



**Building and
Construction
Authority**

**BCA Guidelines for Use of
Unmanned Aircraft (UA) for
Amusement Ride Inspections**

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Foreword

These guidelines were prepared by the Building and Construction Authority (BCA) to assist amusement ride operators and owners in incorporating Unmanned Aircraft (UA) technology into their inspection routines.

The guidelines outline best practices and requirements for using UA in conducting routine inspections of amusement rides. They also serve as a reference for maintenance checks and annual Operating Permit renewal inspections.

The document aims to help operators harness UA technology to enhance the efficiency and effectiveness of their inspection processes whilst maintaining the highest standards of safety.

Unmanned Aircraft (UA) Guidelines for Amusement Ride Structures

1. Introduction

1.1 Purpose of this guideline

The purpose of this guideline is to introduce alternative inspection methods for amusement ride structures using technology-enabled solutions. Unmanned Aircraft (UA), commonly known as drones, are one such solution that can be used to conduct structural inspections.

When used in conjunction with Technical Reference 78 (TR78), this guideline aims to help operators understand how to incorporate these inspection methods while meeting regulatory requirements.

1.2 Technology-enabled solutions (UA) context

UA would be most beneficial for inspections at hard-to-reach areas, especially where traditional access methods are risky, time-consuming or costly. The table below shows a comparison between the use of boom lift and UA for inspections.

Table 1: Comparison Between Boom Lift and UA Inspection Methods

Description	Boom Lift	UA
Minimal site disruption	Inspection typically carried out during the night (Likely due to the time required to set up and move the boom lift)	Inspection can be carried out at any time of the day
Duration	Time consuming due to the movement of the boom lift between locations with tight access	Capable of inspecting any part of the structure
Maximum Height Limitation	43 meters (approximately)	120 meters and above (approximately)
Access to confined spaces	Difficult to inspect hard-to-reach areas	Provides a wider field of view with high resolution imagery from multiple angles
		Capable of inspecting areas that are unsafe for human access

2. Types of UA Inspection Requirements

UA can be used for any inspection that requires a visual mode. This includes:

- AR inspections conducted for the purposes of renewal of Operating Permit (“OP”) under Part 3 of the Amusement Rides Safety Act 2011
- AR inspections conducted as part of the operator’s daily checks

For the purposes of the above-mentioned inspections,

- **All UA regulatory permits, insurance coverage, CAAS activity permit and UA pilot license** under CAAS regulations must be obtained.
- The inspections for amusement rides should adhere to the standards and requirements as set out under the Amusement Rides Safety Act and Regulations 2011 and any other manufacturer or technical specifications that apply for the ride

3. Normative References

- a) TR 78: 2020 Technical Reference Building Facade Inspection Using Unmanned Aircraft Systems (UAS)
- b) TR 78-2: 2020 Technical Reference Building Facade Inspection Using Unmanned Aircraft Systems (UAS)
- c) AC 101-2-1(Rev 4) Advisory Circular from CAAS 3.1.
 - a. *Note: Please refer to CAAS website (www.caas.gov.sg) for the latest version of the Advisory Circular*
- d) CAAS Unmanned Aircraft Regulations Website: <https://www.caas.gov.sg/public-passengers/unmanned-aircraft>

4. Terms and Definitions

For these guidelines, the following terms and definitions apply.

4.1 Authorized Personnel (AP)

A qualified individual designated by the relevant authority or organisation who possesses the necessary competency, training, and certification to oversee, supervise, and approve unmanned aircraft operations and related inspection activities.

4.2 Ride Operator

The operator is the person that has direct control of various functions of an amusement ride.

4.3 Ride Owner

The party that owns the amusement ride. In Singapore, the ride owner is also referred to as the Operating Permit holder which is the party that holds an Operating Permit issued by the Commissioner under Section 14 of the Amusement Rides Safety Act.

4.4 Risk Assessment (RA)

It refers to an assessment tool which aids the USP in considering all possible hazards during the UAS amusement ride structure inspection.

4.5 Qualified Person (QP)

- a) is registered as a specialist professional engineer in the discipline of amusement ride engineering under the Professional Engineers Act (Cap.253); and
- b) has in force a specialist practising certificate issued under that Act.

4.6 Unmanned Aircraft (UA)

It refers to any aircraft that operates, or is designed to operate, autonomously or by remote control without a pilot on board.

4.7 Unmanned Aircraft System (UAS)

It refers to the UA and the associated equipment used to control it remotely.

4.8 UAS Service Provider (USP)

It refers to an organisation that provides commercial service solutions using UAS.

5. General Duties of Parties Involved

5.1 Authorised Personnel (AP)

As UA can be used for inspections of varying nature and purposes, the AP responsible for executing the UA operations and interpreting its results can differ, i.e. they may be staff of the amusement ride operator conducting daily checks, QPs conducting annual checks, or third party engaged for an ad-hoc inspection.

Regardless, the general duties of the authorised personnel include the following pertaining to the use of UA:

1. Pre-Operation Responsibilities:

- a) Provide feasibility assessment on the use of UA for the inspection
- b) Review and approve the UA work plan
- c) Verify that the proposed plan meets all safety and regulatory requirements

2. Duties During Operation:

- a) Supervise and guide the use of UA
- b) Ensure all critical areas of the ride structure are adequately covered
- c) Verify that proper procedures and data collection methods are followed

3. Post-Operation Duties:

- a) Review and analyse the collected data/footage
- b) Interpret and assess findings based on UA results
- c) Prepare and endorse the relevant report
- d) Make recommendations for any necessary actions or improvements
- e) Provide certification or approval as required

During OP renewal, the duties of the AP, who will have to be an QP, will also include:

- *All other responsibilities for the QP as set out under Part 3 of the Amusement Rides Safety Act 2011*
- *Where drone inspection of critical areas is not feasible, operators shall implement alternative inspection methods, including but not limited to access equipment and other appropriate techniques, to maintain inspection integrity.*

5.2 Amusement Ride Operator/Ride Owner

The duties of the Ride Operator include the following pertaining to the use of UA:

1. Pre-Inspection Responsibilities:

- a) Ensure valid UA regulatory permits are in place
- b) Maintain valid insurance coverage (For UA)
- c) Coordinate an inspection schedule with QP / AP and BCA
- d) Coordinate with QP / AP regarding any OP renewal requirements if applicable
- e) Ensure safety measures are in place for UA operations
- f) Prepare the site for inspection (including crowd control measures)

2. Duties During Inspection:

- a) Ensure the ride is not in operation during inspection
- b) Maintain site safety and security
- c) Support the UA inspection team as required
- d) Facilitate coordination between UA operators and QP/AP during inspection
- e) Ensure proper access to all areas needed for inspection
- f) Monitor weather conditions for safe UA operations

3. Post-Inspection Duties:

- a) Maintain inspection records
- b) Implement recommendations from QP/AP
- c) Coordinate with QP / AP on any follow-up actions for OP renewal processes
- d) Follow up on any maintenance requirements identified during UA inspection
- e) Submit required documentation to relevant authorities if OP renewal is involved
- f) Keep all inspection documentation for future reference

During OP renewal, the duties of the Ride Operator also include:

- Make the necessary document submissions to BCA
- All other responsibilities for the Ride Operator as set out under the Amusement Rides Safety Regulations 2011

6. Execution of UA Inspection Operations for AR

This section outlines the major parts comprising a UA inspection operation for AR. Depending on the type of AR and the complexity, there could be differences in the setup of the operation.

This section should be read with reference to TR 78-2020 section 5.2.

6.1 Preparation Phase

- Conduct feasibility study
- Obtain stakeholder approvals
- Conduct Risk Assessments
- Develop the operations plan for the inspection including planned flight paths, maps, inspection coverage, and type of imagery
- Obtain the necessary regulatory permits and approvals including but not limited to:
 - CAAS Activity Permit
 - CAAS Operator Permit
 - UA Pilot License
- Obtain insurance coverage
- Notify affected parties

6.2 Set up Site for Inspection

- Confirmation of site condition, including obstacles, no fly zones, and weather conditions
- Notify affected parties and set up warning signs or safety barriers or deploy safety personnel if needed
- Conduct pre-flight assessment and briefing to confirm plan, safety issues, and team role

6.3 Calibration of Equipment

- Calibrate all drone systems (compass, Inertial Measurement Unit, gimbal, GPS) according to manufacturer specifications prior to flight operations
- Perform calibration in suitable environmental conditions away from electromagnetic reference
- Verify all systems are functioning within normal parameters before commencing operations

6.4 Conduct Inspection Flights

- Follow inspection plan
- Record deviations
- Document captured data including elevated views, close up views, different angles, lighting and video if necessary
- Log UAS operation details including launch time, operation duration and recovery time
- Report incidents to aviation authority

6.5 Post Flight Data Processing

- Review and filter data
- Interpret data
- Submit processed data and report to client
- Recommended retain data for 1 year
- Follow data protection guidelines

7. Standards for UA Inspections

7.1 “As good as human” Principle

- The underlying principle used is that the UA must be able to conduct inspections as good as a human inspector.
- The quality and resolution of the images captured must be on par or better than a human inspector if they were conducting the inspection
- The coverage of the drone must be on par or better than a human inspector if they were conducting the inspection.

7.2 Image Resolution and Camera Requirements for Crack Detection

The table below sets out the minimum requirements for camera and optical imaging equipment to be used in UA inspection of Amusement Rides.

Table 2: Minimum Imaging Parameters and Their Importance

Parameter	Minimum Requirement	Why It Matters
Image Sensor Size	1" (13.2 mm × 8.8 mm)	Larger sensors capture more light and detail, improving image clarity and dynamic range.
Resolution	≥ 12 MP	Higher resolution provides sufficient pixels to resolve small cracks from a distance.
Focal Length	≥ 50 mm (equivalent)	Longer focal lengths narrow the field of view, increasing detail at greater distances.
Ground Sampling Distance (GSD)	≤ 0.5 mm/pixel	Ensures each pixel corresponds to ≤ 0.5 mm on the surface, enabling detection of 2 mm cracks.
Optical Zoom	≥ 3x	Optical zoom maintains image quality while magnifying targets from 3 m away.
Pixel Size	≤ 2.4 μm	Smaller pixels improve detail resolution, while larger pixels enhance low-light performance.

Parameter	Minimum Requirement	Why It Matters
Shutter Type	Global shutter	Adequate shutter speed prevents motion blur during drone movement, critical for sharp crack imaging.
Stabilisation	3-axis gimbal + vibration dampening	Keeps the camera steady for clear, blur-free images during flight.

7.3 Critical Inspection Elements

Critical inspection elements are areas where particular attention must be paid by the inspector because of a higher probability of developing cracks, or due to the critical nature of the component. These elements include:

- Welds
- Structural support members
- Wire ropes under tension
- Any other stress concentrators

Kindly take note that where UA are unable to inspect certain elements or components due to inaccessibility, a physical inspection must be carried out by AP to ensure comprehensive coverage

7.4 UA Inaccessible Areas

UA inaccessible areas should be identified in the planning and recce phases of the operation. This could be due to geometry of the shape, or due to conditions such as environmental exposure or lighting.

Appropriate measures should be taken to ensure that these are checked, either through in-person means, or through alternate imaging methods.

7.5 Ambiguous Data

Ambiguous data should be treated very carefully. The QP should always double check any ambiguous data, and if it cannot be ascertained from another flight of the UA, then an in-person inspection would be required.

Refer to Annex A and Annex B for the recommended forms to be used to document the type of operations, area of operations and inspection findings. These forms are strictly for reference only and should not be taken to be fully exhaustive.

8. Risk Assessment and Mitigation

Prior to carrying out the Amusement Ride using UA, the USP shall conduct a thorough Risk Assessment (RA) to ensure that the UAS flights are piloted in a safe manner to the public. The RA should be carried out with the client who has detailed knowledge of the building to be inspected. Suitable mitigation measures shall be implemented with agreement from the client and without violating any applicable law.

The RA should include (and not be limited to) the following hazards:

- Falling objects
- Electrical hazards
- Interference of signal
- Loss of control of UA
- Collision

A complete RA shall be carried out by USP and client.

9. Personal Data Protection

9.1 Introduction

When collecting data such as images or video recordings using unmanned aircraft during amusement ride inspections, the USP and/or Operator must ensure compliance with all applicable regulatory and statutory requirements.

Please refer to the guidelines established in TR 78-2020 Section 6 for application to amusement ride inspections.

10. Annexes

10.1 Annex A - UA Inspection Report Generation

10.1.1 General Requirement

The inspection report generation is recommended to:

- Include appropriate images representing general conditions, not limited to defect areas
- Use suitable identification systems for reporting, annotating, and listing defects
- Enable easy identification of defect locations to facilitate follow-up repairs

10.1.2 Inspection Results Requirements

The inspection results is recommended to include:

- **General Flight Information** - Flight location, flight date(s) and time(s), purpose of inspection, CAAS activity permit reference number, area of operations, media and file format, UA(s) model, and camera/sensor(s) model and specifications
- **Asset Information** - Operator information, location address, site layout plan, and technical drawings/plans/specifications
- **List of Unsafe Defects Requiring Immediate Action** - Location/elevation, image identification number, component type, description of defect(s), and immediate mitigation measures implemented
- **List of Defects Requiring Remedial Action** - Location/elevation, image identification number, component type, description of defect(s), and follow-up actions/recommendations
- **Image Documentation** - Section/elevation, image identification number, location of defects, component type, defect description, assessment findings, and required actions

10.2 Annex B – Sample UA Inspection Report Template

Note: This form is to be used as a guideline only. Please adapt the form according to your use case.

10.2.1 General Information

Table 4: General Flight Information

Item	Details
Flight Location	[Input location]
Flight Date(s) & Time(s)	[Input dates and times]
Purpose	[Input inspection purpose]
CAAS Permit Reference	[Input reference number]
Areas of Operation	[Input operation areas]
Media Format	[Specify format]
UA Model	[Input model]
Tethered UA	Yes/No
Camera/Sensor Specifications	[Input specifications]

10.2.2 Amusement Ride Information

Operator Information

[Input operator details]

Address

[Input full address]

Site Layout Plan

[Include site layout with inspection areas marked]

Ride Layout and Elevations

[Include ride diagrams with inspection points]

10.2.3 Unsafe Defects Requiring Immediate Action

Table 5: Description of Unsafe Defects and Corresponding Immediate Actions Taken

S/N	Location	Image ID	Component	Defect Description	Immediate Actions Taken
1					
2					

10.2.4 Defects Requiring Remedial Action

Table 6: Description of Defects and Corresponding Remedial Actions Taken

S/N	Location	Image ID	Component	Defect Description	Recommended Actions
1					
2					