NOTICE OF PROPOSED RULE MAKING DGTA 01-11

AAP7001.053 SECTION 2 CHAPTER 1

TECHNICAL AIRWORTHINESS REGULATION 2.8 UNMANNED AIRCRAFT SYSTEMS (UAS)

INTRODUCTION

Applicability

1. This proposal is applicable to all ADF organisations seeking a TAR Recommendation in support of the operation of a Category 1 or Category 2 Unmanned Aircraft System (UAS).

Purpose

2. The purpose of this Notice of Proposed Rule Making (NPRM) is to advise and seek feedback from stakeholders on the proposal to create AAP7001.053 *Technical Airworthiness Management Manual* regulations and guidance related to UAS. The benefits flowing from the proposal are expected to provide applicants for UAS airworthiness instruments with clarity on the TAR's Technical Airworthiness requirements for UAS.

Consultation

3. Technical Airworthiness Regulation (TAREG) 1.1.2 requires that interested persons participate in regulation drafting procedures. The aim of this NPRM is to promulgate background and details of the proposed changes. Advice on how petitions on this proposal are to be presented to the TAR is also provided.

PROPOSAL

Background

4. AAP7001.048, *ADF Airworthiness Manual*, states that there are two categories of UAS, namely Category 1 and Category 2. They are defined as follows:

a. A Category 1 UAS, when operating in the intended roles and environment, is a system for which the consequence of a catastrophic failure can reasonably be expected **to result** in death or serious injury, or significant damage to property.

b. A Category 2 UAS, when operating in the intended roles and environment, is a system for which the consequence of a catastrophic failure can reasonably be expected **not to result** in death or serious injury, or significant damage to property.

5. Where an ADF organisation seeks to operate a Category 1 or Category 2 UAS, the TAR must provide the following support:

a. For a Category 1 UAS to be operated as a State-registered aircraft, the TAR must provide a Type Certification recommendation to the ADF AA;

b. For a Category 1 UAS to be operated as a non-State-registered aircraft, the TAR must endorse the application for operation to the ADF AA; and

c. For a Category 2 UAS to be issued a UAS Operating Permit by an OAA, the TAR must provide a recommendation in respect to the technical airworthiness of the system for the intended operations.

However, neither AAP7001.048 nor AAP7001.053 currently provides insight into the criteria to be used by the TAR to evaluate whether a positive TAR recommendation is warranted.

Objective

6. This NPRM proposes the addition of TAREG 2.8 to AAP7001.053, and the inclusion of guidance at Section 3 Chapter 21. The proposed amendment establishes criteria against which the TAR will evaluate any application for approval to operate a UAS.

7. The benefits of the proposed TAREG 2.8 and associated guidance are as follows:

a. it will provide applicants with clarity on the TAR's expectations for the data and analyses needed to support a positive TAR recommendation,

b. it will provide applicants with the TAR's requirements for initial and ongoing organisational approvals, and

c. it will provide ADF operational staff with clear insight into the scope, and limitations, of any TAR recommendations for UAS airworthiness instruments.

Proposed New AAP7001.053 UAS Regulations and Guidance

8. The proposed changes to TAREG 2.8 are included at Enclosure 1. The proposed UAS guidance is included at Enclosure 2.

HOW TO SUBMIT COMMENTS ON THIS NPRM

Format

9. Responses to this NPRM are to be recorded on the NPRM Response Sheet included at annex A, and as published on the DGTA Intranet and Internet websites.

10. Responses are to be submitted by email to DGTANPRM@defence.gov.au. Hardcopies of the NPRM Comment Sheet are not required.

Timing

11. Comments to NPRM DGTA 01-11 are to be received by close of business 28 Feb 11.

Additional Information

12. Additional information concerning this NPRM is available from Mr Mark Wade, Deputy Director Systems Certification and Integrity (DD SCI-DGTA) on (03) 9256 3555 or mark.wade@defence.gov.au.

DISPOSITION OF COMMENTS RECEIVED

13. A Summary of Responses will be prepared and published on http://intranet.defence.gov.au/dgta/ and http://www.defence.gov.au/dgta/NPRM.htm. DGTA-ADF will not individually acknowledge or respond to comments or submissions.

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WGCDR
Acting Director Aviation Regulation
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12 January 2011

Annex:
A. NPRM DGTA 01-11 - Comment Sheet

Enclosures:
1. Proposed UAS Regulations
2. Proposed UAS Guidance

NPRM DGTA 01-11 Comment Sheet

AAP7001.053 SECTION 2 CHAPTER 1 REGULATION 2 UNMANNED AIRCRAFT SYSTEMS (UAS)

Please return this response sheet by 28 Feb 11, via email attachment to DGTANPRM@defence.gov.au.

Please indicate your acceptance or otherwise of this proposal by ticking the appropriate box below. Additional comments, suggested amendments or alternative action are welcome and may be provided on this response sheet or by separate correspondence.

[ ] The proposal is **acceptable without change**.

[ ] The proposal is **acceptable but would be improved if the following changes were made**:

[ ] The proposal is **not acceptable but would be acceptable if the following changes were made:**

LSN	NPRM Reference: (i.e Regulation number, NPRM paragraph etc)	Comment or suggested change	Explanation
1			
2			
3			
4			

RESOURCE IMPLICATIONS

Please provide specific comment on any significant resource implications that this proposal may have for your organisation, for both its implementation and ongoing compliance. Your comments should address both financial and human resource considerations.

Resource implications – Proposal implementation	
Resource implications – Proposal sustainment	

RESPONDENT DETAILS

Your name:	
Submission date:	
Your organisation:	
Email address:	
Postal address:	
Phone:	
Whose views are represented in your response? **i.e. Is your response the authoritative response from your organisation?**	Responding on behalf of : Individual [ ] ADF AEO/AMO [ ] Commercial AEO/AMO [ ] Wing HQ [ ] Group HQ [ ] ADF Regulatory, Technical or Logistics policy agency [ ] Other commercial entity [ ], Other [ ] Please describe:-
Consent to publish your name as an NPRM respondent within the DGTA-ADF Summary of Responses:	YES [ ] NO [ ]

PROPOSED UAS REGULATIONS

2.8. UNMANNED AIRCRAFT SYSTEMS

2.8.1 Definitions

a. Definitions for Category 1 and Category 2 Unmanned Aircraft Systems (UAS) are presented in AAP7001.048, *ADF Airworthiness Manual*, at MILAVREG 7.

b. For the purposes of this regulation, a UAS shall include the air vehicle, ground control station, command and control link, launch equipment, recovery equipment, and any other equipment that may affect the Technical Airworthiness of the UAS.

c. For the purposes of this regulation, the General Public comprises all personnel, including Defence personnel, not declared Mission Essential.

2.8.2 Applicability

a. This regulation prescribes procedural requirements for the issue of a recommendation by the TAR for:

(1) issue of an airworthiness instrument for a State-registered Category 1 UAS;

(2) approval for a non-State-registered Category 1 UAS to be operated by or on behalf of the ADF; and

(3) issue of a UAS Operating Permit for a Category 2 UAS.

2.8.3 Category 1 UAS

a. Where a Category 1 UAS is to be operated as a State-registered aircraft, TAREGs 2.1 to 2.7 are applicable, with the following exceptions:

(1) TAREG 2.2.7 (Recognition of Prior Acceptance) shall only be applied where the TAR has assessed that the civil or military airworthiness authority:

(i) regulates UAS design in a manner that is comparable with its regulation of manned aircraft of a similar weight;

(ii) promulgates a UAS design standard that presents an equivalent level of safety to the Category 1 UAS design requirements in AAP7001.054; and

(iii) has verified the UAS design complies with that design standard.

(2) TAREG 2.2.6 (Statement of Operating Intent) shall be expanded to document:

(i) the population distributions of Mission Essential Personnel to whom the UAS may present a hazard;

(ii) the population distributions of the General Public to whom the UAS may present a hazard;

(iii) the facilities and ships that may be exposed to a hazard by the UAS; and

(iv) the airspace environments in which the UAS may operate;

(3) TAREG 2.7 (Civil Leased Aircraft) shall only be applied to UAS:

(i) warranting the application of Recognition of Prior Acceptance in accordance with TAREG 2.8.3.a(1); and

(ii) where the UAS engineering and maintenance support arrangements required by the NAA present a level of safety comparable with TAREGs 3, 4 and 5.

b. Where a Category 1 UAS is to be operated as a non-State-registered aircraft under MILAVREG 5.4, the TAR shall provide a positive recommendation for operation of the UAS, provided that:

(1) an SOI meeting TAREG 2.8.3.a(2) has been produced;

(2) the regulation of UAS design by the civil or military Airworthiness Authority would warrant the application of Recognition of Prior Acceptance in accordance with TAREG 2.8.3.a(1);

(3) the prior acceptance is applicable to the configuration being operated by the ADF and the ADF's intended roles and operating environment as defined in the SOI;

(4) the UAS engineering and maintenance support arrangements required by the civil or military airworthiness authority present a level of safety comparable with TAREGs 3, 4 and 5; and

(5) A DAR is appointed to assure the initial and ongoing compliance with TAREG 2.8.3.b(4).

2.8.4 Category 2 UAS

a. The TAR and OAA shall agree on safety targets for the likelihood of the Category 2 UAS causing serious injury or fatality to the General Public and Mission Essential persons.

b. An SOI shall be produced that meets TAREG 2.2.6, expanded to document:

(1) the population distributions of Mission Essential Personnel to whom the UAS may present a hazard;

(2) the population distributions of the General Public to whom the UAS may present a hazard;

(3) the facilities and ships that may be exposed to a hazard by the UAS; and

(4) the airspace environments in which the UAS may be operated.

c. The DAR is entitled to a positive TAR recommendation for a Category 2 UAS Operating Permit, provided that:

(1) the DAR has issued the relevant Design Acceptance certificate;

(2) a document has been produced that summarises the achievements against the Design Acceptance Strategy;

(3) a DAR has been delegated responsibility for the Design Acceptance of the UAS following the issue of the UAS Operating Permit;

(4) engineering support arrangements have been implemented that retain the integrity of the UAS design;

(5) maintenance support arrangements have been implemented that retain the integrity of the UAS design; and

(6) OHS risks have been managed per TAREG 2.4.1.a.(6) and 2.4.1.a.(7).

d. Except as otherwise authorised by the TAR, the DAR shall only issue a Design Acceptance certificate in support of a Category 2 UAS Operating Permit if:

(1) a Design Acceptance strategy has been documented in accordance with TAREG 2.8.4.e;

(2) TAR endorsement for the ADF Statement of Requirement has been achieved in accordance with TAREGs 2.2.3.a.(2) and 2.2.3.a.(3);

(3) the design agency has submitted the data and analyses required by TAREGs 2.2.3.a(5)(i), (ii), (iv), (v), (vi) and (viii);

(4) an examination of the UAS Design has concluded that:

(i) the UAS Design meets the requirements of the ADF SOR,

(ii) the design meets the agreed safety targets for the UAS;

(iii) any airworthiness issues identified through the course of Design Acceptance are resolved to the satisfaction of the TAR and OAA via an Issue Paper; and

(iv) no feature or characteristic of the UAS makes it unsafe for its intended operations.

e. The Design Acceptance strategy shall present a strategy for:

(1) evaluating the competence of the UAS design agency;

(2) estimating the likelihood of serious injury or fatality to Mission Essential personnel (both individually and collectively) as a result of:

(i) unpremeditated descent of the UAS, or

(ii) loss of control of the UAS;

(3) estimating the likelihood of serious injury or fatality to the General Public (both individually and collectively) as a result of:

(i) unpremeditated descent of the UAS, or

(ii) loss of control of the UAS;

(4) estimating the likelihood of a system error presenting erroneous and unflagged navigation data to the UAS operator;

(5) evaluating the functionality and integrity of any manual or automatic flight termination or recovery systems; and

(6) confirming that any UAS systems that contribute to airspace deconfliction, present an appropriate level of performance and integrity.

PROPOSED UAS GUIDANCE

UNMANNED AIRCRAFT SYSTEMS

INTRODUCTION

1. AAP7001.048, *ADF Airworthiness Manual*, presents military aviation regulations for Unmanned Aircraft Systems (UAS) at MILAVREG 7. Two broad categories of UAS (Category 1 and Category 2) are defined in MILAVREG 7, as follows:

   a. A Category 1 UAS, when operating in the intended roles and environment, is a system for which the consequence of a catastrophic failure can reasonably be expected **to result** in death or serious injury, or significant damage to property.

   b. A Category 2 UAS, when operating in the intended roles and environment, is a system for which the consequence of a catastrophic failure can reasonably be expected **not to result** in death or serious injury, or significant damage to property.

2. MILAVREG 7.1 states that a Category 1 UAS shall only be operated as an ADF State-registered aircraft per MILAVREG 2.4, or by or on behalf of the ADF as a non-State-registered aircraft per MILAVREG 5.7. A Category 2 UAS, on the other hand, shall only be operated following the issue of a UAS Operating Permit by the relevant Operational Airworthiness Authority (OAA). Where the ADF seeks to operate a Category 1 or Category 2 UAS, the TAR must provide the following support:

   a. For a Category 1 UAS to be operated as a State-registered aircraft, the TAR must provide a Type Certification recommendation to the ADF AA;

   b. For a Category 1 UAS to be operated as a non-State-registered aircraft, the TAR must endorse the application for operation to the ADF AA;

   c. For a Category 2 UAS to be issued a UAS Operating Permit by an OAA, the TAR must provide a recommendation in respect to the technical airworthiness of the system for the intended operations.

3. TAREG 2.8 presents Technical Airworthiness regulations for Category 1 and Category 2 UAS. This chapter provides additional clarity on the objectives of each regulation, and an acceptable means of compliance.

SCOPE

4. This chapter provides guidance for DARs and project engineering staff in establishing compliance with TAREG 2.8.

GUIDANCE ON TAREG 2.8.1 - "DEFINITIONS"

5. This section provides guidance on the source of, and rationale behind, each of the definitions presented in TAREG 2.8.1.

TAREG 2.8.1a - Definitions for Category 1 and Category 2 Unmanned Aircraft Systems (UAS) are presented in AAP7001.048, ADF Airworthiness Manual, at MILAVREG 7.

Explanation

6. This regulation presents definitions for Category 1 and 2 UAS. Given that the definitions are lengthy, they are not reproduced in the regulation; rather, reference is made to the source of the definitions (ie MILAVREG 7).

TAREG 2.8.1.b - For the purposes of this regulation, a UAS shall include the air vehicle, ground control station, command and control link, launch equipment, recovery equipment, and any other equipment that may affect the Technical Airworthiness of the UAS.

Explanation

7. This regulation ensures that a 'systems' approach to Technical Airworthiness is adopted for UAS, recognising that elements of the UAS other than the air vehicle itself can make a direct contribution to airworthiness. For example, depending on the UAS architecture and operating environment, certain equipment within the ground control station (eg the display of navigation data, the control of flight termination, and so on), might directly affect the safety of personnel on the ground, facilities, ships and also other aircraft. Similarly, separate launch equipment is required by some UAS to propel the UAS to stable flight velocity; under-performance of this equipment could result in the UAS having reduced handling qualities during the initial stages of flight, potentially presenting a hazard to personnel and facilities.

8. DARs are, however, permitted some latitude in deciding which equipment has a direct effect on Technical Airworthiness and therefore warrant regulation. For example, certain equipment within a ground control station (eg the operator's chair, perhaps the air conditioner, etc) may not have a direct effect on Technical Airworthiness, and therefore does not warrant technical regulation. Care must be taken, however, in deciding that certain non-core equipment does not affect Technical Airworthiness. For example, while a UAS payload might be assessed as not contributing to safety, certain payload failure conditions may affect other more critical equipment. System safety assessments provide a suitable vehicle for the DAR to evaluate the airworthiness implications of UAS equipment.

TAREG 2.8.1.c - For the purposes of this regulation, the General Public comprises all personnel, including Defence personnel, not declared Mission Essential.

Explanation

9. A fundamental difference in Technical Airworthiness management between manned and unmanned aircraft is that the former inherently assures the safety of ground-based personnel through assuring the safety of on-board personnel, whereas the latter cannot rely on this mechanism. Technical Airworthiness management of UAS must therefore focus on the safety of ground-based personnel.

10. The ADF may be willing to tolerate different levels of risk for personnel directly involved with a UAS activity (eg UAS crew, ADF ground forces, etc), compared with those personnel not directly involved (eg the general public). As will become evident later in this guidance, establishing safety targets for persons not involved in a UAS activity (and therefore are involuntarily accepting risk) and for persons who are directly involved in a UAS activity (and therefore are voluntarily accepting risk) is a fundamental driver for Technical and Operational airworthiness management of Category 2 UAS. The same concepts may also be relevant for a Category 1 UAS, particularly where challenging roles and operating environments are proposed for the UAS.

11. The ground-based personnel at risk from an ADF UAS can be broadly separated into two groups. First, there are those personnel that are directly associated with the particular UAS mission. This includes not only the personnel involved with launching, operating and recovering the UAS, but also those Defence personnel who are participating in the same mission as the UAS (eg ground troops participating in an exercise). Secondly, there are those personnel who have no direct involvement with the UAS mission, for example the general public and Defence personnel on unrelated business. While no extant international UAS standards or policies currently provide suitable definitions for these groupings, the US Range Commanders Council (RCC) 321-07, *Common Risk Criteria for National Test Ranges: Inert Debris,* does adopt similar classifications. The following definitions, adapted from the RCC standard, are proposed for the two broad groups of ground-based personnel at risk from an ADF UAS:

a. **Mission Essential Personnel**: Those persons necessary to safely and successfully launch, operate and recover the UAS, plus those Defence personnel declared/identified by the OAA as essential to the operation in which the UAS is participating.

b. **General Public**: People who are not declared/identified by the OAA as mission essential personnel. This includes the public plus Defence personnel not essential to a mission, visitors, and personnel/dependents living on the base/facility.

12. It is, however, the OAA's prerogative to define alternate groupings to those defined above. For example, the OAA may define different levels of safety for subsets of Mission Essential personnel (for example ground combatants versus UAS launch/recovery personnel), or may define different levels of safety depending on the UAS operating environment (for example, Australian training exercises versus Australian disaster relief versus overseas wartime operations). If the OAA does elect to define alternate groupings, then these groupings should be applied in lieu of those presented in the regulation and in this chapter.

GUIDANCE ON TAREG 2.8.2 - "APPLICABILITY"

13. This section provides guidance on the rationale behind the 'applicability' requirements of TAREG 2.8.

TAREG 2.8.2.a - This regulation prescribes procedural requirements for the issue of a recommendation by the TAR for:

(1) issue of an airworthiness instrument for a State-registered Category 1 UAS;
(2) approval for a non-State-registered Category 1 UAS to be operated by or on behalf of the ADF; and
(3) issue of a UAS Operating Permit for a Category 2 UAS.

Explanation

14. The requirement for Technical Airworthiness regulation of Category 1 UAS is self-evident; after all, by definition, the catastrophic failure of a Category 1 UAS can reasonably be expected to result in serious injury or fatality. The requirement to regulate the Technical Airworthiness of Category 2 UAS, on the other hand, is not as obvious, since by definition a Category 2 UAS should not pose a safety concern. However, consider the following:

a. During an exercise involving ground troops and a UAS, the OAA may tolerate additional risk if it improves training outcomes. For example, the OAA may allow the UAS to operate for extended periods in close proximity to ground troops.

b. A UAS might spend the vast majority of its time well away from people, and only a brief time near people (eg during takeoff/landing, or perhaps for a brief time during transit), in which case the OAA may feel justified in categorising the UAS as Category 2.

c. Even for UAS that will be used solely within Defence Practice Areas (DPAs), the UAS is likely to have a range that is well beyond the size of the DPA. A UAS system fault may result in the UAS exiting the DPA and presenting a hazard to the general public.

d. An operator's ability to keep the UAS away from people and facilities (including ships) is dependent on the UAS and the operator being presented with navigation and status information of suitable integrity.

e. An operator's ability to effectively de-conflict with other aircraft, depends on the integrity of UAS technical equipment (eg navigation equipment, IFF, data link, lights, etc).

f. Finally, the existence of an effective autonomous recovery system, and a means to manually terminate flight, are key safety elements for a UAS.

Summarised, there are numerous ways in which a Category 2 UAS can present a hazard to civilian and/or military personnel and facilities. The OAA therefore requires technical advice to inform risk treatment decisions. Accordingly, both Category 1 and Category 2 UAS are subject to technical airworthiness regulation.

GUIDANCE ON TAREG 2.8.3 - "CATEGORY 1 UAS"

15. This section provides guidance, including acceptable means of compliance, on each of the regulations specific to Category 1 UAS.

TAREG 2.8.3.a - Where a Category 1 UAS is to be operated as a State-registered aircraft, TAREGs 2.1 to 2.7 are applicable, with the following exceptions:

(1) TAREG 2.2.7 (Recognition of Prior Acceptance) shall only be applied where the TAR has assessed that the civil or military airworthiness authority:

- *(i) regulates UAS design in a manner that is comparable with its regulation of manned aircraft of a similar weight;*
- *(ii) promulgates a UAS design standard that presents an equivalent level of safety to the Category 1 UAS design requirements in AAP7001.054; and*
- *(iii) has verified the UAS design complies with that design standard.*

(2) TAREG 2.2.6 (Statement of Operating Intent) shall be expanded to document:

- *(i) the population distributions of Mission Essential Personnel to whom the UAS may present a hazard;*
- *(ii) the population distributions of the General Public to whom the UAS may present a hazard;*
- *(iii) the facilities and ships that may be exposed to a hazard by the UAS; and*
- *(iv) the airspace environments in which the UAS may operate;*

(3) TAREG 2.7 (Civil Leased Aircraft) shall only be applied to UAS:

- *(i) warranting the application of Recognition of Prior Acceptance in accordance with TAREG 2.8.3.a(1); and*
- *(ii) where the UAS engineering and maintenance support arrangements required by the NAA present a level of safety comparable with TAREGs 3, 4 and 5.*

Explanation

16. This regulation confirms that a Category 1 UAS is subject to essentially the same Technical Airworthiness regulations as manned aircraft, but with minor tailoring to account for the unique UAS feature that the aircrew are remote from the air vehicle. Each area of tailoring is described below.

17. Clause (1). Compared with manned aircraft, UAS airworthiness regulation is still in its infancy. Circa 2010, no civil or military airworthiness authority is regulating UAS design in a manner that the TAR would assess as being comprehensive. TAR agreement to 'prior acceptance' for a UAS therefore cannot be presumed, even where the airworthiness authority is recognised as competent in TAREG 2.2.7.

18. This regulation recognises that there are three elements to the TAR's confidence that Recognition of Prior Acceptance (RPA) for a UAS is warranted. Firstly, the NAA must establish regulations for UAS design that achieve a comparable level of safety to manned aircraft of similar weight. Next, the NAA must define a UAS design standard that presents an appropriate level of safety for regular UAS operations near and over people. Finally the NAA must confirm that the design of a particular UAS meets the design standard.

19. Clause (2). Technical Airworthiness management of a UAS focuses primarily on the safety of ground-based personnel. For a UAS Statement of Operating Intent (SOI) to present a useful basis for Design Acceptance, some additional information is needed beyond the normal SOI requirements for a manned aircraft. This regulation requires a UAS SOI to include details of the personnel, facilities and ships being overflown by the UAS, and the airspace in which the UAS will be operated.

20. Details of personnel/facilities/ships being overflown may initially appear superfluous, given that a Category 1 UAS should be designed so that a crash is a sufficiently rare event. However, the reality is that Category 1 UAS may, for some years, pose a greater hazard to personnel/facilities/ships than some manned aircraft. After all, manned aircraft rely extensively on aircrew to provide a flexible resource for identifying, analysing and dealing with malfunctions and achieving a safe landing, whereas a Category 1 UAS must primarily rely on software to achieve the same result; this is a particularly challenging issue for UAS designers. Until Category 1 UAS can demonstrate a similarly low hazard to personnel/facilities/ships as manned aircraft, operational mitigations may be required to maintain an adequate level of safety. ADF engineers will require a comprehensive understanding of the population distributions of personnel, and the nature of facilities and ships, being overflown by the UAS if they are to advise operators on the type and extent of operational procedures needed to maintain this adequate level of safety.

21. The scope of UAS-specific information required in the SOI may include the following:

a. **Population Distributions**. Information on expected population distributions is essential for characterising the risk presented by the UAS to personnel. Greater fidelity in the information will improve this characterisation, although a pragmatic balance between clarity and computational complexity should be pursued. For example, characterising population distributions as 'people per square kilometre' can be misleading because it may not emphasise dense population centres (eg sports stadiums, schools, bodies of troops, etc) where a UAS crash would be much more likely to cause fatalities. Where possible, expected average population densities, supplemented

by data on peak population densities (stating the size of the area, and population density in that area) will provide the risk analyst with essential information, and should be included in the SOI. Where the precise areas for operation of the UAS are not yet known, proposed likely and worst-case scenarios should be presented.

b. **Facilities**. Significant facilities subjected to a hazard by the UAS should be identified in the SOI. The US military document RCC 323-99, *Range Safety Criteria For Unmanned Air Vehicles, Rationale And Methodology Supplement*, provides useful guidance on this topic, suggesting damage to a facility or property is unacceptable if its damage or destruction could result in one or more of the following severe consequences:

(1) loss or degradation of a major function,

(2) significant monetary loss,

(3) significant environmental impact, and/or

(4) significant cultural impeach.

c. **Ships**. Where a UAS is to be operated over water, information on the numbers and types of civilian and military ships subjected to a hazard by the UAS should be provided.

d. **Airspace Requirements**. Access to shared airspace is a particular challenge for UAS. For example, routine access to Australian Class G airspace by UAS will likely require the inclusion of a 'sense-and-avoid' capability that is acceptable to CASA. Terminal area operations may also be challenging if Air Traffic Control requires the UAS to be 'transparent' to the controllers (ie not differentiated from manned aircraft). Airspace access requirements are therefore a key driver of the functionality and integrity of UAS systems, and need to be comprehensively disclosed in the SOI.

22. Until UAS sense-and-avoid systems are accepted by civilian airworthiness authorities as capable of safely separating manned and unmanned aircraft, airspace deconfliction will remain an operational airworthiness responsibility. However, the DAR must still confirm that UAS systems needed by the operators to support flight in shared airspace (eg transponder, TCAS, communications systems, etc) provide the required functionality and the design is appropriately assured. Note, however, that manned aircraft design standards for these systems may not always be appropriate for a UAS. For example, the transponder on a UAS may require additional functionality to a manned aircraft transponder (eg the ability to automatically 'squawk' a code when the datalink is lost), and in some operating environments the transponder on a UAS may have a greater influence on safety (which in turn may impose increased assurance requirements). Airspace requirements for the UAS should be included in the SOI.

23. Clause (3). As explained previously in this chapter, UAS regulation is an evolving field. For the TAR to accept that a civil leased UAS presents an appropriate level of safety, the TAR expects:

a. the regulation of UAS design by the civilian Airworthiness Authority to present a similar level of safety to manned aircraft; and

b. the regulation of UAS in-service engineering and maintenance support arrangements by the civilian Airworthiness Authority to assure that the integrity of the design is retained.

Paragraph 18 of this chapter provides insight into the TAR's criteria for evaluating the adequacy of UAS design regulation by a civilian airworthiness authority. When assessing the adequacy of UAS engineering and maintenance support regulation, the TAR will confirm the regulation is commensurate with manned aircraft, and hence will be benchmarked against TAREGs 3, 4 and 5.

TAREG 2.8.3.b - Where a Category 1 UAS is to be operated as a non-State-registered aircraft under MILAVREG 5.4, the TAR shall provide a positive recommendation for operation of the UAS, provided that:

(1) an SOI meeting TAREG 2.8.3.a(2) has been produced;

(2) the regulation of UAS design by the civil or military Airworthiness Authority would warrant the application of Recognition of Prior Acceptance in accordance with TAREG 2.8.3.a(1);

(3) the prior acceptance is applicable to the configuration being operated by the ADF and the ADF's intended roles and operating environment as defined in the SOI;

(4) the UAS engineering and maintenance support arrangements required by the civil or military airworthiness authority present a level of safety comparable with TAREGs 3, 4 and 5; and
(5) A DAR is appointed to assure the initial and ongoing compliance with TAREG 2.8.3.b(4).

Explanation

24. MILAVREG 5.4 allows for the operation of non-State-registered aircraft by or on behalf of the ADF. The TAR retains responsibility for assuring the Technical Airworthiness of these aircraft, and therefore requires confidence in the adequacy of the UAS design and the in-service engineering and maintenance support arrangements. This regulation provides the means for the TAR to gain this confidence, as outlined below.

25. Clause (1). This clause requires an SOI, tailored to reflect the unique issues associated with UAS. The SOI will provide information on the roles and operating environment of the UAS, including amongst other things the distribution and characteristics of personnel/facilities/ships to be overflown. This is an essential input to the Design Acceptance process, which must confirm the UAS design presents a satisfactory level of integrity for these roles and operating environments. Paragraphs 20 to 22 of this chapter provide further information.

26. Clause (2). For the TAR to accept that the design of a non-State-registered UAS presents an appropriate level of safety, the responsible Airworthiness Authority must adopt a rigorous approach to the regulation of UAS design. A suitable benchmark is that adopted by the TAR for the Recognition of Prior Acceptance.

27. Clause (3). This clause requires a rigorous analysis of any deltas between the ADF's proposed roles and operating environments, and the roles and operating environments assumed by the responsible Airworthiness Authority. Where deltas are present that may pose and additional hazard to personnel and/or facilities, proposed risk treatments must be presented to the TAR and OAA for approval. An Airworthiness Issue Paper (refer Sect 2 Chap 12) is a suitable medium for achieving and documenting this agreement.

28. Clause (4). The responsible Airworthiness Authority's regulation of UAS engineering and maintenance support should be commensurate with manned aircraft, and hence will be benchmarked against TAREGs 3, 4 and 5.

29. Clause (5). The TAR retains responsibility for assuring the technical airworthiness of UAS operated by or on behalf of the ADF. While the involvement of other Airworthiness Authorities can reduce the burden on the TAR in assuring continuing airworthiness, the responsibility still remains. The appointment of a DAR for in-service support will, amongst other things, provide the TAR with ongoing confidence that:

a. the responsible Airworthiness Authority is providing a suitable level of airworthiness management oversight of the UAS engineering and maintenance support organisations;

b. proposed SOR changes are critically assessed for their impact on technical airworthiness;

c. proposed changes to the role and/or operating environment do not invalidate the TAR's recommendation for operation of the UAS; and

d. any incidents that suggest the UAS design may not meet the level of safety required for a Category 1 UAS are investigated and communicated to the TAR.

GUIDANCE ON TAREG 2.8.4 - "CATEGORY 2 UAS"

30. By definition, the catastrophic failure of a Category 2 UAS is reasonably not expected to result in death or serious injury, or significant damage to property. However, while UAS operating environments are available that absolutely guarantee the safety of personnel and property, these operating environments will inevitably be of little interest to the ADF. Practically, as explained at paragraph 14 of this chapter, the operation of a Category 2 UAS will always pose some risk to the General Public and/or Mission Essential personnel, and therefore Technical Airworthiness regulation is warranted. This section provides guidance on each of the regulations specific to Category 2 UAS.

TAREG 2.8.4.a - The TAR and OAA shall agree on safety targets for the likelihood of the Category 2 UAS causing serious injury or fatality to the General Public and Mission Essential persons.

Explanation

31. The aim of this regulation is to define the agreed tolerable bound (ie the safety target), against which all UAS technical and operational airworthiness considerations can be benchmarked. Depending on the OAA's requirements, one or more safety targets may be defined. For example, different safety targets may be defined for the General Public versus Mission Essential persons, for Australian operations versus overseas wartime operations, or even different safety targets for various types of operations within Australia (eg training versus support to disaster relief operations). Note that, over time, a set of 'standard' UAS safety targets will probably emerge that the ADF accepts as suitable for particular UAS operations, and these can automatically be adopted for future UAS. However, circa 2010, further ADF research and experience is needed to derive a comprehensive and defensible set of safety targets. In the interim, the TAR and OAA will need to agree on safety targets for each new UAS application.

32. The agreed safety target(s), when merged with the population distribution information required by TAREG 2.8.4.b, will define the level of integrity required by the UAS design. For example, where Category 2 UAS operations are required in close proximity to dense population centres, accurate navigation information is a key contributor to meeting the agreed safety target.

33. Safety targets should be defined in terms of individual and collective risk. Definitions for individual and collective risk have been adapted from US Military standard RCC 321-07, *Common Risk Criteria Standards for National Test Ranges* (given the ADF employs this standard for calculating risks due to weapons releases, so the terminology is familiar), as follows:

a. **Individual risk:** The risk that a person will suffer a consequence. Unless otherwise noted, individual risk is expressed as the probability that an individual will suffer a serious injury or fatality due to all hazards from an operation at a specific location.

b. **Collective Risk:** The total risk to all individuals exposed to any hazard from an operation. Unless otherwise noted, collective risk is the mean number of serious injuries or fatalities predicted to result from all hazards associated with an operation. Collective risk is specified as either for a mission or per year. (Note: If each person in a group is subject to the same individual risk, then the collective risk is the individual risk multiplied by the number of people in the group).

The units employed within the above definitions for individual and collective risk are not mandatory. However, where alternative units are to be employed, for example 'fatalities per flight hour' for collective risk, they should be consistently used throughout all analyses.

34. Since safety targets are an essential input to Design Acceptance for a Category 2 UAS, they should be agreed with the OAA, with input from the TAR, early in the procurement lifecycle. An Airworthiness Issue Paper (refer Sect 2 Chap 12) is a suitable medium for achieving and documenting this agreement.

TAREG 2.8.4.b - An SOI shall be produced that meets TAREG 2.2.6, expanded to document:
(1) the population distributions of Mission Essential Personnel to whom the UAS may present a hazard;
(2) population distributions of the General Public to whom the UAS may present a hazard;
(3) the facilities and ships that may be exposed to a hazard by the UAS; and
(4) the airspace environments in which the environments in which the UAS may be operated.

Explanation

35. While by definition the crash of a Category 2 UAS is reasonably not expected to result in death or serious injury, or significant damage to property, paragraph 14 of this chapter explained that a Category 2 UAS can still present a hazard to personnel and/or facilities. Effective analysis and evaluation of this risk is dependent upon the accurate characterisation of the environment in which the UAS will operate. Paragraphs 19 to 22 of this chapter provide guidance on the content of an SOI for a Category 1 UAS; this guidance is equally relevant to a Category 2 UAS.

TAREG 2.8.4.c - The DAR is entitled to a positive TAR recommendation for a Category 2 UAS Operating Permit, provided that:
(1) the DAR has issued the relevant Design Acceptance certificate;
(2) a document has been produced that summarises the achievements against the Design Acceptance Strategy;

(3) a DAR has been delegated responsibility for the Design Acceptance of the UAS following the issue of the UAS Operating Permit;
(4) engineering support arrangements have been implemented that retain the integrity of the UAS design;
(5) maintenance support arrangements have been implemented that retain integrity of the UAS design; and
(6) OHS risks have been managed per TAREG 2.4.1.a.(6) and 2.4.1.a.(7).

Explanation

36. This regulation presents the TAR's requirements for recommending the issue of a UAS Operating Permit for a Category 2 UAS. Each individual clause is examined below.

37. Clauses (1) and (2). These clauses mirror the requirements for Type Certification of manned aircraft, confirming that Design Acceptance is an essential contributor to a positive TAR Recommendation. A DAR must be approved by the TAR for the procurement of the Category 2 UAS, and the DAR must satisfactorily complete and document Design Acceptance certification. Without Design Acceptance certification, the TAR may be unable to provide a TAR Recommendation for the UAS Operating Permit. Where a UAS project office intends to procure a UAS without engaging a suitable DAR (and of course the engineering staff that will support the DAR in achieving Design Acceptance), the relevant OAA should first be approached to confirm that a TAR Recommendation is not essential.

38. Clause (3). The TAR retains responsibility for assuring the technical airworthiness of UAS operated by or on behalf of the ADF. The appointment of a DAR who has been delegated responsibility for the Design Acceptance of the UAS following the issue of the UAS Operating Permit is fundamental to the TAR executing this obligation. The DAR will, amongst other things, provide ongoing confirmation that:

a. a suitable level of airworthiness management oversight of the UAS engineering and maintenance support organisations is being provided;

b. proposed changes to the role and/or operating environment do not invalidate the TAR's recommendation for the UAS Operating Permit;

c. proposed design changes to the UAS do not unacceptably reduce the level of safety of the UAS in the ADF's proposed role and operating environment; and

d. any incidents that suggest the UAS design may not meet the agreed level of safety, are investigated and communicated to the TAR.

39. Clauses (4) and (5). These clauses confirm that some Category 2 UAS equipment is likely to be critical to meeting the defined safety target. Obvious candidates are navigation and flight termination equipment, although there may be others. If so, then effective engineering and maintenance support is required to retain the level of safety agreed by the TAR when issuing the 'TAA Recommendation for UAS Operating Permit'.

40. However, explicit regulatory requirements for engineering and maintenance support, for example compliance with the AEO and AMO requirements of TAREGs 3, 4 and 5, are not specifically directed in the regulation. Rather, the TAR acknowledges that only certain equipment on a Category 2 UAS make a direct contribution to safety, and that the criticality of quality engineering and maintenance support is likely to vary between UAS and between operating environments. For example, modular architectures for key functions may reduce the likelihood of safety-related maintenance errors. Conversely, operational risk treatments might depend heavily on the design integrity of a key system, so future design changes to that system would need to be critically assessed. Given this variability, projects are provided with reasonable latitude to implement pragmatic arrangements for engineering and maintenance support, commensurate with the contribution to safety.

41. Notwithstanding the above, quality engineering and maintenance support arrangements, and rigorous ADF oversight of those arrangements, may reduce the crash rate of a Category 2 UAS and improve mission system serviceability. Projects may therefore elect to pursue full compliance with TAREGs 3, 4 and 5, even though it is potentially in excess of the TAR's requirements for a Category 2 UAS.

42. Finally, while aircraft and engine structural integrity may not directly contribute to safety for a Category 2 UAS, poor management of these issues is likely to increase crash rates, and consequently will have an economic, political and capability impact. Projects should engage with ASI-DGTA and ESI-DGTA to establish

whether the contractor's proposed arrangements for aircraft and engine structural integrity management are pragmatic.

43. **Clause (6).** This clause confirms that the effective management of OH&S is an essential prerequisite for Design Acceptance. Many of the OH&S hazards presented by manned aircraft are also relevant to UAS, for example onboard lasers, hazardous substances, post-crash hazardous materials, and so on. Some UAS may have additional OH&S hazards, for example high energy components in launch equipment, the lack of on-board crew to provide safety interlocks (for example, manually arming non-eyesafe lasers), and so on. The DAR is to ensure all OH&S risks have been assessed, where appropriate gaining OH&S input from a competent authority. When presenting an application for a 'TAA Recommendation for UAS Operating Permit', the DAR is to summarise the outcomes of these activities, and confirm that appropriate treatments have been implemented.

TAREG 2.8.4.d - Except as otherwise authorised by the TAR, the DAR shall only issue a Design Acceptance certificate in support of a Category 2 UAS Operating Permit if:

(1) a Design Acceptance strategy has been documented in accordance with TAREG 2.8.4.e;

(2) TAR endorsement for the ADF Statement of Requirement has been achieved in accordance with TAREGs 2.2.3.a.(2) and 2.2.3.a.(3);

(3) the design agency has submitted the data and analyses required by TAREGs 2.2.3.a(5)(i), (ii), (iv), (v), (vi) and (viii);

(4) an examination of the UAS Design has concluded that:

- ***(i) the UAS Design meets the requirements of the ADF SOR,***
- ***(ii) the design meets the agreed safety target for the UAS;***
- ***(iii) any airworthiness issues identified through the course of Design Acceptance are resolved to the satisfaction of the TAR and OAA via an Issue Paper; and***
- ***(iv) no feature or characteristic of the UAS makes it unsafe for its intended operations.***

Explanation

44. This regulation presents the conditions upon which the DAR may issue a Design Acceptance certificate for a Category 2 UAS. Each clause is examined below.

45. **Clauses (1) and (2).** These two clauses require the DAR to produce and manage a Design Acceptance strategy, and achieve TAR endorsement of the SOR, as per manned aircraft. Both of these requirements are risk reduction measures, in that they provide the TAR with early insight into the eventual basis for a TAR Recommendation for UAS Operating Permit.

46. **Clause (3).** This clause requires the DAR to ensure the design agency has submitted relevant data and analyses, as required for manned aircraft at TAREG 2.2.3a(5). However, the following elements of TAREG 2.2.3a(5) have been omitted:

a. The requirement for a Design Approval Certificate (as required by TAREG 2.2.3.a(5)(iii)) is omitted. As discussed later in this guidance, there is no imperative for the design agency to be approved by the TAR as an AEO, and therefore requiring this certificate may be problematic.

b. The requirements for engine and aircraft structural integrity management plans, as required by TAREG 2.2.3.a(5)(vii), are omitted, since neither aircraft nor engine structural integrity should make a direct contribution to safety for a Category 2 UAS. Notwithstanding this omission, the project may still elect to contract to one or both of these programs as a cost reduction measure, since they may contribute to a lower crash rate.

47. While the requirement for a Type Record as required by TAREG 2.2.3.a(5)(ii) has not been omitted, the DAR is afforded reasonable latitude in complying with this regulation. For example, a comprehensive Type Record would normally be an important contributor to the in-service support of an ADF-owned and maintained UAS, so the requirements of TAREG 2.2.3.a(5)(ii) would be applicable (with tailoring to reflect the nature of UAS). Conversely, where the ADF is conducting a short duration UAS trial, or procuring a UAS via a turn-key lease, then the scope and depth of type design information required by the ADF is probably substantially less. For these latter activities, the DAR may even decide that extant OEM documents satisfactorily define the type design against which Design Acceptance was certified.

48. While the requirement for a Software Management Plan as required by TAREG 2.2.3.a(5)(vi) has not been omitted, the DAR is expected to adopt a pragmatic approach to this requirement. The intention is for the SMP to assure that software changes that may impact UAS safety are adequately controlled. For example,

where software for the payload control system is effectively partitioned from flight control software, an SMP for the payload software is not essential (although the ADF may still wish to employ this useful management tool).

49. **Clause (4).** This clause requires the DAR to confirm that the UAS design is capable of meeting both the requirements of the SOR and the agreed safety target. Where shortfalls are evident that reduce the level of safety, an Issue Paper should be raised to propose risk treatments to the OAA and TAA for approval.

TAREG 2.8.4.e. - The Design Acceptance strategy shall present a strategy for:

(1) evaluating the competence of the UAS design agency;

(2) estimating the likelihood of serious injury or fatality to Mission Essential personnel (both individually and collectively) as a result of:

- ***(i) unpremeditated descent of the UAS, or***
- ***(ii) loss of control of the UAS;***

(3) estimating the likelihood of serious injury or fatality to the General Public (both individually and collectively) as a result of:

- ***(i) unpremeditated descent of the UAS, or***
- ***(ii) loss of control of the UAS;***

(4) estimating the likelihood of a system error presenting erroneous and unflagged navigation data to the UAS operator;

(5) evaluating the functionality and integrity of any manual or automatic flight termination or recovery systems; and

(6) confirming that any UAS systems that contribute to airspace deconfliction, present an appropriate level of performance and integrity.

Background

50. Circa 2010, UAS are often not designed to recognised aerospace standards or practices. Further, the lack of persons on board can allow designers to reduce costs by reducing design integrity, albeit there is normally a limit to how far this is pursued (since lower integrity designs can result in more frequent losses of expensive air vehicles and payloads). A standards-based approach to Design Acceptance may therefore not be practical for a Category 2 UAS. Rather, Design Acceptance will often be based on identifying the critical design features of a UAS needed to achieve the required safety target, and then obtaining assurance that their integrity is commensurate with the effect on safety. Where the design appears inadequate, operational mitigations may be recommended to address the shortfalls.

51. Design Acceptance ultimately provides the TAR with confidence that an engineering assessment of the compatibility between the UAS design and the proposed roles and operating environments (as defined in the SOI) has been completed, and any identified risks have been professionally communicated to an appropriate authority for treatment. Given the importance of Design Acceptance in achieving a positive 'TAR Recommendation for UAS Operating Permit', the Design Acceptance strategy is therefore an integral and essential planning document.

Explanation

52. Each requirement for a Category 2 UAS Design Acceptance strategy is examined below. While a 'TAR Recommendation for UASOP' may still be possible if some elements of the strategy are omitted, they will likely result in the TAR referring risk, potentially unbounded, to the OAA for retention. The OAA should be provided with the opportunity early in the planning cycle, and certainly before any agreements (eg contracts, Letters of Offer and Acceptance, etc) are signed, to confirm this is an acceptable outcome.

53. **Clause (1).** A key element of Design Acceptance is to obtain confidence that the design agency is competent. However, requiring a Category 2 UAS design agency to achieve full AEO certification is likely to be disproportionate to the safety benefit. A more pragmatic means of achieving confidence in the UAS engineering capabilities of the design agency is therefore required. The DAR is afforded reasonable latitude against this requirement. Any one of the following would provide confidence that the design agency is likely to be a competent Category 2 UAS designer:

a. the design agency is well-known for manned aircraft design;

b. UAS designed by this design agency have amassed considerable hours in-service by an ADF-recognised military;

c. an ADF review of the design agency's engineering system confirms that it broadly meets the TAMM's AEO requirements (this could be achieved either via a documentation review or an on-site assessment, as agreed with DGTA);

d. full AEO accreditation of the design agency is achieved; or

e. via another means, as agreed with DGTA.

54. **Clause (2).** Category 2 UAS will inevitably suffer from catastrophic failures that limit or preclude continued safe flight. Depending on the nature of the failure, the likely outcomes are an attempted emergency landing under control, or an uncontrolled ground impact. Common civilian definitions for these two scenarios are as follows:

a. **Unpremeditated descent scenario:** A failure (or combination of failures) which results in the inability to maintain a safe altitude above the surface (eg loss of power, Weight/Altitude/Temperature (WAT) limits etc).

b. **Loss of control scenario:** A failure (or combination of failures) which results in loss of control and may lead to impact at high velocity.

A key differentiator is that the former should allow the UAS on-board systems and/or the operator to guide the UAS to a safer landing location, whereas the latter will probably provide no opportunity for choosing the landing location. While the latter scenario will often result in impact at high velocity, design features such as parachutes may be employed to reduce kinetic energy.

55. As discussed earlier in this chapter, there are numerous scenarios where the forced landing or crash of a Category 2 UAS would present a hazard to Mission Essential personnel. For the OAA to understand the magnitude of this risk, and therefore whether risk avoidance or reduction measures are warranted, a key element of Design Acceptance is to establish the likelihood of serious injury or fatality to Mission Essential personnel, for the roles and operating environments presented in the SOI.

56. Calculating the risk to Mission Essential personnel as a result of an unpremeditated descent is a function of the following:

a. the likelihood of a UAS system failure leading to an unpremeditated descent;

b. the ability of on-board systems to sense the failure and autonomously guide the UAS to a safe landing location;

c. the controllability and likely range of the UAS following likely system failures throughout each phase of flight; and

d. the availability of safe locations, away from Mission Essential personnel and facilities, in which to complete the forced landing.

Where historic data or quality design data is not available for any of these elements, estimates may need to be based on judicious assumptions. For example, engine failures have historically been the primary source of unpremeditated descents, and therefore failure and reliability data for similar engines could be used for estimating numbers of unpremeditated descents if all other sources of failure are assessed as substantially less likely.

57. Calculating the risk to Mission Essential personnel as a result of the loss of control of the UAS is a function of the following:

a. the likelihood of a catastrophic UAS system failure leading to the UAS departing flight, including structural failures, jammed actuators, software faults in flight-critical systems, and so on;

b. the size of the danger area under the UAS, recognising that some failure modes (eg a departing wing) will probably result in the UAS dropping straight to the ground, while others (eg a stuck actuator) may result in the UAS crashing some distance laterally;

c. the distribution of Mission Essential Personnel within this danger area for each phase of flight, which could be estimated as follows:

(1) the DAR could derive, from discussions with operators, the most likely operating scenarios and the most hazardous operating scenario (eg an exercise with a high population of Defence staff, with the UAS flying in close proximity, etc), and for each scenario present an estimate of the likelihood of injury/death of a Defence member; or

(2) using a software modelling tool that has been developed DSTO.

d. Where a parachute is present, and is designed to automatically employ when a catastrophic failure occurs, the likely worst-case UAS drift distance must be taken into account when assessing which Mission Essential personnel are subject to the hazard.

Where historic data or quality design data is not available for any of these elements, estimates may need to be based on judicious assumptions. For example, data from similar classes of UAS may form a suitable basis.

58. Finally, engine and structural failure are likely to be key contributors to unpremeditated descents and losses of control respectively. Advice should be sought from ESI-DGTA and ASI-DGTA when reviewing engine reliability data and assessing the likelihood of catastrophic structural failures respectively. While ASI-DGTA probably cannot accurately quantify the likelihood of a catastrophic structural failure they can, based on available structural data, confirm whether structural failures will be a significant contributor to a given estimated crash rate.

59. To allow the OAA to target any risk avoidance or treatment measures, each of the above analyses should be broken into the different phases of flight, for example take-off, transit, operations and recovery.

60. Clause (3). When a UAS is used outside a Defence Practice Area (DPA), even if only briefly for launch, transit and/or recovery, it presents a hazard to the General Public. Even when a UAS is to be used exclusively within a DPA, certain sub-system failures could result in the UAS breaching the DPA boundary and presenting a hazard to the General Public. For the OAA to be informed as to the magnitude of this risk, and therefore whether risk avoidance or reduction measures are warranted, Design Acceptance must establish the likelihood of serious injury or fatality to the General Public, for the roles and operating environments presented in the SOI.

61. The guidance presented at paragraphs 54 to 59 (ie the likelihood of serious injury or fatality to Mission Essential personnel) is also largely applicable to this clause. However, some additional attributes of the operating environment need to be taken into account, as outlined in the following paragraphs.

62. Where UAS take-off and/or landing at an airfield outside a DPA is proposed, an assessment of the likelihood of serious injury or fatality to the General Public is required. This assessment should cover:

a. the risk to personnel outside the airfield perimeter, given that many airfields are in close proximity to public houses and facilities; and

b. the risk to personnel inside the airfield perimeter, given some airfields accommodate numerous personnel and dangerous facilities (eg fuel tanks, oxygen storage facilities, etc).

63. Where UAS transit outside a DPA is proposed, an assessment of the likelihood of serious injury or fatality to the General Public is required. For the reasons presented at paragraph 14 to this chapter, even the most carefully planned UAS transit, away from populous areas, may still present a risk to personnel and facilities. Where precise transit routes will not be defined prior to the issue of the UAS Operating Permit, a selection of likely and worst-case routes should be used to establish benchmarks against which future transits can be compared.

64. Where UAS operations outside a DPA are proposed, an assessment of the likelihood of serious injury or fatality to the General Public is required. For the reasons presented at paragraph 14 to this chapter, even UAS operations away from populous areas may still present a risk to personnel and facilities. Where precise operating areas will not be defined prior to the issue of the UAS Operating Permit, a selection of likely and worst-case operating areas should be used to establish benchmarks against which future operations can be compared.

65. **Clause (4).** The integrity of UAS navigation data is a fundamental contributor to personnel safety for a Category 2 UAS, since it enables the UAS operator to position the UAS away from ground-based personnel and facilities, and confine the UAS to within its assigned airspace. An assessment of the performance and integrity of the systems providing navigation data is therefore an essential element of Design Acceptance, highlighting for example the position drift rate when GPS signal is lost, the potential for unflagged errors, and so on. Where the penetration of an assigned boundary would result in a significant increase in risk to personnel, facilities and/or other aircraft, the breach should be considered a catastrophic occurrence.

66. **Clause (5).** The absence of crew on a UAS means that some integrity shortfalls in flight-critical systems can be tolerated, provided more frequent crashes are also tolerable. However, integrity shortfalls cannot normally be tolerated in autonomous recovery and flight termination systems. After all, manual flight termination is a key contributor to safety when uncommanded UAS behaviours or unforeseen circumstances occur. Also, when datalink communications with the UAS are lost, as is frequently the case, the UAS is no longer under the control of an operator, so the autonomous recovery system is a key contributor to safety.

67. A flight termination system that uses common elements for both the manual flight termination and autonomous recovery functions, presents a significant single point failure mode. This can result in a 'rogue' UAS that exits its assigned airspace and cannot be controlled, as occurred with a US military 'Fire Scout' UAS near Washington DC in 2010. The likelihood of such an occurrence should be defined as part of the Design Acceptance process, so that the risk can be treated effectively. Unless the maximum fuel range of a UAS is confined within a DPA, the total loss of control of a UAS should be considered a catastrophic occurrence.

68. **Clause (6).** Effective 'sense-and-avoid' systems are widely viewed by major civilian airworthiness authorities as an essential prerequisite for routine UAS access to the national airspace. However, circa 2010, no UAS sense-and-avoid system has been accepted by a major airworthiness authority as presenting an adequate level of safety, and common opinion is that such systems are still some years away. Given the lack of a technical solution to UAS collision avoidance with manned aircraft, airspace deconfliction is an operational airworthiness responsibility in the ADF.

69. Notwithstanding the above, technical equipment can still make a contribution to airspace deconfliction, for example SSR systems, navigation lights, anti-collision lights, position information from navigation systems (both primary and backup), on-board radios for communication with other aircraft, automatic SSR squawking in the event of datalink loss, and so on. Where UAS technical equipment contributes to airspace deconfliction, the DAR is to confirm the equipment performance (eg the brightness of navigation lights) and integrity (eg absence of unflagged errors) is commensurate with its contribution to safety. Any performance and/or integrity shortfalls must be communicated to the appropriate authority for risk treatment.