporting and investigation of an incident or accident involving an AV in the aerodrome.

9 DOCUMENTATION

9.1 The aerodrome operator should keep records of all information involving trials or deployment of AVs, for a minimum of 2 years following the expiry or cancellation of the approved application that was granted for the trial or use of the AV.

9.2 The aerodrome operator should document the procedures established for ensuring safe AV operations at the airside.

APPENDIX A – LIST OF INDUSTRY STANDARDS AND CERTIFICATIONS FOR AV

List of certifications and standards that may be applied to Autonomous Vehicle/Systems/Component

Reference	Title
IEC 62443-3-3	Industrial communication networks. Network and system security
ISO 9001:2015	Quality management systems requirements
ISO/IEC/IEEE 12207:2017	Systems and software engineering – Software life cycle processes
ISO 10007:2017	Quality management – Guidelines for configuration management
ISO/IEC 17024:2012(en)	Conformity assessment – General requirements for bodies operation certification of persons
ISO 26262:2018	Road vehicles – Functional safety
ISO/ PAS 21448:2019	Road vehicles – Safety of the intended functionality
SAE J3016_202104	Taxonomy and Definitions for Terms Related to driving automation systems for on-road motor vehicles
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 62278	Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)
ISO 14001	Environmental management systems
ISO/IEC 17000	Conformity assessment – Vocabulary and general principles
CMMI	Capability Maturity Model Integration
ISO 45001	Occupational health and safety management

APPENDIX B – PERFORMANCE OF AV OPERATIONS AT THE AIRSIDE

Speed

1. An AV should adhere to the speed limits at the airside at all times.

2. An AV should adjust its speed to account for crossing pedestrians, road surface conditions, current and upcoming object sensor detection and visibility to other road and airside users.

3. An AV should not collide with any road or airside user.

Safety distance

4. An AV should maintain an appropriate and pre-determined safety distance between the AV and other stationary or mobile objects (e.g. equipment infrastructure, facilities, road, airside user) for every stage of its intended operations and each area it operates in, such as:

   (a) safety distance between the AV and objects at the equipment staging area, equipment parking area, etc.;

   (b) safety distance between AV and a leading vehicle, if the leading vehicle comes to a complete stop, the AV is able to come to a stop safely behind the vehicle;

   (c) when other vehicles are observed to be cutting into its lane, the AV responds proactively to maintain a safe following distance;

   (d) when at a stop line, the AV's foremost point should not be more than 1.5m away before the nearest edge of the stop line.

Manoeuvres

7. An AV should follow the traffic signals, traffic signs and road markings (i.e. stop or move as directed).

8. An AV should maintain lane discipline as required by the road markings, unless performing a lane change or overtaking.

9. When performing a lane change, an AV should –

   (a) ensure that the lane change manoeuvre does not force any vehicles to take potentially unsafe evasive action;

   (b) signal at least 3 seconds in advance before initiating a lane change manoeuvre;

   (c) cancel the signal after the lane change manoeuvre is completed.

10. When overtaking, an AV should –

(a) ensure that the lane change manoeuvre does not force any vehicles to take potentially unsafe evasive action;

(b) only move into a lane for oncoming traffic if the intended path is safe and clear of traffic.

11. An AV should slow down when another vehicle is trying to overtake the AV.

12. An AV should not overtake another vehicle at the following locations:

(a) A pedestrian crossing;

(b) A road junction;

(c) A corner or a bend; and

(d) On a steep slope or incline.

13. An AV should not overtake another vehicle when –

(a) the vehicle in front is about to overtake another vehicle in front of it;

(b) the vehicle in front is changing from the left to the right lane; or

(c) the vehicle in front of it increases its speed.

14. An AV should only u-turn when –

(a) there is sufficient safety distance from the traffic coming from the opposite direction; and

(b) there are no other vehicles, turning together with an AV on its right.

15. When at pedestrian crossings, an AV should –

(a) give way to pedestrians;

(b) slow down and prepare to stop if a pedestrian appears from outside its field of vision or occlusion at pedestrian crossings;

(c) proceed to move off only after a pedestrian is detected to be off the road.

16. When negotiating junctions, an AV should adopt the following performance:

(a) An AV should slow down its speed and follow the “give way” rules found in the rules on airside vehicles and drivers when negotiating non-signalised junctions;

(b) An AV should keep to the lane corresponding to its lane before turning at a signalised or non-signalised junction;

(c) An AV should enter the lane that permits the intended direction of turn as indicated by road markings;

(d) An AV should signal its intention at least 3 seconds before entering the lane which permits the intended direction of turn and keep the signal on till the turn is completed;

(e) An AV should first stop to allow pedestrians to cross the road when turning left at a signalised junction;

(f) When turning right at a signalised junction, an AV should first stop at a safe distance away from opposing traffic and proceed only when there are neither oncoming vehicles in the opposite direction nor pedestrians.

Hand/Traffic signals

17. An AV should be capable of detecting and responding appropriately to the following signals:

(a) Hand signals given by other road users;

(b) Stop/Go boards signals by personnel due to road traffic works;

(c) Instructions given by authorised officers from Changi Airport Group, Airport Emergency Services, Airport Police Division and Auxiliary Police.

Right of way

18. An AV that is travelling should always look out for and give way to –

(a) Aircraft taxiing, on tow, or on pushback; and

(b) Emergency vehicles.

Traffic signs and road markings

19. An AV should adhere to all traffic signs and road markings that are found in rules on airside vehicles and drivers. They include:

    (a) Airside roadway markings;

    (b) Aircraft stand markings;

    (c) Traffic signs; and

    (d) Work zone signs.

Malfunction

20. During a malfunction, the AV should be able to –

    (a) Safe stop on a parking area; and

    (b) Safe stop along the kerb.