

Advisory Circular

UNMANNED AIRCRAFT (UA) OPERATIONS OVER ROADS WITHIN VISUAL LINE OF SIGHT (VLOS)

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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 show that compliance with a statutory requirement has been achieved. The revision number of the AC is indicated in parenthesis in the suffix of the AC number.

PURPOSE

This Advisory Circular provides an overview of CAAS' assessment methodology for Unmanned Aircraft (UA) operations over roads conducted within visual line of sight (VLOS) when assessing an application for an UA Operator Permit (OP) or a Class 1 Activity Permit (AP1) that involves UA operations over roads.

APPLICABILITY

This AC is applicable for an OP holder intending to conduct UA operations over roads within visual line of sight (VLOS).

For UA operations over roads conducted beyond visual line of sight (BVLOS), operators should refer to AC 101-2-2 for guidance on the assessment methodology and the application process.

RELATED REGULATIONS

This AC relates specifically to Part 2 of Air Navigation (101 – Unmanned Aircraft Operations) Regulations 2019 (“ANR-101”).

RELATED ADVISORY CIRCULARS

- AC 101-2-1 Permits for Unmanned Aircraft Operations
- AC 101-2-2 Beyond Visual Line-of-Sight Operations for Unmanned Aircraft

CANCELLATION

This AC is the first on the subject.

EFFECTIVE DATE

This AC is effective from 1 February 2024.

OTHER REFERENCES

- Road Traffic Act – Road Traffic (Restriction of Speed on Roads) Notification

1 INTRODUCTION

1.1 Given Singapore's high connectivity and dense road network, a large amount of land area is covered by roads with varying degree of traffic density. With the proliferation of UA operations, it is likely that such operations will occur over roads. Accordingly, the ground risks imposed by UA operations are amplified when operating over roads due to possible vehicular accidents caused by distraction or direct collision.

1.2 CAAS has developed a framework for assessing UA operations conducted within VLOS over roads. This framework serves to guide operators to perform the necessary risk assessment on their intended UA operations over roads and mitigate risks to public to the maximum extent possible. The risk assessment performed, and mitigations incorporated will be reviewed as part of the permit assessment process.

2 DEFINITIONS

2.1 Unless the context otherwise requires, the following terms have the meanings indicated as below:

Failure Condition in a Unmanned Aircraft System (UAS) means a condition having an effect on the UAS, either direct or consequential, which is caused or contributed by one or more failures or errors considering flight phases or relevant adverse operational or environmental conditions or external events. The severities of the failure conditions are as follows:

Catastrophic. Failure would prevent continued safe flight and landing resulting in:

- (1) One or more fatalities or serious injury to persons or major property damage external to the UAS; or
- (2) Uncontrolled loss of aircraft.

Hazardous. Failure would reduce the capability of the UAS or the ability of the UAS crew to cope with adverse operating conditions to the extent it would result in at least one of the following:

- (1) Physical distress to persons, including injuries, or property damage external to the UAS; or
- (2) A large reduction in safety margins or functional capabilities; or
- (3) Higher workload such that the UAS crew cannot be relied upon to perform their tasks accurately or completely.

Major. Failure would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be:

- (1) Potential of physical discomfort to persons or minor property damage external to UAS.
- (2) A significant reduction in safety margin or functional capabilities.
- (3) A significant increase in crew workload or in conditions impairing crew efficiency.

Minor. Failure would not significantly reduce the aircraft safety. Failure would also involve crew actions but it should be well within their capabilities. It may include slight reduction in safety margin or functional capabilities and a slight increase in crew workload (e.g. Routine flight plan change).

No Effect. Failure would have no effect on safety. (E.g. Failure conditions that only affect the operational capability of the aircraft.)

3 ASSESSMENT METHODOLOGY FOR UA OPERATIONS CONDUCTED WITHIN VLOS OVER ROADS

3.1 When assessing an application to conduct UA operations over roads, CAAS uses a set of requirements that commensurate with the associated risks of the UA operations. This includes taking into consideration the duration of flight over road, the traffic density of the road and the corresponding UA airworthiness and robustness of the operator’s operational processes.

3.2 The operator should devise the operation based on the risk category for the intended operation described in Table 1, and meet the requirements accordingly. The risk categorisation is based on the speed limit, the number of lanes being crossed, and the type of road.

Risk Category	Descriptor of Road	Requirements
High Risk Road	Speed Limit of more than 50 km/h	<ul style="list-style-type: none"> To use the most expeditious route across the road and minimise flight time over road to the extent possible. To minimise distraction to drivers and road users. To perform risk assessment to determine risk of operations and propose mitigation measures. To include measures / procedures to recover the UA should it fall onto the road during operations. The UAS should have a probability of a catastrophic failure condition that does not exceed 1×10^{-6} per flight hour. To establish the specific operational procedures and processes for operations over roads in the operation procedures document.
Medium Risk Road	<ul style="list-style-type: none"> Roads within silver zones or school zones; Speed Limit of less than 50 km/h <u>but</u> more than 2 lanes; or Speed Limit of 50 km/h (regardless of number of lanes) 	<ul style="list-style-type: none"> To use the most expeditious route across the road and minimise flight time over road to the extent possible. To minimise distraction to drivers and road users. To perform risk assessment to determine risk of operations and propose risk mitigation measures. To establish measures / procedures to recover the UA should it fall onto the road during operations. The UAS should have a probability of a catastrophic failure condition that does not exceed 1×10^{-4} per flight hour. To include the specific operational procedures and processes for operations over roads in the operation procedures document.

<p>Low Risk Road</p>	<p>Speed Limit of less than 50 km/h <u>and</u> limited to roads with no more than 2 lanes</p>	<p>To strictly abide by the following conditions:</p> <ul style="list-style-type: none"> • To use the most expeditious route across the road and minimise flight time over road to the extent possible. • To minimise distraction to drivers and road users. • To not overfly any pedestrians. • To perform pre-flight checks and ensure UA airworthiness before flight. • To establish procedures for emergency handling of the UA and be familiarized with them before flight. • To recover the UA expeditiously should UA fall onto the road or the pedestrian footpaths adjacent to the road during operations. Should this be not possible, the police need to be notified immediately. • To include the specific operational procedures and processes for operations over roads in the operation procedures document. <p>Note: The operator will need to make a declaration on abiding with the above conditions when applying for an AP1.</p>
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Table 1: Risk category of roads being crossed by an UA

3.3 The operator is to refer to the *Road Traffic Act – Road Traffic (Restriction of Speed on Roads) Notification* for the speed limit of road.

3.4 As illustrated in Figure 1, the operator should determine the total number of lanes at the juncture in which UA crossing is planned to take place.

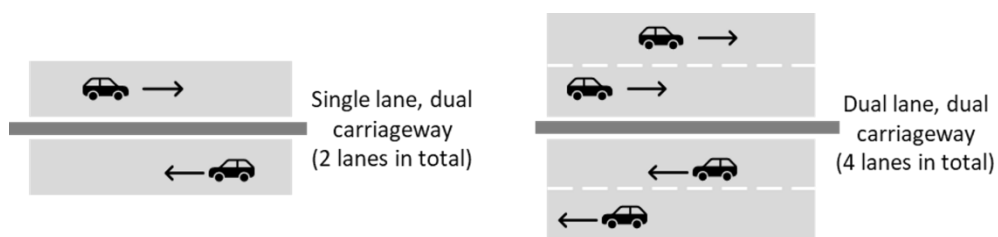


Figure 1: Diagram describing lanes and carriageways

3.5 Should there be crossing of more than one road within the intended operation, the operator will have to take the most stringent requirements applicable to all roads within the operation. For example, in Figure 2, if the UA were to cross the 2-lane road and 4-lane road in one crossing, the total number of lanes crossed would be 6, and the higher speed limit among the 2 roads would be applied.

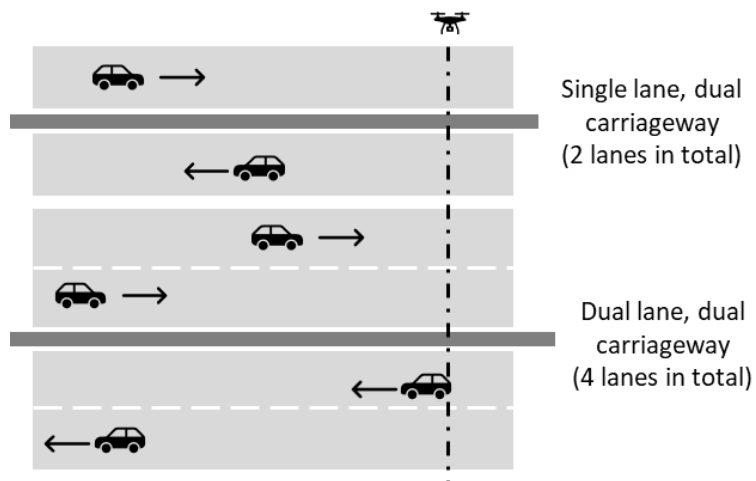


Figure 2: Diagram showing a UA operating across 2 roads

4 INFORMATION ON VLOS OPERATIONS OVER ROADS IN OP AND AP1 APPLICATIONS

4.1 An operator who conducts VLOS operations over roads should include the assessment into his/her application for a UA OP and/or AP1. The applicant may refer to AC 101-2-1 and the CAAS website for guidance on the process to apply for OP and AP1 permits.

4.2 An existing OP holder who has not been approved to perform VLOS operations over roads before and wishes to do so, will need to put up a variation of OP application (for medium and high risk roads, as relevant) together with a new AP1 Permit application.

4.3 The information on VLOS operations over roads to be included in an OP or AP1 application is summarised in Table 2.

	Operator Permit (OP)	Class 1 Activity Permit (AP1)
High Risk Road	Provide the following: <ol style="list-style-type: none"> 1. Compliance Checklist 2. System Safety Assessment 3. Supporting documents to show that the UA has probability of a catastrophic failure condition of 1×10^{-6} per flight hour. <p>For subsequent applications within the same risk road tier, operator need not apply for a variation of OP and may proceed immediately to apply for an AP1.</p>	Provide the following: <ol style="list-style-type: none"> 1. Compliance Checklist 2. Risk assessment 3. Operational Process and procedures to mitigate risk of UA operations over roads
Medium Risk Road	Provide the following: <ol style="list-style-type: none"> 1. Compliance Checklist 2. System Safety Assessment 3. Supporting documents to show that the UA has probability of a catastrophic failure condition of 1×10^{-4} per flight hour. <p>For subsequent applications within the same risk road tier, operator need not apply for a variation of OP and may proceed immediately to apply for an AP1.</p>	Provide the following: <ol style="list-style-type: none"> 1. Compliance Checklist 2. Risk assessment 3. Operational Process and procedures to mitigate risk of UA operations over roads

Low Risk Road	NA	Provide the following: <ol style="list-style-type: none"> 1. Compliance Checklist 2. Declaration of compliance to conditions in eSOMS. 3. Operations Procedures should demonstrate that low risk road conditions are met.
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Table 2: Documents to be provided when applying permits for UA operations over roads

4.4 An applicant should include the following information in the application:

- (a) Compliance checklist (*refer to form downloadable from CAAS website*)
 - (1) Description of the intended operation
 - (i) Details of the area of operation and the operating environment. All roads to be overflowed during the operation should be listed, and their risk categorisation assigned based on the descriptor included in Table 1.
 - (ii) Type of operation and how the operation is conducted.
 - (2) The appropriate operational risk category proposed by the applicant based on the guidance from Table 1, together with justifications to support the assessment.
- (b) Operational procedures and processes for operations over roads. Detailed procedures and processes including all checklists, to demonstrate that there are necessary safeguards and mitigations to ensure safety of operations.
- (c) Specific to medium and high risk road categories, In addition to the above-mentioned information, the applicant is to provide:
 - (1) System safety assessment which includes the following but not limited to:
 - (i) Functional Hazard Analysis (FHA)
 - (ii) Failure Mode Effect and Criticality assessment (FMECA)
 - (iii) Fault Tree Analysis (FTA)
 - (2) Evidence of meeting requirements listed in Table 1. Substantiations provided should be supported by evidence as attestation of the UAS' airworthiness and adequacy of the risk mitigation measures. Where applicable, evidence should consist of one or more forms of the following types:
 - Direct evidence from analysis
 - Direct evidence from demonstration (rig testing, representative prototype ground and flight operation, operational experience)
 - Direct quantitative safety evidence
 - Direct qualitative safety evidence
 - Direct evidence from hazard risk assessment
 - Direct evidence from the design review process
 - Direct technical description of design features and system functions
 - Direct qualitative evidence of good design (design requirements and practices)

- Process evidence showing good UA life-cycle safety issue management
- Any other quantitative and/or qualitative analysis to demonstrate compliance.

4.5 OP or AP1 applications that involve UA operation over roads are more complex and may need longer processing time. Such OP or AP1 applications should therefore be made early.