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STANAG 4671 (EDITION 1) – UNMANNED AERIAL VEHICLES SYSTEMS AIRWORTHINESS REQUIREMENTS (USAR)

Reference: PFP(JCGUAV)D(2007)0002 dated 9 May 2007

1. The enclosed NATO Standardization Agreement, which has been ratified by nations as reflected in the NATO Standardization Document Database (NSDD), is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

ACTION BY NATIONAL STAFFS

3. National staffs are requested to examine their ratification status of the STANAG and, if they have not already done so, advise the Defence Investment Division through their national delegation as appropriate of their intention regarding its ratification and implementation.

Juan A. MORENO
Vice Admiral, ESP(N)
Director, NATO Standardization Agency

Enclosure:
STANAG 4671(Edition 1)

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STANAG 4671
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

NATO STANDARDIZATION AGENCY
(NSA)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: UNMANNED AERIAL VEHICLES SYSTEMS AIRWORTHINESS REQUIREMENTS (USAR)

Promulgated on 3 September 2009

Juan A. MORENO
Vice Admiral, ESP(N)
Director, NATO Standardization Agency

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date Entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Director NATO Standardization Agency under the authority vested in him by the NATO Standardization Organization Charter.

2. No departure may be made from the agreement without informing the tasking authority in the form of a reservation. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

4. Ratification, implementation and reservation details are available on request or through the NSA websites (internet http://nsa.nato.int; NATO Secure WAN http://nsa.hq.nato.int)

FEEDBACK

5. Any comments concerning this publication should be directed to NATO/NSA, Bvd. Leopold III, 1110 Brussels, Belgium.

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NATO STANDARDIZATION AGREEMENT
(STANAG)

STANAG 4671 - UNMANNED AERIAL VEHICLE SYSTEMS AIRWORTHINESS REQUIREMENTS (USAR)

Related documents: None

AIM

1. The aim of this agreement is to establish a baseline set of airworthiness standards in relation to the design and construction of military UAVs.

AGREEMENT

2. Participating nations agree to adopt the USAR in their national certification standards for military UAVs, recording national reservations where appropriate.

TERMS AND DEFINITIONS

3. Terms used in this document are defined at Annex A for the purpose of this document only.

DETAILS OF AGREEMENT

4. **General**. If a National Certifying Authority states that a UAV System airworthiness is compliant with STANAG 4671 (and any appropriate national reservations), then, from an airworthiness perspective, that UAV System should have streamlined approval to fly in the airspace of other NATO countries, if those countries have also ratified this STANAG.

5. Along with immediate improvements in UAV interoperability and mission effectiveness, the USAR will provide a common starting datum for the long-term assessment of UAV airworthiness by allowing the comparison of systems designed and built to common standards.

6. **Implementation of the Agreement.** This STANAG is considered implemented when a nation has issued the necessary orders putting the contents of this agreement into effect.

Introduction

GENERAL

This document contains a set of technical airworthiness requirements intended primarily for the airworthiness certification of fixed-wing military UAV Systems with a maximum take-off weight between 150 and 20,000 kg that intend to regularly operate in non-segregated airspace. Certifying Authorities may apply these certification requirements outside these limits where appropriate.

These requirements represent the minimum applicable requirements to meet the safety objectives defined by paragraph 1309 and its associated AMC. It may be augmented by additional special conditions (i.e. additional airworthiness requirements) required by individual Certifying Authorities. USAR is intended for application by Certifying Authorities within each country's relevant national regulatory framework.

These requirements may not be sufficient for the certification of UAV Systems with unconventional, novel or extremely complex features. Additionally, USAR may be insufficient for UAV Systems with a design usage spectrum significantly different from that of General Aviation. Nevertheless, the USAR may have significant value for assessing all or parts of such systems and Certifying Authorities are encouraged where appropriate to use these requirements as a basis for certification of such systems within their national regulatory frameworks.

UAV Systems (including block upgrades to legacy systems) designed prior to the approval of this document may not comply with these requirements. Appropriate standards and airworthiness certification for these systems for flight in non-segregated airspace, many of which are consistent with this document, are the responsibility of each military Certifying Authority.

A glossary is at Annex A and a listing of abbreviations used within the document is at Annex B to this introduction.

Throughout this document, the term 'Type Certificate' refers to any document issued by a National Certifying Authority that within the regulatory framework of that Nation certifies compliance as determined by the National Certifying Authority with USAR. Where the Certifying Authority issues an alternative document to a Type Certificate (such as a Release To Service, Military Aircraft Type Qualification Certificate or Flight Permit, which may include items outside the scope of USAR) it is expected that the degree of compliance with USAR will be clearly stated therein.

SCOPE, DERIVATION AND STRUCTURE OF USAR

USAR SCOPE

The intention of this document is to correspond as closely as practicable to a comparable minimum level of airworthiness for fixed-wing aircraft as embodied in documents such as 14 CFR[1] Part 23 and EASA[2] CS-23 (from which it is derived) whilst recognising that there are certain unique features of UAV Systems that require particular additional requirements or subparts.

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1 Code of Federal Regulations
2 European Aviation Safety Agency

In line with the JAA-Eurocontrol Taskforce recommendations, the following areas are not covered by this airworthiness code:

- Control station security,
- Security of the command and control data link from willful interference,
- Airspace integration and segregation of aircraft (including “sense and avoid”),
- The competence, training and licensing of UAV system crew, maintenance and other staff,
- Approval of operating, maintenance and design organizations,
- The type of operation,
- Vehicle Management and Navigation requirements,
- Frequency spectrum allocation,
- Noise, emission, and other environmental certification,
- Launch/landing equipment that is not safety critical and which does not form part of the Type Certification Basis,
- Operation of the payload (other than its potential to hazard the aircraft),
- Carriage and release of weapons, pyrotechnics and other functioning or non-functioning stores designed for release during normal operations,
- Non-deterministic flight, in the sense that UAV flight profiles are not pre-determined or UAV actions are not predictable to the UAV crew,
- Sea-basing,
- Piloting from an external or internal control box,
- Supersonic flight.

It is expected that these areas will be subject to other forms of approval by Certifying Authority in order to ensure a total aviation safety approach. Where such approval requires technical assessment, the Certifying Authority may supplement these requirements with suitable additional conditions as appropriate.

It is recognized that ‘sense and avoid’ is a key enabling issue for UAV operations. The derivation and definition of ‘sense and avoid’ requirements is primarily an operational issue and hence outside the scope of USAR. However, once these requirements have been clarified, any system designed and installed to achieve these objectives is an item of installed equipment within a UAV System and hence falls under the airworthiness requirements of USAR.

DERIVATION OF THE USAR

This document is an airworthiness code derived from EASA CS-23 (ex JAR 23) requirements supplemented by elements from the following UAV systems airworthiness and safety documents:

Title	Date
JAA Eurocontrol UAV Task Force – Final Report	05/2004
Airworthiness standard for Unmanned aerial vehicles, RAI-UAV - Ente Nazionale Aviazone Civile – (Italy)	1999
Design standards UAV - Civil Aviation Safety Authority (Australia)	05/2000
Design and airworthiness requirements for UAV systems – DEF STAN 00-970 Part 9 (UK MOD)	05/2002
USICO (Unmanned Safety Issues for Civil Operations)– WP 2400 – Certification review item (CRI) “stall demonstration”	01/2004

Title	Date
AC23.1309-1C – Equipment, Systems, and Installations in Part 23 Airplanes – FAA. (USA)	03/1999
TSO C23d – Minimum Performance Standards for Parachute assemblies and Components, Personnel (USA)	07/1992
Special Conditions ; Ballistic Recovery Systems Cirrus SR-20 Installation – 14 CFR Part 23 – FAA (USA)	10/1997

USAR STRUCTURE

These requirements consist of 9 interrelated sub parts, covering the following areas:

		UAV System				
		UAV	Command and control data link	Communication system	UAV control station	Other ancillary elements
A	General	x	x	x	x	x
B	UAV Flight	x				
C	UAV Structure	x				x
D	UAV Design and Construction	x				x
E	UAV Powerplant	x				
F[3]	Equipment	x				
G	Operating limitations and information	x	x	x	x	x
H	Command and control data link Communication system		x	x		
I	UAV control station				x	

Subparts A-G are derived directly from CS-23. While subparts H and I follow the format of CS-23, they are unique to USAR.

Paragraph numbers throughout subparts A-G correspond directly to CS-23. Where an entire paragraph is not applicable to a UAV system, it is deleted and annotated ‘not applicable’. If a sub-paragraph is not applicable, it is deleted and annotated ‘not applicable’. Where a paragraph is applicable or partly applicable but its location within sections A-G of CS-23 is inconsistent with UAV Systems (e.g. the logical location in the context of UAV Systems is in section H or I), a cross-reference is included at the original location with the annotation ‘not applicable in this subpart’. Where a paragraph is unique to USAR, it is identified as such and its paragraph numbering is marked with the prefix ‘U’.

A cross-reference table between USAR and CS-23 is available in annex 3. This cross-reference table states all USAR paragraphs that have been inspired or adapted from CS-23 but that, due to the structure of USAR could not be maintained in their original CS-23 numbering/position. Their new numbering/position in USAR is mentioned in the cross-reference table.

3 Note: Paragraph 1309 (in subpart F) and its AMC applies to the entire UAV System and not only to the aerial vehicle.

These requirements also include Book 2, consisting of material describing acceptable means of compliance. This feature is similar to FAA or EASA advisory material and allows a full set of UAV System certification documentation to be referenced in a single volume.

TYPE CERTIFICATION (OR EQUIVALENT) PROCESS

USAR has been created to mirror as closely as possible the structure and content of CS-23. Safety assurance assumes that the requirements are used in a process using the same or broadly equivalent steps to Type Certification of 14 CFR Part23/EASA CS-23 aircraft. Where the procedures used by a Certifying Authority differ substantially from this approach, the Authority is expected to determine that the process used ensures that an equivalent level of safety is achieved.

Therefore, it is expected that USAR will normally be used to define the UAV System Type Certification Basis (or equivalent national document) using the applicable paragraphs of the USAR Airworthiness Code (Book 1), completed by the related USAR Acceptable Means of Compliance (Book 2). AMCs are non-exclusive means of demonstrating compliance with USAR, and Certifying Authorities, in parallel with civil regulatory systems, may define or approve alternate equivalent means where appropriate. Where the Certifying Authority has imposed additional conditions, it is expected that the Certifying Authority will approve the acceptable means of compliance.

It is further assumed that the Certifying Authority will issue a Military Type Certificate or equivalent national document, if applicable with a Type Certification Data Sheet, or equivalent national document(s), containing as a minimum:

- System Identification
- System configuration details
- Requested operating frequencies
- Statement of compliance with USAR (including if applicable additional conditions, exemptions and deviations)
- List of approved publications – Operating and maintenance
- Issuing Agency
- Date of Issue

SPECIAL CONDITIONS AND SPECIAL MILITARY AIRWORTHINESS REQUIREMENTS

In addition to the requirements of USAR, it is expected that national certifying authorities may impose extra airworthiness requirements (for instance cold soak). Where these are of a nature similar to Special Conditions usually imposed by civilian certifying authorities and potentially applicable to both civil or military applications, these will be known as Special Conditions.

It is also expected that UAV systems certified or assessed using USAR will be employed in a variety of military roles and/or modes, all or some of which may involve manoeuvres or use of special equipment or payloads that fall outside the scope of these requirements. It is expected that national authorities will address these modes by the use of special military airworthiness requirements. Special military airworthiness requirements recognize the unique nature of military operations, and are analogous to Special Conditions or similar terminology used by a civilian Certifying Authority. They are to be applied and assessed in a similar manner to Special Conditions.

It is expected that any special military airworthiness requirements that result in an actual or potential hazard condition that reduces the margin of safety below the levels required by paragraph 1309 and its associated AMC, whether temporary or permanent, will be addressed by suitable operational restrictions. Where this is not possible, the condition is to be clearly identified in the Type Certificate as resulting in the system operating at a level of safety below that required by USAR. The resulting technical and/or operational risk associated with the special military airworthiness requirements are expected to be assessed and accepted using relevant national procedures.

SPECIAL MILITARY MODES OF OPERATION RESULTING IN REDUCTION OF LEVEL OF SAFETY

Where for military reasons a UAV System contains special military modes whose operation would result in a level of safety below that required by USAR, type certification to USAR may still be carried out providing that a sufficiently robust segregation is achieved between the special modes when inactive and the basic UAV System. An example of a special military mode may be weapons or stores arming and release or operation of electromagnetic spectrum emitters.

Annex A to USAR Introduction : Glossary

Airfield An area that is used or intended to be used for the landing and takeoff of UAV, and includes its buildings and facilities, if any.
Antenna Margin (or link margin) The amount (usually expressed in dB) by which a received signal lies above a predetermined lower limit for desired message quality.
Automatic The execution of a predefined process or event that requires UAV System crew initiation.
Autonomous The execution of predefined processes or events that do not require direct UAV System crew initiation and/or intervention
Availability Avialability of a data link is the long-term ratio of the actual RF channel operation time to scheduled RF channel operation time.
Catastrophic Failure conditions that result in a worst credible outcome of at least uncontrolled flight (including flight outside of pre-planned or contingency flight profiles/areas) and/or uncontrolled crash, which can potentially result in a fatality. Or Failure conditions which could potentially result in a fatality to UAV crew or ground staff.
Communication system A means that allows ATC communication between the UAV crew in the remote control station and the air traffic control service.
Data link A wireless communication channel between one or more UCS and one or more UAV, or between multiple UAV. Its utility may include but is not limited to exchange of command & control or payload data. A data link may consist of: (1) **Uplink** – Transmittal of UAV crew commands from the UCS to the UAV. (2) **Downlink** – Transmittal of UAV status data from the UAV to the UCS.
Decision Point The height below which a go around may not be safely performed (i.e., there will be ground contact that may damage the UAV).
Designated UAV Operator The UAV system designated UAV operator in the UAV Control Station tasked with overall responsibility for operation and safety of the UAV system. Equivalent to the pilot in command of a manned aircraft.
Effective maximum range Measure of data link coverage over a horizontal distance that is a function of frequency, availability, bit error rate, climate area and altitude.
Electromagnetic Compatibility (EMC) The ability of equipment or a system to function in its electromagnetic environment without causing intolerable electromagnetic disturbances to anything in that environment.
Electromagnetic Environment (EME) EME is the totality of electromagnetic phenomena existing at a given location.
Electromagnetic Interference (EMI) Any electromagnetic disturbance, whether intentional or not, which interrupts, obstructs, or otherwise degrades or limits the effective performance of electronic or electrical equipment.
Electromagnetic Vulnerability (EMV) The characteristics of a system that cause it to suffer degradation in performance of, or inability to perform, its specified task as a result of electro-magnetic interference.

Emergency recovery capability Procedure that is implemented through UAV crew command or through autonomous design means in order to mitigate the effects of critical failures with the intent of minimising the risk to third parties. This may include automatic pre-programmed course of action to reach a predefined and unpopulated forced landing or recovery area.
Extremely remote Occurrence between 10^{-5} and 10^{-6} per flight hour.
Failure conditions A condition having an effect on either the UAV or third parties, or both, either direct or consequential, which is caused or contributed to by one or more failures or errors considering flight phase and relevant adverse operational or environmental conditions or external events.
Fireproof With respect to materials, components and equipment, means the capability to withstand the application of heat by a flame, for a period of 15 minutes without any failure that would create a hazard to the UAV. The flame will have the following characteristics:– Temperature 1100°C ± 80°C Heat Flux Density 116 KW/m2 ± 10 KW/m2 For materials this is considered to be equivalent to the capability of withstanding a fire at least as well as steel or titanium in dimensions appropriate for the purposes for which they are used.
Fire-resistant With respect to materials, components and equipment, means the capability to withstand the application of heat by a flame, as defined for 'Fireproof', for a period of 5 minutes without any failure that would create a hazard to the UAV. For materials this may be considered to be equivalent to the capability of withstanding a fire at least as well as aluminium alloy in dimensions appropriate for the purposes for which they are used.
Flight control system The flight control system comprises sensors, actuators, computers and all those elements of the UAV System, necessary to control the attitude, speed and flightpath of the UAV. The flight control system can be divided into 2 parts: **Flight control computer** – A programmable electronic system that operates the flight controls in order to carry out the intended inputs. **Flight controls** – sensors, actuators and all those elements of the UAV System (except the flight control computer), necessary to control the attitude, speed and flightpath of the UAV. Flight controls can further be defined as: **Primary flight control –** Primary flight controls are those used in the UAV by the flight control system for the immediate control of pitch, roll, yaw and speed. **Secondary flight control -** Secondary controls are those controls other than primary flight controls, such as wheel brakes, spoilers and tab controls.
Flight load factor The ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the UAV) to the weight of the UAV. A positive flight load factor is one in which the aerodynamic force acts upward, with respect to the UAV.
Flight Envelope Protection A system that prevents the UAV from exceeding its designed operating limits.
Flight termination system A system to immediately terminate flight.
Forced landing A condition resulting from one or a combination of failure conditions that prevents the UAV from normal landing on its planned main landing site although the flight control system is still able to maintain the UAV controllable and maneuverable.
Frequent Occurrence more than 10^{-3} per flight hour.

Full-time (data display context) Required during all phases of flight.
Functional hazard assessment (FHA) A systematic, comprehensive examination of UAV and system functions to identify potential Minor, Major, Hazardous and Catastrophic failure conditions that may arise as a result of a malfunction or failure to function.
Ground staff Qualified personnel necessary for ground operations (such as supplying the UAV with fuel and maintenance) as stated in the UAV System Flight Manual or in the UAV Maintenance Manual.
Hand over The operation that consists in performing a UAV command and control transfer from one UCS to another one or from one workstation to another one in the same UCS.
Hazardous Failure conditions that either by themselves or in conjunction with increased crew workload, result in a worst credible outcome of a controlled-trajectory termination or forced landing potentially leading to the loss of the UAV where it can be reasonably expected that a fatality will not occur. Or Failure conditions which could potentially result in serious injury to UAV crew or ground staff.
Horizontal surface balancing load A load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.
Infrastructure (in the context of UCS) The basic facilities, services and installations needed for the functioning of the UCS which may include power supply, shelter, communication systems etc.
Intervisibility The performance of a LOS (line of sight) data link signal, taking into consideration the interposed land mass between the UAV antennas and the UCS antennas.
Landing The phase of a UAV system mission that involves the return of a UAV to the ground or sea surface. This also includes the return of the UAV to the surface via parachute.
Latency Delay in time between the sending of a unit of data at one end of a connection, until the receipt of that unit at the destination.
Launch Catapult and rocket assisted Take-off.
Launch safety trace The area, associated with a UAV launch, in which there may be a hazard which could result in a risk to personnel, equipment or property.
Line of Sight A visually unobstructed straight line through space between the transmitter and receiver.
Link Budget A calculation involving the gain and loss factors associated with the antennas, transmitters, transmission lines and propagation environment used to determine the maximum distance at which a transmitter and receiver can successfully operate.
Major Failure conditions that either by themselves or in conjunction with increased crew workload, result in a worst credible outcome of an emergency landing of the UAV on a predefined site where it can be reasonably expected that a serious injury will not occur. Or Failure conditions which could potentially result in injury to UAV crew or ground staff.
Masking Blockage of data link due to fuselage blockage or unfavourable UAV attitude.
Minor Failure conditions that do not significantly reduce UAV safety and involve UAV crew actions that are well within their capabilities. These conditions may include a slight reduction in safety margins or functional capabilities, and a slight increase in UAV crew workload.

Minimum demonstration speed Vmin DEMO The minimum demonstration speed Vmin DEMO is the minimum speed demonstrated by the Applicant by flight test, while possibly adjusting or inhibiting flight control protection features, using the procedure and meeting the flight characteristics specified in USAR.201.
Minimum engine performance Is defined as the lowest level of acceptable performance. This level of performance is due to deterioration and variation within a family of engines due to manufacturing and control tolerances. This represents a predetermined variation below the specification performance of a family of engines. This performance level is predetermined for an aircraft and usually expressed as a percentage of Specification. Ninety-five percent is often, but not always, the minimum level used. Engines falling below this level of performance would be removed from service.
Must Used to indicate a mandatory requirement (see also “shall”).
Part-time (data display context) Only required during certain phases of flight upon UAV crew request.
Payload Device or equipment carried by the UAV, which performs the mission assigned. The useful payload comprises all elements of the air vehicle that are not necessary for flight but are carried for the purpose of fulfilling specific mission objectives.
Probable Occurrence between 10^{-3} and 10^{-4} per flight hour.
Refusal speed (V_{Rf}) The speed above which a takeoff may not be safely aborted. V_{Rf} is equivalent to V_1 as used for manned aircraft.
Remote (System safety context) Occurrence between 10^{-4} and 10^{-5} per flight hour.
Safety critical control A control requiring immediate action to ensure continued safe flight.
Shall Used to indicate a mandatory requirement (see also “must”).
Should Used to indicate a preferred, but not mandatory, method of accomplishment.
Switchover The operation that consists of performing the transfer of the UAV command and control from one data link channel to another channel within the same UCS.
Take-off The process by which a UAV leaves the surface and attains controlled flight (includes launch via catapult or rocket assistance).
Type Certificate Refers to any document issued by a National Certifying Authority that within the regulatory framework of that Nation certifies compliance as determined by the National Certifying Authority with USAR.
Type Certification Basis The document elaborated by the Applicant with the Certifying Authority based on the airworthiness code and is specifically applicable to the design of the UAV System to be certified. It may also include Special Conditions as detailed in the Introduction of USAR.
UAV An aircraft which is designed to operate with no human pilot on board and which does not carry personnel. Moreover a UAV : • Is capable of sustained flight by aerodynamic means, • Is remotely piloted or automatically flies a pre-programmed flight profile, • Is reusable, • Is not classified as a guided weapon or similar one shot device designed for the delivery of munitions.
UCS flight control Flight controls used by the UAV crew in the UCS to operate the UAV in the semi-automatic mode of control as defined in USAR 1329.

UAV control station A facility or device from which the UAV is controlled and/or monitored for all phases of flight considering USAR.U2 (a).
UAV Crew A UAV crew is made up of one or more qualified people responsible for monitoring and controlling the flightpath and flight status of one or more UAV. Includes the Designated UAV Operator and also all staff responsible for operating on-board systems (e.g. payload).
UAV System A UAV System comprises individual UAV System elements consisting of the aerial vehicle (UAV), the UAV control station and any other UAV System elements necessary to enable flight such as a command and control data link, communication system and take-off and landing element. There may be multiple UAV, UCS, or take-off and landing elements within a UAV System.
Uncontrolled crash A condition resulting from one or a combination of failure conditions that prevents the flight control system from maintaining the UAV controllable and maneuverable until the impact on the ground.
Unsafe A condition or situation that is likely to cause a Hazardous or more serious event.
Workload – The amount of work assigned to or expected from a person in a specified time.
Workstation - A computer interface between an individual UAV crew member and the UAV to perform the functions of mission planning, flight control and monitoring and for display and evaluation of the downloaded image and data (where applicable).

Annex B to USAR Introduction : Abbreviations

°C	Degree Celsius
°F	Degree Fahrenheit
AC	Advisory Circular
AMC	Acceptable Means of Compliance
ANC	Army Navy Civil Committee
APU	Auxiliary Power Unit
ARP	Aerospace Recommended Practices
AIT	Auto-Ignition Temperature
BLOS	Beyond Line of Sight
BVID	Barely Visible Damages
C.G. or c.g.	Centre of Gravity
CAS	Calibrated Air Speed
cc	Cubic centimeter
CCA	Common Cause Analysis
CEP	Circular Error Probability
CFR	Code of Federal Regulations
C_L	Lift coefficient of aircraft
cm	Centimeter
CNA	Aerodynamic normal force coefficient
CRT	Cathode Ray Tube
CS	Certification Specification
CS-23	Certification Specification for Normal, Utility, Aerobatic and Commuter category aeroplanes
CS-25	Certification Specification for Large aeroplanes
CS-VLA	Certification Specification for Very Light aeroplanes
DAL	Development Assurance Level
Def Stan	Defence Standard
EAS	Equivalent Air Speed
EASA	European Aviation Safety Agency
ECS	Environmental Control System
EFIS	Electronic Flight Information System
EMC	Electromagnetic Compatibility
EME	Electromagnetic Environment
EMI	Electromagnetic Interference
EMV	Electromagnetic Vulnerability
FAA	Federal Aviation Administration
ft	Feet
FCS	Flight Control System
FEM	Finite Elements Model
FHA	Functional Hazard Assessment
FMEA	Failure Mode Effects Analysis
FOD	Foreign Object Damage
fps	feet per second
FTR	Fatigue Type Record
g	Acceleration due to gravity
GPS	Global Positioning System
h	hour
IAS	Indicated Air Speed
in	Inch
JAA	Joint Aviation Authorities
KCAS	Knots Calibrated Air Speed
kg	Kilogram
km	Kilometer
kPa	Kilo Pascal
kt	Knot

l	Liter
lb	Pound
LOS	Line of Sight
m	Meter
mm	Millimeter
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MoD	Ministry of Defence
N	Newton
n	Load Factor
NATO	North Atlantic Treaty Organization
NDT/I	Non Destructive Techniques and Inspection
psi	Pounds per square inch
PSSA	Preliminary System Safety Assessment
RAI	Registro Aeronautico Italiano
RF	Radiofrequency
RPM	Revolutions per Minute
s	Second
SPC	Sortie Profiles Codes
SSA	System Safety Assessment
STANAG	Standard Agreement (NATO)
STR	Static Type Record
TSO	Technical Standard Order
UAV	Unmanned Aerial Vehicle
UCS	UAV Control Station
UK	United Kingdom
US	United States of America
USAR	UAV Systems Airworthiness Requirements
USICO	UAV Safety Issues for Civil Aviation
UV	Ultra Violet
$V_{min\ DEMO}$	Minimum Demonstrated Airspeed
V_A	Design manoeuvring speed
V_C / M_C	Design Cruising Speed / Mach
V_D / M_D	Design Dive Speed /Mach
V_{EF}	Speed at which the Critical Engine is assumed to fail
V_F	Speed at which Flaps are Fully Extended
V_{FE}	Flap Extended Speed
V_G	Negative Manoeuvring Load Factor Speed
VLA	Very Light Aircraft
V_{MO} / M_{MO}	Maximum Operating Limit Speed.
V_{MC}	Control Speed with Critical Engine Inoperative
V_{MCG}	Minimum Control Speed on the Ground
V_{NE}	Never Exceed Speed
V_{NO}	maximum structural cruising speed
V_R	Rotation Speed
V_{REF}	Reference Landing Approach Speed
V_{Rf}	Refusal Speed
V_S	Stalling Speed
V_{S0}	Stalling Speed or Minimum Steady Flight Speed in Landing Configuration
V_{S1}	Stalling Speed or Minimum Steady Flight Speed in Take off Configuration
V_{SF}	Computed Stalling Speed with Flaps fully extended at the Design Weight
V_{SSE}	Minimum safe speed with one Engine inoperative
W	Watts
WP	Work Package

Annex C to USAR Introduction
Cross-reference table with EASA CS-23 for paragraphs transferred to subpart I

CS §	USAR § in subpart I	CS Subject
207 (a), (d)	1789 (a)	Stall warning
207 (b)	1789 (b)	Stall warning
671 (b)	1731 (a)	Controls arrrangement
679 (a)	1825	Control system lock warning
699	1791	Wing flap position indicator
729 part of (e)	1793 (a)	Landing Gear position indicator
729 (f)	1793 (b)	Landing Gear warning
771	1703	Pilot compartment
777	1731	Cockpit controls
779	1735	Motion and effect of cockpit controls
781 (a) and (b)	1733 (c) and (d)	Cockpit control and knob shape
841 (b) (5), (6) and (7)	1795	Pressurised cabins
863 (c)	1817	Flammable fluid fire protection
991 (c)	1797	Fuel pumps warning
995 (a) (b) and (g)	1743 (a) (b) and (c)	Fuel controls
1001 (f) and (g)	1745 (a) and (b)	Fuel jettisoning system
1091 (b)(4)	1747	Air induction system
1091 (b)(5)	1799	Air induction system
1141 (g)	1803	Powerplant controls : general
1142	1751	APU controls
1143 (a) through (f)	1751	Engine controls
1145	1753	Ignition switches
1147 (a)	1755	Mixture controls
1149	1757	Propeller and pitch controls
1153	1759	Propeller feathering control
1155	1761	Turbine engine reverse thrust and propeller pitch settings below the flight regime
1157	1763	Carburettor air temperature controls
1165 (d)	1801	Engine ingnition warning
1189 (c)	1805	Shut-off controls
1189 (a) (6)	1765 (a)	Shut-off means
1303	1723	Flight and navigation instruments
1305	1725	Powerplant instruments
1311	1727	Electronic display instrument system
1321	1721	Arrangement and visibility
1322	1785	Warning, caution and advisory lights
1326	1819	Pitot heat indication system
1329 (h)	1790	AP mode of operation
1331 (a) 1rst sentence	1821	Instruments using a power source – power indicator
1331 (a) 2nd sentence	~1721	Instruments using a power source – location
1335	1790	Flight director systems
1337 (b) 1rst paragraph	1729 (a)	Fuel quantity indicator
1337 (b)(5), (6)	1729 (a)(1) and (2)	Fuel quantity indicator
1337 (d)(2)	1729 (b)	Oil quantity indicator
1351(b)(1)(i) and (iii)	1717 (a)(1) and (2)	Risk of electrical shock to the crew
1351 (c)(4)	1809 (a)	Warning and indications (electrical systems)
1351 (d)	1809 (b)	Warning and indications (electrical systems)
1381	1705	Instrument lights
1416 (c)	1811	Pneumatic de-icer boot system indication means
1431 (c), (d) and (e) and	1707	Electronic equipment

AMC (e)		
1435 (a)(2)	1813	Hydraulic systems indicators
1457	1709	Cockpit voice recorders
1523	1704	Minimum flight crew
1543	1733 (b)	Instrument markings: general
1545	1835	Airspeed data
1547	1837	Magnetic direction indicator
1549	1839	Powerplant and auxiliary power unit instruments
1551	1841	Oil quantity indicator
1553	1843	Fuel quantity indicator
1555	1845	Control markings
1559	1849	Operating limitations indications
1563	1835 (e)	Airspeed data

When "~" is used it means " approximates".

BOOK 1 – AIRWORTHINESS CODE

subpart A - GENERAL

1	USAR.1 Applicability (a) This airworthiness code is primarily applicable to fixed wing UAV Systems of maximum take-off weight of more than 150 kg and less than 20,000 kg. It may also be applied to UAV Systems of any other maximum take-off weight where considered applicable by the Certifying Authority. (b) A UAV System that needs for normal operation the presence of a pilot that directly controls the UAV using a control box (e.g., stick, rudder pedals, throttles, etc.) is not covered by USAR.
U2	USAR.U2 Assumptions (a) A UAV System comprises individual UAV System elements consisting of the aerial vehicle (UAV), the UAV control station (UCS) and any other UAV System elements necessary to enable flight such as a command and control data link, communication system and take-off and landing element. There may be multiple UAV, UCS, or take-off and landing elements within a UAV System. (b) It is assumed in USAR that the UAV System is designed in order to provide to the UAV crew the capability to command and control the UAV for all phases of flight in normal, abnormal and emergency operation, except for some specific points mentioned in USAR paragraphs (e.g. autonomous flight in case of data link loss). (c) Special Conditions can be prescribed by the Certifying Authority if the airworthiness requirements of this code do not contain adequate or appropriate safety standards, because (1) The UAV System has novel or unusual design features relative to the design practices on which the applicable USAR is based; or (2) The intended use of the UAV System is unconventional; or (3) Experience from other similar UAV Systems in service or UAV Systems having similar design features, has shown that unsafe conditions may develop. (d) Every Special Condition must be defined at the beginning of the certification process on the request of the Applicant in order to define the Type Certification Basis applicable to the type of UAV System to be certificated. (e) USAR requirements are mostly based upon CS-23 requirements as a reference code tailored to UAV Systems. When establishing the Type Certification Basis for a particular UAV System, the Applicant is entitled to propose the replacement of specific paragraphs by alternative criteria, based upon the use and/or the tailorization of other recognised airworthiness codes requirements (such as CS-VLA, CS-25,…), pending on the UAV System under consideration and presentation of appropriate rationale. Such alternative approach shall be subject to the Certifying Authority acceptance. (f) As USAR is based on CS-23 airworthiness code, it is assumed that twin or multi-engine UAV Systems are designed in such a manner that no single engine failure might affect the safety of the flight. As a consequence, USAR paragraphs request that engine installation and associated systems be independent and that no single failure might affect the safe operation of more than an engine. Nevertheless it might be possible to consider and certify (under a Special Condition "Multi engine, single propulsion system") any UAV System as a single propulsion UAV System whatever the number of engines installed. Whatever the failure, UAV safety objectives will have to be satisfied, and it shall be demonstrated that following any failure of the propulsion component the UAV will have a behaviour similar or better than a single engine UAV.

	(g) Where a UAV System is designed with more than 2 engines, a Special Condition shall be established with the Certifying Authority to accommodate conditions where more than one engine is inoperative.
U15	USAR.U15 UAV System ancillary elements Where a UAV System includes any ancillary elements necessary to enable safe flight (such as, for instance, launch and landing elements), Special Conditions in addition to USAR.1581 (a)(2) must be established and agreed with the Certifying Authority to ensure safe operations.
U17	USAR.U17 Design usage spectrum See AMC.17 (a) The Applicant must present to the Certifying Authority the design usage spectrum for the UAV System for which certification is requested. This statement shall form part of the UAV System document set. (b) The certification of the UAV is tied to a specific design usage spectrum. Modification and/or addition of missions may require the UAV to be re-certified for these missions.
U19	USAR.U19 Special military modes of operation See AMC.19 The special military modes of operation, when inactive, must be shown not to reduce the UAV System level of safety below that required by USAR.

subpart B – UAV FLIGHT

	GENERAL
21	USAR.21 Proof of Compliance See AMC.21 Each requirement of this subpart must be met at each appropriate combination of weight and centre of gravity within the range of loading conditions for which certification is requested. This must be shown (1) By tests upon a UAV of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing; and (2) By systematic investigation of each probable combination of weight and centre of gravity, if compliance cannot be reasonably inferred from combinations investigated.
23	USAR.23 Load Distribution Limits (a) Ranges of weight and centres of gravity for each payload configuration within which the UAV may be safely operated must be established. They must include the range for lateral centres of gravity if possible loading conditions can result in significant variation of their positions that could ultimately result in flight characteristics changes. (b) The load distribution shall consider the following: (1) Any load configuration (considering partial or complete installation) specified by the Applicant and agreed to by the Certifying Authority; (2) Expenditure of any expendable useful load items (e.g., fuel, payload); and (3) The extremes of the above plus the most critical combination of special or alternate load items. (c) The load distribution must not exceed (1) The limits selected by the Applicant; (2) The limits at which the structure is proven; or (3) The limits at which compliance with each applicable flight requirement of this subpart is shown.
25	USAR.25 Weight Limits (a) Maximum weight. The maximum weight is the highest weight at which compliance with each applicable requirement of USAR (other than those complied with at the design landing weight) is shown. The maximum weight must be established so that it is (1) Not more than the least of (i) The highest weight selected by the Applicant; or (ii) The design maximum weight, which is the highest weight at which compliance with each applicable structural loading condition of USAR (other than those complied with at the design landing weight) is shown; or (iii) The highest weight at which compliance with each applicable flight requirement is shown, and,

	(2) Not less than the weight with (i) maximum payload in terms of weight, oil at full tank capacity, and at least enough fuel for one half-hour of maximum continuous power operation ; or (ii) minimum payload in terms of weight, and oil and fuel at full tank capacity. (b) Minimum weight. The minimum weight (the lowest weight at which compliance with each applicable requirement of USAR is shown) must be established so that it is not more than the sum of (1) The basic weight determined under USAR.29; (2) Not applicable (3) The weight of (i) For turbojet powered UAV, 5% of the total fuel capacity of that particular fuel tank arrangement under investigation; and (ii) For other UAV, the fuel necessary for one-half hour of operation at maximum continuous power.
29	USAR.29 Basic Weight and Corresponding Centre of Gravity (a) The basic weight and corresponding centre of gravity must be determined by weighing the UAV with (1) Fixed ballast (if applicable); (2) Unusable fuel determined under USAR.959; and (3) Full operating fluids, including (i) Oil; (ii) Hydraulic fluid; and (iii) Other fluids required for normal operation of UAV. (4) the payload or load configuration specified by the Applicant and agreed to by the Certifying Authority, or without payload if such a configuration is to be approved. (b) The condition of the UAV at the time of determining basic weight must be one that is well defined and can be easily repeated.
31	USAR.31 Removable Ballast Removable ballast may be used in showing compliance with the flight requirements of this subpart, if (a) The place(s) for carrying ballast is properly designed and installed; and (b) Instructions are included in the UAV System Flight Manual, approved manual material, or markings and placards, for the proper placement of the removable ballast under each loading condition for which removable ballast is necessary.
33	USAR.33 Propeller Speed and Pitch Limits (a) General. The propeller speed and pitch must be limited to values that will assure safe operation under normal operating conditions. (b) Propellers not controllable in flight. For each propeller whose pitch cannot be controlled in flight

	(1) During take-off and initial climb at the all-engine(s)-operating climb speed specified in USAR.65, the propeller must limit the engine rpm, at full throttle or at maximum allowable take-off manifold pressure, to a speed not greater than the maximum allowable take-off rpm; and (2) During a closed throttle glide at maximum achievable speed maintained by the flight control system, the propeller may not cause an engine speed above 110% of maximum continuous speed. (c) Controllable pitch propellers without constant speed controls. Each propeller that can be controlled in flight, but that does not have constant speed controls, must have a means to limit the pitch range so that (1) The lowest possible pitch allows compliance with sub-paragraph (b) (1) of this paragraph; and (2) The highest possible pitch allows compliance with sub-paragraph (b) (2) of this paragraph. (d) Controllable pitch propellers with constant speed controls. Each controllable pitch propeller with constant speed controls must have (1) With the governor in operation, a means at the governor to limit the maximum engine speed to the maximum allowable take-off rpm; and (2) With the governor inoperative, a means to limit the maximum engine speed to 103% of the maximum allowable take-off rpm with the propeller blades at the lowest possible pitch and with take-off power setting, the UAV stationary, and no wind.
PERFORMANCE	
45	USAR.45 General (a) Unless otherwise prescribed, the performance requirements of this subpart must be met for (1) Still air and standard atmosphere at sea level, and (2) Ambient atmospheric conditions, and, (3) Minimum engine performance. (b) Performance data must be determined over not less than the following ranges of conditions (1) Airfield or launch site altitude from sea-level to maximum take-off altitude at which certification is requested; and (2) temperatures from standard to 30°C above standard; or (3) the maximum ambient atmospheric temperature at which compliance with the cooling provisions of USAR.1041 to USAR.1047 is shown, if lower. (c) Performance data must be determined with the cowl flaps or other means for controlling the engine cooling air supply in the position used in the cooling tests required by USAR.1041 to USAR.1047. (d) The available propulsive thrust must correspond to engine power or thrust, not exceeding the approved power or thrust, less (1) Installation losses; and (2) The power absorbed by the accessories and services appropriate to the particular ambient atmospheric conditions and the particular flight condition.

	(e) The performance as affected by engine power or thrust must be based on a relative humidity of (1) 80% at and below standard temperature; and (2) 34% at and above standard temperature plus 28°C (plus 50°F). Between the two temperatures listed in sub-paragraphs (e) (1) and (e) (2) of this paragraph the relative humidity must vary linearly. (f) Unless otherwise prescribed in determining the take-off and landing distances, changes in the UAV's configuration, speed and power or thrust must be made in accordance with procedures established by the Applicant for operation in service. These procedures must be able to be executed consistently by UAV crew of average skill in atmospheric conditions reasonably expected to be encountered in service. (g) The following, as applicable, must be determined on a smooth, dry, hard-surfaced runway and zero headwind (1) Take-off distance of USAR.53 (b); (2) Accelerate-stop distance or critical field length of USAR.55; (3) Not applicable, (4) Landing distance of USAR.75. The effect on these distances of operation on other types of surface (e.g. grass, gravel) when dry, may be determined or derived and these distances listed in accordance with USAR.1583 (p). (h) Not applicable
49	USAR.49 Stalling Speed (a) V_{S0} and V_{S1} are the stalling speeds or the minimum steady flight speed, in knots (CAS), at which the UAV is controllable with (1) For reciprocating engine-powered UAV, engine(s) idling, the throttle(s) closed or at not more than the power necessary for zero thrust at a speed not more than 110% of the stalling speed; and (2) For turbine engine-powered UAV, the propulsive thrust may not be greater than zero at the stalling speed, or, if the resultant thrust has no appreciable effect on the stalling speed, with engine(s) idling and throttle(s) closed; (3) Propeller(s) in the take-off position; (4) The UAV in the condition existing in the test or calculation in which V_{S0} and V_{S1} are being used; (5) Centre of gravity in the position which results in the highest value of V_{S0} and V_{S1}; and (6) Weight used when V_{S0} or V_{S1} are being used as a factor to determine compliance with a required performance standard. (b) V_{S0} and V_{S1} must be determined by (1) analysis based on a calculation method agreed with the Certifying Authority, or (2) by flight tests using the procedure and meeting the flight characteristics specified in USAR.201. (c) Not applicable.

U50	USAR.U50 Minimum demonstration speed If the stalling speed is not demonstrated by flight tests, a "minimum demonstration speed" will be considered. (a) The minimum demonstration speed $V_{min\ DEMO}$ is the minimum speed demonstrated by the Applicant by flight test, while possibly adjusting or inhibiting flight control protection features, using the procedure and meeting the flight characteristics specified in USAR.201. (b) The minimum demonstration speed $V_{min\ DEMO}$ must be less than r times the minimum steady flight speed (except take-off and landing) allowed by the flight envelope protection maintained by the flight control system as defined in USAR.334. The r ratio shall not be above 0.95 and shall be agreed with the Certifying Authority.
51	USAR.51 Take-off Speeds Except for catapult assisted or rocket assisted take-off UAV, the following applies (a) The rotation speed V_R (if applicable), is the speed at which the UAV crew or the flight control system makes a control input with the intention of lifting the UAV out of contact with the runway . (1) For multi-engined UAV, V_R must not be less than the greater of (i) 1.05 V_{MC}, and, (ii) 1.10 V_{S1}; except if it is demonstrated than a lower speed do not affect safe take-off due to UAV System performance whatever the combination of environmental conditions. (2) For single engined UAV, V_R must not be less than V_{S1}. (3) Not applicable. (b) The speed at 15 m (50 ft) must not be less than (1) For multi-engined UAV , the greater of (i) A speed that is shown to be safe for continued flight (or land-back, if applicable) under all reasonably expected conditions, including turbulence and complete failure of the critical engine and compliant with the requirement established in USAR.63; and (ii) 1.10 V_{MC}; and (iii) 1.20 V_{S1} (2) For single-engined UAV, the greater of (i) A speed that is shown to be safe under all reasonably expected conditions, including turbulence and complete engine failure and compliant with the requirement established in USAR.63; and (ii) 1.20 V_{S1}. (c) Not applicable
53	USAR.53 Take-off Performance Except for catapult assisted or rocket assisted take-off UAV, the following applies : (a) The take-off distance must be determined in accordance with sub-paragraph (b), using speeds determined in accordance with USAR.51 (a) and (b).

	(b) The distance required to take-off and climb to a height of 15 m (50 ft) above the take-off surface must be determined for each weight, altitude and temperature within the operational limits established for take-off with (1) Take-off power or thrust on each engine; (2) Wing flaps in the take-off position(s); and (3) Landing gear extended in the take-off position (c) Take-off performance as required by USAR.53 (a) and USAR.55 must be determined with the operating engines within approved operating limitations. (d) Maximum rotation rate (if applicable) is to be determined such that resulting dynamic effects do not lead to unsafe conditions or reduction in loading or manoeuvers safety margins.
55	USAR.55 Accelerate-stop Distance or Critical Field Length See AMC.55 Except for catapult assisted or rocket assisted take-off UAV, the critical field length must be determined as follows: (a) For multi engine UAV, the critical field length is the sum of the distances necessary to (1) Accelerate the UAV from a standing start to V_{EF} with all engines operating; (2) Within the same distance either accelerate the UAV from V_{EF} to V_{Rf}, assuming the critical engine fails at VEF; or come to a full stop from the point at which V_{EF} is reached. V_{EF} is the calibrated airspeed at which the critical engine is assumed to fail and the same distance is required to either continue the takeoff or stop. The V_{EF} must be selected for the UAV, but must not be less than V_{MCG} determined under USAR.149 (f). (b) For single engine UAV, the accelerate-stop distance is the sum of the distances necessary to (1) Accelerate the UAV from a standing start to V_{Rf} with engine operating; (2) Come to a full stop from the point at which V_{Rf} is reached. (c) Means other than wheel-brakes may be used to determine the critical field length if that means (1) Is safe and reliable; and (2) Is used so that consistent results can be expected under normal operating conditions; and (3) Provides that all wheels remain on the ground during braking. (d) The following shall be included in the ground roll calculation (1) Engine spool down characteristics (2) System and UAV crew reaction time to sense a failure and make the appropriate response to the failure. (3) If applicable, the time for UAV configuration changes (e.g. flap retractions, chute deployment, etc).

	57 Take-off path Not applicable.
	59 Take-off distance and take-off run Not applicable.
	61 Take-off flight path Not applicable.
63	USAR.63 Climb: General (a) Compliance with the requirements of USAR.65, USAR.66, USAR.67, USAR.69 and USAR.77 must be shown (1) Out of ground effect; and (2) At speeds which are not less than those at which compliance with the powerplant cooling requirements of USAR.1041 to USAR.1047 has been demonstrated. (3) Unless otherwise specified, with one engine inoperative, at a bank angle not exceeding 5 degrees. (4) For catapult assisted or rocket assisted take-off UAV when the UAV leaves the flight safety area associated to the launch safety trace required in USAR.283 (b) Compliance must be shown with USAR.65, USAR.67, where appropriate and USAR.77 at maximum take-off or landing weight, as appropriate in a standard atmosphere, or (c) At weights, as a function of airfield or launch site altitude and ambient temperature, within the operational limits established for take-off and landing respectively. (d) Not applicable
65	USAR.65 Climb: All Engines Operating (a) Each UAV must have a steady gradient of climb at sea level of at least 5 % with (1) Not more than maximum continuous power on each engine; (2) The landing gear retracted (if such a configuration is designed); (3) The wing flaps in the take-off position(s); and (4) A climb speed not less than the greater of 1.1 V_{MC} and 1.2 V_{S1} for multi-engined UAV and not less than 1.3 V_{S1} for single-engined UAV (b) For configurations with retractable landing gear, each UAV must have a steady gradient of climb at sea level of at least 2.5 % with (1) Not more than maximum continuous power on each engine; (2) The landing gear extended (3) The wing flaps in the take-off position(s); and (4) A climb speed not less than the greater of 1.1 V_{MC} and 1.2 V_{S1} for multi-engined UAV and not less than 1.2 V_{S1} for single-engined UAV

66	USAR.66 Take-off Climb: One-engine-inoperative for multi-engine UAV The steady gradient of climb or descent must be determined at each weight, altitude and ambient temperature within the operational limits established by the Applicant with (1) The critical engine inoperative and its propeller in the position it rapidly and automatically assumes; (2) The remaining engine at take-off power or thrust; (3) The landing gear extended in the take-off position except that, if the landing gear can be retracted in not more than 7 seconds and the gear retraction sequence does not have a higher drag profile than the gear deployed configuration, it may be assumed to be retracted; (4) The wing flaps in the take-off position(s); (5) The wings level; and (6) A climb speed equal to that achieved at 15 m (50 ft) in the demonstration of USAR.53.
67	USAR.67 Climb: One-engine-inoperative for multi-engine UAV (1) The steady gradient of climb must not be less that 2% at an altitude of 122 m (400 ft) above the take-off surface must be measurably positive with (i) The critical engine in-operative and its propeller in the minimum drag position; (ii) The remaining engine at take-off power or thrust; (iii) The landing gear retracted (if applicable); (iv) The wing flaps in the take-off position(s); and (v) A climb speed equal to that achieved at 15 m (50 ft) in the demonstration of USAR.53. (2) For configurations with retractable landing gear, the steady gradient of climb must not be less than 0.5% at an altitude of 122 m (400 ft) above the take-off surface, as appropriate with (i) The critical engine in-operative and its propeller in the minimum drag position; (ii) The remaining engine at take-off power or thrust; (iii) The landing gear extended; (iv) The wing flaps in the take-off position(s); and (v) A climb speed equal to that achieved at 15 m (50 ft) in the demonstration of USAR.53. (3) The steady gradient of climb must not be less than 0.8 % at an altitude of 422 m (1 500 ft) above the take-off or landing surface, as appropriate with (i) The critical engine in-operative and its propeller in the minimum drag position; (ii) The remaining engine at not more than maximum continuous power or thrust; (iii) The landing gear retracted; (iv) The wing flaps retracted; and (v) A climb speed not less than 1.2 V_{S1}.

69	USAR.69 En-route Climb/Descent (a) All engines operating The steady gradient and rate of climb must be determined at each weight, altitude and ambient temperature within the operational limits established by the Applicant with (1) Not more than maximum continuous power or thrust on each engine; (2) The landing gear retracted; (3) The wing flaps retracted; and (4) A climb speed not less than 1.3 V_{S1}. (b) One-engine-inoperative The steady gradient and rate of climb/descent must be determined at each weight, altitude and ambient temperature within the operational limits established by the Applicant with (1) The critical engine inoperative and its propeller in the minimum drag position; (2) The remaining engine at not more than maximum continuous power or thrust; (3) The landing gear retracted; (4) The wing flaps retracted; and (5) A climb speed not less than 1.2 V_{S1}.
71	USAR.71 Glide The maximum horizontal distance travelled in still air, in nautical miles per 1 000 ft of altitude lost in a glide, and the speed necessary to achieve this, must be determined with the engine inoperative and its propeller in the minimum drag position, landing gear and wing flaps in the most favourable available position.
73	USAR.73 Reference Landing Approach Speed Except where a UAV is designed to be recovered by parachute, the reference landing approach speed, V_{REF}, must not be less than the greater of (1) V_{MC}, determined under USAR.149 (c), and, (2) 1.3 V_{S0}, except if it is demonstrated that a lower speed does not affect safe landing due to UAV System performance whatever the combination of environmental conditions.
75	USAR.75 Landing Distance Except where a UAV is designed to be recovered by parachute, the horizontal distance necessary to land and come to a complete stop from a point 15 m (50 ft) above the landing surface must be determined, for standard temperatures at each weight and altitude within the operational limits established for landing, as follows: (a) A steady approach at not less than V_{REF}, determined in accordance with USAR.73 as appropriate, must be maintained down to 15 m (50-foot) height and the steady approach must be at a gradient of descent selected by the Applicant, called “standard slope”, down to the 15 m (50-foot) height. (b) A constant configuration must be maintained throughout the manoeuvre; (c) The landing must be made without excessive (limiting factor should be brakes, structure, landing gear, structural fatigue) vertical acceleration or tendency to bounce, nose-over, ground loop or porpoise.

	(d) It must be shown that a safe transition to the balked landing conditions of USAR.77 can be made from the conditions that exist at the 15 m (50 ft) height, at maximum landing weight or the maximum landing weight for altitude and temperature of USAR.63 (c). (e) The brakes must not be used so as to cause excessive wear of brakes or tyres. (f) Retardation means other than wheelbrakes may be used if that means (1) Is safe and reliable; (2) Is used so that consistent results can be expected in service; and (g) If any device is used that depends on the operation of any engine, and the landing distance would be increased when a landing is made with that engine inoperative, the landing distance must be determined with that engine inoperative unless the use of other compensating means will result in a landing distance not more than that with each engine operating.
77	USAR.77 Balked Landing (a) Except where a UAV is designed to be recovered by parachute, the steady gradient of climb must not be less than 2.5 % with (1) Take-off power on each engine; (2) The landing gear extended; (3) The wing flaps in the landing position; except that if the flaps may be safely retracted without loss of altitude and without sudden changes of angle of attack, they may be retracted ; and, (4) A climb speed equal to V_{REF}, as defined in USAR.73 (b) Not applicable (c) Not applicable (d) Minimum balked landing height shall be determined. This is defined as the minimum height above the ground where a successful balked landing could be performed safely.
FLIGHT CHARACTERISTICS	
141	USAR.141 General (a) The UAV must meet the requirements of USAR.143 to USAR.253. When operated in the automatic control mode the UAV should be shown to have acceptable controllability, manoeuvrability and stability characteristics throughout the flight envelope protection (see USAR.334 and USAR.1329) maintained by the flight control system, without requiring exceptional skill or alertness from the UAV crew. (b) The UAV must demonstrate the fulfilment of the “flight characteristics” requirements at all practical loading conditions and all operating altitudes, not exceeding the maximum operating altitude established under USAR.1527, for which certification has been requested.
	CONTROLLABILITY AND MANOEUVRABILITY
143	USAR.143 General (a) The UAV must be safely controllable and manoeuvrable during all flight phases including (1) Take-off (except for rocket assisted or catapult assisted take-off UAV, see USAR.282); (2) Climb;

	(3) Level flight, including mission relevant special manoeuvres; (4) Descent; (5) Go-around (except where UAV is designed to be recovered by parachute, see USAR.290); and (6) Landing (power on and power off) with the wing flaps extended and retracted (except where UAV is designed to be recovered by parachute, see USAR.290). (7) Ground taxi (see USAR.231 to USAR.235). (b) It must be possible to make a smooth transition from one flight phase and/or condition to another (including turns and slips) without danger of exceeding the limit load factor, under any probable operating condition, (including, for multi-engined UAVs, those conditions normally encountered in the sudden failure of any engine). (c) Not applicable
	145 Longitudinal control Not applicable. (see USAR.171)
	147 Directional and lateral control Not applicable. (see USAR.171)
149	USAR.149 Minimum Control Speed (a) V_{MC} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the UAV , with that engine still inoperative, and thereafter maintain straight flight at the same speed with an angle of bank not more than 5°. The method used to simulate critical engine failure must represent the most critical mode of powerplant failure with respect to controllability expected in service. (b) V_{MC} for take-off must not exceed 1.2 V_{S1}, (where V_{S1} is determined at the maximum take-off weight) and must be determined with the most unfavourable weight and centre of gravity position and with the UAV airborne and the ground effect negligible, for the take-off configuration(s) with (1) Maximum available take-off power or thrust initially on each engine; (2) The UAV trimmed for take-off; (3) Flaps in the take-off position(s); (4) Landing gear retracted; and (5) All propeller controls in the recommended take-off position throughout. (c) Except where UAV is designed to be recovered by parachute, the requirements of sub-paragraph (a) must also be met for the landing configuration with (1) Maximum available take-off power or thrust initially on each engine; (2) The UAV trimmed for an approach with all engines operating at V_{REF} at an approach gradient equal to the steepest used in the landing distance demonstration of USAR.75; (3) Flaps in the landing position; (4) Landing gear extended; and

	(5) All propeller controls throughout in the position recommended for approach with all engines operating. (d) A minimum speed to intentionally render the critical engine inoperative must be established and designated as the safe, intentional, one-engine inoperative speed, V_{SSE}. (e) At V_{MC}, it must not be necessary to reduce power or thrust of the operative engine . During the manoeuvre the UAV must not assume any dangerous attitude and it must be possible to prevent a heading change of more than 20°. (f) Except for rocket assisted or catapult assisted take-off UAV, V_{MCG}, the minimum control speed on the ground, is the calibrated airspeed during the takeoff run, at which, when the critical engine is suddenly made inoperative and with its propeller, if applicable, in the position it automatically achieves, it is possible for the flight control system to maintain control of the UAV to enable the take-off to be safely continued . In the determination of V_{MCG}, assuming that the path of the UAV accelerating with all engines operating is along the centreline of the runway, its path from the point at which the critical engine is made inoperative to the point at which recovery to a direction parallel to the centreline is completed, may not deviate more than 9.1m (30ft) laterally from the centreline at any point. V_{MCG} must be established, with: (1) The UAV in each take-off configuration or, at the option of the Applicant, in the most critical take-off configuration; (2) Maximum available take-off power or thrust on the operating engines; (3) The most unfavourable centre of gravity; (4) The UAV trimmed for takeoff; and (5) The most unfavourable weight in the range of take-off weights.
	151 Aerobatic manoeuvres Not applicable.
	153 Control during landings Not applicable.
	155 Elevator control force in manoeuvres Not applicable.
	157 Rate of roll Not applicable.
161	USAR.161 Trim The Flight Control System (FCS) must trim the UAV in such a manner that a maximum of control remains and that dynamic characteristics and safety margins are not compromised.
STABILITY	
171	USAR.171 General See AMC.171 (a) The UAV, augmented by the FCS including all degraded modes, must be longitudinally, directionally and laterally stable in any condition normally encountered in service, at any combination of weight and centre of gravity for which certification is requested. (b) Transient response in all axes during transition between different flight conditions and flight modes must be smooth, convergent, and exhibit damping characteristics with minimal overshoot of the intended flight path.

	(c) In addition to data obtained by computation or modelling, stability analysis must be supported by the results of relevant flight tests.
	175 Demonstration of static longitudinal stability Not applicable.
	177 Static directional and lateral stability Not applicable.
	181 Dynamic stability Not applicable.
	STALLS
201	USAR.201 Wings Level Stall (a) Flight tests shall be conducted in straight flight for each relevant UAV flaps configuration, with the engine at idle position and for the most appropriate combination of weight and centre of gravity while reducing the speed at a decelerating rate of approximately 1kt/s (1) up to the time the UAV stalls, or (2) until $V_{min\ DEMO}$, if the stalling speed is not to be demonstrated in compliance with USAR.50, and, (i) no stall tendency shall occur down to $V_{min\ DEMO}$, (ii) $V_{min\ DEMO}$ shall be lower by the margin established under USAR.50 than the minimum steady flight speed (except take-off and landing) allowed by the flight envelope protection maintained by the flight control system. (b) These flight tests may be conducted, while possibly adjusting or inhibiting flight control protection features.
203	USAR.203 Stall protection in wing level and turning flight (a) Flight tests shall be conducted in straight flight and in the maximum bank angle allowed by the flight control protection features for each relevant UAV flaps configuration for the most unfavourable combination of weight, centre of gravity and engine setting while abruptly reducing speed command as per relevant flight control mode. (b) During these tests, it should be shown that (1) the steady speed achieved should remain greater than or equal to the minimum steady flight speed (except take-off and landing) allowed by the flight envelope protection maintained by the flight control system. (2) No unsafe characteristics occur.
	207 Stall warning Not applicable in this subpart (see USAR.1789 Low speed warning)
	SPINNING
221	USAR.221 Spinning and tumbling The UAV must be designed characteristically incapable of intential spinning/tumbling (all spin and tumbling modes) due to the flight envelope protection maintained by the flight control system or other means to be substantiated by the Applicant unless in defined circumstances agreed to by the Certifying Authority (i.e. used as a flight termination system in compliance with USAR 1412).

	GROUND HANDLING CHARACTERISTICS
231	USAR.231 Longitudinal Stability and Control A UAV may have no uncontrollable tendency to nose over in any reasonably expected operating condition, including rebound during landing (except for parachute operations) or take-off. Wheel brakes (where fitted) must operate smoothly and may not induce any undue tendency to nose over.
233	USAR.233 Directional Stability and Control (a) A 90° cross-component of wind velocity, demonstrated to be safe for taxiing (except for UAV not designed for taxiing), take-off and landing must be established and must be not less than 0.2 V_{S0}. (b) Except where UAV is designed to be recovered by parachute only, it must be satisfactorily controllable in power-off landings at normal landing speed, without using brakes or engine power to maintain a straight path until the speed has decreased to less than 50% of the speed at touchdown. (c) Except for UAV not designed for taxiing it must have adequate directional control during taxiing. (d) Not applicable
235	USAR.235 Operation On Unpaved Surfaces See AMC.235 (a) The UAV must be demonstrated to have satisfactory characteristics and the shock-absorbing mechanism must not damage the UAV when the UAV is taxied on the roughest ground that may reasonably be expected in normal operation (except for UAV not designed for taxiing) and when take-off and landings are performed on unpaved runways having the roughest surface that may reasonably be expected in normal operation. (b) If the UAV System Flight Manual restrict UAV operation to paved taxiways and runways only : (1) the requirements for taxi, take-off and landing on unpaved runway are not applicable, and, (2) the UAV System Flight Manual shall give all operational indications to face emergency landing on unpaved runways.
	237 Operation on water Not applicable.
	239 Spray characteristics Not applicable.
U249	USAR.U249 Transportation and storage (a) Where a UAV System or part of the System is designed to be transportable by any means during normal operations or System use, it shall be demonstrated that no environmental factors associated with the means of transportation shall adversely affect any requirement of these standards. (b) It shall be demonstrated that any special equipment used for transportation during normal operations (for instance special containers, cradles etc) provides the appropriate level of environmental protection for the method of transport used. (c) Where a UAV System or part of the System is reconfigured for transportation, it shall be shown that the expected number of reconfigurations in any System life cycle will not adversely affect any requirement of USAR. (d) Where a UAV System or part of the System is designed to be placed in storage as part of the normal usage pattern, it shall be demonstrated that no environmental factors associated with preparation for storage, storage, or recovery from storage shall adversely affect any factor/requirement of these standards.

	(e) In this part environmental factors relating to transportation or storage shall include all shock, vibration, water and moisture, particulate matter, electromagnetic, thermal, and other foreseeable conditions or effects likely to be encountered during transportation or storage that would adversely affect any requirement of these standards.
MISCELLANEOUS FLIGHT REQUIREMENTS	
251	USAR.251 Vibration and Buffeting There must be no vibration or buffeting severe enough to result in structural damage and each part of the UAV must be free from excessive vibration, under any appropriate speed and power or thrust conditions up to at least the minimum value of V_D allowed in USAR.335. In addition there must be no buffeting in any normal flight condition severe enough to interfere with the satisfactory control of the UAV
253	USAR.253 High Speed Characteristics If a maximum operating speed V_{M0}/M_{M0} is established under USAR.1505 (c), the following speed increase and recovery characteristics must be met (a) Operating conditions and characteristics likely to cause inadvertent speed increases (including upsets in pitch and roll) must be simulated with the UAV trimmed at any likely speed up to V_{M0}/M_{M0}. These conditions and characteristics include gust upsets, levelling off from climb and descent from Mach to airspeed limit altitude. (b) Allowing for UAV crew or flight control system reaction time after occurrence of effective inherent or artificial speed warning specified in USAR.1723, it must be shown that the UAV can be recovered to a normal attitude and its speed reduced to V_{MO}/M_{MO} without (1) Exceeding V_D/M_D, the maximum speed shown under USAR.251, or the structural limitations; or (2) Buffeting that would impair the UAV ability for recovery. (c) There may be no control reversal about any axis at any speed up to the maximum speed shown under USAR.251.
CATAPULT ASSISTED AND ROCKET ASSISTED TAKE-OFF UAV	
U280	USAR.U280 Launch performance (a) The UAV must achieve sufficient energy and controllability at the end of the launch phase to ensure safe and controllable fly-away under the most adverse combination of environmental and operating conditions (1) at a minimum of 1.15 V_{S1} or 1.15 V_{MC}, whichever is the higher ; (2) in order to comply with requirements of USAR.51 (b), USAR.65 and USAR.67. The launch phase ends when the UAV leaves the flight safety area associated to the launch safety trace required in USAR.283. (b) The launch performance (launch parameters settings, launch speed) must be determined for each weight, altitude, temperature and wind condition within the operational limits established for take-off in addition to requirement specified in USAR.53. (c) It must be shown by tests that the acceleration sustained by the UAV during the launch phase do not lower UAV engine performance in a manner that could be inadequate for safe operation (d) A manual abort function must be easily accessible to the UAV crew in order to cancel the UAV launch at any time before the irreversible catapult or rocket ignition phase.

U281	USAR.U281 Transition to normal flight attitude (a) The transition to normal flight attitude or normal in-flight UAV configuration must be such that no possibility of conflict exists between the UAV and its launch platform or any other object under any combination of environmental conditions. (b) The UAV must remain in a predictable flight condition throughout the launch phase.
U282	USAR.U282 UAV active control In case of launch without active control by the flight control system of the air vehicle attitude or direction, the UAV must not diverge beyond its recoverable limit and the active control must be reinstated before the UAV reaches the boundary of its launch safety trace.
U283	USAR.U283 Launch safety trace See AMC.283 The limits of the launch safety trace around the launch platform must be determined for each weight, altitude, wind conditions, and temperature within the operational limits established for take-off.
	PARACHUTE LANDING SYSTEM
U290	USAR.U290 UAV performance before parachute landing (a) The UAV flight performance and control characteristics must be adequate for all intended parachute landing procedure under all specified operational conditions. (b) Two modes of landing by parachute can be foreseen: (1) a normal landing mode where a parachute is used in a regular way after every flight, and, (2) an emergency landing mode where a parachute is used in case of emergency. (c) It must be possible to abort the normal landing procedure at any point prior to the initiation of the final deployment sequence and it must be shown that a safe transition to a normal flight mode or go around conditions can be made. (d) The normal and emergency parachute landing sequence must be precisely defined in the UAV System Flight Manual including for normal landing the approach phase and the go around procedure.
U291	USAR.U291 Parachute landing characteristics (a) The normal landing under parachute must be made without excessive vertical acceleration or tendency to bounce, nose over, ground loop or porpoise. (b) The minimum parachute safety height must ensure a correct parachute deployment sequence and must ensure that the UAV descent under a fully inflated parachute is stabilised whatever the combination of environmental conditions. (c) The parachute must be deployed at a height greater or equal to the minimum parachute safety height above ground, which depends on the timing of the parachute sequence. (d) The minimum parachute safety height must be stated in the UAV System Flight Manual. (e) Special attention must be given to the static and dynamic stability of the UAV during the parachute landing phase : movements of the UAV and of the parachute must not lead to unsafe characteristics.
U292	USAR.U292 Parachute landing performance (a) The normal parachute landing must be designed to allow a precise landing on the ground surface with a CEP to be stated in the UAV System Flight Manual under and calculated under any combination of environmental conditions.

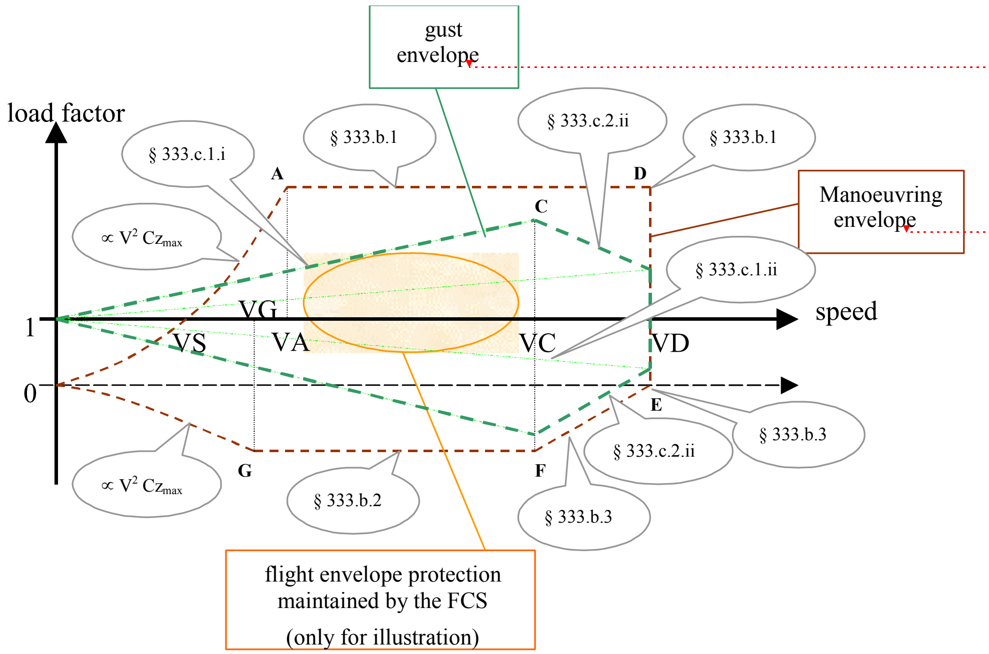
	(b) It must be shown that the parachute landing sequence is a reliable, repeatable and predictable safe operation (1) at every combination of weight and balance of the UAV for which certification is requested, (2) in the most adverse weather conditions (wind, rain, icing, …) for which approval is requested, (3) throughout the life cycle of the UAV System. (c) The features of the terrain over which the parachute landing can be performed in normal condition must be stated in the UAV System Flight Manual, in particular its acceptable slope.
U293	USAR.U293 Parachute landing safety trace The limits of the parachute landing safety trace must be determined for each weight, altitude and temperature within the operational limits established for landing.

subpart C – UAV STRUCTURE

GENERAL	
301	USAR.301 Loads See AMC.301 (a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads. (b) Unless otherwise provided, the air and ground loads must be placed in equilibrium with inertia forces, considering each item of mass in the UAV . These loads must be distributed to conservatively approximate or closely represent actual conditions. Methods used to determine load intensities and distribution on canard and tandem wing configurations must be validated by flight test measurement unless the methods used for determining those loading conditions are shown to be reliable or conservative on the configuration under consideration. (c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account. (d) Simplified structural design criteria may be used when agreed with the Certifying Authority if they result in design loads not less than those prescribed in USAR.331 to USAR.511. (e) The requirements of subpart C must be assessed for each payload configuration.
302	USAR.302 Canard or Tandem Wing Configurations The forward structure of a canard or tandem wing configuration must (a) Meet all requirements of subpart C and subpart D of USAR applicable to a wing; and (b) Meet all requirements applicable to the function performed by these surfaces.
303	USAR.303 Factor of Safety The factor of safety shall not be lower than 1.5 for structure whose failure would lead to a Hazardous or more serious failure condition. For other structure, the factor of safety shall not be lower than 1.25. For a factor of safety less than 1.5, the Applicant must provide justification to be agreed to by the Certifying Authority.
305	USAR.305 Strength and Deformation (a) The structure must be able to support p x limit loads (proof loads) without detrimental, permanent deformation. At any load up to proof loads, the deformation may not interfere with safe operation. The ratio p is defined between 105% and 115% as agreed by the Certifying Authority. (b) The structure must be able to support ultimate loads without failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the three second limit does not apply.
307	USAR.307 Proof of Structure See AMC.307 (a) Compliance with the strength and deformation requirements of USAR.305 must be shown for each critical load condition, including fire conditions (see USAR.865). Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made up to a level considered to be sufficient and agreed with the Certifying Authority. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated.

	(b) Certain parts of the structure must be tested as specified in Subpart D of USAR. (c) When analytical methods are used to show compliance with the ultimate load strength, it must be shown that: (1) The effects of deformation are not significant; or (2) The deformations involved are fully accounted for in the analysis; or the methods and assumptions used are sufficient to cover the effects of these deformations
FLIGHT LOADS	
321	USAR 321 General See AMC.321 (c) (a) Flight load factors represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the UAV) to the weight of the UAV. A positive flight load factor is one in which the aerodynamic force acts upward, with respect to the UAV. (b) Compliance with the flight load requirements of this subpart must be shown at each critical combination of (1) altitude within the range in which the UAV may be expected to operate; (2) weight from the design minimum weight to the design maximum weight; (3) centre of gravity between the allowable center of gravity limits; (4) altitude, weight and centre of gravity, for any practicable distribution of disposable load within the operating limitations specified in USAR.1583 to USAR.1589. (c) When significant the effects of compressibility must be taken into account. (d) The significant forces acting on the UAV must be placed in equilibrium in a rational or conservative manner. The linear inertia forces must be considered in equilibrium with power or thrust and all aerodynamic loads, while the angular (pitching) inertia forces must be considered in equilibrium with power or thrust and all aerodynamic moments. Critical power or thrust values in the range from zero to maximum continuous power or thrust must be considered. (e) The manoeuvres which need to be considered in the load establishment are those resulting from combination of possible (taking into account the UAV System design) control surface deflections and power or thrust settings. The resulting load conditions must be established in a rational or conservative manner and must consider: (1) the UAV System nominal modes of control, (2) the UAV System failure modes where probability of occurrence is higher than extremely remote. Such conservative manoeuvre conditions may be, if convenient, based on conventional type manoeuvre (symmetrical manoeuvres, roll manoeuvres, yaw manoeuvres) such as defined in USAR.331, USAR.349 and USAR.351. (f) The UAV System design shall be such that the loads possibly encountered during the defined usage spectrum, considering approved procedures may not exceed the loads to which the UAV System is certified.

331	USAR.331 Symmetrical Flight Conditions (a) The appropriate balancing horizontal tail load must be accounted for in a rational or conservative manner when determining the wing loads and linear inertia loads corresponding to any of the symmetrical flight conditions specified in USAR.331 to USAR.341. (b) The incremental horizontal tail loads due to manoeuvring and gusts must be reacted by the angular inertia of the UAV in a rational or conservative manner. (c) Mutual influence of the aerodynamic surfaces must be taken into account when determining flight loads.



333	USAR.333 Flight Envelope See AMC.333 (c) (a) General. Compliance with the strength requirements of this subpart must be shown at any combination of airspeed and load factor on and within the boundaries of a flight envelope (similar to the one in sub-paragraph (d) of this paragraph) that represents the envelope of the flight loading conditions specified by the manoeuvring and gust criteria of sub-paragraphs (b) and (c) of this paragraph respectively. (b) Manoeuvring envelope. Except where limited by maximum (static) lift coefficients, the UAV is assumed to be subjected to symmetrical manoeuvres resulting in the following limit load factors: (1) The positive manoeuvring load factor specified in USAR.337 at speeds up to V_D; (2) The negative manoeuvring load factor specified in USAR.337 at V_C; and (3) Factors varying linearly with speed from the specified value at V_C to 0.0 at V_D

	(c) Gust envelope The UAV is assumed to be subjected to symmetrical vertical and lateral gusts in level flight. The resulting limit load factors must correspond to the conditions determined as follows: positive (up) and negative (down) gust values at VC and VD should be determined by rational analysis of the intended use of the UAV system, considering the time spent at low altitude levels and the cruise speed (consistent with the design usage spectrum defined in USAR.17), however as a minimum: (i) Positive (up) and negative (down) gusts of 15.2 m/s (50 fps at V_C must be considered at altitudes between sea level and 6096 m (20,000 ft). The gust velocity may be reduced linearly from 15.2 m/s (50 fps) at 6096 m (20,000 ft) to 7.6 m/s (25 fps) at 15,240 m (50,000 ft); and (ii) Positive and negative gusts of 7.6 m/s (25 fps) at V_D must be considered at altitudes between sea level and 6096 m (20,000 ft). The gust velocity may be reduced linearly from 7.6 m/s (25 fps) at 6096 m (20,000) ft to 3.8 m/s (12.5 fps) at 15,240 m (50,000 ft). (d) Flight envelope : see figure. where : V_A : design manoeuvring speed V_C : design cruising speed V_D : design diving speed V_G : negative manoeuvring load factor speed V_S : stalling speed
U334	USAR.U334 Flight envelope protection (a) Flight envelope protection shall be implemented in the flight control system as follows: (1) Characteristics of each envelope protection feature must be smooth, appropriate to the phase of flight and type of manoeuvre (2) Limit values of protected flight parameters must be compatible with (i) UAV structural limits, (ii) required safe and controllable manoeuvring of the UAV, (iii) margin to Hazardous or more serious failure conditions. (3) The minimum speed allowed by the flight control system must be compatible with the margin specified in USAR.50. (4) The UAV must respond to intentional dynamic manoeuvring within a suitable range of parameter limit (5) Dynamic characteristics such as damping and overshoot must also be appropriate for the manoeuvre and limit parameter concerned (6) Characteristics of the flight control system must not result in residual oscillations in commanded output due to combinations of flight envelope protection limits and any other flight control internal limit. (b) When simultaneous envelope protection limits are engaged, adverse coupling or adverse priority must not result. (c) The Applicant must define clearly the borders and prioritization within the control system of the flight envelope protection maintained by the flight control system.

335	USAR.335 Design Airspeeds The selected airspeeds are equivalent airspeeds (EAS). (a) Design cruising speed, V_C. For V_C, the following apply (1) V_C shall be defined according to UAV operating requirements. (2) Not applicable (3) Not applicable (4) At altitudes where an M_D is established, a cruising speed M_C limited by compressibility may be selected. (b) Design dive speed, V_D. For V_D the following apply: (1) V_D/M_D may not be less than 1.25 V_C/M_C; however where credit may be claimed from existing experience and / or high speed flight envelope protection, lesser margin values may be considered. (2) Not applicable (3) Not applicable (4) Compliance with sub-paragraph (1) of this paragraph need not be shown if V_D/M_D is selected so that the minimum speed margin between V_C/M_C and V_D/M_D is the greater of the following: (i) The speed increase resulting when, from the initial condition of stabilised flight at V_C/M_C, the UAV is assumed to be upset, flown for 20 seconds along a flight path 7.5° below the initial path and then pulled up with a load factor of 1.5 (0.5 g. acceleration increment). At least 75% maximum continuous power for reciprocating engines and maximum cruising thrust for turbines, or, if less, the thrust required for V_C/M_C for both kinds of engines, must be assumed until the pull-up is initiated, at which point power reduction devices may be used; and (ii) Mach 0.05 (at altitudes where M_D is established). (c) Design manoeuvring speed V_A. For V_A, the following applies: (1) V_A may not be less than $V_S.n^{1/2}$ where (i) V_S is a computed stalling speed with flaps retracted at the design weight, normally based on the maximum UAV normal force coefficients, C_{NA}; and (ii) n is the limit manoeuvring load factor used in design. (2) The value of V_A need not exceed the value of V_C used in design. (d) Not applicable.
337	USAR.337 Limit Manoeuvring Load Factors (a) The minimum positive limit manoeuvring load factor n is the minimum of 2.1 + 10900/(W+4536) (where W = design maximum take-off weight in kg) or 3.8; (b) The negative limit manoeuvring load factor may not be less than 0.4 times the positive load factor (c) Manoeuvring load factors lower than those specified in this section may be used if the UAV has design features that make it impossible to intentionally exceed these values in flight.

341	USAR 341 Gust Load Factors See AMC.341 (b) (a) Each UAV must be designed for loads on each lifting surface resulting from gusts specified in USAR.333(c). (b) The gust load for a canard or tandem wing configuration must be computed using a rational analysis. (c) Not applicable
343	USAR.343 Design Fuel Loads See AMC.343 (b) (a) The disposable load combinations must include each fuel load in the range from zero fuel to the selected maximum fuel load. The zero fuel load does not include the unusable fuel remaining. (b) If fuel is carried in the wings, the maximum allowable weight of the UAV without any fuel in the wing tank(s) must be established as "maximum zero wing fuel weight" if it is less than the maximum weight. (c) Not applicable
345	USAR.345 High Lift Devices See AMC.345 (d) (a) If flaps or similar high lift devices are to be used for take-off, approach or landing, the UAV, with the flaps fully extended at V_F, is assumed to be subjected to symmetrical manoeuvres and gusts within the range determined by (1) Manoeuvring, to a positive limit load factor of 2.0 or according to those values defined by USAR.337 (c) application if lower; and (2) Positive and negative gust of 7.6 m/s (25 fps) acting normal to the flight path in level flight. (b) V_F must be assumed to be not less than 1.4 VS or 1.8 V_{SF}, whichever is greater, where V_S is the computed stalling speed with flaps retracted at the design weight; and V_{SF} is the computed stalling speed with flaps fully extended at the design weight. However, if an automatic flap load limiting device is used, the UAV may be designed for the critical combinations of airspeed and flap position allowed by that device. (c) In determining external loads on the UAV as a whole, thrust, slipstream and pitching acceleration may be assumed to be zero. (d) The flaps, their operating mechanism and their supporting structures, must be designed for the conditions prescribed in sub-paragraph (a) of this paragraph. In addition, with the flaps fully extended at speed V_F the following conditions, taken separately, must be accounted for: (1) A head-on gust having a velocity of 7.6 m/s (25 fps) (EAS), combined with propeller slipstream corresponding to 75% of maximum continuous power or thrust; and (2) The effects of propeller slipstream corresponding to maximum take-off power or thrust.
347	USAR.347 Unsymmetrical Flight Conditions The UAV is assumed to be subjected to the unsymmetrical flight conditions of USAR.349 and USAR.351. Unbalanced aerodynamic moments about the centre of gravity must be reacted in a rational or conservative manner, considering the principal masses furnishing the reacting inertia forces.

349	UAV.349 Rolling Conditions The wing and wing bracing must be designed for the following loading conditions: (a) Unsymmetrical wing loads . Unless the following values result in unrealistic loads, the rolling accelerations may be obtained by modifying the symmetrical flight conditions in USAR.333 (d) as follows: in condition A, assume that 100% of the semi-span wing air load acts on one side of the UAV and 75% of this load acts on the other side. (b) The loads resulting from the aileron deflections and speeds specified in USAR.455, in combination with a UAV load factor of at least two thirds of the positive manoeuvring load factor used for design. Unless the following values result in unrealistic loads, the effect of aileron displacement on wing torsion may be accounted for by adding the following increment to the basic airfoil moment coefficient over the aileron portion of the span in the critical condition determined in USAR.333 (d) . $\Delta C_m = -0.01\delta$ where – ΔC_m = is the moment coefficient increment; and δ is the down aileron deflection in degrees in the critical condition.
351	USAR.351 Yawing Conditions The UAV must be designed for yawing loads on the vertical surfaces resulting from the loads specified in USAR.441 to USAR.445.
361	USAR.361 Engine Torque (a) The mounting arrangement for each engine and its supporting structure must be designed for the effects of (1) A limit engine torque corresponding to take-off power or thrust and propeller speed acting simultaneously with 75% of the limit loads from flight condition A of USAR.333 (d); (2) A limit engine torque corresponding to maximum continuous power or thrust and propeller speed acting simultaneously with the limit loads from flight condition A of USAR.333 (d); and (3) For turbo-propeller installations, in addition to the conditions specified in sub-paragraphs (a) (1) and (a) (2) of this paragraph, a limit engine torque corresponding to take-off power or thrust and propeller speed, multiplied by a factor accounting for propeller control system malfunction, including quick feathering, acting simultaneously with 1g level flight loads. In the absence of a rational analysis, a factor of 1.6 must be used. (b) For turbine-engine installations, the mounting arrangement for each engine and supporting structure must be designed to withstand each of the following: (1) A limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming); and (2) A limit engine torque load imposed by the maximum acceleration of the engine. (c) The limit engine torque to be considered under sub-paragraph (a) of this paragraph must be obtained by multiplying the mean torque by a factor of (1) 1.25 for turbo-propeller installations; (2) 1.33 for engines with five or more cylinders; and (3) Two, three, or four, for engines with four, three or two cylinders, respectively.

363	USAR.363 Sideload On Engine Mount (a) The mounting arrangement for each engine and its supporting structure must be designed for a limit load factor in a lateral direction, for the sideload on the engine mount, of not less than (1) 1.33; or (2) One-third of the limit load factor for flight condition A. (b) The sideload prescribed in sub-paragraph (a) of this paragraph may be assumed to be independent of other flight conditions.
365	USAR.365 Pressurised Compartment Loads For each pressurised compartment, the following apply: (a) The UAV structure must be strong enough to withstand the flight loads combined with pressure differential loads from zero up to the maximum relief valve setting. (b) The external pressure distribution in flight and any stress concentrations, must be accounted for. (c) If landings may be made, with the compartment pressurised, landing loads must be combined with pressure differential loads from zero up to the maximum allowed during landing. (d) The UAV structure must be strong enough to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33 omitting other loads. (e) If a pressurised compartment has two or more compartments, separated by bulkheads or a floor, the primary structure must be designed for the effects of sudden release of pressure in any compartment with external opening . This condition must be investigated for the effects of failure of the largest opening in the compartment. The effects of intercompartmental venting may be considered.
367	USAR.367 Unsymmetrical Loads Due to Engine Failure (a) The UAV must be designed for the unsymmetrical loads resulting from the failure of the critical engine. Turbopropeller UAV must be designed for the unsymmetrical loads resulting from the failure of the critical engine including the following conditions in combination with a single malfunction of the propeller drag limiting system, (1) At speeds between V_{MC} and V_D, the loads resulting from power failure because of fuel flow interruption are considered to be limit loads; (2) At speeds between V_{MC} and V_C, the loads resulting from the disconnection of the engine compressor from the turbine or from loss of the turbine blades are considered to be ultimate loads; (3) The time history of the thrust decay and drag build-up occurring as a result of the prescribed engine failures must be substantiated by test or other data applicable to the particular engine-propeller combination; and (4) Not applicable (see USAR.367 (c)). (b) Not applicable. (c) The timing and magnitude of the corrective action performed automatically by the flight control system must be conservatively estimated, considering the characteristics of the particular engine-propeller- UAV combination.

369	USAR.369 Rear Lift Truss Loads (a) If a rear lift truss is used, it must be designed for conditions of reversed airflow at a design speed of $V = 7.29(\frac{W}{S})^{1/2} + 16.1$ (km/h) where W/S = wing loading at design maximum take-off weight (kg/m²). (b) Either aerodynamic data for the particular wing section used, or a value of C_L equalling 0.8 with a chordwise distribution that is triangular between a peak at the trailing edge and zero at the leading edge, must be used.
371	USAR.371 Gyroscopic and Aerodynamic Loads See AMC.371 The mounting arrangement for each engine and its supporting structure must be designed for the gyroscopic, inertia and aerodynamic loads that result, with the engine(s) and propeller(s), if applicable at maximum continuous rpm, under either (1) The conditions prescribed in USAR.351 and USAR.423; or (2) All possible combinations of the following in the limits allowed by the flight control system : (i) a yaw velocity of 150% of the maximum predicted yaw rotational velocity within the flight envelope maintained by the flight control system (ii) a pitch velocity of 150% of the maximum predicted pitch rotational velocity within the flight envelope maintained by the flight control system; (iii) a normal load factor of 150% of the maximum predicted load factor within the flight envelope maintained by the flight control system; and (iv) Maximum continuous thrust.
373	USAR.373 Speed Control Devices If speed control devices (such as spoilers and drag flaps) are incorporated for use in en-route conditions (a) The UAV must be designed for the symmetrical manoeuvres and gusts prescribed in USAR.333, USAR.337 and USAR.341 and the yawing manoeuvres and lateral gusts in USAR.441 and USAR.443, with the device extended at speeds up to the maximum operational speed for that device; and (b) If the device has automatic operating or load limiting features, the UAV must be designed for the manoeuvre and gust conditions prescribed in sub-paragraph (a) of this paragraph at the speeds and corresponding device positions that the mechanism allows.
CONTROL SURFACE AND SYSTEM LOADS	
391	USAR.391 Control Surface Loads The control surface loads specified in USAR.397 to USAR.459 are assumed to occur in the conditions described in USAR.331 to USAR.351.
393	USAR.393 Loads Parallel to Hinge Line See AMC.393 (a) and AMC.393 (b) (a) Control surfaces and supporting hinge brackets must be designed to withstand inertia loads acting parallel to the hinge line.

	(b) In the absence of more rational data, the inertia loads may be assumed to be equal to KW, where (1) K = 24 for vertical surfaces; (2) K = 12 for horizontal surfaces; and (3) W = weight of the movable surfaces.
395	USAR 395 Control System Loads (a) Each flight control system and its supporting structure must be designed for loads corresponding to at least 125% of the computed hinge moments of the movable control surface in the conditions prescribed in USAR.391 to USAR.459. In addition, the following apply: (1) The system limit loads need not exceed the higher of the loads that can be sustained by the servocontrols or actuators. (2) The design must, in any case, provide a rugged system for service use, considering jamming, ground gusts, taxiing downwind (if the UAV is designed to taxi), control inertia and friction. (b) A 125% factor on computed hinge movements must be used to design elevator, aileron and rudder systems. However, a factor as low as 1.0 may be used if hinge moments are based on accurate flight test data, the exact reduction depending upon the accuracy and reliability of the data. (c) Forces occurring from the actuating system are assumed to act at the appropriate attachments of the control system to the control surface horns.
397	USAR.397 Limit Control Forces and Torques (a) In the control surface flight loading condition, the air loads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any force occurring from the actuating system within the range specified in USAR.397 (b). (b) The control system must be able to bear the maximum loads and torques generated by the actuating system.
	399 Dual control system Not applicable.
405	USAR.405 Secondary Flight Control Secondary controls, (i.e. all flight controls other than primary flight controls (see definition of primary flight controls in USAR.673(a)), such as wheel brakes, spoilers and tab controls, must be designed for the maximum forces that the actuating system is likely to apply to those controls.
407	USAR.407 Trim Tab Effects The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum effort of the actuating system. In these cases, the tabs are considered to be deflected in the direction that would assist the system. These deflections must correspond to the maximum degree of "out of trim" expected at the speed for the condition under consideration.
409	USAR.409 Tabs Control surface tabs must be designed for the most severe combination of airspeed and tab deflection likely to be obtained within the flight envelope protection for any usable loading condition.
415	USAR.415 Ground Gust Conditions (a) The control system must be investigated as follows for control surface loads due to ground gusts and taxiing downwind (if the UAV is designed to taxi): (1) If an investigation of the control system for ground gust loads is not required by sub-paragraph (2)

of this paragraph, but the Applicant elects to design a part of the control system for these loads, these loads need only be carried from control surface horns through the nearest stops or gust locks and their supporting structures.

(2) The effects of surface loads due to ground gusts and taxiing downwind must be investigated for the entire control system according to the formula

$$H = K\,c\,S\,q$$

where

H = limit hinge moment (N.m);

c = mean chord of the control surface aft of the hinge line (m);

S = area of control surface aft of the Hinge line (m²);

q = dynamic pressure (psf) based on a design speed not less than $2.01\sqrt{W/S} + 4.45$ (m/s) (where W/S=wing loading at design maximum weight (lbs/ft^2)) except that the design speed need not exceed 26.8 m/s (88 fps); and

K = limit hinge moment factor for ground gusts derived in subparagraph (b) of this paragraph. (For ailerons and elevators, a positive value of K indicates a moment tending to depress the surface and a negative value of K indicates a moment tending to raise the surface.

(b) The limit hinge moment factor K for ground gusts must be derived as follows:

Surface	K	Postion of controls
(a) Aileron	0.75	Mid-position
(b) Aileron	± 0.50	Ailerons at full throw: + moment on one aileron, - moment on the other
(c) (d) Elevator	± 0.75	(c) Elevator full up (-) (d) Elevator full down (+)
(e) (f) Rudder	± 0.75	(e) Rudder in neutral (f) Rudder at full throw

(c) At all weights between the Empty Weight and the maximum weight declared for tie-down stated in the appropriate Manual, any declared tie-down points and surrounding structure, control system, surfaces and associated gust locks must be designed to withstand the limit load conditions arising when tied-down, resulting from wind speeds of up to 120 km/h (65 knots) horizontally from any direction.

HORIZONTAL TAIL SURFACES

421 USAR.421 Balancing Loads

(a) A horizontal surface balancing load is a load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.

(b) Horizontal balancing surfaces must be designed for the balancing loads occurring at any point on the limit manoeuvring envelope and in the flap conditions specified in USAR.345.

423	USAR.423 Manoeuvring Loads Each horizontal surface and its supporting structure, and the main wing of a canard or tandem wing configuration, if that surface has pitch control, must be designed for manoeuvring loads imposed by the following conditions: (a) A sudden movement of the pitching control, at the speed V_A, as limited by the control stops, or, maximum force of the servocontrols or actuators, whichever is critical, to (1) the maximum aft movement, and, (2) the maximum forward movement. (b) A sudden aft movement of the pitching control at speeds above V_A, followed by a forward movement of the pitching control resulting in the following combinations of normal and angular acceleration: Condition / Normal acceleration (n) / Angular acceleration (radian/sec²) Nose-up pitching / 1.0 / $+\frac{72.2}{V_{/km/h}} n_m (n_m - 1.5) \left(+\frac{39}{V_{/kt}} n_m (n_m - 1.5)\right)$ Nose-down pitching / n_m / $-\frac{72.2}{V_{/km/h}} n_m (n_m - 1.5) \left(-\frac{39}{V_{/kt}} n_m (n_m - 1.5)\right)$ where n_m = positive limit manoeuvring load factor used in the design of the UAV; and $V_{/km/h}$ = initial speed in km/h. The conditions in this paragraph involve loads corresponding to the loads that may occur in a "checked manoeuvre" (a manoeuvre in which the pitching control is suddenly displaced in one direction and then suddenly moved in the opposite direction). The deflections and timing of the "checked manoeuvre" must avoid exceeding the limit manoeuvring load factor. The total horizontal surface load for both nose-up and nose-down pitching conditions should be based on the actual control surface movement in response to the pitch demand and is the sum of the balancing loads at V and the specified value of the normal load factor n, plus the manoeuvring load increment due to the specified value of the angular acceleration. (c) A movement of the pitching control to cause a transition from steady level flight at a speed within the flight envelope protection maintained by the flight control system or on the boundary of the flight envelope as specified in USAR333 to the appropriate extreme steady normal acceleration condition.
425	USAR.425 Gust Loads (a) Each horizontal surface other than a main wing, must be designed for loads resulting from (1) Gust velocities specified in USAR.333 (c) with flaps retracted; and (2) Positive and negative gusts of 7.6 m/s (25 fps) nominal intensity at V_F corresponding to the flight conditions specified in USAR.345(a)(2). (b) Reserved. (c) When determining the total load on the horizontal surfaces for the conditions specified in sub-paragraph (a) of this paragraph, the initial balancing loads for steady unaccelerated flight at the pertinent design speeds, V_F, V_C and V_D must first be determined. The incremental load resulting from the gusts must be added to the initial balancing load to obtain the total load.

	(d) In the absence of a more rational analysis, the incremental load due to the gust must be computed as follows only on UAV configurations with aft-mounted, horizontal surfaces, unless its use elsewhere is shown to be conservative: $$\Delta L_{ht} = \frac{\rho o K_g U_{de} V a_{ht} S_{ht}}{2}\left(1 - \frac{d\varepsilon}{d\alpha}\right)$$ where ΔL_{ht} = Incremental horizontal tail load (N); ρo = Density of air at sea – level (kg/m^3); K_g = Gust alleviation factor defined in USAR.341; U_{de} = Derived gust velocity (m/s); V = Aeroplane equivalent speed (m/s); a_{ht} = Slope of aft horizontal tail lift curve (per radian); S_{ht} = Area of aft horizontal tail (m^2) $\left(1 - \frac{d\varepsilon}{d\alpha}\right)$ = Downwash factor
427	USAR.427 Unsymmetrical Loads (a) Horizontal surfaces other than main wing and their supporting structure must be designed for unsymmetrical loads arising from yawing and slipstream effects, in combination with the loads prescribed for the flight conditions set forth in USAR.421 to USAR.425. (b) In the absence of more rational data for UAV that are conventional in regard to location of engines, wings, horizontal surfaces other than main wing, and fuselage shape (1) 100% of the maximum loading from the symmetrical flight conditions may be assumed on the surface on one side of the plane of symmetry; and (2) The following percentage of that loading must be applied to the opposite side: % = 100-10 (n-1), where n is the specified positive manoeuvring load factor, but this value may not be more than 80%. (c) For UAV that are not conventional (such as UAV with horizontal surfaces other than main wing having appreciable dihedral or supported by the vertical tail surfaces) the surfaces and supporting structures must be designed for combined vertical and horizontal surface loads resulting from each prescribed flight condition taken separately.
VERTICAL SURFACES	
441	USAR.441 Manoeuvring loads See AMC.441 (a) At speeds up to V_A the vertical surfaces must be designed to withstand the following conditions. In computing the loads, the yawing velocity may be assumed to be zero: (1) With the UAV in unaccelerated flight at zero yaw, it is assumed that the rudder control is suddenly displaced to the maximum deflection, as limited by the control stops or by the maximum effort provided by the servocontrols or actuators (2) With the rudder deflected as specified in sub-paragraph (1) , it is assumed that the UAV yaws to the overswing sideslip angle. In lieu of a rational analysis, an overswing angle equal to 1.5 times the static sideslip angle of sub-paragraph (3) may be assumed.

	(3) A yaw angle of 15° with the rudder control maintained in the neutral position (except as limited by the maximum effort sustained by the servocontrols or actuators). (b) The loads imposed by the following additional manoeuvre must be substantiated at speeds from V_A to V_D/M_D. When computing the tail loads: (1) The UAV must be yawed to the largest attainable steady state sideslip angle with the rudder at maximum deflection caused by any one of the following: (i) Control surface stops; (ii) Maximum available effort sustained by the servocontrols or actuators; (iii) not applicable (2) The rudder must be suddenly displaced from the maximum deflection to the neutral position. (c) The yaw angles specified in sub-paragraph (a) (3) may be reduced if the yaw angle chosen for a particular speed cannot be exceeded in (1) Steady slip conditions; (2) Uncoordinated rolls from steep banks; or (3) Sudden failure of the critical engine with delayed corrective action.
443	USAR.443 Gust Loads See AMC.443 (a) Vertical surfaces must be designed to withstand, in unaccelerated flight at speed V_C, lateral gusts of the values prescribed for V_C in USAR.333 (c). (b) Not applicable. (c) In the absence of a more rational analysis, the gust load must be computed as follows: $$\Delta L_{vt} = \frac{\rho o K_{gt} U_{de} V_{avi} S_{vt}}{2}$$

	where –
	ΔL_{vt} = Vertical surface loads (N);
	$K_{gt} = \frac{0.88\mu gt}{5.3+\mu gt}$ = gust alleviation factor;
	$\mu gt = \frac{2W}{\rho \overline{C}_t g a_{vt} S_{vt}} \left(\frac{K}{l_{vt}}\right)^2$ = lateral mass ratio;
	ρo = Density of air at sea – level (kg/m ^{3});
	U_{de} = Derived gust velocity (m/s);
	ρ = Air density (Kg/m ^{3});
	W = the applicable weight of the aeroplane in the particular load case (N);
	S_{vt} = Area of vertical surface (m ^{2});
	$\overline{C}_t$ = Mean geometric chord of vertical surface (m);
	a_{vt} = Lift curve slope of vertical surface (per radian);
	K = Radius of gyration in yaw (m);
	l_{vt} = Distance from aeroplane c.g. to lift centre of vertical surface (m);
	g = Acceleration due to gravity (m/sec ^{2}); and
	V = Aeroplane equivalent speed (m/s);
445	USAR.445 Outboard fins or winglets (a) If outboard fins or winglets are included on the horizontal surfaces or wings, the horizontal surfaces or wings must be designed for their maximum load in combination with loads induced by the fins or winglets and moment or forces exerted on horizontal surfaces or wings by the fins or winglets. (b) If outboard fins or winglets extend above and below the horizontal surface, the critical vertical surface loading (the load per unit area as determined under USAR.441 and USAR.443) must be applied to (1) The part of the vertical surfaces above the horizontal surface with 80% of that loading applied to the part below the horizontal surface; and (2) The part of the vertical surfaces below the horizontal surface with 80% of that loading applied to the part above the horizontal surface; (c) The endplate effects of outboard fins or winglets must be taken into account in applying the yawing conditions of USAR.441 and USAR.443 to the vertical surfaces in sub-paragraph (b) . (d) When rational methods are used for computing loads, the manoeuvring loads of USAR.441 on the vertical surfaces and the one-g horizontal surface load, including induced loads on the horizontal surface and moments or forces exerted on the horizontal surfaces by the vertical surfaces, must be applied simultaneously for the structural loading condition.
	AILERONS AND SPECIAL DEVICES
455	USAR.455 Ailerons The ailerons must be designed for the loads to which they are subjected, allowance may be made for the capability of the flight control system (such as rate of movement or limitations on deflection). (1) In the neutral position during symmetrical flight conditions; and

	(2) By the following deflections, except as limited by the maximum force provided by the servocontrols or actuators , during unsymmetrical flight conditions: (i) Sudden maximum displacement of the aileron control at V_A. Suitable allowance may be made for control system deflections. (ii) Sufficient deflection at V_C, where V_C is more than V_A, to produce a rate of roll not less than obtained in sub-paragraph (2)(i). (iii) Sufficient deflection at V_D to produce a rate of roll not less than onethird of that obtained in sub-paragraph (2)(i).
459	USAR.459 Special devices Special devices using aerodynamic surfaces (such as slats and spoilers) or structure whose failure conditions would cause Hazardous or more serious failure condition effect, must be designed for the loads to which they are subjected. These loads must be determined from test data or using proven or acceptable design procedures.
GROUND LOADS	
471	USAR.471 General See AMC.471 (a) The limit ground loads specified in this subpart are considered to be external loads and inertia forces that act upon a UAV structure. In each specified ground load condition, the external reactions must be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner. (b) The requirements described in USAR.473 to USAR.499 are not applicable to UAV designed to be recovered by parachute.
473	USAR.473 Ground load conditions and assumptions (a) The ground load requirements of this subpart must be complied with at the design maximum weight except that USAR.479, USAR.481 and USAR.483 may be complied with at a design landing weight (the highest weight for landing conditions at the maximum descent velocity) allowed under sub-paragraphs (b) and (c) . (b) The design landing weight may be as low as (1) 95% of the maximum weight if the minimum fuel capacity is enough for at least one-half hour of operation at maximum continuous power or thrust plus a capacity equal to a fuel weight which is the difference between the design maximum weight and the design landing weight; or (2) The design maximum weight less the weight of 25% of the total fuel capacity. (c) The design landing weight of a multi-engine UAV may be less than that allowed under sub-paragraph (b) if (1) The UAV meets the one engine- inoperative climb requirements of USAR.67; and (2) Compliance is shown with the fuel jettisoning system requirements of USAR.1001. (d) The selected limit vertical inertia load factor at the centre of gravity of the UAV for the ground load conditions prescribed in this subpart may not be less than that which would be obtained when landing with a descent velocity (V), in meters per second (feet per second), equal to 4.4 $(W/S)^{1/4}$ (with W in kg and S in m²), except that this velocity need not be more than 3.0 m (10 ft) per second and may not be less than 2.1 m (7 ft) per second. These prescribed descent velocities may be modified if it is shown that the UAV has design features that make it impossible to develop these velocities or it can be shown that alternate safe values may be chosen based upon previous experience.

	(e) Wing lift not exceeding two-thirds of the weight of the UAV may be assumed to exist throughout the landing impact and to act through the centre of gravity. The ground reaction load factor may be equal to the inertia load factor minus the ratio of the above assumed wing lift to the UAV weight. (f) If energy absorption tests are made to determine the limit load factor corresponding to the required limit descent velocities, these tests must be made under USAR.723 (a). (g) No inertia load factor used for design purposes may be less than 2.67, nor may the limit ground reaction load factor be less than 2.0 at design maximum weight, unless these lower values will not be exceeded in taxiing at speeds up to take-off speed over terrain as rough as that expected in service, as specified in USAR.235.
477	USAR.477 Landing gear arrangement USAR.479 to USAR.483, or the conditions in Appendix C, apply to UAV with conventional wheeled / skids arrangements of main and nose gear, or main and tail gear.
479	USAR.479 Level landing conditions (a) For a level landing, the UAV is assumed to be in the following attitudes: (1) For UAV with tail wheels / skids, a normal level flight attitude; (2) For UAV with nose wheels, attitudes in which (i) The nose and main wheels contact the ground simultaneously; and (ii) The main wheels contact the ground and the nose wheel is just clear of the ground. The attitude used in subdivision (i) of this sub-paragraph may be used in the analysis required under subdivision (ii) of this sub-paragraph. (b) When investigating landing conditions, the drag components simulating the forces required to accelerate the tyres and wheels up to the landing speed (spin-up) must be properly combined with the corresponding instantaneous vertical ground reactions, and the forward-acting horizontal loads resulting from rapid reduction of the spin-up drag loads (spring-back) must be combined with vertical ground reactions at the instant of the peak forward load, assuming wing lift and a tyre sliding coefficient of friction of 0.8. However, the drag loads may not be less than 25% of the maximum vertical ground reaction (neglecting wing lift). (c) In the absence of specific tests or a more rational analysis for determining the wheel spinup and spring-back loads for landing conditions, the method set forth in Appendix D must be used. If Appendix D is used, the drag components used for design must not be less than those given by Appendix C. (d) For UAV with tip tanks or large overhung masses (such as turbo-propeller or jet engines) supported by the wing, the tip tanks and the structure supporting the tanks or overhung masses must be designed for the effects of dynamic responses under the level landing conditions of either sub-paragraph (a) (1) or (a) (2) (ii). In evaluating the effects of dynamic response, a UAV lift equal to the weight of the UAV may be assumed. The most unfavourable configuration has to be retained for the application of this paragraph.
481	USAR.481 Tail down landing conditions See AMC.481 (a) For a tail down landing, the UAV is assumed to be in the following attitudes: (1) For UAV with tail wheels, an attitude in which the main and tail wheels contact the ground simultaneously. (2) For UAV with nose wheels, a stalling attitude, or the maximum angle allowing ground clearance by each part of the UAV, whichever is less.

	(b) For UAV with either tail or nose wheels / skids, ground reactions are assumed to be vertical, with the wheels up to speed before the maximum vertical load is attained. (c) For design of tail skid and affected structure and empennage including balancing weight attachment, the tail skid load in a tail down landing (main landing gear free from ground) must be calculated as follows: $P = 4mg \frac{i_y^2}{i_y^2 + L^2}$ where: P = tail skid load (N) m = mass of the UAV (kg) g = acceleration of gravity (m/s2) iy = radius of gyration of the UAV (m) L = distance between tail skid and UAVc.g. (m)
483	USAR.483 One-wheel landing conditions For the one-wheel landing condition, the UAV is assumed to be in the level attitude and to contact the ground on one side of the main landing gear. In this attitude, the ground reactions must be the same as those obtained on that side under USAR.479.
485	USAR.485 Sideload conditions (a) For the sideload condition, the UAV is assumed to be in a level attitude with only the main wheels contacting the ground and with the shock absorbers and tyres in their static positions. (b) The limit vertical load factor must be 1.33, with the vertical ground reaction divided equally between the main wheels. This value can be reduced to 1.2 if UAV operations are restricted to paved taxiways and runways only (subject to statement in the UAV System Flight Manual). (c) The limit side inertia factor must be 0.83, with the side ground reaction divided between the main wheels so that (1) 0.5 (W) is acting inboard on one side; and (2) 0.33 (W) is acting outboard on the other side. (d) The side loads prescribed in sub-paragraph (c) are assumed to be applied at the ground contact point and the drag loads may be assumed to be zero.
493	USAR.493 Braked roll conditions Under braked roll conditions, with the shock absorbers and tyres in their static positions, the following applies: (a) The limit vertical load factor must be 1.33. (b) The attitudes and ground contacts must be those described USAR.479 for level landings. (c) A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction of 0.8 must be applied at the ground contact point of each wheel with brakes, except that the drag reaction need not exceed the maximum value based on limiting brake torque.
497	USAR.497 Supplementary conditions for tail wheels In determining the ground loads on the tail wheel and affected supporting structures, the following applies: (a) For the obstruction load, the limit ground reaction obtained in the tail down landing condition is assumed to act up and aft through the axle at 45°. The shock absorber and tyre may be assumed to be in their static positions.

	(b) For the sideload, a limit vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude, is assumed. In addition (1) If a swivel is used, the tail wheel is assumed to be swivelled 90° to the UAV longitudinal axis with the resultant ground load passing through the axle; (2) If a lock, steering device, or shimmy damper is used, the tail wheel is also assumed to be in the trailing position with the sideload acting at the ground contact point; and (3) The shock absorber and tyre are assumed to be in their static positions. (c) If a tail wheel, bumper, or an energy absorption device is provided to show compliance with USAR.925 (b), the following applies: (1) Suitable design loads must be established for the tail wheel, bumper, or energy absorption device; and (2) The supporting structure of the tail wheel, bumper, or energy absorption device must be designed to withstand the loads established in sub-paragraph (c) (1) . (d) In determining the ground loads on the tail skid and affected supporting structures, the following applies: (1) Except as provided in (d)(2), if the c.g. of the unloaded UAV – in side view – is situated behind the ground contact area of the main landing gear, the rear portion of the fuselage, the tail skid and the empennage must be designed to withstand the loads arising when the tail landing skid is raised to its highest possible position, consistent with the main wheel remaining on the ground, and is then released and allowed to fall freely. (2) If the c.g. in all loading conditions is situated behind the ground contact area of the main landing gear (d)(1) need not be applied.
499	USAR.499 Supplementary conditions for nose wheels In determining the ground loads on nose wheels and affected supporting structures and assuming that the shock absorbers and tyres are in their static positions, the following conditions must be met: (a) For aft loads, the limit force components at the axle must be (1) A vertical component of 2.25 times the static load on the wheel; and (2) A drag component of 0.8 times the vertical load. (b) For forward loads, the limit force components at the axle must be (1) A vertical component of 2.25 times the static load on the wheel; and (2) A forward component of 0.4 times the vertical load. (c) For sideloads, the limit force components at ground contact must be (1) A vertical component of 2.25 times the static load on the wheel; and (2) A side component of 0.7 times the vertical load. (d) For UAV with a steerable nose wheel which is controlled by hydraulic or other power, at design take-off weight with the nose wheel in any steerable position the application of 1.33 times the full steering torque combined with a vertical reaction equal to 1.33 times the maximum static reaction on the nose gear must be assumed. However, if a torque limiting device is installed, the steering torque can be reduced to the maximum value allowed by that device.

	(e) Not applicable
	505 Supplementary conditions for ski-planes Not applicable.
507	USAR.507 Jacking and lifting loads (a) The UAV must be designed for the loads developed when it is supported on jacks lifting equipment or by appropriate number of authorized ground staff at the design maximum weight assuming the following load factors for landing gear jacking points or lifting points at a three-point attitude and for primary flight structure jacking or lifting points in the level attitude. (1) Vertical load factor of 1.35 times the static reactions. (2) Fore, aft and lateral load factors of 0.4 times the vertical static reactions. (b) The horizontal loads at the jack or lift points must be reacted by inertia forces so as to result in no change in the direction of the resultant loads at the jack or lift points. (c) The horizontal loads must be considered in all combinations with the vertical load.
509	USAR.509 Towing loads For UAV designed to be towed, the towing loads must be applied to the design of tow fittings and their immediate attaching structure. (a) The towing loads specified in sub-paragraph (d) must be considered separately. These loads must be applied at the towing fittings and must act parallel to the ground. In addition (1) A vertical load factor equal to 1.0 must be considered acting at the centre of gravity; and (2) The shock struts and tyres must be in their static positions. (b) For towing points not on the landing gear but near the plane of symmetry of the UAV, the drag and side tow load components specified for the auxiliary gear apply. For towing points located outboard of the main gear, the drag and side tow load components specified for the main gear apply. Where the specified angle of swivel cannot be reached, the maximum obtainable angle must be used. (c) The towing loads specified in sub-paragraph (d) must be reacted as follows: (1) The side component of the towing load at the main gear must be reacted by a side force at the static ground line of the wheel to which the load is applied. (2) The towing loads at the auxiliary gear and the drag components of the towing loads at the main gear must be reacted as follows: (i) A reaction with a maximum value equal to the vertical reaction must be applied at the axle of the wheel to which the load is applied. Enough UAV inertia to achieve equilibrium must be applied. (ii) The loads must be reacted by UAV inertia.

(d) The prescribed towing loads are as follows, where W is the design maximum weight:

Tow point	Position	Load		
		Magnitude	No.	Direction
Main Gear		0.225 W per main gear unit	1	Forward, parallel to drag axis
			2	Forward, at 30° to drag axis
			3	Aft, parallel to drag axis
			4	Aft, at 30° to drag axis
Auxilliary Gear	Swivelled forward	0.30W	5	Forward
			6	Aft
	Swivelled aft	0.30W	7	Forward
			8	Aft
	Swivelled 45° from forward	0.15W	9	Forward, in plane of wheel
			10	Aft, in plane of wheel
	Swivelled 45° from aft	0.15W	11	Forward, in plane of wheel
			12	Aft, in plane of wheel

511 USAR.511 Ground load; unsymmetrical loads on multiple-wheel units

(a) Pivoting loads. The UAV is assumed to pivot about one side of the main gear with

(1) The brakes on the pivoting unit locked; and

(2) Loads corresponding to a limit vertical load factor of 1 and coefficient of friction of 0.8, applied to the main gear and its supporting structure.

(b) Unequal tyre loads. The loads established under USAR.471 to USAR.483 must be applied in turn, in a 60/40% distribution, to the dual wheels and tyres in each dual wheel landing gear unit.

(c) Deflated tyre loads. For the deflated tyre condition

(1) 60% of the loads established under USAR.471 to USAR.483 must be applied in turn to each wheel in a landing gear unit; and

(2) 60% of the limit drag and sideloads and 100% of the limit vertical load established under USAR.485 and USAR.493 or lesser vertical load obtained under sub-paragraph (1), must be applied in turn to each wheel in the dual wheel landing gear unit.

521 Water load conditions

Not applicable.

523 Design weights and centre of gravity positions

Not applicable.

525 Application of loads

Not applicable.

527 Hull and main float load factors

Not applicable.

	529 Hull and main float landing conditions Not applicable.
	531 Hull and main float landing conditions Not applicable.
	533 Hull and main float bottom pressures Not applicable.
	535 Auxiliary float loads Not applicable.
	537 Seawing loads Not applicable.
	561 Emergency landing conditions – General Not applicable.
	562 Emergency landing dynamic conditions Not applicable.
	FATIGUE EVALUATION
U570	USAR.U570 General See AMC.570, AMC.603 (a) and AMC.603 (b) (a) Fatigue and damage tolerance demonstration shall depend on the predicted life time, usage spectrum and maintenance philosophy of the UAV System for which certification is requested. (b) For UAV Systems for which certification is requested for very short life time (less than 5 cycles) (1) static strength demonstration using ultimate loads, see USAR.305(b), is required, and, (2) USAR.572 to USAR.575 may not be applicable however this must be agreed with the Certifying Authority. (c) For other UAV Systems, fatigue and damage tolerance analysis must be carried out. The demonstration level and exhaustivity shall be adapted to predicted life time using USAR.572 to USAR.575. Consideration shall be given to fatigue monitoring, in agreement with the Certifying Authority. (d) The requirements of USAR.570 are applicable for both metallic or composite structures.
572	USAR.572 Metallic fuselage, wing, empennage and associated structures See AMC.572 (a) The strength, detail design, and fabrication of those parts of the airframe structure whose failure would be Catastrophic must be evaluated using a rational analysis of the intended use, construction method and maintenance philosophy of the air vehicle under one or more of the following unless it is shown that the structure, operating stress level, materials and expected uses are comparable, from a fatigue standpoint, to a similar design that has had extensive satisfactory service experience. Fail safe strength investigation is not sufficient by itself as a criterion to assure structural integrity under repeated loads unless approved by the Certifying Authority. (1) A safe life approach supported by a fatigue strength investigation in which the structure is shown by tests, or by analysis supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected in service; or

	(2) A fail-safe strength investigation in which it is shown by analysis, tests, or both, that Catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structure is able to withstand a static ultimate load factor of 75 percent of the critical limit load factor at Vc. These loads must be multiplied by a factor of 1.15 unless the dynamic effects of failure under static load are otherwise considered. (3) The damage tolerance evaluation of USAR.573(b). (b) Each evaluation required by this paragraph must: (1) Include typical loading spectra (e.g. taxi if the UAV is designed to, ground-air-ground cycles, manoeuvre, gust); (2) Account for any significant effects due to the mutual influence of aerodynamic surfaces; and (3) Consider any significant effects from propeller slipstream loading, and buffet from vortex impingements.
573	USAR.573 Damage tolerance and fatigue evaluation of structure See AMC.573 (a) (1) & (3), AMC.573 (a) (4) and AMC.573 (b) (a) Composite airframe structure. Composite airframe structure must be evaluated under this paragraph instead of USAR.572. The composite airframe structure, the failure of which would result in Catastrophic loss of the UAV, in each wing (including canards, tandem wings, and winglets), empennage, their carrythrough and attaching structure, moveable control surfaces and their attaching structure, fuselage, and pressurised compartments must be evaluated using the damage-tolerance criteria prescribed in sub-paragraphs (a)(1) through (a)(4) unless shown to be impractical. If the Applicant establishes that damage-tolerance criteria is impractical for a particular structure, the structure must be evaluated in accordance with sub-paragraphs (a)(1) and (a)(6) for safe-life designed UAV. Where bonded joints are used, the structure must also be evaluated in accordance with sub-paragraph (a)(5) . The effects of material variability and environmental conditions on the strength and durability properties of the composite materials must be accounted for in the evaluations required by this paragraph. (1) It must be demonstrated by tests, or by analysis supported by tests, that the structure is capable of carrying ultimate load with damage up to the threshold of detectability considering the inspection procedures employed. (2) The growth rate or no-growth of damage that may occur from fatigue, corrosion, manufacturing flaws or impact damage, under repeated loads expected in service, must be established by tests or analysis supported by tests. (3) The structure must be shown by residual strength tests, or analysis supported by residual strength tests, to be able to withstand critical limit flight loads, considered as ultimate loads, with the extent of detectable damage consistent with the results of the damage tolerance evaluations. For pressurised compartment, the following loads must be withstood: (i) Critical limit flight loads with the combined effects of normal operating pressure and expected external aerodynamic pressures. (ii) The expected external aerodynamic pressures in 1g flight combined with a compartment differential pressure equal to 1.1 times the normal operating differential pressure without any other load. (4) The damage growth, between initial detectability and the value selected for residual strength demonstrations, factored to obtain inspection intervals, must allow development of an inspection program suitable for application by operation and maintenance personnel. (5) For any bonded joint, the failure of which would result in catastrophic loss of the UAV, the limit load capacity must be substantiated by one of the following methods:

	(i) The maximum disbonds of each bonded joint consistent with the capability to withstand the loads in sub-paragraph (a)(3) must be determined by analysis, test, or both. Disbonds of each bonded joint greater than this must be prevented by design features; or (ii) Proof testing must be conducted on each production article that will apply the critical limit design load to each critical bonded joint; or (iii) Repeatable and reliable non-destructive inspection techniques must be established that ensure the strength of each joint. (6) Structural components for which the damage tolerance method is shown to be impractical must be shown by component fatigue tests, or analysis supported by tests, to be able to withstand the repeated loads of variable magnitude expected in service. Sufficient component, subcomponent, element, or coupon tests must be done to establish the fatigue scatter factor and the environmental effects. Damage up to the threshold of detectability and ultimate load residual strength capability must be considered in the demonstration. (b) Metallic airframe structure. If the Applicant elects to use USAR.572(a)(3), then the damage tolerance evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. The determination must be by analysis supported by test evidence and, if available, service experience. Damage at multiple sites due to fatigue must be included where the design is such that this type of damage can be expected to occur. The evaluation must incorporate repeated load and static analyses supported by test evidence. The extent of damage for residual strength evaluation at any time within the operational life of the UAV must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand critical limit flight loads, considered as ultimate, with the extent of detectable damage consistent with the results of the damage tolerance evaluations. Fatigue test article tear-down and storage requirements must be approved by the Certifying Authority. For pressurised compartment, the following load must be withstood: (1) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in this subpart, and (2) The expected external aerodynamic pressures in 1g flight combined with a compartment differential pressure equal to 1.1 times the normal operating differential pressure without any other load.
575	USAR.575 Inspections and other procedures Each inspection or other procedure, based on an evaluation required by USAR.572 and USAR.573, must be established to prevent catastrophic failure and must be included in the limitations section of the instructions for continued airworthiness required by USAR.1529. Cracks meeting the inspection-based requirements in terms of crack growth and residual strength shall not result in the rupture of critical parts of the structure. See also USAR.603.
	CATAPULT ASSISTED AND ROCKET ASSISTED TAKE-OFF UAV
U585	USAR.U585 Launch load factor The maximum forces applied by the launch system to the relevant components of the UAV System must be consistent with the structural acceleration limitation of the UAV ; therefore : (a) The relevant components of the UAV System must be designed to sustain a longitudinal load compliant with the maximum continuous load factor applied by the launch system combined with the factor prescribed in USAR.303. This requirement must be complied with at the maximum and minimum take-off weight. (b) The design of the launcher must ensure that the acceleration and the rate of change of acceleration (jerk) are controlled such that the UAV System does not sustain damage during launch.

	(c) The fatigue effects of repeated launches shall be considered for the launch system and, in accordance with USAR.570, for the air vehicle including payloads.
U586	USAR.U586 Use of trolley or shuttle (a) Any structure such as trolley or shuttle which is used to transfer the accelerating forces to the air vehicle or to stabilise the air vehicle during launch, must be capable of withstanding the acceleration and subsequent decelerations without causing any damage to the air vehicle. (b) The interface of the trolley or shuttle and the UAV must be such as to ensure controlled, reliable and safe separation at lift off. (c) The moving trolley or shuttle must exhibit adequate control and stability, both during acceleration and subsequent retardation following separation.
U587	USAR.U587 Rocket assisted take-off The use of rocket must not cause damage to the airframe of the UAV arising from heat, blast or aerodynamic interference from the rocket efflux. The UAV integrity must be maintained following the release of rocket(s) in flight.
PARACHUTE LANDING SYSTEM	
U595	USAR.U595 Limit load factor See AMC.595 (a) (a) The structural design of the UAV and the integrity of onboard equipment must be consistent with the maximum deceleration due to (1) the deployment of the parachute (2) the impact of the UAV on the ground taking into account any shock absorber system, for the worst case conditions, agreed to with the Certifying Authority. (b) The maximum deceleration forces must take into account all the conditions under which the deployment of the parachute is possible within the flight envelope protection as prescribed in USAR.334, especially if the parachute is to be used under emergency conditions.
U596	USAR.U596 UAV dragging on the ground The parachute system must include means for preventing the dragging of the UAV by the wind after impact with the landing surface.
U597	USAR.U597 Sacrificial elements Where sacrificial elements of the structure are used to deploy the parachute or to activate the shock absorber system, (a) the number of such elements must be minimised (b) the structural integrity of the UAV airframe must not be reduced after the release or operation of these sacrificial elements.
U598	USAR.U598 Extracting devices The use of extracting device (mechanical, pyrotechnics, …) must not cause any damage to the UAV air frame or to the landing system assets.
U599	USAR.U599 Installation of the parachute in the airframe Consideration shall be given to the following aspects of the parachute installation: (a) The packing of the parachute, installation in the airframe and attachments to the airframe should take

	account of all potential operational conditions and in particular, launch accelerations, which may affect its safety. (b) All components of the parachute landing system should be made for ventilation and drainage of the parachute canister and associated structure to ensure the sound condition of the system. (c) Adequate means should be provided to permit the close examination of the parachute and other system components to ensure proper functioning, alignment, lubrication, and adjustment during the required inspection of the system. (d) Each fitting point of the parachute straps and the surrounding structures should be designed for the maximum expected opening loads with a safety factor not less than 1.5. (e) The installation of the parachute in the airframe should be designed in order to mitigate the effects of possible oscillation of the UAV once the parachute is deployed in the air and at the impact on the ground.

subpart D – UAV DESIGN AND CONSTRUCTION

	GENERAL
601	USAR.601 General See AMC.601 The suitability of each questionable design detail and part having an important bearing on safety in operations, must be established by tests.
603	USAR.603 Materials and workmanship For metallic materials, see AMC.603 (a); for composite materials, see AMC.603 (b) (a) The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must (1) Be established by experience or tests; (2) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and (3) Take into account the effects of environmental conditions, such as temperature, humidity, UV, chemical, solvent, fuel, electromagnetic radiation, and airborne particulates expected in service. (b) Workmanship must be of a high standard. (c) All hazardous materials shall be identified and their safe use will be accounted for.
605	USAR.605 Fabrication methods (a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as glueing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed under an approved process specification. (b) Each new UAV System fabrication method must be substantiated by a test programme.
607	USAR.607 Fasteners See AMC.607 (b) (a) Each removable fastener must incorporate two retaining devices if the loss of such fastener would preclude continued safe flight and landing. (b) Fasteners and their locking devices must not be adversely affected by the environmental conditions associated with the particular installation. (c) No self-locking nut may be used on any bolt subject to rotation in operation unless a nonfriction locking device is used in addition to the self-locking device.
609	USAR.609 Protection of structure See AMC.609 Each part of the structure must (a) Be suitably protected against deterioration or loss of strength in service due to any cause, including (1) Weathering;

	(2) Corrosion; and (3) Abrasion; and (b) Unless it is detrimental to the function, there must be adequate provisions for ventilation and drainage.
611	USAR.611 Accessibility provisions See AMC.611 For each part that requires maintenance, inspection, or other servicing, appropriate means must be incorporated into the UAV design to allow such servicing to be accomplished. The inspection means for each item must be appropriate to the inspection interval for the item.
613	USAR.613 Material strength properties and design values See AMC.613 (a) Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis. (b) The design values must be chosen to minimise the probability of structural failure due to material variability. Except as provided in sub-paragraph (e), compliance with this paragraph must be shown by selecting design values that assure material strength with the following probability: (1) Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component; 99% probability with 95% confidence. (2) For redundant structure, in which the failure of individual elements would result in applied loads being safely distributed to other load carrying members; 90% probability with 95% confidence. (c) The effects of temperature on allowable stresses used for design in an essential component or structure must be considered where thermal effects are significant under normal operating conditions. Also, thermal degradation from an in-flight fire condition shall be considered (see USAR.865). (d) The design of structure must minimise the probability of catastrophic fatigue failure particularly at points of stress concentration. (e) Design values greater than the guaranteed minimum's required by this paragraph may be used where only guaranteed minimum values are normally allowed if a "premium selection" of the material is made in which a specimen of each individual item is tested before use to determine that the actual strength properties of the particular item will equal or exceed those used in design. (f) Materials repairs should have conditions and properties to satisfy design requirements. (g) Appropriate Non-Destructive Techniques and Inspection (NDT/I) processes and technology shall be implemented throughout the UAV life cycle (from design through operational support) to assure that the UAV is produced with integrity, properly evaluated, tested and maintained to meet design quality levels and performance requirements. Initial and recurring inspection intervals shall be established in accordance with USAR Appendix G (Instructions for Continued Airworthiness) to identify and characterize specific defect types, sizes, and locations critical to material integrity. Alloys prone to insidious failure modes (e.g.., hydrogen embrittlement) shall not be used in the design unless specifically approved by the Certifying Authority.
619	USAR.619 Special factors The factor of safety prescribed in USAR.303 must be multiplied by the highest pertinent special factors of safety prescribed in USAR.621 to USAR.625 for each part of the structure whose strength is

	(1) Uncertain; (2) Likely to deteriorate in service before normal replacement; or (3) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.
621	USAR.621 Casting factors The approved national standards regarding the casting factors shall be considered and agreed with the Certifying Authority.
623	USAR.623 Bearing factors (a) Each part that has clearance (free fit) and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion. (b) For control surface hinges and control system joints, compliance with the factors prescribed in USAR.657 and USAR.693 respectively, meets paragraph (a) .
625	USAR.625 Fitting factors No fitting factor need to be used for those primary attachments where a safety factor of 1.5 is applied (see USAR.303). For each fitting (a part or terminal used to join one structural member to another), the following applies: (a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1.15 must be applied to each part of (1) The fitting; (2) The means of attachment; and (3) The bearing on the joined members. (b) No fitting factor need be used for joint designs based on comprehensive test data (such as continuous joints in metal plating, welded joints and scarf joints in wood). (c) For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member. (d) Not applicable.
627	USAR.627 Fatigue strength The structure must be designed, as far as practicable, to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service.
629	USAR.629 Flutter See AMC.629 and AMC.629 (j) (a) It must be shown by the methods of (b) and (c), that the UAV is free from flutter, control reversal and divergence for any condition of operation within the limit V-n envelope defined in USAR.333. In addition (1) Adequate tolerances must be established for quantities which affect flutter; including speed, damping, mass balance and control system stiffness; and (2) The natural frequencies of main structural components must be determined by vibration tests or other approved methods.

	(b) Flight flutter tests are only required if rational flutter analysis based on the results of ground vibration tests show any predicted flutter is less than a 20% speed margin over V_D/M_D or any critical flutter mechanism has a total damping (aerodynamic and structural) of less than 2% at V_D/M_D. In case such flight tests are required, they must be made to show that the UAV is free from flutter, control reversal and divergence and to show by these tests that : (1) Proper and adequate attempts to induce flutter have been made within the speed range of the flight envelope protection maintained by the flight control system. (2) The vibratory response of the structure during the test indicates freedom from flutter; (3) A proper margin of damping exists at the maximum speed allowed by the flight envelope protection; and (4) There is no large and rapid reduction in damping as the maximum speed allowed by the flight envelope protection is approached. (c) Any rational analysis used to predict freedom from flutter, control reversal and divergence for normal conditions without failures, malfunctions or adverse conditions shall cover all combinations of altitudes and speed encompassed by the V_D/M_D versus altitude envelope enlarged at all points by an increase of 15 percent in equivalent airspeed at constant Mach number and constant altitude. In addition a proper margin of stability must exist at all speeds up to V_D/M_D and there must be no large and rapid reduction in stability as V_D/M_D is approached. (d) Not applicable (e) For UAV where the propeller is mounted on the lifting surfaces, the dynamic evaluation must include (1) Whirl mode degree of freedom which takes into account the stability of the plane of rotation of the propeller and significant elastic, inertial and aerodynamic forces; and (2) Propeller, engine, engine mount and UAV structure stiffness and damping variations appropriate to the particular configuration. (f) Freedom from flutter, control reversal and divergence must be shown at speed up to V_D after failure, malfunction, or disconnection of any single element in the primary flight control system, any tab control surface, or any flutter damper if the failure is shown not to be extremely remote. (g) For UAV showing compliance with the fail-safe criteria of USAR.572, the UAV must be shown by analysis to be free from flutter up to V_D/M_D after fatigue failure, or obvious partial failure of a principal structural element. (h) For UAV showing compliance with the damage-tolerance criteria of USAR.573, the UAV must be shown by analysis to be free from flutter up to V_D/M_D with the extent of damage for which residual strength is demonstrated. (i) For modifications to the type design which could affect the flutter characteristics compliance with sub-paragraph (a) must be shown, except that analysis alone, which is based on previously approved data, may be used to show freedom from flutter, control reversal and divergence. (j) Control surface backlash should be keps to a minimum.
U631	USAR.U631 Bird strike SeeAMC.631 (a) The UAV must be designed to assure that impact with a 2 lb bird shall not result in an uncontrolled flight and/or uncontrolled crash, when the velocity of the UAV at impact (relative to the bird along the UAV's flight path) is equal to Vc at sea level, selected under USAR.335. Compliance may be shown by analysis

	only when based on tests carried out on sufficiently representative structures of similar design. (b) The degree of protection of the UAV against bird strike shall be determined by rationale analysis of the intended size and use of the UAV and shall be agreed by the Certifying Authority.
U635	USAR.U635 Ground equipment affecting flight safety If a UAV system contains ground equipment affecting flight safety not defined in this code, such equipment shall be designed using the applicable standards and shown not to adversely affect any requirement of this code.
WINGS	
641	USAR.641 Proof of strength The strength of wings must be proven by load tests or by combined structural analysis and load tests.
CONTROL SURFACES	
651	USAR.651 Proof of strength (a) Rational and conservative analysis or limit load tests or combined structural analysis and load tests of control surfaces are required. These tests must include the horn or fitting to which the control system is attached. (b) In structural analyses, rigging loads due to wire bracing must be accounted for in a rational or conservative manner.
655	USAR.655 Installation (a) Movable surfaces must be installed so that there is no interference between any surfaces, their bracing or adjacent fixed structure, when one surface is held in its most critical clearance positions and the others are operated through their full movement. (b) If an adjustable stabiliser is used, it must have stops that will limit its range of travel to that allowing safe flight and landing.
657	USAR.657 Hinges (a) Control surface hinges, except ball and roller bearing hinges, must have a factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing. (b) For ball or roller bearing hinges, the approved rating of the bearing may not be exceeded.
659	USAR.659 Mass balance The supporting structure and the attachment of concentrated mass balance weights used on control surfaces must be designed for (a) 24g normal to the plane of the control surface; (b) 12g fore and aft; and (c) 12g parallel to the hinge line.
CONTROL SYSTEMS	
671	USAR.671 General See AMC.671 (a) Each control must operate easily, smoothly and positively enough to allow proper performance of its functions.

	(b) Not applicable in this subpart (see USAR.1731 Controls - General) (c) Each flight control system shall have a fatigue evaluation determined in accordance with USAR 570 at least equal to the specified life of the UAV, unless otherwise agreed with the Certifying authority. This shall be demonstrated by a fatigue test.
	672 Stability augmentation and automatic power operating systems Not applicable.
673	USAR.673 Primary and secondary flight controls (a) Primary flight controls are those used in the UAV by the flight control system for the immediate control of pitch, roll and yaw. (b) Secondary flight controls are defined in USAR.405
675	USAR.675 Stops (a) Each flight control must have stops that positively limit the range of motion of each movable aerodynamic surface controlled by the system. (b) Each stop must be located so that wear, slackness, or take-up adjustments will not adversely affect the control characteristics of the UAV because of a change in the range of surface travel. (c) Each stop must be able to withstand any loads corresponding to the design conditions for the control system.
677	USAR.677 Trim systems (a) Proper precautions must be taken to prevent inadvertent, improper, or abrupt auto-trim tab operation by the flight control system. (b) Trimming devices must be designed so that, when any one connecting or transmitting element of the primary flight controls fails, adequate control for safe flight and landing is available with (1) For single-engine UAV, the longitudinal trimming devices; or (2) For multi-engine UAV, the longitudinal and directional trimming devices. (c) Tab controls must be irreversible unless the tab is properly balanced and has no unsafe flutter characteristics. Irreversible tab systems must have adequate rigidity and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the UAV structure. (d) It must be demonstrated that the UAV is safely controllable by the flight control system and that the UAV crew can perform all the manoeuvres and operations necessary to effect a safe landing following any probable powered trim system runaway that reasonably might be expected in service. The demonstration must be conducted at the critical UAV weights and centre of gravity positions.
679	USAR.679 Primary or secondary flight controls lock If there is a device to lock the flight controls (a) Not applicable in this subpart (see USAR.1825 Flight control system lock warning) (b) There must be a means to (1) Warn the ground staff when the device is engaged; (2) Not applicable. (c) The device must have a means to preclude the possibility of it becoming inadvertently engaged in flight.

681	USAR.681 Limit load static tests (a) Compliance with the limit load requirements of USAR must be shown by rational and conservative analysis or by tests in which (1) The direction of the test loads produces the most severe loading in the primary flight controls ; and (2) Each fitting, pulley and bracket used in attaching the system to the main structure is included. (b) Compliance must be shown (by analyses or individual load tests) with the special factor requirements for control system joints subject to angular motion.
683	USAR.683 Operation tests See AMC.683 (a) It must be shown by operation tests that, when the controls are operated with the system loaded as prescribed in sub-paragraph (b) , the system is free from (1) Jamming; (2) Excessive friction; (3) Excessive deflection. (4) Excessive freeplay (b) The prescribed test loads are (1) For the entire system, loads corresponding to the limit air loads on the appropriate surface, or the maximum loads and torques generated by the actuating system, whichever are less; and (2) For secondary controls, loads not less than those corresponding to the maximum servocontrols or actuators force .
685	USAR.685 Control system details (a) Each detail of each control system must be designed and installed to prevent jamming, chafing and interference from payloads , loose objects, or the freezing of moisture. (b) There must be means to prevent the entry of foreign objects into places where they would jam the system. (c) There must be means to prevent the slapping of cables or tubes against other parts. (d) Each element of the flight control system must have design features, or must be distinctively and permanently marked, to minimise the possibility of incorrect assembly that could result in malfunctioning of the control system. (e) UAV control systems need to be resistant to external and internal sources of electromagnetic interference in accordance with USAR.1431.
687	USAR.687 Spring devices The reliability of any spring device used in the control system must be established by tests simulating service conditions unless failure of the spring will not cause flutter or unsafe flight characteristics.
689	USAR.689 Cable systems (a) Each cable, cable fitting, turn-buckle, splice and pulley used must meet approved specifications. In addition (1) No cable smaller than 3.2 mm (1/8 in) diameter may be used in primary flight controls ;

	(2) Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations; and (3) There must be means for visual inspection at each fairlead, pulley, terminal and turnbuckle. (b) Each kind and size of pulley must correspond to the cable with which it is used. Each pulley must have closely fitted guards to prevent the cables from being misplaced or fouled, even when slack. Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange. (c) Fairleads must be installed so that they do not cause a change in cable direction of more than 3°. (d) Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system. (e) Turnbuckles must be attached to parts having angular motion in a manner that will positively prevent binding throughout the range of travel. (f) Tab control cables may be less than 3.2mm (1/8 inch) diameter in UAV that are safely controllable with the tabs in the most adverse positions.
693	USAR.693 Joints See AMC.693 (a) Control system joints (in push-pull systems) that are subject to angular motion, except those in ball and roller bearing systems, must have a special factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball or roller bearings, the approved ratings may not be exceeded. (b) All elastomeric bearings shall be: (1) Suitable for the expected loads and the environment that the bearing will experience. (2) Selected from a Qualified Products List.
697	USAR.697 Wing flap controls (a) Each wing flap control must be designed so that, when the flap has been placed in any position upon which compliance with the performance requirements of USAR is based, the flap will not move from that position unless the control is adjusted or is moved by the automatic operation of a flap load limiting device. (b) The rate of movement of the flaps in response to the operation of the UAV crew's control or flight control system must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power or thrust and attitude.
	699 Wing flap position indicator Not applicable in this subpart (see USAR.1791 Wing flap position indicator)
701	USAR.701 Flap interconnection (a) The main wing flaps and related movable surfaces as a system must (1) Be synchronised by a mechanical interconnection between the movable flap surfaces that is independent of the flap drive system or by an approved equivalent means; or (2) Be designed so that the occurrence of any failure of the flap system that would result in an unsafe flight characteristic of the UAV is extremely improbable; or (b) The UAV must be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces (mechanically interconnected surfaces are to be considered as a single surface).

	(c) If an interconnection is used in multi-engine UAV, it must be designed to account for the unsymmetrical loads resulting from flight with the engine on one side of the plane of symmetry inoperative and the remaining engine at take-off power or thrust. For single-engine UAV and multi-engine UAV with no slipstream effects on the flaps, it may be assumed that 100% of the critical air load acts on one side and 70% on the other.
703	USAR.703 Take-off protection If the UAV is an unsafe take-off configuration, either (a) the UAV crew and ground staff (where applicable) must be notified; or (b) the initiation of take-off must be automatically prevented.
LANDING GEAR	
	721 General Not applicable.
U722	USAR.U722 Landing gear - General The following section is for conventional landing gear arrangements. If novel designs are proposed the acceptance methods shall be agreed with the Certifying Authority.
723	USAR.723 Shock absorption tests (a) It must be shown that the limit load factors selected for design in accordance with USAR.473 for take-off and landing weights, respectively, will not be exceeded. This must be shown by energy absorption tests except that analysis based on tests conducted on a landing gear system with identical energy absorption characteristics may be used for increases in previously approved take-off and landing weights. (b) The landing gear may not fail, but may yield, in a test showing its reserve energy absorption capacity, simulating a descent velocity of 1.2 times the limit descent velocity, assuming wing lift equal to the weight of the UAV .
725	USAR.725 Limit drop tests (a) If compliance with USAR.723 (a) is shown by free drop tests, these tests must be made on the complete UAV, or on units consisting of wheel, tyre and shock absorber, in their proper relation, from free drop heights not less than those determined by the following formula: $h (m) = 0.0132 (Mg/S)^{1/2}$ However, the free drop height may not be less than 0.234 m (9.2 inches) and need not be more than 0.475 m (18.7 inches). (b) If the effect of wing lift is provided for in free drop tests, the landing gear must be dropped with an effective weight equal to $M_e = M (h + [1-L]d) / (h + d)$ where M_e = the effective weight to be used in the drop test (kg); h = Specified free drop height (m); d = deflection under impact of the tyre (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (m); M = MM for main gear units (kg), equal to the static weight on that unit with the UAV in the level attitude (with the nose wheel clear in the case of the nose wheel type UAV); M = MT for tail gear units (kg), equal to the static weight on the tail unit with the UAV in the tail-down attitude;

	M = MN for nose wheel units (kg), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the UAV acts at the centre of gravity and exerts a force of 1.0g downward and 0.33g forward; and L = the ratio of the assumed wing lift to the UAV weight, but not more than 0.667. g = The acceleration due to gravity (m/s^2) (c) The limit inertia load factor must be determined in a rational or conservative manner, during the drop test, using a landing gear unit attitude and applied drag loads, that represent the landing conditions. (d) The value of d used in the computation of M_e in sub-paragraph (b) may not exceed the value actually obtained in the drop test. (e) The limit inertia load factor must be determined from the drop test in sub-paragraph (b) according to the following formula: $n = n_j (M_e / M) + L$ where n_j = the load factor developed in the drop test (that is, the acceleration (dv/dt) in g's recorded in the drop test) plus 1.0; and M_e, M and L are the same as in the drop test computation. (f) The value of n determined in accordance with sub-paragraph (e) may not be more than the limit inertia load factor used in the landing conditions in USAR.473.
726	USAR.726 Ground load dynamic tests (a) If compliance with the ground load requirements of USAR.479 to USAR.483 is shown dynamically by drop test, one drop test must be conducted that meets USAR.725 except that the drop height must be (1) 2.25 times the drop height prescribed in USAR.725 (a); or (2) Sufficient to develop 1.5 times the limit load factor. (b) The critical landing condition for each of the design conditions specified in USAR.479 to USAR.483 must be used for proof of strength.
727	USAR.727 Reserve energy absorption drop tests (a) If compliance with the reserve energy absorption requirements in USAR.723 (b) is shown by free drop tests, the drop height may not be less than 1.44 times that specified in USAR.725. (b) If the effect of wing lift is provided for, the units must be dropped with an effective mass equal to $M_e = M (h / [h + d])$ when the symbols and other details are the same as in USAR.725.
729	USAR.729 Landing gear extension and retraction system See AMC.729 (g) (a) General. For UAV with retractable landing gear, the following apply: (1) Each landing gear retracting mechanism and its supporting structure must be designed for maximum flight load factors with the gear retracted and must be designed for the combination of friction, inertia, brake torque and air loads, occurring during retraction at any airspeed up to 1.6 V_{S1} with flaps retracted and for any load factor up to those specified in USAR.345 for the flaps-extended condition. (2) The landing gear and retracting mechanism, including the wheel well doors, must withstand flight loads, including loads resulting from all yawing conditions specified in USAR.351, with the landing gear extended at any speed up to at least 1.6 V_{S1} with the flaps retracted.

	(b) Landing gear lock. There must be positive means (other than the use of hydraulic pressure) to keep the landing gear extended. (c) Emergency operation. For a UAV having retractable landing gear , there must be means to extend the landing gear in the event of either (1) Any reasonably probable failure in the normal landing gear operation system; or (2) Any reasonably probable failure in a power source that would prevent the operation of the normal landing gear operation system. (d) Operation test. The proper functioning of the retracting mechanism must be shown by operation tests. (e) If a retractable landing gear is used, there must be landing gear position sensor and switches to actuate the indicator in the UCS (see USAR.1793) to inform the UAV crew that each gear is secured in the extended (or retracted) position. If switches are used, they must be located and coupled to the landing gear mechanical system in a manner that prevents an erroneous indication of either "down and locked" if each gear is not in the fully extended position, or of "up and locked" if each landing gear is not in the fully retracted position. (f) Not applicable in this subpart (see USAR.1793 Landing gear position and warning) (g) Equipment located in the landing gear bay. If the landing gear bay is used as the location for equipment other than the landing gear, that equipment must be designed and installed to minimise damage.
731	USAR.731 Wheels (a) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with (1) Design maximum weight; and (2) Critical centre of gravity. (b) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of USAR .
733	USAR.733 Tyres (a) Each landing gear wheel must have a tyre whose approved tyre ratings (static and dynamic) are not exceeded (1) By a load on each main wheel tyre (to be compared to the static rating approved for such tyres) equal to the corresponding static ground reaction under the design maximum weight and critical centre of gravity; and (2) By a load on nose wheel tyres (to be compared with the dynamic rating approved for such tyres) equal to the reaction obtained at the nose wheel, assuming the mass of the UAV to be concentrated at the most critical centre of gravity and exerting a force of 1.0 M_g downward and 0.31 M_g forward (where M_g is the design maximum weight), with the reactions distributed to the nose and main wheels by the principles of statics and with the drag reaction at the ground applied only at wheels with brakes. (b) If specially constructed tyres are used, the wheels must be plainly and conspicuously marked to that effect. The markings must include the make, size, number of plies and identification marking of the proper tyre. (c) Each tyre installed on a retractable landing gear system must, at the maximum size of the tyre type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tyre and any part of the structure or systems.

735	USAR.735 Brakes See AMC.735 (c) (a) The landing brake kinetic energy capacity rating of each main wheel brake assembly must not be less than the kinetic energy absorption requirements determined under either of the following methods: (1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight. (2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula: $KE = ½MV^2/N$ where KE = Kinetic energy per wheel (Joules); M = Mass at design landing weight (kg); V = UAV speed in m/s. V must be not less than V_{S0}, the power off stalling speed of the UAV at sea level, at the design landing weight, and in the landing configuration; and N = Number of main wheels with brakes. (3) Arresting cable, barrier net or other unconventional braking/arresting devices are out of scope regarding brake energy absorption on wheels and must belong to Special Condition category. The design of any arrestor system shall ensure that it retards the air vehicle without imparting forces and accelerations in excess of those for which its airframe and internal equipment are designed. (b) Brakes must be able to prevent the wheels from rolling on a paved runway with take-off power or thrust in the critical engine, but need not prevent movement of the UAV with wheels locked. (c) During the landing distance determination required by USAR.75, the pressure in the wheel braking system must not exceed the pressure specified by the brake manufacturer. (d) If anti-skid devices are installed, the devices and associated systems must be designed so that no single probable malfunction or failure will result in a hazardous loss of braking ability or directional control of the UAV. (e) A rejected take-off at V_{Rf} shall not lead to a hazardous or more serious failure conditions.
	737 Skis Not applicable.
745	USAR.745 Nose/tail-wheel steering (a) If nose/tail-wheel steering is installed, it must be demonstrated that it properly works during take-off and landing, in cross-winds and in the event of an engine failure or its use must be limited to low speed manoeuvring. (b) Movement of the steering control must not interfere with correct retraction or extension of the landing gear.
	751 Main float buoyancy Not applicable
	753 Main float design Not applicable

	755 Hull Not applicable
	757 Auxiliary floats Not applicable
	PAYLOAD AND EQUIPMENT COMPARTMENTS
	771 Pilot compartment Not applicable in this subpart (see USAR.1703 UAV crew workplace).
	773 Pilot compartment view Not applicable.
775	USAR.775 Payload transparencies The design of payload transparencies and radomes in pressurised compartments must be based on factors specific to high altitude operation, including (1) The effects of continuous and cyclic pressurisation loading; (2) The inherent characteristics of the material used; (3) The effects of temperatures and temperature gradients; (4) The effects on the structural integrity of the UAV in the occurrence of wall pressurisation fracture, either by flaw or by explosion; and, (5) Safety-of-flight critical viewing areas of camera and sensor windows shall be maintained free of fog, frost and other obstructions for all steady state and transient ground and flight operating conditions within the specified UAV environmental envelope. They shall be designed to withstand foreign object damage (FOD) from birds, hail, runway, taxiway, and ramp debris.
	777 Cockpit controls Not applicable in this subpart (see USAR.1731 General)
	779 Motion and effect of cockpit controls Not applicable in this subpart (see USAR.1735 Motion and representation of controls)
	781 Cockpit control knob shape Not applicable in this subpart (see USAR.1733 Conventional controls and indicators)
783	USAR.783 Doors, covers and hatches (a) Not applicable (b) Not applicable (c) Not applicable (d) Not applicable (e) Each external door and hatch must comply with the following requirements: (1) There must be a means to lock and safeguard each external door and hatch, including payload and service type doors, against inadvertent opening in flight, as a result of mechanical failure or failure of a single structural element, either during or after closure.

	(2) There must be a provision for direct visual inspection of the locking mechanism to determine if the external door or hatch, for which the initial opening movement is not inward, is fully closed and locked. The provisions must be discernible, under operating lighting conditions, by inspection and maintenance staff using a flashlight or an equivalent lighting source.
	785 Seats, berths, litters, safety belts and shoulder harnesses Not applicable.
787	USAR.787 Payload compartments Each payload compartment must (1) Be designed for the maximum weight and distribution of contents and for the critical load distributions at the appropriate maximum load factors corresponding to the flight and ground load conditions of USAR. (2) Have means to prevent the contents of any compartment from becoming a hazard by shifting, and to protect any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operations.
	791 Passenger information signs Not applicable.
	803 Emergency evacuation Not applicable.
	805 Flight crew emergency exits Not applicable
	807 Emergency exits Not applicable
	811 Emergency exit marking Not applicable
	812 Emergency lighting Not applicable
	813 Emergency exit access Not applicable
	815 Width of aisle Not applicable
	831 Ventilation Not applicable
PRESSURISATION	
841	USAR.841 Pressurised compartments (a) Not applicable (b) If necessary for structural protection, pressurised compartments should have the following valves (or their equivalent) (1) A pressure relief valve (or its equivalent) to automatically limit the positive pressure differential to a predetermined value at the maximum rate of flow delivered by the pressure source. The pressure differential is positive when the internal pressure is greater than the external.

	(2) A reverse pressure differential relief valve (or its equivalent) to automatically prevent a negative pressure differential that would damage the structure. (3) Not applicable. (4) Not applicable. (5) Not applicable in this subpart (see USAR.1795 Pressurised compartment indicator). (6) Not applicable. (7) Not applicable in this subpart (see USAR.1795 Pressurised compartment indicator). (8) Not applicable.
843	USAR.843 Pressurisation tests (a) Strength test. The complete pressurised compartment, including doors, windows, canopy and valves, must be tested as a pressure vessel for the pressure differential specified in USAR.365 (d). (b) Functional tests. The following functional tests must be performed: (1) Tests of the functioning and capacity of the positive and negative pressure differential valve. (2) Tests of the pressurisation system to show proper functioning under each possible condition of pressure, temperature and moisture, up to the maximum altitude for which certification is requested.
	FIRE PROTECTION
U850	USAR.U850 Fire protection – General Specific UAV fire protection requirements presented in USAR aim at minimizing the risk of fire that may lead to uncontrolled UAV flight and crash and potential damages to third parties. Compliance with those requirements must show that this general intent is met, in particular that: (a) Electrical installation and propulsion systems (including related materials) are adequately designed (see USAR.1359, USAR.1181 and appendix F), and, (b) Consideration must be given to protection of flight critical structure and systems (such as flight control system). (c) The flammability, toxicity, smoke effects and thermal decomposition of the materials must be considered in design.
	851 Fire extinguishers Not applicable.
	853 Passenger and crew compartment interiors Not applicable.
	855 Cargo and baggage compartment fire protection Not applicable.
	859 Combustion heater fire protection Not applicable.

863	USAR.863 Flammable fluid fire protection See AMC.863 (a) In each area where flammable fluids or vapours might escape by leakage of a fluid system, there must be means to minimise the probability of ignition of the fluids and vapours and the resultant hazard if ignition does occur. (b) Compliance with sub-paragraph (a) must be shown by analysis or tests and the following factors must be considered: (1) Possible sources and paths of fluid leakage and means of detecting leakage. (2) Flammability characteristics of fluids, including effects of any combustible or absorbing materials. (3) Possible ignition sources, including electrical faults, over-heating of equipment, static electricity, lightning and malfunctioning of protective devices. (4) Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents. (5) Ability of UAV components that are critical to safety of flight to withstand fire and heat. (c) Not applicable in this subpart (see USAR.1817 Flammable fluid fire protection) (d) Each area where flammable fluids or vapours might escape by leakage of a fluid system must be identified and defined.
865	USAR.865 Fire protection of flight control system components, engine mounts and other flight structure See AMC.865 Flight control system components, engine mounts, and other flight structure located in designated fire zones, or in adjacent areas that would be subjected to the effects of fire in the designated fire zones, must be constructed of fireproof material or be shielded so that they are capable of withstanding the effects of a fire. Engine vibration isolators must incorporate suitable features to ensure that the engine is retained if the non-fireproof portions of the isolators deteriorate from the effects of a fire.
	ELECTRICAL BONDING AND LIGHTNING PROTECTION
867	USAR.867 Electrical bonding and protection against lightning and static electricity See AMC.867 (a) (a) The UAV must be protected against catastrophic effects from lightning and static electricity. A lightning analysis assessment has to be carried out and agreed with the Certifying Authority. (b) For metallic components, compliance with sub-paragraph (a) may be shown by (1) Bonding the components and grounding them properly to the airframe; or (2) Designing the components so that a strike will not result in a catastrophic event. (c) For non-metallic components, compliance with sub-paragraph (a) may be shown by (1) Designing the components to minimise the effect of a strike; or (2) Incorporating acceptable means of diverting the resulting electrical current so as not to result in a Catastrophic event.

	871 Levelling means Not applicable
	PARACHUTE LANDING SYSTEM
U881	USAR.U881 Parachute design See AMC.881 (a) Where a UAV is designed to be recovered by parachute, (a) materials and workmanship shall be of a quality which documented experience or tests have conclusively demonstrated to be suitable for the manufacture of parachute assemblies and components (b) All materials shall remain functional for storage and use from -40°C to +93.3°C, and from 0 to 100% relative humidity. (c) All plated ferrous parts shall be treated to minimise hydrogen embrittlement. (d) Stitching shall be of a type that will not unravel when broken (e) Information concerning parachute assemblies and components must be furnished in the UAV System documentation, including : (1) part number (2) manufacturer's name and address (3) maximum operating limits (4) instruction for packing method and inspection at approved intervals (5) instruction for continued airworthiness. (f) Where practicable parachute assemblies shall be designed for operational re-use, parachute attachments must have a fatigue evaluation determined in accordance with USAR 570, unless otherwise agreed with the Certifying Authority.

subpart E – UAV POWERPLANT

	GENERAL
901	USAR.901 Installation See AMC.901 (a) For the purpose of USAR, the UAV powerplant installation includes each component that (1) Is necessary for propulsion; and (2) Affects the safety of the major propulsive units. (b) Each powerplant installation must be constructed and arranged to (1) Ensure safe operation over the full envelope of operating conditions (in particular, the maximum operating altitude) for which approval is requested. (2) Be accessible for necessary inspections and maintenance, (3) Account for all static, dynamic and oscillatory characteristics of the UAV System. (c) Engine covers, cowls and nacelles must be easily removable or openable by the inspection and maintenance staff to provide adequate access to and exposure of the engine compartment for the required pre-flight checks. (d) Each turbine engine installation must be constructed and arranged to (1) Result in carcass vibration characteristics that do not exceed those established during the type certification of the engine. (2) Provide continued safe operation without a hazardous loss of power or thrust while being operated in rain for at least 3 minutes with the rate of water ingestion being not less than 4% by weight, of the engine induction airflow rate at the maximum installed power or thrust approved for take-off and at flight idle. (e) The powerplant installation must comply with (1) The installation instructions provided under (i) The engine Type Certificate or any qualification accepted by the Certifying Authority, and (ii) The propeller Type Certificate or any qualification accepted by the Certifying Authority. (2) The applicable provisions of this subpart, (3) USAR.903 (a)(2) requirement. (f) Each auxiliary power unit installation must meet the applicable portions of USAR.

903	USAR.903 Engines and auxiliary power units See AMC.903(a) and AMC.903(f) (a) Engine Type Certificate (1) Each engine must have a Type Certificate or any qualification accepted by the Certifying Authority (2) In addition, each turbine engine must either (i) Comply with - ingestion of hail, rain and foreign objects risk qualification, and, - bird strike and ingestion risk qualification agreed with the Certifying Authority, or (ii) Be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition. (b) Turbine engine installations. For turbine engine installations (1) Design precautions must be taken to minimise the hazards to the UAV in the event of an engine rotor failure or of a fire originating inside the engine which burns through the engine case. (2) The powerplant systems associated with engine control devices, systems and instrumentation must be designed to give reasonable assurance that those operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service. (c) Engine isolation. In multiple-engine applications, the powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or the failure or malfunction (including destruction by fire in the engine compartment) of any system that can affect an engine will not (1) Prevent the continued safe operation of the remaining engines; or (2) Require immediate action by any UAV crew for continued safe operation of the remaining engine. (d) Starting and stopping (1) Any techniques and associated limitations for engine starting and stopping must be established and included in the UAV System Flight Manual and in the UAV Maintenance Manual. (2) For safety purpose, there must be a means to prevent inadvertent engine starting on the ground. (3) The design of the installation must be such that risk of fire or mechanical damage to the engine or UAV, as a result of starting the engine in any conditions in which starting is to be permitted, is reduced to a minimum. (e) Restart capability (1) Engine restart capability and demonstration should be weighed with the risk of engine loss and corresponding emergency procedures as defined in USAR.1413 and related operational limitations. (2) Where restart capability is required, (i) Any techniques and associated limitations must be established and included in the UAV System Flight Manual, or applicable operating placards must be included in the UCS.

	(ii) It must be demonstrated in flight that when restarting engines following a false start, all fuel or vapour is discharged in such a way that it does not constitute a fire hazard. (iii) Restart envelope. An altitude and airspeed envelope must be established for the UAV for in-flight engine restarting. (iv) For turbine engine-powered UAV, if the minimum windmilling speed of the engines, following the in-flight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine-driven electrical power generating system must be provided to permit in-flight engine ignition for restarting. (f) Auxiliary power units. Each APU must comply with APU qualification agreed with the Certifying Authority
	904 Automatic power reserve system Not applicable.
905	USAR.905 Propellers See AMC.905 (d), AMC.905 (e) and AMC.905 (g) (a) Each propeller must have a Type Certificate or any qualification accepted by the Certifying Authority. (b) Engine power and propeller shaft rotational speed may not exceed the limits for which the propeller is certificated. (c) Each featherable propeller must have a means to unfeather it in flight. (d) Propeller systems that allow variation of blade pitch angle during flight shall be designed such that failure of the variable pitch mechanism or components or of its control system, causes the blades to revert to a condition that enables the UAV to continue in safe, controlled flight and landing. (e) If certified for icing conditions, all areas of the UAV forward of the pusher propeller that are likely to accumulate and shed ice into the propeller disc during any operating condition must be suitably protected to prevent ice formation, or it must be shown that any ice shed into the propeller disc will not create a hazardous condition. (f) Each pusher propeller must be marked so that the disc is conspicuous under normal daylight ground conditions. (g) If the engine exhaust gases are discharged into the pusher propeller disc, it must be shown by tests, or analysis supported by tests, that the propeller is capable of continuous safe operation. (h) All engine cowlings, access doors, and other removable items must be designed to ensure that they will not separate from the UAV and contact the pusher propeller.
907	USAR.907 Propeller vibration See AMC.907 (a) (a) Each propeller other than a conventional fixed pitch wooden propeller must be shown to have vibration stresses, in normal operating conditions, that do not exceed values that have been shown by the propeller manufacturer to be safe for continuous operation. This must be shown by (1) Measurement of stresses through direct testing of the propeller; (2) Comparison with similar installations for which these measurements have been made; or (3) Any other acceptable test method or service experience that proves the safety of the installation.

	(b) Proof of safe vibration characteristics for any type of propeller, except for conventional, fixed-pitch, wood propellers must be shown where necessary.
909	USAR.909 Turbo charger systems See AMC.909 (a) and AMC.909 (d) (1) (a) Each turbo charger must be approved under the engine Type Certificate or it must be shown that the turbo charger system, while in its normal engine installation and operating in the engine environment (1) Can withstand, without defect, an endurance test of a time specified by the Certifying Authority, and (2) Will have no adverse effect upon the engine. (b) Control system malfunctions, vibrations and abnormal speeds and temperatures expected in service may not damage the turbo charger compressor or turbine. (c) Each turbo charger case must be able to contain fragments of a compressor or turbine that fails at the highest speed that is obtainable with normal speed control devices in-operative. (d) Each intercooler installation, where provided, must comply with the following: (1) The mounting provisions of the intercooler must be designed to withstand the loads imposed on the system; (2) It must be shown that, under the installed vibration environment, the intercooler will not fail in a manner allowing portions of the intercooler to be ingested by the engine, and (3) Airflow through the intercooler must not discharge directly on any UAV component unless such discharge is shown to cause no hazard to the UAV under all operating conditions. (e) Engine power, cooling characteristics, operating limits, and procedures affected by the turbocharger system installations must be evaluated. Turbocharger operating procedures and limitations, where appropriate, must be included in the UAV System Flight Manual in accordance with USAR.1581.
925	USAR.925 Propeller clearance Propeller clearances with the UAV at the most adverse combination of weight and centre of gravity and with the propeller in the most adverse pitch position, may not be less than the following: (a) Ground clearance. (1) For UAV designed for conventional take-off or landing on a runway, there must be a clearance of at least 18 cm (7 in) (for each UAV with nose wheel landing gear) or 23 cm (9 in) (for each UAV with tail wheel landing gear) between each propeller and the ground with the landing gear statically deflected and in the level, normal take-off, or taxiing attitude, whichever is the most critical. In addition, for each UAV with conventional landing gear struts using fluid or mechanical means for absorbing landing shocks, there must be positive clearance between the propeller and the ground in the level take-off attitude with the critical tyre completely deflated and the corresponding landing gear strut bottomed. Positive clearance for UAV using leaf spring struts is shown with a deflection corresponding to 1.5g. Exemptions from clearance limits described above have to be agreed with the Certifying Authority. (2) For rocket assisted take-off or catapult assisted take-off UAV, there must be a clearance of at least 10 cm between the propeller and the launch system (catapult, launching ramp, …). This clearance must be kept during all the launching phase.

	(3) For UAV designed to be recovered by parachute and except for UAV using wood propeller, the propeller must be subject to appropriate inspection after each recovery except if it has been shown by analysis, simulation or test that the integrity of the propeller after ground impact is never affected whatever the combination of weight, balance and environmental conditions. Inspection procedures must be documented. (b) Aft mounted propellers. Except for catapult assisted and rocket assisted take-off UAV, in addition to the clearance specified in sub-paragraph (a) a UAV with an aft mounted propeller must be designed such that the propeller will not contact the runway surface when the UAV is in the maximum pitch attitude attainable during normal take-off and landings. (c) Not applicable (d) Structural clearance. In the most adverse conditions, there must be (1) At least 25 mm (1 in) radial clearance between the blade tips and the UAV structure, plus any additional radial clearance necessary to prevent harmful vibration; (2) At least 12.7 mm (½ in) longitudinal clearance between the propeller blades or cuffs and stationary parts of the UAV; and (3) Positive clearance between other rotating parts of the propeller or spinner and stationary parts of the UAV.
929	USAR.929 Engine installation ice protection Propellers and other components of complete engine installations must be protected against the accumulation of ice as necessary to enable satisfactory functioning without appreciable loss of thrust when operated in the icing conditions for which certification is requested.
933	USAR.933 Thrust reversing systems (a) For turbojet and turbofan thrust reversing systems (1) Each system intended for ground operation only must be designed so that during any reversal in flight the engine will produce no more than flight idle thrust. In addition, it must be shown by analysis or test, or both, that (i) Each operable reverser can be restored to the forward thrust position; or (ii) The UAV is capable of continued safe flight and landing under any possible position of the thrust reverser. (2) Each system intended for in-flight use must be designed so that no unsafe condition will result during normal operation of the system, or from any failure (or likely combination of failures) of the reversing system, under any operating condition including ground operation. Failure of structural elements need not be considered if the probability of this kind of failure is extremely remote. (3) Each system must have means to prevent the engine from producing more than idle thrust when the reversing system malfunctions, except that it may produce any greater thrust that is shown to allow directional control to be maintained, with aerodynamic means alone, under the most critical reversing condition expected in operation. (b) For propeller thrust reversing systems (1) Each system must be designed so that no single failure (or reasonably likely combination of failures) or malfunction of the system will result in unwanted reverse thrust under any expected operating condition. Failure of structural elements need not be considered if this kind of failure is extremely remote.

	(2) Compliance with sub-paragraph (b) (1) may be shown by failure analysis or testing, or both, for propeller systems that allow propeller blades to move from the flight lowpitch position to a position that is substantially less than that at the normal flight low-pitch position.
934	USAR.934 Turbojet and turbofan engine thrust reverser system tests See AMC.934 Thrust reverser systems of turbojet or turbofan engines must meet the appropriate requirements agreed with the Certifying Authority.
937	USAR.937 Turbopropeller-drag limiting systems (a) Turbopropeller-powered UAV propeller-drag limiting systems must be designed so that no single failure or malfunction of any of the systems during normal or emergency operation results in propeller drag in excess of that for which the UAV was designed under the structural requirements of USAR. Failure of structural elements of the drag limiting systems need not be considered if the probability of this kind of failure is extremely remote. (b) As used in this paragraph, drag limiting systems include manual or automatic devices that, when actuated after engine power loss can move the propeller blades toward the feather position to reduce windmilling drag to a safe level.
939	USAR.939 Powerplant operating characteristics See AMC.939 (c) (a) Turbine engine powerplant operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operations within the range of operating limitations of the UAV and of the engine. (b) Turbocharged reciprocating engine operating characteristics must be investigated in flight to an appropriate degree to assure that no adverse characteristics, such as a result of an inadvertent overboost, surge, flooding, or vapour lock, are present during normal or emergency operation of the engine(s) throughout the range of operating limitations of both UAV and engine. (c) For turbine engines, the air inlet system must not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine or instability greater than that allowed by the engine specification.
943	USAR.943 Negative acceleration No hazardous malfunction of an engine, an auxiliary power unit approved for use in flight, or any component or system associated with the powerplant or auxiliary power unit may occur when the UAV is operated at the negative accelerations within the flight envelope protection maintained by the flight control system as detailed in USAR.334. This must be shown for the greatest value and duration of the acceleration expected in service.
FUEL SYSTEM	
951	USAR.951 General (a) Each fuel system must be constructed and arranged to ensure fuel flow at a rate and pressure established for proper engine and auxiliary power unit functioning under each likely operating condition, including any manoeuvre for which certification is requested and during which the engine or auxiliary power unit is permitted to be in operation. (b) Each fuel system must be arranged so that (1) No fuel pump can draw fuel from more than one tank at a time; or (2) There are means to prevent introducing air into the system.

	(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 27°C (80°F) and having 0.75cc of free water per 3.8 l (US-gallon) added and cooled to the most critical condition for icing likely to be encountered in operation.
953	USAR.953 Fuel system independence (a) Each fuel system for a multi-engine UAV must be arranged so that, in at least one system configuration, the failure of any one component will not result in the loss of power of more than one engine or require immediate action by the UAV crew to prevent the loss of power of more than one engine. Nevertheless, automatic actions are compliant with USAR.953. (b) If a single fuel tank (or series of fuel tanks interconnected to function as a single fuel tank) is used on a multi-engine UAV, the following must be provided: (1) Independent tank outlets for each engine, each incorporating a shutoff valve at the tank. This shutoff valve may also serve as the firewall shutoff valve required if the line between the valve and the engine compartment does not contain more than one US quart of fuel (or any greater amount shown to be safe) that can escape into the engine compartment. (2) At least two vents arranged to minimize the probability of both vents becoming obstructed simultaneously. (3) Filler caps designed to minimize the probability of incorrect installation or inflight loss. (4) A fuel system in which those parts of the system from each tank outlet to any engine are independent of each part of the system supplying fuel to any other engine.
954	USAR.954 Fuel system lightning protection The fuel system must be designed and arranged to prevent the ignition of fuel vapour within the system in consistency with the lightning protection requirements defined in USAR.867 by (a) Direct lightning strikes to areas having a high probability of stroke attachment ; (b) Swept lightning strokes on areas where swept strokes are highly probable; and (c) Corona or streamering at fuel vent outlets.
955	USAR.955 Fuel flow (a) General. The ability of the fuel system to provide fuel at the rates specified in this paragraph and at a pressure sufficient for proper engine operation must be shown in the attitude that is most critical with respect to fuel feed and quantity of unusable fuel. These conditions may be simulated in a suitable mock-up. In addition (1) The quantity of fuel in the tank may not exceed the amount established as the unusable fuel supply for that tank under USAR.959 (a) plus that necessary to show compliance with this paragraph; (2) If there is a fuel flowmeter, it must be blocked during the flow test and the fuel must flow through the test-meter or its by-pass. (3) If there is a flowmeter without a bypass, it must not have any failure mode that would restrict fuel flow below the level required in this fuel flow demonstration; (4) The fuel flow must include that flow needed for vapour return flow, jet pump drive flow and for all other purposes for which fuel is used. (b) Gravity systems. The fuel flow rate for gravity systems (main and reserve supply) must be 150% of the fuel consumption of the engine at the maximum take-off power or thrust approved under USAR.

	(c) Pump systems. The fuel flow rate for each pump system (main and reserve supply) for each reciprocating engine, must be 125% of the fuel flow required by the engine at the maximum takeoff power or thrust approved under USAR. (1) This flow rate is required for each main pump and each emergency pump, and must be available when the pump is operating as it would during take-off; (2) Not applicable (3) The fuel pressure, with main and emergency pumps operating simultaneously, must not exceed the fuel inlet pressure limits of the engine, unless it can be shown that no adverse effect occurs. (d) Auxiliary fuel systems and fuel transfer systems. Sub-paragraphs (b), (c) and (f) apply to each auxiliary and transfer system, except that (1) The required fuel flow rate must be established upon the basis of maximum continuous power or thrust and engine rotational speed, instead of take-off power and fuel consumption; and (2) Where appropriate, if there are operating instructions related to fuel management in the UCS, a lesser flow rate may be used for transferring fuel from any auxiliary tank into a larger main tank. This lesser flow rate must be adequate to maintain maximum continuous power or thrust but the flow rate must not overfill the main tank at lower engine power or thrust. (e) Multiple fuel tanks. For reciprocating engines that are supplied with fuel from more than one tank, if engine power loss becomes apparent due to fuel depletion from the tank selected, it must be possible after switching to any full tank, in level flight, to obtain 75% maximum continuous power or thrust on that engine in not more than (1) 10 seconds for naturally aspirated single-engine UAV; (2) 20 seconds for turbocharged single-engine UAV, provided that 75% maximum continuous naturally aspirated power is regained within 10 seconds; or (3) 20 seconds for multi-engine UAV. (f) Turbine engine fuel systems. Each turbine engine fuel system must provide at least 100% of the fuel flow required by the engine under each intended operation condition and manoeuvre. The conditions may be simulated in a suitable mock-up. This flow must (1) Be shown with the UAV in the most adverse fuel feed condition (with respect to altitudes, attitudes and other conditions) that is expected in operation; and (2) For multi-engine UAV, notwithstanding the lower flow rate allowed by sub-paragraph (d), be automatically uninterrupted with respect to any engine until all the fuel scheduled for use by that engine has been consumed. In addition, (i) For the purposes of this paragraph, "fuel scheduled for the use by that engine" means all fuel in any tank intended for use by a specific engine. (ii) The fuel system design must clearly indicate the engine for which fuel in any tank is scheduled. (iii) Compliance with this paragraph must require no UAV crew action after completion of the engine starting phase of operations. (3) For single engine UAV, require no UAV crew action after completion of the engine starting phase of operations unless means are provided that unmistakenly alert the UAV crew to take any needed action at least five minutes prior to the needed action; such UAV crew action must not cause any change in engine operation; and such UAV crew action must not distract UAV crew attention from essential flight duties during any phase of operations for which the UAV is approved.

957	USAR.957 Flow between interconnected tanks (a) It must be impossible, in a gravity feed system with interconnected tank outlets, for enough fuel to flow between the tanks to cause an overflow of fuel from any tank vent under the conditions in USAR.959, except that full tanks must be used. (b) If fuel can be pumped from one tank to another in flight, the fuel tank vents and the fuel transfer system must be designed so that no structural damage to any UAV component can occur because of overfilling of any tank.
959	USAR.959 Unusable fuel supply See AMC.959 (a) (a) The unusable fuel supply for each tank must be established as not less than that quantity at which the first evidence of malfunctioning occurs under the most adverse fuel feed condition occurring under each intended operation and flight manoeuvre involving that tank. Fuel system component failures need not be considered. (b) In addition, the effect on the unusable fuel quantity as a result of a failure of any pump must be determined.
961	USAR.961 Fuel system hot weather operation See AMC.961 (a) Each fuel system must be free from vapour lock when using fuel at its critical temperature, with respect to vapour formation, when operating the UAV in all critical operating and environmental conditions (including ambient pressure) for which approval is requested. (b) For turbine fuel, the initial temperature must be 43°C, -0°C, + 2.7°C (110°F, -0°F, +5°F) or the maximum outside air temperature for which approval is requested, whichever is more critical.
963	USAR.963 Fuel tanks: general (a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid and structural loads that it may be subjected to in operation. (b) Each flexible fuel tank liner must be shown to be suitable for the particular application. (c) Each integral fuel tank must have adequate facilities for interior inspection and repair. (d) The total usable capacity of the fuel tanks must be enough for at least ½ hour of operation at maximum continuous power or thrust. (e) Each fuel quantity indicator must be adjusted, as specified USAR.1729 (b), to account for the unusable fuel supply determined under USAR.959 (a).
965	USAR.965 Fuel tank tests (a) Each fuel tank must be able to withstand the following pressures without failure or leakage: (1) For each conventional metal tank and non-metallic tank with walls not supported by the UAV structure, a pressure of 24 kPa (3.5 psig), or that pressure developed during maximum ultimate acceleration with a full tank, whichever is greater. (2) For each integral tank, the pressure developed during the maximum limit acceleration of the UAV with a full tank, with simultaneous application of the critical limit structural loads. (3) For each non-metallic tank with walls supported by the UAV structure and constructed in an acceptable manner using acceptable basic tank material and with actual or simulated support conditions, a pressure of 14 kPa (2 psig) for the first tank of a specific design. The supporting structure must be designed for the critical loads occurring in the flight or landing strength conditions

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combined with the fuel pressure loads resulting from the corresponding accelerations.

(b) Each fuel tank with large, unsupported, or unstiffened flat surfaces, whose failure or deformation could cause fuel leakage, must be able to withstand the following test without leakage, failure or excessive deformation of the tank walls:

(1) Each complete tank assembly and its support must be vibration tested while mounted to simulate the actual installation.

(2) Except as specified in sub-paragraph (b) (4) , the tank assembly must be vibrated for 25 hours (or the maximum UAV endurance for which certification is requested if more than 25 hours) at a total displacement of not less than 0.8 of a mm (1/32 in) (unless another displacement is substantiated) while 2/3 filled with water or other suitable test fluid.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any rpm within the normal operating range of engine or propeller speeds is critical, the test frequency of vibration is the number of cycles per minute obtained by multiplying the maximum continuous propeller speed in rpm by 0.9 for propeller-driven UAV, except that for non-propeller driven UAV, the test frequency of vibration is 2 000 cycles per minute.

(ii) If only one frequency of vibration resulting from any rpm within the normal operating range of engine or propeller speeds is critical, that frequency must be the test frequency.

(iii) If more than one frequency of vibration resulting from any rpm within the normal operating range of engine or propeller speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under sub-paragraph (3) (ii) and (iii), the time of test must be adjusted to accomplish the same number of vibration cycles that would be accomplished in 25 hours (or the maximum UAV endurance for which certification is requested if more than 25 hours) at the frequency specified in sub-paragraph (b) (3) (i) .

(5) During the test, the tank assembly must be rocked at a rate of 16 to 20 complete cycles per minute, through an angle of 15° on either side of the horizontal (30° total), about an axis parallel to the axis of the fuselage, for 25 hours (or the maximum UAV endurance for which certification is requested if more than 25 hours).

(c) Each integral tank using methods of construction and sealing not previously proven to be adequate by test data or service experience must be able to withstand the vibration test specified in sub-paragraphs (1) to (4) of paragraph (b).

(d) Each tank with a non-metallic liner must be subjected to the sloshing test outlined in sub-paragraph (5) of paragraph (b), with the fuel at room temperature. In addition, a specimen liner of the same basic construction as that to be used in the UAV must, when installed in a suitable test tank, withstand the sloshing test with fuel at a temperature of 43°C (110°F).
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<tr><td>967</td><td>
USAR.967 Fuel tank installation

See AMC.967

(a) Each fuel tank must be supported so that tank loads are not concentrated. In addition

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports;

(2) Padding must be non-absorbent or treated to prevent the absorption of fuel;

(3) If a flexible tank liner is used, it must be supported so that it is not required to withstand fluid loads;
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	(4) Interior surfaces adjacent to the liner must be smooth and free from projections that could cause wear, unless (i) Provisions are made for protection of the liner at those points; or (ii) The construction of the liner itself provides such protection. (5) A positive pressure must be maintained within the vapour space of each bladder cell under all conditions of operation except for a particular condition for which it is shown that a zero or negative pressure will not cause the bladder cell to collapse; and (6) Siphoning of fuel (other than minor spillage) or collapse of bladder fuel cells may not result from improper securing or loss of the fuel filler cap. (b) Each tank compartment must be able to be ventilated and drained to prevent the accumulation of flammable fluids or vapours. Each compartment adjacent to a tank that is an integral part of the UAV structure must also be ventilated and drained. (c) No fuel tank may be on the engine side of the firewall. There must be at least 13 mm (½ in) of clearance between the fuel tank and the firewall. No part of the engine nacelle skin that lies immediately behind a major air opening from the engine compartment may act as the wall of an integral tank. (d) Not applicable (e) Fuel tanks must be designed, located and installed so as to retain fuel, (1) In consistency with safety objectives as stated in AMC.1309 regarding forced landing conditions, and, (2) Except where a UAV is designed to be recovered by parachute under conditions likely to occur when the UAV lands on a paved runway at a normal landing speed under each of the following conditions: (i) The UAV in a normal landing attitude and its landing gear retracted. (ii) The most critical landing gear leg collapsed and the other landing gear legs extended. In showing compliance with sub-paragraph (e) (2), the tearing away of an engine mount must be considered unless all the engines are installed above the wing or on the tail or fuselage of the UAV. (3) Where a UAV is designed to be recovered by parachute, so as to retain fuel under conditions likely to occur at the impact on the ground under following conditions (i) The UAV in a normal landing attitude and its shock absorber cushions not inflated, (ii) The most critical shock absorber cushions configuration taking into account inflated and non inflated cushions. (4) Where a UAV is designed for rocket assisted take-off or catapult assisted take-off, so as to retain fuel under conditions likely to occur on the launch ramp and during the initial takeoff phase.
969	USAR.969 Fuel tank expansion space Each fuel tank must have an expansion space of not less than 2% of the tank capacity, unless the tank vent discharges clear of the UAV (in which case no expansion space is required). It must be impossible to fill the expansion space inadvertently with the UAV in the normal ground attitude.

971	USAR.971 Fuel tank sump (a) Where appropriate, each fuel tank must have a drainable sump with an effective capacity, in the normal ground and flight attitudes, of 0.25% of the tank capacity, or 0.24 litres (0.05 Imperial gallon/ 1/16 US-gallon), whichever is greater. (b) Each fuel tank must allow drainage of any Hazardous quantity of water from any part of the tank to its sump with the UAV in the normal ground attitude. (c) Where required by the Certifying Authority, each reciprocating engine fuel system must have a sediment bowl or chamber that is accessible for drainage; has a capacity of 30 cm3 (1 fl oz) for every 75.7 litres (16.7 Imperial gallon/20 US-gallon) of fuel tank capacity; and each fuel tank outlet is located so that, in the normal flight attitude, water will drain from all parts of the tank except the sump to the sediment bowl or chamber. (d) Each sump, sediment bowl and sediment chamber drain required by sub-paragraphs (a), (b) and (c) must comply with the drain provisions of USAR.999 (b) (1) and (2).
973	USAR.973 Fuel tank filler connection See AMC.973 (a) Each fuel tank filler connection must be marked as prescribed in USAR.1557 (c). (b) Spilled fuel must be prevented from entering the fuel tank compartment or any part of the UAV other than the tank itself. (c) Each filler cap must provide a fuel-tight seal for the main filler opening. However, there may be small openings in the fuel tank cap for venting purposes or for the purpose of allowing passage of a fuel gauge through the cap provided such openings comply with the requirements of USAR.975 (a). (d) There must be a means to insure that there is no electrical potential difference between the fuel filling points (except the pressure fuelling connection points) and the ground fuel equipment. (e) For UAV with engines requiring gasoline as the only permissible fuel, the inside diameter of the fuel filler opening must be no larger than 60 mm (2.36 in). (f) For UAV with turbine engines, the inside diameter of the fuel filler opening must be no smaller than 75 mm (2.95 in).
975	USAR.975 Fuel tank vents and carburettor vapour vents See AMC.975 (a) Each fuel tank must be vented from the top part of the expansion space. In addition (1) Each vent outlet must be located and constructed in a manner that minimises the possibility of it being obstructed by ice or other foreign matter; (2) Each vent must be constructed to prevent siphoning of fuel during normal operation; (3) The venting capacity must allow the rapid relief of excessive differences of pressure between the interior and exterior of the tank; (4) Airspaces of tanks with interconnected outlets must be inter-connected; (5) There may be no points in any vent line where moisture can accumulate with the UAV in either the ground or level flight attitudes unless drainage is provided . (6) No vent may terminate at a point where the discharge of fuel from the vent outlet will constitute a fire hazard ; and

	(7) Vents must be arranged to prevent the loss of fuel, except fuel discharged because of thermal expansion, when the UAV is parked in any direction on a ramp having a 1% slope and when the UAV is on the launching ramp or catapult for the UAV designed for rocket assisted or catapult assisted take-off. (8) Vents must be arranged to prevent re-ingestion of vented fuel or fuel vapours back into the UAV. (b) Each carburettor with vapour elimination connections and each fuel injection engine employing vapour return provisions must have a separate vent line to lead vapours back to the top of one of the fuel tanks. If there is more than one tank and it is necessary to use these tanks in a definite sequence for any reason, the vapour vent line must lead back to the fuel tank to be used first, unless the relative capacities of the tanks are such that return to another tank is preferable. (c) Not applicable
977	USAR.977 Fuel tank outlet (a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must (1) For reciprocating engine-powered UAV, have appropriate mesh density; and (2) For turbine engine-powered UAV, prevent the passage of any object that could restrict fuel flow, damage any fuel system component or result in loss of power. (b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line. (c) The diameter of each strainer must be at least that of the fuel tank outlet. (d) Each strainer must be accessible for inspection and cleaning.
979	USAR.979 Pressure fuelling systems For pressure fuelling systems, the following applies: (a) Each pressure fuelling system fuel manifold connection must have means to prevent the escape of hazardous quantities of fuel from the system if the fuel entry valve fails. (b) An automatic shut-off means must be provided to prevent the quantity of fuel in each tank from exceeding the maximum quantity approved for that tank. This means must allow checking for proper shut-off operation before each fuelling of the tank; (c) A means must be provided to prevent damage to the fuel system in the event of failure of the automatic shut-off means prescribed in sub-paragraph (b). (d) All parts of the fuel system up to the tank which are subjected to fuelling pressures must have a proof pressure of 1.33 times and an ultimate pressure of at least 2.0 times, the surge pressure likely to occur during fuelling.
FUEL SYSTEM COMPONENTS	
991	USAR.991 Fuel pumps (a) Main pumps. For main pumps, the following apply: (1) For reciprocating engine installations having fuel pumps to supply fuel to the engine, at least one pump for each engine must meet USAR.955. This pump is a main pump. (2) For turbine engine installations, each fuel pump required for proper engine operation, or required to meet the fuel system requirements of this subpart (other than those in sub-paragraph (b)), is a main pump. In addition

	(i) There must be at least one main pump for each turbine engine; (ii) The power supply for the main pump for each engine must be independent of the power supply for each main pump for any other engine; and (iii) For each main pump, provision must be made to allow the by-pass of each positive displacement fuel pump other than a fuel injection pump approved as part of the engine. (b) Emergency pumps. There must be an emergency pump immediately available to supply fuel to the engine if any main pump (other than a fuel injection pump approved as part of an engine) fails. The power supply for each emergency pump must be independent of the power supply for each corresponding main pump. (c) Not applicable in this subpart (see USAR.1797 Fuel pumps warning) (d) Operation of any fuel pump may not affect engine operation so as to create a hazard, regardless of the engine power or thrust setting or the functional status of any other fuel pump, except for jet engines fitted with an afterburning system, where an emergency pump is limited to engine dry operation.
993	USAR.993 Fuel system lines and fittings See AMC.993 (a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure and accelerated flight conditions. (b) Each fuel line connected to components of the UAV between which relative motion could exist must have provisions for flexibility. (c) Each flexible connection in fuel lines that may be under pressure and subjected to axial loading must use flexible hose assemblies. (d) Each flexible hose must be shown to be suitable for the particular application. (e) No flexible hose that is shown to be adversely affected by exposure to high temperatures may be used where excessive temperatures will exist during operation or after shut-down of an engine or auxiliary power unit. (f) Fuel system fittings shall be designed to prevent degradation caused by electrical potentials developed by dissimilar metals.
994	USAR.994 Fuel system components Fuel system components in an engine nacelle or in the fuselage shall be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway in accordance with safety objectives as stated in AMC.1309 regarding forced landing conditions.
995	USAR.995 Fuel valves and controls See AMC.995 (see also USAR.1743 Fuel controls) (a) There must be a means on board, commanded from the UCS, to allow UAV crew to rapidly shut off, in flight, the fuel to each engine individually. (b) No shut-off valve, if present, may be on the engine side of any firewall. (c) Each valve and fuel system control must be supported so that loads resulting from its operation or from accelerated flight conditions are not transmitted to the lines connected to the valve.

	(d) Each valve and fuel system control must be installed so that gravity and vibration will not affect the selected position. (e) Each fuel valve handle and its connections to the valve mechanism must have design features that minimise the possibility of incorrect installation. (f) Each valve must be constructed, or otherwise incorporate provisions, to preclude incorrect assembly or connection of the valve. (g) If fuel tanks valves are installed on the UAV for ground procedures purpose, these fuel tank selector valves must (1) Require a separate and distinct action to place the selector in the “OFF” position; and (2) Have the tank selector positions located in such a manner that it is impossible for the selector to pass through the “OFF” position when changing from one tank to another.
997	USAR.997 Fuel strainer or filter See AMC.997 There must be a fuel strainer or filter between the fuel tank outlet and the inlet of either the fuel metering device or an engine driven positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must (a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable; (b) Have a sediment trap and drain except that it need not have a drain if the strainer or filter is easily removable for drain purposes; (c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself, unless adequate strength margins under all loading conditions are provided in the lines and connections; and (d) Have the capacity (with respect to operating limitations established for the engine) to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine during its type certification. (e) Not applicable
999	USAR.999 Fuel system drains See AMC.999 (a) There must be at least one drain to allow safe drainage of the entire fuel system with the UAV in its normal ground attitude. (b) Each drain required by sub-paragraph (a) and USAR.971 must (1) Discharge clear of all parts of the UAV; (2) Have a drain valve (i) That has manual or automatic means for positive locking in the closed position; (ii) That is readily accessible; (iii) That can be easily opened and closed;

	(iv) That allows the fuel to be caught for examination; (v) That can be observed for proper closing; and (vi) That is either located or protected to prevent fuel spillage in the event of a landing with landing gear retracted, for UAV incorporating a rectractable landing gear.
1001	USAR.1001 Fuel jettisoning system (a) If the design landing weight is less than that permitted under the requirements of USAR.473 (b), the UAV must have a fuel jettisoning system installed that is able to jettison enough fuel to bring the maximum weight down to the design landing weight. The average rate of fuel jettisoning must be at least 1% of the maximum weight per minute, except that the time required to jettison the fuel need not be less than 10 minutes. (b) Fuel jettisoning must be demonstrated at maximum weight with flaps and landing gear up and in (1) A power-off glide at 1.4 V_{S1}; and (2) A climb, at the speed at which one engine in-operative en-route climb data has been established in accordance with USAR.69 (b), with the critical engine inoperative and the remaining engine at maximum continuous power or thrust; and (3) Level flight at 1.4 V_{S1}, if the results of the tests in the conditions specified in sub-paragraphs (1) and (2) show that this condition could be critical. (c) During the flight tests prescribed in sub-paragraph (b), it must be shown that (1) The fuel jettisoning system and its operation are free from fire hazard; (2) The fuel discharges clear of any part of the UAV; (3) Fuel or fumes do not enter any parts of the UAV; and (4) The jettisoning operation does not adversely affect the controllability of the UAV. (d) For reciprocating engine powered UAV, the jettisoning system must be designed so that it is not possible to jettison the fuel in the tanks used for take-off and landing below the level allowing 45 minutes flight at 75% maximum continuous power or thrust. However, if there is an auxiliary control independent of the main jettisoning control, the system may be designed to jettison all the fuel. (e) For turbine engine-powered UAV, the jettisoning system must be designed so that it is not possible to jettison fuel in the tanks used for take-off and landing below the level allowing climb from sea level to 3048 m (10 000 ft) and thereafter allowing 45 minutes cruise at a speed for maximum range. (f) Not applicable in this subpart (see USAR.1745 Fuel jettisonning control) (g) Not applicable in this subpart (see USAR.1745 Fuel jettisonning control) (h) The fuel jettisoning system must be designed so that any reasonably probable single malfunction in the system will not result in a hazardous condition due to unsymmetrical jettisoning of, or inability to jettison, fuel. (i) Fuel jettisoning must be performed by the UAV crew. Nevertheless, in case of total loss of data link, automatic procedures of fuel jettisoning must be assessed according to safety objectives stated in USAR.1309.

OIL SYSTEM

1011	USAR.1011 General See AMC.1011 (b) (a) For oil systems and components that have been approved under the engine airworthiness requirements and where those requirements are equal to or more severe than the corresponding requirements of subpart E of USAR, that approval need not be duplicated. Where the requirements of subpart E of USAR are more severe, substantiation must be shown to the requirements of subpart E. (b) Each engine and auxiliary power unit must have an independent oil system that can supply it with an appropriate quantity of oil at a temperature not above that safe for continuous operation. (c) The usable oil tank capacity may not be less than the product of the endurance of the UAV under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to ensure adequate circulation and cooling. (d) For an oil system without an oil transfer system, only the usable oil tank capacity may be considered. The amount of oil in the engine oil lines, the oil radiator and the feathering reserve, may not be considered. (e) If an oil transfer system is used and the transfer pump can pump some of the oil in the transfer lines into the main engine oil tanks, the amount of oil in these lines that can be pumped by the transfer pump may be included in the oil capacity. (f) Where engine lubrication is based on a fuel/oil mixture, an appropriate and reliable means for providing it must be substantiated under any combination of environmental conditions.
1013	USAR.1013 Oil tanks (a) Installation. Each oil tank must be installed to (1) Meet the requirements of USAR.967 (a) and (b); and (2) Withstand any vibration, inertia and fluid loads expected in operation. (b) Expansion space. Oil tank expansion space must be provided so that (1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10% of the tank capacity or 1.9 litres (0.42 Imperial gallon/0.5 US-gallon) and each oil tank used with a turbine engine has an expansion space of not less than 10% of the tank capacity; and (2) It is impossible to fill the expansion space inadvertently with the UAV in the normal ground attitude. (c) Filler connection. Each oil tank filler connection must be marked as specified in USAR.1557 (c). Each recessed oil tank filler connection of an oil tank used with a turbine engine, that can retain any appreciable quantity of oil, must have provisions for fitting a drain. (d) Vent. Oil tanks must be vented as follows: (1) Each oil tank must be vented to the engine from the top part of the expansion space so that the vent connection is not covered by oil under any normal flight condition. (2) Oil tank vents must be arranged so that condensed water vapour that might freeze and obstruct the line cannot accumulate at any point. (3) Not applicable

	(e) Outlet. No oil tank outlet may be enclosed by any screen or guard that would reduce the flow of oil below a safe value at any operating temperature. No oil tank outlet diameter may be less than the diameter of the engine oil pump inlet. Each oil tank used with a turbine engine must have means to prevent entrance into the tank itself, or into the tank outlet, of any object that might obstruct the flow of oil through the system. There must be a shut-off valve at the outlet of each oil tank used with a turbine engine, unless the external portion of the oil system (including oil tank supports) is fire-proof. (f) Flexible liners. Each flexible oil tank liner must be of an acceptable kind. (g) Each oil tank filler cap of an oil tank that is used with an engine must provide an oil tight seal.
1015	USAR.1015 Oil tank tests Each oil tank must be tested under USAR.965, except that (a) The applied pressure must be 34 kPa (5 psig) for the tank construction instead of the pressures specified in USAR.965 (a). (b) For a tank with a non-metallic liner the test fluid must be oil rather than fuel as specified in USAR.965 (d) and the slosh test on a specimen liner must be conducted with the oil at 121°C (250°F); and (c) For pressurised tanks used with a turbine engine, the test pressure may not be less than 34 kPa (5 psig) plus the maximum operating pressure of the tank.
1017	USAR.1017 Oil lines and fittings (a) Oil lines. Oil lines must meet USAR.993 and must accommodate a flow of oil at a rate and pressure adequate for proper engine functioning under any normal operating conditions. (b) Breather lines. Breather lines must be arranged so that (1) Condensed water vapour or oil that might freeze and obstruct the line cannot accumulate at any point; (2) The breather discharge will not constitute a fire hazard if foaming occurs, or cause emitted oil to pollute critical sensors in terms of flight safety. (3) The breather does not discharge into the engine air induction system; (4) Not applicable (5) The breather outlet is protected against blockage by ice or foreign matter. (c) Oil system fittings shall be designed to prevent degradation caused by electrical potentials developed by dissimilar metals.
1019	USAR.1019 Oil strainer or filter (a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements: (1) Each oil strainer or filter that has a by-pass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked. (2) The oil strainer or filter must have the capacity (with respect to operating limitations established for the engine) to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine for its type certification. (3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate a means to indicate contamination before it reaches the capacity established in accordance with sub-paragraph (2)

	(4) The by-pass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimised by appropriate location of the by-pass to ensure that collected contaminants are not in the bypass flow path. (5) An oil strainer or filter that has no by-pass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in USAR.1725 (c). (b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.
1021	USAR.1021 Oil system drains A drain or drains must be provided to allow safe drainage of the oil system. Each drain must (a) Be accessible; (b) Have drain valves, or other closures, employing manual or automatic shut-off means for positive locking in the closed position; and (c) Be located or protected to prevent inadvertent operation.
1023	USAR.1023 Oil radiators Each oil radiator and its supporting structures must be able to withstand the vibration, inertia and oil pressure loads to which it would be subjected in operation.
1027	USAR.1027 Propeller feathering system (a) If the propeller feathering system uses engine oil and that oil supply can become depleted due to failure of any part of the oil system, a means must be incorporated to reserve enough oil to operate the feathering system. (b) The amount of reserved oil must be enough to accomplish feathering and must be available only to the feathering pump. (c) The ability of the system to accomplish feathering with the reserved oil must be shown. (d) Provision must be made to prevent sludge or other foreign matter from affecting the safe operation of the propeller feathering system.
<u>COOLING</u>	
1041	USAR.1041 General (a) The powerplant and auxiliary power unit cooling provisions must maintain the temperatures of : (1) powerplant components (2) engine fluids (3) auxiliary power unit components and fluids within the limits established for those components, and, (4) fluids under the most adverse ground, waterand flight operations to the maximum altitude and maximum ambient atmospheric temperature conditions for which approval is requested, and after normal engine and auxiliary power unit shutdown.

	(b) In the event of failure of the normal mode of cooling, an alternative method of cooling shall be provided for safety of flight critical components, if required. (c) Pressurized components of cooling systems must have appropriate proof and burst testing.
1043	USAR.1043 Cooling tests (a) General. Compliance with USAR.1041 must be shown on the basis of tests, for which the following apply: (1) If the tests are conducted under ambient atmospheric temperature conditions deviating from the maximum for which approval is requested, the recorded powerplant temperatures must be corrected under sub-paragraphs (c) and (d) , unless a more rational correction method is applicable. (2) Corrected temperatures determined under sub-paragraph (a) (1) must not exceed established limits. (3) The fuel used during the cooling tests must be of the minimum grade approved for the engine(s). (4) For turbocharged engines, each turbocharger must be operated through that part of the climb profile for which operation with the turbocharger is requested. (5) For reciprocating engines with manual mixture control, the mixture settings must be the leanest recommended for climb. (b) Maximum ambient atmospheric temperature. A maximum ambient atmospheric temperature corresponding to sea-level conditions of at least the intended maximum operating ambient temperature plus 5°C. The Applicant may select a maximum ambient atmospheric temperature corresponding to sealevel conditions of less than 38°C (100°F). (c) Correction factor (except cylinder barrels). Temperatures of engine fluids and powerplant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature for the relevant altitude for which approval has been requested and the temperature of the ambient air at the time of the first occurrence of the maximum fluid or component temperature recorded during the cooling test. (d) Correction factor for cylinder barrel temperatures. Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature for the relevant altitude for which approval has been requested and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.
1045	USAR.1045 Cooling test procedures for turbine engine-powered UAV See AMC.1045 and AMC.1045 (b) (a) Compliance with USAR.1041 must be shown for all phases of operation. The UAV must be flown in the configurations, at the speeds and following the procedures recommended in the UAV System Flight Manual for the relevant stage of flight, corresponding to the applicable performance requirements, which are critical relative to cooling. (b) Temperatures must be stabilised under the conditions from which entry is made into each stage of flight being investigated, unless the entry condition normally is not one during which component and engine fluid temperatures would stabilise (in which case, operation through the full entry condition must be conducted before entry into the stage of flight being investigated in order to allow temperatures to reach their natural levels at the time of entry). The take-off cooling test must be preceded by a period during which the powerplant component and engine fluid temperatures are stabilised with the engines at ground idle. (c) Cooling tests for each stage of flight must be continued until (1) The component and engine fluid temperatures stabilise; or

	(2) The stage of flight is completed; or (3) An operating limitation is reached.
1047	USAR.1047 Cooling test procedures for reciprocating engine-powered UAV See AMC.1047 Compliance with USAR.1041 must be shown for the climb (or descent, for multi-engined UAV with negative one-engine-inoperative rates of climb) stage of flight. The UAV must be flown in the configurations, at the speeds and following the procedures recommended in the UAV System Flight Manual, corresponding to the applicable performance requirements, which are critical relative to cooling.
LIQUID COOLING	
1061	USAR.1061 Installation (a) General. Each liquid-cooled engine must have an independent cooling system (including coolant tank) installed so that: (1) Each coolant tank is supported so that tank loads are distributed over a large part of the tank surface; (2) There are pads or other isolation means between the tank and its supports to prevent chafing; and (3) Pads or any other isolation means that is used must be non-absorbent or must be treated to prevent absorption of flammable fluids; and (4) No air or vapour can be trapped in any part of the system, except the coolant tank expansion space, during filling or during operation. (b) Coolant tank. The tank capacity must be at least 3.8 litres (0.83 Imperial gallon/1 USgallon), plus 10% of the cooling system capacity. The Applicant may apply for a lower tank capacity on the basis of a rational analysis taking into account the cooling provisions for the engine. In addition (1) Each coolant tank must be able to withstand the vibration, inertia and fluid loads to which it may be subjected in operation; (2) Each coolant tank must have an expansion space of at least 10% of the total cooling system capacity; and (3) It must be impossible to fill the expansion space inadvertently with the UAV in the normal ground attitude. (c) Filler connection. Each coolant tank filler connection must be marked as specified in USAR.1557 (c). In addition (1) Spilled coolant must be prevented from entering the coolant tank compartment or any part of the UAV other than the tank itself; and (2) Each recessed coolant filler connection must have a drain that discharges clear of the entire UAV. (d) Lines and fittings. Each coolant system line and fitting must meet the requirements of USAR.993, except that the inside diameter of the engine coolant inlet and outlet lines may not be less than the diameter of the corresponding engine inlet and outlet connections. (e) Radiators. Each coolant radiator must be able to withstand any vibration, inertia and coolant pressure load to which it may normally be subjected. In addition

	(1) Each radiator must be supported to allow expansion due to operating temperatures and prevent the transmittal of harmful vibration to the radiator; and (2) If flammable coolant is used, the air intake duct to the coolant radiator must be located so that (in case of fire) flames from the nacelle cannot strike the radiator. (f) Drains. There must be an accessible drain that (1) Drains the entire cooling system (including the coolant tank, radiator and the engine) when the UAV is in the normal ground attitude; (2) Discharges clear of the entire UAV; and (3) Has means to positively lock it closed.
1063	USAR.1063 Coolant tank tests Each coolant tank must be tested under USAR.965, except that (a) The test required by USAR.965 (a) (1) must be replaced with a similar test using the sum of the pressure developed during the maximum ultimate acceleration with a full tank or a pressure of 24 kPa (3.5 psig), whichever is greater, plus the maximum working pressure of the system; and (b) For a tank with a non-metallic liner the test fluid must be coolant rather than fuel as specified in USAR.965 (c) and the slosh test on a specimen liner must be conducted with the coolant at operating temperature.
INDUCTION SYSTEM	
1091	USAR.1091 Air induction system See AMC.1091 (a) The air induction system for each engine and auxiliary power unit and their accessories must supply the air required by that engine and auxiliary power unit under the operating conditions for which certification is requested. (b) Each reciprocating engine installation must be shown to have adequate air intake sources and must meet the following: (1) Primary air intakes may open within the cowling if that part of the cowling is isolated from the engine accessory section by a fire-resistant diaphragm or if there are means to prevent the emergence of backfire flames. (2) Each alternate air intake (if applicable) must be located in a sheltered position and may not open within the cowling if the emergence of backfire flames will result in a hazard. (3) The supplying of air to the engine through the alternate air intake (if applicable) system may not result in a loss of excessive power or thrust in addition to the power loss due to the rise in air temperature. (4) Not applicable in this subpart (see USAR.1747 Air induction control) (5) Not applicable in this subpart (see USAR.1799 Air induction indicator) (c) For turbine engine-powered UAV (1) There must be means to prevent hazardous quantities of fuel leakage or overflow from drains, vents or other components of flammable fluid systems from entering the engine or auxiliary power unit and their accessories intake system; and

	(2) The UAV must be designed to prevent water or slush on the runway, taxi way, or other airfield operating surfaces from being directed into the engine or auxiliary power unit air intake ducts in hazardous quantities, and the air intake ducts must be located or protected so as to minimise the ingestion of foreign matter during take-off, landing and taxiing. (3) The air inlet system must not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine or instability that would result in surge, flameout, or instability greater than that allowed by the engine specification, in line with USAR.939 (c).
1093	USAR.1093 Induction system icing protection See AMC.1093 and AMC.1093 (b) (a) Reciprocating engines. Each reciprocating engine air induction system must have means to prevent and eliminate icing. Unless this is done by other means, it must be shown that, in air free of visible moisture at a temperature of -1°C (30°F) (1) Each UAV with sea-level engines using conventional venturi carburettors has a preheater that can provide a heat rise of 50°C (90°F) with the engines at 75% of maximum continuous power or thrust; (2) Each UAV with altitude engines using conventional venturi carburettors has a preheater that can provide a heat rise of 67°C (120°F) with the engines at 75% of maximum continuous power or thrust; (3) Each UAV with altitude engines using carburettors tending to prevent icing has a preheater that, with the engines at 60% of maximum continuous power or thrust, can provide a heat rise of (i) 56°C (100°F); or (ii) 22°C (40°F), if a fluid de-icing system meeting the requirements of USAR.1095 to USAR.1099 is installed; (4) Each UAV with sea level engine(s) using fuel metering device tending to prevent icing has a sheltered alternate source of air with a preheat of not less than 16°C (60°F) with the engines at 75 percent of maximum continuous power; (5) Each UAV with sea level or altitude engine(s) using fuel injection systems having metering components on which impact ice may accumulate has a preheater capable of providing a heat rise of 42° C (75 °F) when the engine is operating at 75 percent of its maximum continuous power; (6) Each UAV with sea level or altitude engine(s) using fuel injection systems not having fuel metering components projecting into the airstream on which ice may form, and introducing fuel into the air induction system downstream of any components or other obstruction on which ice produced by fuel evaporation may form, has a sheltered alternate source of air with a preheat of not less than 16ºC (60ºF) with the engines at 75 percent of its maximum continuous power or thrust. (b) Turbine engines (1) Each turbine engine and its air inlet system must operate throughout the flight power range of the engine (including idling), without the accumulation of ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power or thrust (i) Under the icing conditions specified by the Certifying Authority; and (ii) In snow, both falling and blowing, within the limitations established for the UAV for such operation. (2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between -9° and -1°C (between 15° and 30°F) and has a liquid water content not less than

	0.3 grams per cubic metre in the form of drops having a mean effective diameter not less than 20 microns, followed by momentary operation at take-off power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Certifying Authority. (c) Reciprocating engines with superchargers. For UAV with reciprocating engines having superchargers to pressurise the air before it enters the carburettor, the heat rise in the air caused by that supercharging at any altitude may be utilised in determining compliance with sub-paragraph (a) if the heat rise utilised is that which will be available, automatically, for the applicable altitudes and operating condition because of supercharging.
1095	USAR.1095 Carburettor de-icing fluid flow rate See AMC.1095 (a) If a carburettor de-icing fluid system is used, (a) It must be able to simultaneously supply each engine with a rate of fluid flow as agreed by the Certifying Authority. (b) The fluid must be introduced into the air induction system (1) Close to, and upstream of, the carburettor; and (2) So that it is equally distributed over the entire cross section of the induction system air passages.
1097	USAR.1097 Carburettor de-icing fluid system capacity (a) The capacity of each carburettor de-icing fluid system (1) May not be less than the greater of (i) That required to provide fluid at the rate specified in USAR.1095 for a time equal to 3% of the maximum endurance of the UAV; or (ii) 20 minutes at that flow rate; and (2) Need not exceed that required for a duration of operations as agreed with the Certifying Authority. (b) If the available preheat increases the temperature of more than 28°C (50°F) but less than 56°C (100°F), the capacity of the system may be decreased in proportion to the heat rise available in excess of 28°C (50°F).
1099	USAR.1099 Carburettor de-icing fluid system detail design Each carburettor de-icing fluid system must meet the applicable requirements for the design of a fuel system, except as specified in USAR.1095 and USAR.1097.
1101	USAR.1101 Induction air preheater design Each exhaust-heated, induction air preheater must be designed and constructed to (a) Ensure ventilation of the preheater when the induction air preheater is not being used during engine operation. (b) Allow inspection of the exhaust manifold parts that it surrounds; and (c) Allow inspection of critical parts of the preheater itself.
1103	USAR.1103 Induction system ducts (a) Each induction system duct must drain to prevent the accumulation of fuel or moisture in the normal ground and flight attitudes. No drain may discharge where it will cause a fire hazard.

	(b) Each duct connected to components between which relative motion could exist must have means for flexibility. (c) Each flexible induction system duct must be capable of withstanding the effects of temperature extremes, fuel, oil, water, and solvents to which it is expected to be exposed in service and maintenance without hazardous deterioration or delamination. (d) For reciprocating engine installations, each induction system duct must be: (1) Strong enough to prevent induction system failures resulting from normal backfire conditions; and (2) Fire resistant in any compartment for which a fire extinguishing system is required. (e) Each inlet system duct for an auxiliary power unit must be (1) Fireproof within the auxiliary power unit compartment; (2) Fireproof for a sufficient distance upstream of the auxiliary power unit compartment to prevent hot gas reverse flow from burning through the duct and entering any other compartment of the UAV in which a hazard would be created by the entry of the hot gases; (3) Constructed of materials suitable to the environmental conditions expected in service, except in those areas requiring fireproof or fire resistant materials; and (4) Constructed of materials that will not absorb or trap Hazardous quantities of flammable fluids that could be ignited by a surge or reverse-flow condition. (f) Not applicable
1105	USAR.1105 Induction system screens If induction system screens are used on reciprocating engines (a) Each screen must be upstream of the carburettor or fuel injection system; (b) No screen may be in any part of the induction system that is the only passage through which air can reach the engine, unless (1) The available preheat increases the temperature of more than 56°C (100°F); and (2) The screen can be de-iced by heated air; (c) No screen may be de-iced by alcohol alone; and (d) It must be impossible for fuel to strike any screen.
1107	USAR.1107 Induction system filters On reciprocating-engine installations, if an air filter is used to protect the engine against foreign material particles in the induction air supply (a) Each air filter must be capable of withstanding the effects of temperature extremes, rain, fuel, oil, and solvents to which it is expected to be exposed in service and maintenance; and (b) Each air filter must have a design feature to prevent material separated from the filter media from interfering with proper fuel metering operation.
1109	USAR.1107 Turbocharger bleed air system (a) The pressurized air system may not be subject to hazardous contamination following any probable failure of the turbocharger or its lubrication system.

	(b) The turbocharger supply air must be taken from a source where it cannot be contaminated by harmful or hazardous gases or vapours following any probable failure or malfunction of the engine exhaust, hydraulic, fuel, or oil system causing a fire hazard or safety issues for the UAV.
1111	USAR.1111 Turbine engine bleed air system For turbine engine bleed air systems, the following applies: (a) No major or more serious event may result if duct rupture or failure occurs anywhere between the engine port and the UAV unit served by the bleed air. (b) Engine performance degradation shall be quantified as a function of bleed air usage. (c) Not applicable. (d) Adequate compartment ventilation must be provided for cooling hot duct surfaces where the Auto-Ignition Temperature (AIT)of combustible materials is exceeded. (e) Ducts whose surface temperature exceeds the AIT must be insulated such that the outside surface temperature is less than AIT. (f) The design must prohibit combustible fluids from direct impingement on duct surfaces.
<u>EXHAUST SYSTEM</u>	
1121	USAR.1121 General For powerplant and auxiliary power unit installations, the following applies: (a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard (b) Each exhaust system part with a surface hot enough to ignite flammable fluids or vapours must be located or shielded so that leakage from any system carrying flammable fluids or vapours will not result in a fire caused by impingement of the fluids or vapours on any part of the exhaust system including shields for the exhaust system. (c) Each exhaust system must be separated by fireproof shields from adjacent flammable parts of the UAV that are outside of the engine and auxiliary power unit compartment. (d) No exhaust gases may discharge dangerously near any fuel or oil system drain. (e) No exhaust gases may be discharged where they will cause any hazard (1) to critical sensors in terms of flight safety, and, (2) to ground staff necessary for ground operations as stated in the UAV System Flight Manual or in the UAV Maintenance Manual. (f) Each exhaust system component must be ventilated to prevent points of excessively high temperature. (g) If significant traps exist, each turbine engine and auxiliary power unit exhaust system must have drains discharging clear of the UAV, in any normal ground and flight attitude, to prevent fuel accumulation after the failure of an attempted engine or auxiliary power unit start. (h) Each exhaust heat exchanger must incorporate means to prevent blockage of the exhaust port after any internal heat exchanger failure. (1) For the purposes of compliance with USAR.603 the failure of any part of the exhaust system will adversely affect safety.

1123	USAR.1123 Exhaust system For powerplant installations, the following apply: (a) Exhaust piping must be heat and corrosion resistant, and must have provisions to prevent failure due to expansion by operating temperatures. (b) Piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operation; and (c) Piping connected to components between which relative motion could exist must have means for flexibility.
1125	USAR.1125 Exhaust heat exchangers For reciprocating engine-powered UAV, each exhaust heat exchanger must be constructed and installed to withstand the vibration, inertia and other loads that it may be subjected to in normal operation. In addition (1) Each exchanger must be suitable for continued operation at high temperatures and resistant to corrosion from exhaust gases; (2) There must be means for inspection of critical parts of each exchanger. (3) Not applicable.
POWERPLANT CONTROLS AND ACCESSORIES	
1141	USAR.1141 UAV Powerplant controls: general See AMC.1141 (e) (a) Not applicable (b) Each flexible control must be shown to be suitable for the particular application. (c) Each control must be able to maintain any necessary position without tendency to creep due to control loads or vibration. (d) Each control must be able to withstand operating loads without failure or excessive deflection. (e) For turbine engine-powered UAV, no single failure or malfunction in any powerplant control system shall cause a hazardous or more serious event. (f) The portion of each powerplant control located in the engine compartment that is required to be operated in the event of fire must be at least fire resistant. (g) Not applicable in this subpart (see USAR.1803 Powerplant power assisted valve indicator))
	1142 Auxiliary power unit controls Not applicable in this support (see USAR.1751 Engine and APU controls)
1143	USAR1143 Engine controls See AMC.1143 (a) Not applicable in this subpart (see USAR.1751 Engine controls) (b) Not applicable in this subpart (see USAR.1751 Engine controls) (c) Not applicable in this subpart (see USAR.1751 Engine controls) (d) Not applicable in this subpart (see USAR.1751 Engine controls)

	(e) Not applicable in this subpart (see USAR.1751 Engine controls) (f) Not applicable in this subpart (see USAR.1751 Engine controls) (g) For reciprocating single-engine UAV, each power or thrust control must be designed so that if the control separates at the engine fuel metering device, (1) the UAV is capable of continuing safe flight, or, (2) the severity of such a failure mode is not hazardous or more serious.
	1145 Ignition switches Not applicable in this subpart (see USAR.1753 Ignition switches)
1147	USAR.1147 Mixture controls See AMC.1147 (a) Not applicable in this subpart (see USAR.1755 Mixture controls) (b) Each engine mixture control must be designed so that, if the control separates at the engine fuel metering device, the UAV is capable of continuing safe flight.
	1149 Propeller speed and pitch controls Not applicable in this subpart (see USAR.1757 Propeller speed and pitch controls)
	1153 Propeller feathering controls Not applicable in this subpart (see USAR.1759 Propeller feathering controls)
	1155 Turbine engine reverse thrust and propeller pitch settings below the flight regime Not applicable in this subpart (see USAR.1761 Turbine engine reverse thrust and propeller pitch settings below the flight regime)
	1157 Carburettor air temperature controls Not applicable in this subpart (see USAR.1763 Carburettor air temperature controls)
1163	USAR.1163 Powerplant accessories (a) Each engine mounted accessory must (1) Be approved for mounting on the engine involved and use the provisions on the engines for mounting; or (2) Have torque limiting means on all accessory drives in order to prevent the torque limits established for those drives from being exceeded; and (3) In addition to sub-paragraphs (a) (1) or (a) (2), be sealed to prevent contamination of the engine oil system and the accessory system. (b) Electrical equipment subject to arcing or sparking must be installed to minimise the probability of contact with any flammable fluids or vapours that might be present in a free state. (c) Each generator rated at or more than 6 kilowatts must be designed and installed to minimise the probability of a fire hazard in the event it malfunctions. (d) If the continued rotation of any accessory remotely driven by the engine is hazardous when malfunctioning occurs, a means to prevent rotation without interfering with the continued operation of the engine must be provided.

	(e) Each accessory driven by a gearbox that is not approved as part of the powerplant driving the gearbox must (1) Have torque limiting means to prevent the torque limits established for the affected drive from being exceeded; (2) Use the provisions on the gearbox for mounting; and (3) Be sealed to prevent contamination of the gearbox oil system and the accessory system.
1165	USAR.1165 Engine ignition systems Where engine restart capability is required, (a) Each battery ignition system must be supplemented by a generator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted. (b) The capacity of batteries and generators must be large enough to meet the simultaneous demands of the engine ignition system and the greatest demands of any electrical system components that draw from the same source. (c) The design of the engine ignition system must account for (1) The condition of an inoperative generator; (2) The condition of a completely depleted battery with the generator running at its normal operating speed; and (3) The condition of a completely depleted battery with the generator operating at idling speed if there is only one battery. (d) Not applicable in this subpart (see USAR.1801 Engine ignition warning). (e) Each turbine engine ignition system must be independent of any electrical circuit that is not used for assisting, controlling or analysing the operation of that system. (f) Not applicable
<u>POWERPLANT FIRE PROTECTION</u>	
1181	USAR.1181 Designated fire zones; regions included For powerplants, designated fire zones are (a) For reciprocating engines (1) The power section; (2) The accessory section; (3) Any complete powerplant compartment in which there is no isolation between the power section and the accessory section. (b) For turbine engines (1) The compressor and accessory sections; (2) The combustor, turbine and tailpipe sections that contain lines or components carrying flammable fluids or gases.

	(3) Any complete powerplant compartment in which there is no isolation between compressor, accessory, combustor, turbine and tailpipe sections. (c) Any auxiliary power unit compartment; and (d) Any fuel burning heater and other combustion equipment installation.
	1182 Nacelle areas behind firewalls Not applicable.
1183	USAR.1183 Lines, fittings and components (a) Except as provided in sub-paragraph (b), each component, line and fitting carrying flammable fluids, gas or air in any area subject to engine fire conditions must be at least fire resistant, except that flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any nonfireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. Flexible hose assemblies (hose and end fittings) must be shown to be suitable for the particular application. (b) Sub-paragraph (a) does not apply to (1) Lines, fittings and components which are already approved as part of a Type Certificated engine; and (2) Vent and drain lines and their fittings, whose failure will not result in, or add to, a fire hazard.
1189	USAR.1189 Shut-off means See AMC.1189 (a) (5) (a) For each multi-engined UAV the following apply: (1) Each engine installation must have means to shut off or otherwise prevent hazardous quantities of fuel, oil, de-icing fluid and other flammable liquids from flowing into, within, or through any engine compartment, except in lines, fittings and components forming an integral part of an engine. (2) The closing of the fuel shut-off valve for any engine may not make any fuel unavailable to the remaining engine that would be available to that engine with that valve open. (3) Operation of any shut-off means may not interfere with the later emergency operation of other equipment such as propeller feathering devices. (4) Each shut-off must be outside of the engine compartment unless an equal degree of safety is provided with the shut-off inside the compartment. (5) No hazardous amount of flammable fluid may drain into the engine compartment after shut-off . (6) Not applicable in this subpart (see USAR.1765 Shut-off controls) (b) Turbine engine installations need not have an engine oil system shut-off if (1) The oil tank is integral with, or mounted on, the engine; and (2) All oil system components external to the engine are fireproof or located in areas not subject to engine fire conditions. (c) Power-operated valves must be designed so that the valve will not move from the selected position under vibration conditions likely to exist at the valve location (see also USAR.1805 Shut-off valve indicator).

1191	USAR.1191 Firewalls See AMC.1191 (e) (a) Each engine, auxiliary power unit, fuel burning heater and other combustion equipment must be isolated from the rest of the UAV by firewalls, shrouds or equivalent means. (b) Each firewall or shroud must be constructed, so that no hazardous quantity of liquid, gas or flame can pass from that compartment to other parts of the UAV. (c) Each opening in the firewall or shroud must be sealed with close fittings, fireproof grommets, bushings or firewall fittings offering at least as much thermal and flame protection as the firewall itself. (d) Reserved. (e) Each firewall, shroud and firewall fitting must be fireproof and protected against corrosion.
1192	USAR.1192 Engine accessory compartment diaphragm For air-cooled radial engines, the engine power section and all portions of the exhaust system must be isolated from the engine accessory compartment by a diaphragm that meets the firewall requirements of USAR.1191.
1193	USAR.1193 Cowling and nacelle See AMC.1193 (a) Each cowling must be constructed and supported so that it can resist any vibration, inertia and air loads to which it may be subjected in operation. (b) There must be means for rapid and complete drainage of each part of the cowling in the normal ground and flight attitudes. No drain may discharge where it will cause a fire hazard. (c) Cowling must be at least fireproof. (d) Each part around an opening in the engine compartment cowling must be at least fire-resistant for a distance of not less than 61 cm (24 in) from of the opening. (e) Each part of the cowling subjected to high temperatures due to its nearness to exhaust system ports or exhaust gas impingement, must be fireproof. (f) Each nacelle of a multi-engine UAV with turbocharged engines must be designed and constructed so that with the landing gear retracted, a fire in the engine compartment will not burn through a cowling or nacelle and enter a nacelle area other than the engine compartment.
	1195 Fire extinguishing systems Not applicable.
	1197 Fire extinguishing agents Not applicable.
	1199 Extinguishing agent containers Not applicable.
	1201 Fire extinguishing system materials Not applicable.
1203	USAR.1203 Fire detector system A fire detection system must be installed in each designated fire zone, as defined in USAR.1181, and comply with the following:

	(a) Each fire detector system must be constructed and installed to withstand the vibration, inertia and other loads and environmental stresses (salt fog, humidity, dirt, etc.) to which it may be subjected in operation. (b) No fire detector, wiring or components may be adversely affected by any fuel, oil, water, other fluids, or fumes that might be present. (c) There must be means to allow the UAV crew to check, in flight, the functioning of each fire detector electric circuit. (d) The detector, wiring and other components of each fire detection system in a designated fire zone must be at least fire-resistant. (e) The fire detection system must be designed to minimise false warnings or inappropriate warnings and if they occur shall not result in a hazardous or more serious event.

subpart F - EQUIPMENT

	GENERAL
1301	USAR.1301 Function and installation Each item of installed equipment must (a) Be of a kind and design appropriate to its intended function; (b) Be labelled as to its identification, function or operating limitations, or any applicable combination of these factors; (c) Be installed according to limitations specified for that equipment; (d) Function properly when installed.
	1303 Flight and navigation instruments Not applicable in this subpart (see USAR.1723 Flight and navigation data)
	1305 Powerplant instruments Not applicable in this subpart (see USAR.1725 Powerplant data)
U1307	USAR.U1307 Environmental control system (ECS) See AMC.1307 Cooling must be provided for flight critical equipment as required for it to meet its performance and reliability for the intended lifetime. a) The ECS design shall incorporate the system safety requirements of the UAV. b) The ECS shall meet all safety requirements when operating under installed conditions over the design envelope and maintain integration integrity to ensure the UAV safety-of-flight. c) The UAV shall incorporate an alternate means of cooling of safety-critical avionics when the primary ECS is non-operational. d) The ECS design (including emergency equipment and/or auxiliary methods) shall provide an acceptable pressure environment for equipment affecting safety-of-flight. e) Normal and emergency pressurization requirements and status shall be indicated at the UCS. f) Safety-critical items such as flight controls, avionics and communications shall function long enough to safely land the aircraft if ECS function is lost and alternate methods are not available to insure airworthy operations. g) ECS normal and emergency procedures shall be included in the UAV System flight manual. h) Adequate controls and displays for the ECS shall be installed in the UCS or other appropriate locations to allow the ECS to function as intended. Sufficient cautions, warnings, and advisories are provided to alert the UAV crew to problems in time for corrective action to be taken from a safety of flight perspective. i) No single ECS subsystem failure (including UCS functions that are critical to air vehicle flight safety) shall result in loss of UAV. j) Bleed air or other compressed air duct system shall be monitored for leaks and structural integrity. Hot air leaking from damaged ducting shall not cause ignition of any flammable fluids or other materials or cause

	damage to safety-critical equipment. Shutdown capability, with a UCS advisory or warning, shall be provided when a potentially damaging or fire-producing leak occurs. The sensors for the leak detection system shall recover their required leak detection function following exposure to a leak. k) The UAV thermal management system shall be stable for all flight conditions and environments. The mass flow and delivery temperature of cooling medium shall be sufficient for the air vehicle heat loads and provide the necessary thermal stability to ensure safety-of-flight.
1309	USAR.1309 Equipment, systems and installations See AMC.1309 (b) (a) The UAV system must be designed to reduce the risk to people including UAV crew, maintainers and third parties to a level acceptable to the Certifying Authority. It must also be designed to reduce the risk of material loss or damage to a level acceptable to the Certifying Authority. (1) Where any function of a UAV System is essential to, or can prejudice, continued safe flight and landing of the UAV, that function, and the equipment performing the function, (including equipment remote from the UAV), shall be considered as part of the UAV system for the purposes of the validity of the certificate of airworthiness. It must comply with the applicable airworthiness requirements set out in this code and AMC 1309 should be used as guidance. (2) Each item of equipment, each system, and each installation: (i) When performing its intended function, may not adversely affect the response, operation, or accuracy of any: - Equipment essential to safe operation; or - Other equipment unless there is a means to inform the UAV crew of the effect. (ii) Must be designed to prevent hazards to the UAV System in the event of a probable malfunction or failure. (b) The design of each item of equipment, each system, and each installation must be examined separately and in relationship to other systems and installations to determine (1) if the UAV is dependent upon its function for continued safe flight and landing and (2) if failure of a system would significantly reduce the capability of the UAV or the ability of the UAV crew to cope with adverse operating conditions. Each item of identified equipment, system and installations categorised by (1) or (2) must be designed to comply with the following additional requirements: (1) It must perform its intended function under any foreseeable operating condition. (2) When systems and associated components are considered separately and in relation to other systems, the Applicant must prove that there is an acceptable inverse relationship between the probability of occurrence of any failure condition and its severity. (3) Warning information must be provided to alert the UAV crew to unsafe system operating conditions and to enable the UAV crew to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimise UAV crew errors that could create additional hazards. (4) Compliance with the requirements of sub-paragraph (b) (2) may be shown by analysis and, where necessary, by appropriate ground, flight, or simulator test. The analysis must consider (i) Possible modes of failure, including malfunctions and damage from external sources;

(ii) The probability of multiple failures, and the probability of undetected faults;

(iii) The resulting effects on the UAV and third parties, considering the stage of flight and operating conditions; and

(iv) The UAV crew warning cues, corrective action required, and the UAV crew's capability of determining faults.

(c) Each item of equipment, each system, and each installation whose functioning is required for certification and that requires a power supply, is an "essential load" on the power supply. This power supply must not affect the safety of the UAV. The power sources and the system must be able to supply the following power loads in all probable operating combinations and for probable maximum duration:

(1) Loads connected to the power distribution system with the system functioning normally.

(2) Essential loads after failure of

(i) Any one engine on a multi-engine UAV; or

(ii) Any power converter or energy storage device.

(3) Essential loads for which an alternate source of power is required by the operating rules or to enable the desired or specified level of redundancy, after any failure or malfunction in any one power supply system, distribution system, or other utilization system.

(4) Redundant systems shall utilize redundant power sources where possible in order to maintain the desired level of safety (or failure probability) realized by that level of redundancy.

(d) In determining compliance with sub-paragraph (c) (2), the power loads may be assumed to be reduced under a monitoring procedure consistent with safety in the kinds of operations authorised.

(e) In showing compliance with this paragraph with regard to the electrical power system and to equipment design and installation, critical environmental and atmospheric conditions, including radio frequency energy and the effects (both direct and indirect) of lightning strikes, must be considered in accordance with USAR.867. For electrical generation, distribution, and utilisation equipment required by or used in complying with this subpart, the ability to provide continuous, safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis, or reference to previous comparable service experience on other UAV.

(f) As used in this paragraph, "systems" refers between one and other to all pneumatic systems, fluid systems, electrical systems, mechanical systems, powerplant systems included in the UAV design, UCS, command and control data link and communication system except for the following :

(1) UAV powerplant systems provided as part of the certificated engine,

(2) the UAV flight structure whose requirements are specific in subpart C and D of USAR.

	1311 Electronic display instrument systems Not applicable in this subpart (see USAR.1727 Electronic data display)
	1321 Arrangement and visibility Not applicable in this subpart (see USAR.1721 Arrangement and visibility)
	1322 Warning caution and advisory lights Not applicable in this subpart (see USAR.1785 Warning caution and advisory information colour code)

	MEASURING DEVICES INSTALLATION
1323	USAR.1323 Airspeed measuring device If a pitot tube is used the the following applies : (a) The design and installation of each airspeed measuring device must provide positive drainage of moisture from the pitot static plumbing. (b) Each airspeed measuring device must have a heated pitot tube or an equivalent means of preventing malfunction due to icing. For all airspeed measuring devices : (c) Each airspeed measurement sensor must be calibrated to measure true airspeed at sea-level with a standard atmosphere and with a minimum practicable measuring device calibration error when the corresponding pitot and static pressures are applied. The airspeed measuring device system must further be calibrated in flight to determine the system error exclusive of instrument error. The system error may not exceed 3% of the calibrated airspeed or 9.3 km/h (5 knots), whichever is greater, throughout the following speed ranges: (1) 1.3 V_{S1} to V_{MO}/M_{MO} or V_{NE}, whichever is appropriate with flaps retracted. (2) 1.3 V_{S1} to V_{FE} with flaps extended. (d) Where dual or greater airspeed measurements are required by system redundancy and flight safety requirements, the respective pitot tubes or other airspeed measuring devices must be far enough apart to avoid damage to both tubes in a collision with a bird.
1325	USAR.1325 Static pressure measuring device See AMC.1325(e) (a) Each measuring device provided with static pressure case connections must be so vented that the influence of UAV speed, airflow variations, moisture, or other foreign matter will have minimum effect on the accuracy of the device except as noted in sub-paragraph (b) (3) . (b) If a static pressure measuring device is necessary for the functioning of systems, or devices, it must comply with the provisions of sub-paragraphs (1) to (3) . (1) The design and installation of a static pressure measuring device must be such that (i) Positive drainage of moisture is provided; (ii) Chafing of the tubing and excessive distortion or restriction at bends in the tubing, is avoided; and (iii) The materials used are durable, suitable for the purpose intended and protected against corrosion. (2) A proof test must be conducted to demonstrate the integrity of the static pressure measuring device in the following manner: (i) Unpressurised UAV. Evacuate the static pressure system to a pressure differential of approximately 3.4·kPa (1 inch of mercury) or to a reading on the altimeter, 305 m (1 000 ft) above the UAV elevation at the time of the test. Without additional pumping for a period of 1 minute, the loss of indicated altitude must not exceed 30 m (100 ft) on the altimeter.

	(ii) Pressurised UAV. Evacuate the static pressure system until a pressure differential equivalent to the maximum compartment pressure differential for which the UAV is Type Certificated is achieved. Without additional pumping for a period of 1 minute, the loss of indicated altitude must not exceed 2% of the equivalent altitude of the maximum compartment differential pressure or 30 m (100 ft), whichever is greater. (3) If a static pressure system is provided for any device, or system required by the operating rules, each static pressure port must be designed or located in such a manner that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not altered when the UAV encounters icing conditions. An anti-icing means or an alternate source of static pressure may be used in showing compliance with this requirement. If the altitude data provided by the alternate static pressure system differs from the altitude data provided by the primary static system by more than 15m (50 ft), an automatic correction must be provided in the UCS and/or the automatic control system for the alternate static system. (c) Except as provided in sub-paragraph (d) , if the static pressure measuring device incorporates both a primary and an alternate static pressure source, the means for selecting one or the other source must be designed so that (1) When either source is selected, the other is blocked off; and (2) Both sources cannot be blocked off simultaneously. (d) For unpressurised UAV, sub-paragraph (c) (1) does not apply if it can be demonstrated that the static pressure system calibration, when either static pressure source is selected, is not changed by the other static pressure source being open or blocked. (e) Each static pressure measuring device must be calibrated in flight to determine the system error. The system error, in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding measuring device calibration error, may not exceed that determined with the Certifying Authority for an agreed appropriate configuration and speed range. (f) Reserved. (g) For UAV prohibited from flight under known icing conditions in accordance with USAR.1525, sub-paragraph (b) (3) does not apply.
	1326 Pitot heat indication systems Not applicable in this subpart (see USAR.1819 Pitot heat indicator)
1327	USAR.1327 Magnetic heading measuring device (a) Except as provided in sub-paragraph (b): (1) Each magnetic heading measuring device, if existing, must be installed so that its accuracy is minimally affected by the UAV's vibration or magnetic fields; and (2) The compensated installation may not have a deviation, in level flight, greater than 10° on any heading. (b) A magnetic non-stabilised direction measuring device, if existing, may deviate more than 10° due to the operation of electrically powered systems if either a magnetic stabilised direction measuring device, which does not have a deviation in level flight greater than 10° on any heading, or a gyroscopic direction measuring device is installed. Deviations of a magnetic non-stabilised direction measuring device of more than 10° must be automatically compenstated in accordance with USAR.1837.

1329	USAR.1329 Flight control system See AMC.1329 (e), AMC.1329 (i) and AMC.1329 (j) The flight control system comprises sensors, actuators, computers and all those elements of the UAV System, necessary to control the attitude, speed and trajectory of the UAV. The flight control system must meet the following: (a) The modes of control of the UAV must be the following categories, which may be selected at any time in flight by the UAV crew: (1) automatic : in this mode the UAV attitude, speed and flight path are fully controlled by the flight control system. No input from the UCS is needed other than to load or modify the required flight plan. (2) semi-automatic : with this type of control the UAV crew commands outer loop parameters such as altitude, heading and air speed. The flight control system operates the UAV controls to achieve the commanded outer loop parameter value. (b) The flight control system must be designed so that a UAV crew of average skill can operate the UAV System with acceptable workload, (c) The flight control system must apply limits to manoeuvres to keep the UAV in the flight envelope protection as defined in USAR.334 (d) The UAV crews must have the opportunity to intervene at any time during the flight to manage safe control of the UAV, except : (1) during emergency situations such as total loss of data link, (2) during launch phase before achieving the minimum safe flight parameters, (3) during landing phase after reaching the decision point as defined in USAR.1490 and USAR.1492, (4) for UAV designed to be recovered by parachute, during the landing phase under parachute, (5) for rocket or catapult assisted take-off UAV, during the launch phase before reaching the limits specified in USAR.282. (e) The flight control system must be designed and adjusted so that, within the range of adjustment (if any) available to UAV crew, it cannot produce an unsafe condition. (f) The flight control system must be designed so that a single malfunction will not produce a hardover signal in more than one control axis except if the effect of this malfunction is lower or equal to a minor failure severity. If the flight control system integrates signals from auxiliary controls or furnishes signals for operation of other equipment, positive interlocks and sequencing of engagement to prevent improper operation are required. (g) There must be protection against adverse interaction of integrated components, resulting from a malfunction. (h) Not applicable in this subpart (see USAR.1790 UAV mode of control indicator) (i) Use of active flight controls for load alleviation, stability augmentation, and/or flutter suppression must comply with the control system stability requirements as agreed by the Certifying Authority. (j) The flight control system must have a comprehensive self-test available and operating during all phases of flight, including preflight.

1331	USAR.1331 Measuring devices using a power source For each measuring device that is safety critical for continued safe operation that uses a power source, the following apply: (a) The power must be sensed at or near the point where it enters the measuring device (see also USAR.1821). For electric and vacuum/pressure measuring device, the power is considered to be adequate when the voltage or the vacuum/pressure, respectively, is within approved limits. (b) The installation and power supply systems must be designed so that- (1) The failure of one device will not interfere with the proper supply of energy to the remaining device; and (2) The failure of the energy supply from one source will not interfere with the proper supply of energy from any other source. (c) There must be at least two independent sources of power (not driven by the same engine on multi-engine UAV), and a manual or an automatic means to select each power source.
	1335 Flight director systems Not applicable in this subpart (see USAR.1790 UAV mode of control indicator)
1337	USAR.1337 Powerplant installation measuring device (a) The following requirements apply (1) Each powerplant and auxiliary power unit measuring device line, hose and pipe must meet the requirements of USAR.993. (2) Each line, hose or pipe carrying flammable fluids under pressure must (i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line, hose or pipe fails; and (ii) Be installed and located so that the escape of fluids would not create a hazard. (3) Each powerplant and auxiliary power unit measuring device that utilises flammable fluids must be installed and located so that the escape of fluid would not create a hazard. (b) See USAR.1729. In addition, the following requirements apply (1) Each fuel quantity measuring device must be calibrated to read “zero” during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under USAR.959 (a); (2) Each exposed sight gauge used as a fuel quantity indicator must be protected against damage (leakage, …); (3) Each sight gauge that forms a trap in which water can collect and freeze must have means to allow drainage on the ground; (4) There must be a means to indicate the amount of usable fuel in each tank when the UAV is on the ground. (5) Not applicable in this subpart (see USAR. 1729 Fuel quantity and oil quantity data). (6) Not applicable in this subpart (see USAR. 1729 Fuel quantity and oil quantity data).

	(c) Fuel flowmeter system. If a fuel flowmeter system is installed, each metering component must have a means to by-pass the fuel supply if malfunctioning of that component severely restricts fuel flow. (d) Oil quantity indicator. There must be a means to indicate the quantity of oil in each tank when the UAV is on the ground (see also USAR.1729 Fuel quantity and oil quantity data)
ELECTRICAL SYSTEMS AND EQUIPMENT	
1351	USAR.1351 General See AMC.1351 (a)(2) (a) Electrical system capacity. Each electrical system must be adequate for the intended use. In addition (1) Electric power sources, their transmission cables, and their associated control and protective devices, must be able to furnish the required power at the proper voltage to each load circuit essential for safe operation; and (2) Compliance with sub-paragraph (1) must be shown by an electrical load analysis, or by electrical measurements, that account for the electrical loads applied to the electrical system in all probable combinations and for probable duration. Consideration shall be given to every payload configuration. (b) Functions. For each electrical system, the following apply: (1) Each system, when installed, must be (i) Free from hazards in itself, in its method of operation, and in its effects on other parts of the UAV; (ii) Protected from fuel, oil, water, other detrimental substances and mechanical damage; (iii) Not applicable in this subpart (see USAR.1717 UCS electrical systems). (2) Electric power sources must function properly when connected in combination or independently. (3) No failure or malfunction of any electric power source may impair the ability of any remaining source to supply load circuits essential for safe operation. (4) Reserved. (c) UAV Generating system. There must be at least one electrical power generating device if the electrical system supplies power to load circuits essential for safe operation. In addition (1) Each electrical power generating device must be able to deliver its continuous rated power, or such power as is limited by its regulation system; (2) Electrical power generating device voltage control equipment must be able to dependably regulate the electrical power generating device output within rated limits; (3) Automatic means must be provided to prevent either damage to any electrical power generating device, or adverse effects on the UAV electrical system, due to reverse current. A means must also be provided to disconnect each electrical power generating device from the battery and the other electrical power generating device(s). (4) Not applicable in this subpart (see USAR.1809 UAV electrical systems warning and indicator) (5) Each electrical power generating device must have an overvoltage control designed and installed to prevent damage to the electrical system, or to equipment supplied by the electrical system, that could result if that electrical power generating device were to develop an overvoltage condition.

	(d) Not applicable in this subpart (see USAR.1809 UAV electrical systems warning and indicator) (e) Fire resistance. Electrical equipment must be so designed and installed that in the event of a fire in the engine compartment, during which the surface of the firewall adjacent to the fire is heated to 1 100°C (2 000°F) for 5 minutes or to a lesser temperature substantiated for the UAV, the equipment essential to continued safe operation and located behind the firewall will function satisfactorily and will not create an additional fire hazard. For UAV designed to be recovered by parachute, the complete landing sequence must be still possible ; this may be shown by tests or by analysis. (f) External power. If provisions are made for connecting external power to the UAV and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no incompatible external power supply e.g. a reverse polarity, or a reverse phase sequence, can supply power to the UAV's electrical system. The external power connection must be located so that its use will not result in a hazard to the UAV or ground crew. The location should be such that there is no detrimental effect to the UAV structure. (g) Not applicable.
1353	USAR.1353 Storage battery or emergency power supply design and installation (a) Each storage battery or emergency power supply must be designed and installed as prescribed in this paragraph. (b) Safe cell temperatures and pressures must be maintained during any probable charging and discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge) (1) At maximum regulated voltage or power; (2) During a flight of maximum duration; and (3) Under the most adverse cooling condition likely to occur in service. (c) Compliance with sub-paragraph (b) must be shown by tests unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem. (d) No explosive gases emitted by any battery or emergency power supply in normal operation, or as the result of any probable malfunction in the charging system or battery or emergency power supply installation, may accumulate in hazardous quantities within the UAV. (e) No corrosive fluids or gases that may escape from the battery or emergency power supply may damage surrounding structures or adjacent essential equipment. (f) Each battery or emergency power supply installation capable of being used to start an engine or auxiliary power unit must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery or emergency power supply can generate during a short circuit of the battery or emergency power supply or of any individual cells. (g) Battery installations must have (1) A system to control the charging rate of the battery automatically so as to prevent battery overheating; or (2) A battery temperature sensing and over temperature warning system with a means for automatically disconnecting the battery from its charging source in the event of an over temperature condition; or (3) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

	(h) In the event of a complete loss of the primary electrical power generating system, any battery or emergency power supply must be capable of providing enough electrical power to those loads that are essential to perform emergency procedures as defined in USAR.1413 during the associated time duration. This time duration includes the time needed for the UAV crew to recognise the loss of generated power and to take appropriate action. (i) Where applicable, battery installations must be compliant with the appropriate national regulations regarding battery safety.
1357	USAR.1357 Circuit protective devices See AMC.1357 (a) (a) Protective devices, such as fuses or circuit breakers, must be installed in all electrical circuits other than (1) The main circuits of starter motors used during starting only; and (2) Circuits in which no hazard is presented by their omission. (b) A protective device for a circuit essential to flight safety may not be used to protect any other circuit. (c) Where installed, each remote resettable circuit protective device ("trip free" device in which the tripping mechanism cannot be over-ridden by the operating control) must be designed so that (1) A remote operation to be done by the UAV crew is required to restore service after tripping; and (2) If an overload or circuit fault exists, the device will open the circuit regardless of the position of the operating control. (3) Where automatic resettable circuit protection devices are used they must be designed so they comply with (c) (2) and restore circuit integrity on removal of fault condition. (d) Not applicable. (e) Not applicable.
1359	USAR.1359 Electrical system fire protection (a) Components of the electrical system must meet the applicable fire protection requirements of USAR.U850 and USAR.U865. (b) Electrical cables, terminals and equipment in designated fire zones, that are used during emergency procedures, must be at least fire-resistant. (c) Insulation on electrical wire and cable must be self-extinguishing when tested at an angle of 60° in accordance with the applicable portions of Appendix F of USAR or other approved equivalent methods. The average burn length must not exceed 76 mm (3 in) and the average flame time after removal of the flame source must not exceed 30 seconds. Drippings from the test specimen must not continue to flame for more than an average of 3 seconds after falling.
1361	USAR.1361 Master switch arrangement See AMC.1361 (a) There must be a master switch arrangement on the UAV to allow ready disconnection by ground staff of each electric power source from the power distribution systems when the UAV is on the ground and except as provided in sub-paragraph (b). (b) Load circuits may be connected so that they remain energised when the master switch is open; if

	(1) The circuits are isolated, or physically shielded, to prevent their igniting flammable fluids or vapours that might be liberated by the leakage or rupture of any flammable fluid systems; and (2) The circuits are required for continued operation of the engine; or (3) The circuits are protected by circuit protective devices with a rating of five amperes or less adjacent to the electric power source. In addition, two or more circuits installed in accordance with the requirements of sub-paragraph (b) (2) must not be used to supply a load of more than five amperes. (c) Not applicable in this subpart (see USAR.1732 Safety critical controls).
1365	USAR.1367 Electric cables and equipment (a) Each electric connecting cable must be of adequate capacity. (b) Any equipment that is associated with any electrical cable installation and that would overheat in the event of a circuit overload or fault must be flame resistant (c) Means of identification must be provided for electrical cables, connectors and terminals. (d) Electrical cables must be installed such that the risk of mechanical damage and/or damage caused by fluids, vapours or sources of heat, is minimised. (e) Main power cables (including generator cables) must be designed to allow a reasonable degree of deformation and stretching without failure and must (1) Be separated from flammable fluid lines; or (2) Be shrouded by means of electrically insulated flexible conduit or equivalent, which is in addition to the normal cable insulations. (f) Where a cable cannot be protected by a circuit protection device or other overload protection it must not cause a fire hazard under fault conditions.
1367	USAR.1367 Switches Each switch must be (a) Able to carry its rated current; (b) Constructed with enough distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting; (c) Accessible to appropriate maintenance staff ; and (d) Labelled as to operation and the circuit controlled.
LIGHTS	
	1381 Instrument lights Not applicable in this subpart (see USAR.1705 UAV crew workplace lights)
1383	USAR.1383 Taxi and landing lights If needed, each taxi and landing light must be designed and installed so that (a) If a sensor is required for taxi, take-off or landing phase then there should be no dangerous glare from taxi and landing lights that would affect UAV operational safety. (b) Not applicable

	(c) It provides enough light for all intended operations; and (d) It does not cause a fire hazard in any configuration.
1385	USAR.1385 Position light system installation (a) General. Each part of each position light system must meet the applicable requirements and each system as a whole must meet the requirements of USAR.1387 to USAR.1397. (b) Left and right position lights. Left and right position lights must consist of a red and a green light spaced laterally as far apart as practicable and installed on the UAV such that, with the UAV in the normal flying position, the red light is on the left side and the green light is on the right side. (c) Rear position light. The rear position light must be a white light mounted as far aft as practicable on the tail or on each wing tip. (d) Light covers and colour filters. Each light cover or colour filter must be at least flameresistant and may not change colour or shape or lose any appreciable light transmission during normal use. (e) The position lights must be able to be switched on and off from the UCS and while the UAV is in flight.
1387	USAR.1387 Position light system dihedral angles (a) Except as provided in sub-paragraph (e), each position light must, as installed, show unbroken light within the dihedral angles described in this paragraph. (b) Dihedral angle L (left) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the UAV, and the other at 110° to the left of the first, as viewed when looking forward along the longitudinal axis. (c) Dihedral angle R (right) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the UAV, and the other at 110° to the right of the first, as viewed when looking forward along the longitudinal axis. (d) Dihedral angle A (aft) is formed by two intersecting vertical planes making angles of 70° to the right and to the left, respectively, to a vertical plane passing through the longitudinal axis, as viewed when looking aft along the longitudinal axis. (e) If the rear position light, when mounted as far aft as practicable in accordance with USAR.1385 (c), cannot show unbroken light within dihedral angle A (as defined in sub-paragraph (d)), a solid angle or angles of obstructed visibility totalling not more than 0.04 steradians is allowable within that dihedral angle, if such solid angle is within a cone whose apex is at the rear position light and whose elements make an angle of 30° with a vertical line passing through the rear position light.
1389	USAR.1389 Position light distribution and intensities (a) General. The intensities prescribed in this paragraph must be provided by new equipment with each light cover and colour filter in place. Intensities must be determined with the light source operating at a steady value equal to the average luminous output of the source at the normal operating voltage of the UAV. The light distribution and intensity of each position light must meet the requirements of sub-paragraph (b) (b) Position lights. The light distribution and intensities of position lights must be expressed in terms of minimum intensities in the horizontal plane, minimum intensities in any vertical plane and maximum intensities in over-lapping beams, within dihedral angles L, R and A, must meet the following requirements: (1) Intensities in the horizontal plane. Each intensity in the horizontal plane (the plane containing the longitudinal axis of the UAV and perpendicular to the plane of symmetry of the UAV) must equal or exceed the values in USAR.1391. (2) Intensities in any vertical plane. Each intensity in any vertical plane (the plane perpendicular to the horizontal plane) must equal or exceed the appropriate value in USAR.1393, where I is the minimum

	intensity prescribed in USAR.1391 for the corresponding angles in the horizontal plane. (3) Intensities in overlaps between adjacent signals. No intensity in any overlap between adjacent signals may exceed the values in USAR.1395, except that higher intensities in overlaps may be used with main beam intensities substantially greater than the minima specified in USAR.1391 and USAR.1393, if the overlap intensities in relation to the main beam intensities do not adversely affect signal clarity. When the peak intensity of the left and right position lights is more than 100 candelas, the maximum overlap intensities between them may exceed the values in USAR.1395 if the overlap intensity in Area A is not more than 10% of peak position light intensity and the overlap intensity in Area B is not more than 2·5% of peak position light intensity. (c) Rear position light installation. A single rear position light may be installed in a position displaced laterally from the plane of symmetry of a UAV if (1) The axis of the minimum cone of illumination is parallel to the flight path in level flight; and (2) There is no obstruction aft of the light and between planes 70° to the right and left of the axis of maximum illumination.
1391	USAR.1391 Minimum intensities in the horizontal plane of position lights Each position light intensity must equal or exceed the applicable values in the following table:

Dihedral angle (light included)	Angle from right or left of longitudinal axis measured from dead ahead	Intensity (candelas)
L and R	0° to 10°	40
(red and green)	10° to 20°	30
	20° to 110°	5
A (rear white) ……	110° to 180°	20

1393	USAR.1393 Minimum intensities in any vertical plane of position lights Each position light intensity must equal or exceed the applicable values in the following table:

Angle above or below the horizontal plane	Intensity
0	1.00 I.
0° to 5°	0.90 I.
5° to 10°	0.80 I.
10° to 15°	0.70 I.
15° to 20°	0.50 I.
20° to 30°	0.30 I.
30° to 40°	0.10 I.
40° to 90°	0.05 I.

1395 USAR.1395 Maximum intensities in overlapping beams of position lights

No position light intensity may exceed the applicable values in the following table, except as provided in USAR.1389 (b) (3):

Overlaps	Maximum Intensity	
	Area A (Candelas)	Area B (Candelas)
Green in dihedral angle L	10	1
Red in dihedral angle R	10	1
Green in dihedral angle A	5	1
Red in dihedral angle A	5	1
Rear White in dihedral angle L	5	1
Rear White in dihedral angle R	5	1

Where

(a) Area A includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 10° but less than 20°; and

(b) Area B includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 20°.

1397 USAR.1397 Colour specifications

Each position light colour must have the applicable International Commission on Illumination chromaticity co-ordinates as follows:

(a) Aviation red –
"y" is not greater than 0.335; and
"z" is not greater than 0.002.

(b) Aviation green –
"x" is not greater than 0.440 – 0.320y;
"x" is not greater than y – 0.170; and
"y" is not less than 0.390 – 0.170x.

(c) Aviation white –
"x" is not less than 0.300 and not greater than 0.540;
"y" is not less than "x – 0.040" or "y° – 0.010",
whichever is the smaller; and
"y" is not greater than "x + 0.020" nor "0.636 – 0.400x";
Where "y°" is the "y" co-ordinate of the Planckian radiator for the value of "x" considered.

1399 Riding light

Not applicable.

1401 USAR.1401 Anti-collision light system

(a) General. The UAV must have an anti-collision light system that

(1) Consist of one or more approved anti-collision lights located so that their light will not detract from the conspicuity of the position lights; and

(2) Meet the requirements of sub-paragraphs (b) to (f) .

(b) Field of coverage. The system must consist of enough lights to illuminate the vital areas around the UAV, considering the physical configuration and flight characteristics of the UAV. The field of coverage must extend in each direction within at least 75° above and 75° below the horizontal plane of the UAV, except that there may be solid angles of obstructed visibility totalling not more than 0.5 steradians.

(c) Flashing characteristics. The arrangement of the system, that is, the number of light sources, beam width, speed of rotation, and other characteristics, must give an effective flash frequency of not less than 40, nor more than 100, cycles per minute. The effective flash frequency is the frequency at which the UAV's complete anti-collision light system is observed from a distance, and applies to each sector of light including any overlaps that exist when the system consists of more than one light source. In overlaps, flash frequencies may exceed 100, but not 180, cycles per minute.

(d) Colour. Each anti-collision light must be either aviation red or aviation white and must meet the applicable requirements of USAR.1397.

(e) Light intensity. The minimum light intensities in any vertical plane, measured with the red filter (if used) and expressed in terms of "effective" intensities, must meet the requirements of sub-paragraph (f) . The following relation must be assumed:

$$Ie = \frac{\int_{t1}^{t2} I(t)dt}{0.2 + (t2 - t1)}$$

where
Ie = effective intensity (candelas).
I(t) = instantaneous intensity as a function of time.
(t2 – t1) = flash time interval (seconds).

Normally, the maximum value of effective intensity is obtained when t2 and t1 are chosen so that the effective intensity is equal to the instantaneous intensity at t2 and t1.

(f) Minimum effective intensities for anticollision lights. Each anti-collision light effective intensity must equal or exceed the applicable values in the following table:

Angle above or below the horizontal plane	Intensity (candelas)
0° to 5°	400
5° to 10°	240
10° to 20°	80
20° to 30°	40
30° to 75°	20

SAFETY EQUIPMENT AND EMERGENCY CAPABILITY

1411 General

Not applicable.

U1412 USAR.U1412 Emergency recovery capability

See USAR.1412 (a)(2) and AMC.1412 (e)

(a) The UAV System must integrate an emergency recovery capability that consists of :

(1) a flight termination system, procedure or function that aims to immediately end normal flight, or,

(2) an emergency recovery procedure that is implemented through UAV crew command or through autonomous design means in order to mitigate the effects of critical failures with the intent of minimising the risk to third parties, or,

(3) any combination of USAR.1412 (a) (1) and USAR.1412 (a) (2).

	(b) The emergency recovery capability must function as desired over the whole flight envelope under the most adverse combination of environmental conditions (c) The emergency recovery capability must be safeguarded from interference leading to inadvertent operation. (d) The emergency recovery capability must receive its electrical power, if needed, from the bus that provides the maximum reliability for operation. In case of complete loss of the primary electrical power generating system, it must automatically switch to the battery. (e) Use of explosives to perform in-flight total destruction of the air vehicle is not an acceptable means of compliance to USAR.1412 (f) Where the emergency recovery capability includes a pre-programmed course of action to reach a predefined site where it can be reasonably expected that fatality will not occur, the dimensions of such areas must be stated in the UAV System Flight Manual.
U1413	USAR.U1413 Engine shut down procedure In the event of an engine failure that causes shutdown, the following requirements apply : (a) the UAV must be designed to retain sufficient control and manoeuvrability until it has reached a forced landing area. (b) therefore, the emergency electrical power must be designed in such a way that its reliability and duration are compatible with USAR.1413 (a). The time period needed to perform a glide from maximum certificated altitude to sea level and reach a forced landing area includes the time needed for the UAV crew to recognise the failure and to take appropriate action, if required. (c) the engine shut down procedure must be analysed considering the existence of the emergency recovery capability specified in USAR.1412
	1415 Ditching equipment Not applicable.
1416	USAR.1416 De-icer system If certification with ice protection provisions is desired and a de-icer system is installed (a) The system must meet the requirements specified in USAR.1419. (b) The system and its components must be designed to perform their intended function under any normal system operating temperature or pressure. (c) Not applicable in this subpart (see USAR.1811 Pneumatic de-icer boot system indicator)
1419	USAR.1419 Ice protection If certification with ice protection provisions is desired, compliance with the following requirements must be shown: (a) The recommended procedures for the use of the ice protection equipment must be set forth in the UAV System Flight Manual or in approved manual material. (b) An analysis must be performed to establish, on the basis of the UAV's operational needs, the adequacy of the ice protection system for the various components of the UAV. In addition, tests of the ice protection system must be conducted to demonstrate that the UAV is capable of operating safely in continuous maximum and intermittent maximum icing conditions (c) Compliance with all or portions may be accomplished by reference, where applicable because of similarity of the designs to analysis and tests performed for the type certification of a Type Certificated UAV.

	(d) When monitoring of the external surfaces of the UAV by the UAV crew is required for proper operation of the ice protection equipment, it must be ensured that the monitoring can be done in all operating and environmental conditions.
MISCELLANEOUS EQUIPMENT	
1431	USAR.1431 Electronic equipment (a) In showing compliance with USAR.1309 (b)(1) and (2) with respect to radio and electronic equipment and their installations, critical environmental conditions must be considered. (b) Radio and electronic equipment, controls, and wiring must be installed so that operation of any unit or system of units will not adversely affect the simultaneous operation of any other radio or electronic unit, or system of units. (c) Not applicable in this subpart (see USAR.1707 Communication system) (d) Not applicable in this subpart (see USAR.1707 Communication system) (e) Not applicable in this subpart (see USAR.1707 Communication system) (f) Electronic payload equipment and wiring must be installed so that operation will not adversely affect the simultaneous operation of any other radio or electronic unit, or system of units. (g) All sensitive and essential equipment as identified in (a) must be protected against internal and external sources of electromagnetic interference (EMI).
1435	USAR.1435 Hydraulic systems (a) Design. Each hydraulic system must be designed as follows: (1) Each hydraulic system and its elements must withstand, without yielding, the structural loads expected in addition to hydraulic loads. (2) Not applicable in this subpart (see USAR.1813 Hydraulic systems indicator) (3) There must be means to ensure that the pressure, including transient (surge) pressure, in any part of the system will not exceed the safe limit above design operating pressure and to prevent excessive pressure resulting from fluid volumetric changes in all lines which are likely to remain closed long enough for such changes to occur. (4) The minimum design burst pressure must be 2.5 times the operating pressure. (5) There must be adequate means to protect hydraulic systems critical to continued safe flight resulting from fluid loss. (6) All materials in contact with the hydraulic fluid shall be compatible with the hydraulic fluid over the temperature range, functional, service and storage conditions the hydraulic system will experience. (b) Tests. Each system must be substantiated by proof pressure tests. When proof-tested, no part of any system may fail, malfunction, or experience a permanent set. The proof load of each system must be at least 1.5 times the maximum operating pressure of that system. (c) Accumulators. A hydraulic accumulator or reservoirs may be installed on the engine side of any firewall if (1) It is an integral part of an engine or propeller system, or (2) The reservoir is non-pressurised and the total capacity of all such non-pressurised reservoirs is one litre (one US-quart) or less.

1437	USAR.1437 Accessories for multi-engine UAV For multi-engine UAV, engine-driven accessories essential to safe operation must be distributed among the two engines so that the failure of any one engine will not impair safe operation through the malfunctioning of these accessories.
1438	USAR.1438 Pressurisation and pneumatic systems (a) Pressurisation system elements must be burst pressure tested to 2.0 times, and proof pressure tested to 1.5 times, the maximum normal operating pressure. (b) Pneumatic system elements must be burst pressure tested to 3.0 times, and proof pressure tested to 1.5 times, the maximum normal operating pressure. (c) An analysis, or a combination of analysis and test, may be substituted for any test required by sub-paragraph (a) or (b) if the Certifying Authority finds it equivalent to the required test.
	1441 Oxygen equipment and supply Not applicable.
	1443 Minimum mass flow of supplemental oxygen Not applicable.
	1445 Oxygen distribution system Not applicable.
	1447 Equipment standards for oxygen dispensing units Not applicable.
	1449 Means for determinig use of oxygen Not applicable.
	1450 Chemical oxygen generaors Not applicable.
	1451 Fire protection for oxygen equipment Not applicable.
	1453 Protection for for oxygen equipment from rupture Not applicable.
	1457 Cockpit voice recorder Not applicable in this subpart (see USAR.1709 Voice recorders)
1459	USAR.1459 UAV onboard flight recorders See AMC.1459 (a) If required, each flight recorder must be installed so that: (1) It is supplied with airspeed, altitude, and directional data obtained from sources that meet the accuracy requirements of USAR.1323, USAR.1325 and USAR.1327, as appropriate; (2) The vertical acceleration sensor is rigidly attached; (3) It receives its electrical power from the bus that provides the maximum reliability for operation of the flight recorder without jeopardising service to essential or emergency loads; (4) There is an aural or visual means for pre-flight checking of the recorder for proper recording of data in the storage medium.

	(5) Except for recorders powered solely by the engine-driven electrical generator system, there is an automatic means to simultaneously stop a recorder that has a data erasure feature and prevent each erasure feature from functioning, within 10 minutes after crash impact; (6) A universal time reference signal is recorded. For instance, the GPS time signal can be used for this purpose. (b) Each non-ejectable record container must be located and mounted so as to minimise the probability of container rupture resulting from crash impact and subsequent damage to the record from fire. (c) A correlation must be established between the flight recorder readings of airspeed, altitude, and heading and the corresponding readings (taking into account correction factors) of the UAV crew's data displayed in the UCS. The correlation must cover the airspeed range over which the UAV is to be operated, the range of altitude to which the UAV is limited, and 360° of heading. Correlation may be established on the ground as appropriate. (d) Each recorder container must (1) Be either bright orange or bright yellow; (2) Have reflective tape affixed to its external surface to facilitate its location under water; and (3) Have an underwater locating device, when required by the operating rules, on or adjacent to the container which is secured in such a manner that they are not likely to be separated during crash impact. (e) Any novel or unique design or operational characteristics of the UAV must be evaluated to determine if any dedicated parameters must be recorded on flight recorders in addition to or in place of existing requirements.
1461	USAR.1461 Equipment containing high energy rotors (a) Equipment containing high energy rotors must meet sub-paragraphs (b), (c) or (d) . (b) High energy rotors contained in equipment must be able to withstand damage caused by malfunctions, vibration, abnormal speeds and abnormal temperatures. In addition (1) Auxiliary rotor cases must be able to contain damage caused by the failure of high energy rotor blades; and (2) Equipment control devices, systems and instrumentation must reasonably ensure that no operating limitations affecting the integrity of high energy rotors will be exceeded in service. (c) It must be shown by test that equipment containing high energy rotors can contain any failure of a high energy rotor that occurs at the highest speed obtainable with the normal speed control devices inoperative. (d) Equipment containing high energy rotors must be located where rotor failure will not adversely affect continued safe flight.
U1481	USAR.U1481 Payloads (a) A payload is a device or equipment carried by the UAV, which performs the mission assigned. The payload comprises all elements of the air vehicle that are not necessary for flight but are carried for the purpose of fulfilling specific mission objectives. It is assumed that a UAV System Type Certification Basis may be released for several payload configurations. (b) Where a UAV System is designed to carry payloads, the integration and operation of those payloads must (1) not adversely affect the safe flight and control of the UAV; (2) be shown as electromagnetically compatible (EMC) with systems on board of the UAV;

	(3) meet safety objectives as provided in USAR.1309.
U1485	USAR.U1485 Environmental Control System (ECS) See AMC.1485 (a) If installed, the ECS must comply with the system safety requirements applicable to the UAV. (b) The ECS must meet all safety requirements when operating under installed conditions over the design envelope and maintain integration integrity to ensure the UAV safety-of-flight. (c) In the event that the primary ECS is non-operational the UAV system design must comply with either (1) or (2) such that no single ECS subsystem failure shall result in loss of UAV. (1) Incorporated secondary/emergency systems capable of maintaining flight safety critical conditions. Such systems shall be capable of operating until either; the primary ECS is available or safe landing is achieved. (2) Allow the continued function of the safety critical operations (flight controls, avionics and communications) until safe landing is achieved. (d) ECS normal and emergency procedures must be included in the UAV System Flight Manual. (e) Adequate controls and displays for the ECS must be installed in the UCS or other appropriate locations to allow the ECS to function as intended. Sufficient cautions, warnings, and advisories must be provided to alert the UAV crew to problems in time for corrective action to be taken from a safety-of-flight perspective.
AUTOMATIC TAKE-OFF SYSTEM - AUTOMATIC LANDING SYSTEM	
U1490	USAR.U1490 General See AMC.1490 (f)(2) When a UAV System, designed for conventional take-off and landing on a runway is equipped with an automatic take-off system or an automatic landing system or both, it should meet the following requirements (a) Once the automatic take-off or landing mode has been engaged, the UAV crew monitors the whole process from the UCS, via the command and control data link, but is not required to perform any manual "piloting action", except manual abort, where required, as per provisions of USAR.1492. (b) The automatic function will reside in the UAV airborne control laws algorithms and will utilize navigation and flight path tracking inputs in such a manner as to not degrade the overall redundancy or level of safety of the flight control system. When off-board sensors are utilized via data-links, the continued safe flight of the vehicle must be ensured in the event of a loss of that data-link. (c) The automatic system may cause no unsafe sustained oscillations or undue attitude changes or control activity as a result of configuration or power changes or any other disturbance to be expected in normal operation. (d) Automatic take-off system or automatic landing system data and status must be displayed in the UCS. All indications must be designed to minimise crew errors. (e) *Take-off* (1) Once the automatic take-off mode has been engaged, the brake release, the take-off run and the rotation are fully automatic : UAV runway steering flightpath, speed, configuration, engine settings and UAV flightpath after lift off are controlled by the automatic take-off system.

	(2) In case of failure that could adversely affect safe flight or exceedance from predefined limits occurring during the take-off run at every speed up to the rotation speed V_R or the proper refusal speed (if applicable), an automatic abort function shall be provided to stop the UAV on the runway. (f) *Landing* (1) Once the automatic landing mode has been engaged, the approach, landing and ground roll are fully automatic until the UAV reaches full stop or after a safe taxiing speed is reached and UAV crew changes to a manual taxi mode: UAV flightpath, speed, configuration, engine settings, runway steering and braking after touch down are controlled by the automatic landing system. (2) In case of failure or exceedance from the predefined limits of a convergence window occurring during the approach, an automatic go around function shall be provided above a certain height called "Decision Point", at which such a go around may be safely performed (i.e. with no ground contact that may damage the UAV).
U1492	USAR.U1492 Manual abort function Where a UAV System is designed for conventional take-off and landing on a runway, it must include the following function : (a) The automatic system must incorporate a manual abort function. Its control shall be easily accessible to the UAV crew in order to (1) stop the UAV on the runway during the take-off run at every speed up to refusal speed or rotation speed V_R, whichever is less. (2) where it is safe to perform, initiate a go around during the landing phase at every height down to a Decision Point. (b) Specific go around procedure shall be provided in the UAV System Flight Manual under USAR.1585 (j).

subpart G – OPERATING LIMITATIONS AND INFORMATION

	GENERAL
1501	USAR.1501 General (a) Each operating limitation specified in USAR.1505 to USAR.1527 and other limitations and information necessary for safe operation must be established. (b) The operating limitations and other information necessary for safe operation must be made available to the UAV crew as prescribed in USAR.1541 to USAR.1589. (c) The requirements of this section may not be applicable to all UAV configurations.
1505	USAR.1505 Airspeed limitations (a) The never-exceed speed V_{NE} must be established so that it is (1) Not less than 0.9 times the minimum value of V_D allowed under USAR.335; and (2) Not more than the lesser of (i) 0.9 V_D established under USAR.335; or (ii) 0.9 times the maximum speed shown under USAR.251. (b) The maximum structural cruising speed V_{NO} must be established so that (1) it is not more than the lesser of (i) V_C established under USAR.335; or (ii) 0.89 V_{NE} established under sub-paragraph (a) . (2) the maximum speed allowed by the flight envelope protection maintained by the flight control system is equal or less than V_{NO}. (c) Sub-paragraphs (a) and (b) do not apply to turbine UAV or to UAV for which a design diving speed V_D/M_D is established under USAR.335 (b) (2). For those UAV, a maximum operating limit speed (V_{MO}/M_{MO} airspeed or Mach number, whichever is critical at a particular altitude) must be established as a speed that may not be deliberately exceeded in any regime of flight (climb, cruise, or descent) unless a higher speed is authorised for flight test or UAV crew training operations. V_{MO}/M_{MO} must be established so that it is not greater than the design cruising speed V_C/M_C and so that it is sufficiently below V_D/M_D and the maximum speed shown under USAR.251 to make it highly improbable that the latter speeds will be inadvertently exceeded in operations. The speed margin between V_{MO}/M_{MO} and V_D/M_D or the maximum speed shown under USAR.251 may not be less than the speed margin established between V_C/M_C and V_D/M_D under USAR.335(b), or the speed margin found necessary in the flight tests conducted under USAR.253. The maximum speed allowed by the flight envelope protection maintained by the flight control system must be equal or less than V_{MO}/M_{MO}.
1507	USAR.1507 Manoeuvring speed The maximum operating manoeuvring speed, V_O, must be established as an operating limitation. V_O is a selected speed that is not greater than $V_{Sn}^{1/2}$ established in USAR.335(c).

1511	USAR.1511 Flap extended speed (a) The flap extended speed V_{FE} must be established so that it is (1) Not less than the minimum value of V_F allowed in USAR.345 (b); and (2) Not more than V_F established under USAR.345 (a), (c) and (d). (b) Additional combinations of flap setting, airspeed and engine power may be established if the structure has been proven for the corresponding design conditions.
1513	USAR.1513 Minimum control speed The minimum control speed(s) V_{MC}, determined under USAR.149 (b), must be established as an operating limitation(s).
1519	USAR.1519 Weight and centre of gravity The weight and centre of gravity ranges for each payload configuration, determined under USAR.23 must be established as operating limitations.
1521	USAR.1521 Powerplant limitations (a) General. The powerplant limitations prescribed in this section must be established so that they do not exceed the corresponding limits for which the engines or propellers are approved by the Certifying Authority. (b) Take-off operation. The powerplant take-off operation must be limited by (1) The maximum rotational speed (rpm); (2) The maximum allowable manifold pressure where the UAV is equipped with reciprocating engine with a controllable propeller or a turbocharger ; (3) The maximum allowable gas temperature (for turbine engines); (4) The time limit for the use of the power or thrust corresponding to the limitations established in sub-paragraphs (1) to (3); and (5) The maximum allowable cylinder head (as applicable), liquid coolant and oil temperatures. (6) The minimum oil pressure, minmum gas temperature, minimum coolant temperature, and minimum oil temperature. (c) Continuous operation. The continuous operation must be limited by (1) The maximum rotational speed; (2) The maximum allowable manifold pressure where the UAV is equipped with reciprocating engine with a controllable propeller or a turbocharger ; (3) The maximum allowable gas temperature (for turbine engines); and (4) The maximum allowable cylinder head, oil and liquid coolant temperatures. (5) The minimum oil pressure, minmum gas temperature, minimum coolant temperature, and minimum oil temperature. (d) Fuel grade / designation. The minimum fuel grade (for reciprocating engines), or fuel designation (for turbine engines), must be established so that it is not less than that required for the operation of the engines within the limitations in sub-paragraphs (b) and (c).

	(e) Ambient temperature. For all UAV, ambient temperature limitations (including limitations for winterisation installations if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions of USAR.1041 to USAR.1047 is shown.
1522	USAR.1522 Auxiliary power unit limitations If an auxiliary power unit is installed, the limitations established for the auxiliary power unit must be specified in the operating limitations for the UAV.
	1523 Minimum Flight Crew Not applicable in this subpart (see USAR.1704 Minimum UAV Crew).
	1524 Maximum passenger seating configuration Not applicable.
1525	USAR.1525 Kinds of operation The kinds of operation (such as flight rules, day or night) and the meteorological conditions (such as icing) to which the operation of the UAV System is limited or from which it is prohibited, must be established appropriate to the installed equipment.
1527	USAR.1527 Maximum operating altitude The maximum altitude up to which operation is allowed, as limited by flight, structural, powerplant, functional, or equipment characteristics, must be established.
1529	USAR.1529 Instructions for continued airworthiness Instructions for continued airworthiness in accordance with Appendix G must be prepared.
INFORMATION, MARKINGS AND PLACARDS	
1541	USAR.1541 General (a) Each element of the UAV System (UAV, UCS, launch and landing elements, …) must contain (1) The information, markings and placards specified in this subpart and in subpart I; and (2) Any additional information, markings and placards required for the safe operation if it has unusual design, operating, or handling characteristics. (b) Each marking and placard of the UAV System prescribed in sub-paragraph (a) (1) Must be displayed in a conspicuous place; and (2) May not be easily erased, disfigured or obscured. (c) The information, placards and marking information must be furnished in the UAV System Flight Manual. (d) The units of measurement used on placards must the same as those furnished in the UAV System Flight Manual or displayed to the UAV crew.
1543	USAR.1543 Instrument markings: general (see also USAR.1733 Conventional controls and indicators) For each instrument installed on the UAV, (a) When markings are on the cover glass of the instrument, there must be means to maintain the correct alignment of the glass cover with the face of the dial; and (b) Each arc and line must be wide enough and located to be clearly visible to the ground staff. (c) All related instruments must be calibrated in compatible units.

	1545 Airspeeed indicator Not applicable in this subpart (see USAR.1835 Airspeed data).
	1547 Magnetic direction indicator Not applicable in this subpart (see USAR.1837 Magnetic heading or track data).
	1549 Powerplant and auxiliary power unit instruments Not applicable in this subpart (see USAR.1839 Powerplant and auxiliary power unit data).
1551	USAR.1551 Oil quantity indicator (see also USAR.1841 Oil quantity data) Where an oil quantity indicator is installed on the UAV for use by the ground staff, it must be marked in sufficient increments to indicate readily and accurately the quantity of oil.
1553	USAR.1553 Fuel quantity indicator (see also USAR.1843 Fuel quantity data) Where a fuel quantity indicator is installed on the UAV for use by the ground staff, a red radial line must be marked on each indicator at the calibrated zero reading.
1555	USAR.1553 Control markings on the UAV (see also USAR.1845 Control markings in the UCS) If installed on the UAV, (a) Each control (switch, button, selector, …) on the UAV must be plainly marked as to its function and method of operation. (b) Not applicable. (c) For powerplant fuel controls (1) Each fuel tank selector control on the UAV must be marked to indicate the position corresponding to each tank and to each existing cross feed position. (2) Not applicable. (3) The conditions under which the full amount of usable fuel in any restricted usage fuel tank can safely be used must be stated on a placard adjacent to the selector valve for that tank. (4) Not applicable (d) Not applicable. (e) For accessory, auxiliary and emergency controls (1) Not applicable (2) Each emergency control must be red and must be marked as to method of operation. No control other than an emergency control shall be this colour.
1557	USAR.1557 Miscellaneous information markings and placards (a) Payload compartments and ballast location. Each payload compartment, and each ballast location, must have a placard stating any limitations on contents, including weight, that are necessary under the loading requirements.

	(b) Not applicable (c) Fuel filler openings must be marked at or near the filler cover with : (1) the type of the fluid, and, (2) the permissible product designation, as indicated in the maintenance and operational handbook. (d) Not applicable (e) The system voltage of each direct current installation must be clearly marked adjacent to its external power connection. (f) Emergency access placards. Each placard and operating control for each emergency access panel must be red. A placard must be near each emergency access panel control and must clearly indicate the location of that access panel control and its method of operation.
	1559 Operating limitations Not applicable in this subpart (see USAR.1849 Operating limitations indications).
	1561 Safety Equipment Not applicable.
	1563 Airspeed placards Not applicable in this subpart (see USAR.1835 (e))
	1567 Flight Manoeuvre placard Not applicable.
UAV SYSTEM FLIGHT MANUAL	
1581	USAR.1581 General (a) A UAV System Flight Manual must be submitted to the Certifying Authority and it must contain the following: (1) Information required by USAR.1583 to USAR.1589. (2) Other information that is necessary for safe operation because of design, operating or handling characteristics. In particular, any information associated with the UCS , the command and control data link, the communication system and any other ancillary elements necessary to enable flight such as launch and landing elements must be stated in specific subpart of the UAV System Flight Manual with emphasis on deployment and operation limitations. (3) Further information necessary to comply with the relevant operating rules. (b) Approved information (1) Each part of the UAV System Flight Manual containing information prescribed in USAR.1583 to USAR.1589 must be approved by the Certifying Authority, segregated, identified and clearly distinguished from each unapproved part of that UAV System Flight Manual. (2) Not applicable. (c) The units used in the UAV System Flight Manual must be the same as those marked on the appropriate indicators, data display and placards both on the UAV and in the UCS. (d) All UAV System Flight Manual operational airspeeds must, unless otherwise specified, be presented as indicated Airspeeds.

	(e) The UAV system flight manual must be readily accessible to the UAV crew in the UCS. (f) Revisions and/or amendments. Each UAV System Flight Manual must contain a means for recording the incorporation of revisions and/or amendments. (g) If the UCS is capable of operating more than one UAV, the maximum number of UAVs that can be safely controlled from the UCS must be stated in the UAV System Flight Manual. In addition, the UAV System Flight Manual must contain procedures for UAV handover within a same UCS, where this capability exists. (h) Hazardous effects of radiation emitted from the UAV on fuel, ordinance, and personnel must be stated in the UAV System Flight Manual, and appropriate stand-off distances provided if the UAV is emitting radiation. (i) For UAVs with a battery, environmental limitations and potential hazards associated with the battery must be stated in the UAV System Flight Manual.
1583	USAR.1583 Operating limitations The UAV System Flight Manual must contain operating limitations determined under USAR, including the following: (a) Airspeed limitations (1) Information necessary for the marking of the airspeed limits on the indicator as required in USAR.1835, and the significance of each of those limits and of the colour coding used on the indicator. (2) The speeds V_{MC}, V_O, V_{LE} and V_{LO} and their significance. (3) Not applicable (b) Powerplant limitations (1) Limitations required by USAR.1521. (2) Explanation of the limitations, when appropriate. (3) Information necessary for marking the data displayed in the UCS and required by USAR.1839 to USAR.1843. (4) Fuel and oil designation and limitation (5) For two-stroke engine, the fuel/oil ratio. (c) Weight (1) The maximum weight; and (2) The maximum landing weight, if the design landing weight selected by the Applicant is less than the maximum weight. (3) UAV performance operating limitations as follows: (i) The maximum take-off weight for each airfield altitude and ambient temperature within the range selected by the Applicant if the UAV System complies with the climb requirements of USAR.63 (c).

(ii) The maximum landing weight for each airfield altitude and ambient temperature within the range selected by the Applicant if the UAV System complies with the landing requirements of USAR.63 (c).

(4) The maximum take-off weight for each airfield altitude and ambient temperature within the ranges selected by the Applicant at which the critical field length determined under USAR.55 is equal to the available runway length plus the length of any stopway, if utilised.

(5) Not applicable

(6) The maximum zero wing fuel weight where relevant as established in accordance with USAR.343.

(d) Centre of gravity. The established centre of gravity limits.

(e) Authorised manoeuvres : see USAR.3.

(f) Manoeuvre load factor. The positive and negative limit load factors in g's,

(g) Minimum UAV crew and maximum ground station capacity. The number and functions of the minimum UAV crew determined under USAR.1704. In addition, the maximum number of persons allowed to occupy the UCS must be stated in the UAV System Flight Manual in accordance with USAR.1702(a).

(h) Kinds of operation. A list of the kinds of operation to which the UAV System is limited or from which it is prohibited under USAR.1525, and also a list of installed equipment that affects any operating limitation and identification as to the equipment's required operational status for the kinds of operation for which approval has been granted.

(i) Maximum operating altitude. The maximum altitude established under USAR.1527.

(j) Not applicable .

(k) Allowable lateral fuel loading. The maximum allowable lateral fuel loading differential, if less than the maximum possible.

(l) Payload loading. The following information for each payload compartment or zone:

(1) The maximum allowable load; and

(2) The maximum intensity of loading.

(m) Systems. Any limitations on the use of UAV systems and equipment.

(n) Ambient temperatures. Where appropriate maximum and minimum ambient air temperatures for operation.

(o) Smoking. Any restrictions on smoking in the UCS and in the vicinity of any UAV System elements.

(p) Types of surface. A statement of the types of surface on which operation may be conducted (see USAR.45 (g) and USAR.1587 (a) (4), (c)(2) and (d)(4)).

(q) Deployment limitations : all limitations induced by the deployment of the UCS, the command and control data link, the launch and landing elements and any ancillary systems must be stated in the UAV System Flight Manual.

(r) Communication system and command and control data link limitations : the limitations and performances of the communication system and of the command and control data link must be stated in the UAV System Flight Manual and also the effect of link loss on performance limitation. The requested operating frequencies must be stated in the UAV System Flight Manual.

	(s) Automatic take-off and landing system (if applicable). The UAV System Flight Manual must state (1) Limitations (wind, turbulence, …) and performance for which the automatic take-off and landing system is certificated (2) Permitted configurations (e.g. flap setting, number of engines operating, …) (3) Normal and emergency procedures (4) Minimum required equipment that must be serviceable before engaging the automatic take-off and landing system.
1585	USAR.1585 Operating procedures (a) Information concerning normal, abnormal (if applicable) and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including (1) An explanation of significant or unusual flight or ground handling characteristics; (2) The maximum demonstrated values of crosswind for take-off and landing and procedures and information pertinent to operations in crosswinds; (3) A recommended speed for flight in rough air. This speed must be chosen to protect against the occurrence, as a result of gusts, of structural damage to the UAV and loss of control (e.g. stalling); (4) If applicable, procedures for restarting any engine in flight, including the effects of altitude; (5) Procedures, speeds and configuration(s) for making a normal approach and landing in accordance with USAR.73 and USAR.75 and a transition to the balked landing condition. (b) In addition to sub-paragraph (a), for a single-engined UAV (where emergency recovery includes a glide), the procedures, speeds and configuration(s) for a glide following engine failure in accordance with USAR.71 and the subsequent forced landing, must be furnished. (c) In addition to sub-paragraph (a), for all multi-engined UAV, the following information must be furnished: (1) Procedures, speeds and configuration(s) for making an approach and landing with one or more engine(s) inoperative; (2) Procedures, speeds and configuration(s) for making a go-around with one or more engine(s) inoperative and the conditions under which a go-around can be performed safely, or a warning against attempting a go-around. (3) The V_{SSE} determined in USAR.149.(d) In addition to sub-paragraphs (a) and (b) or (c) as appropriate, the following information must be furnished. (i) Procedures, speeds and configuration(s) for making a normal take-off in accordance with USAR.51 (a) and (b) USAR.53 (a) and (b) and the subsequent climb in accordance with USAR.65 and USAR.69 (a); (ii) Procedures for abandoning a takeoff due to engine failure or other cause. (d) In addition to sub-paragraphs (a), (c) and (d) for multi-engined UAV, the information must include (1) Procedures and speeds for continuing a take-off following engine failure and the conditions under which take-off can safely be continued, or a warning against attempting to continue the take-off; (2) Procedures, speeds and configurations for continuing a climb following engine failure, after take-off, in accordance with USAR.67, or en-route, in accordance with USAR.69 (b).

	(e) In addition to sub-paragraphs (a) and (c), the information must include (1) Procedures, speeds and configuration(s) for making a normal take-off; (2) Procedures and speeds for carrying out an accelerate-stop in accordance with USAR.55; (3) Procedures and speeds for continuing a take-off following engine failure, (f) Fuel. (1) For multi-engine UAV, information identifying each operating condition in which the fuel system independence prescribed in USAR.953 is necessary for safety must be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section. (2) The UAV System flight manual shall describe how maximum capacity refuelling is to be accomplished with the requested mission loads. (g) For each UAV showing compliance with USAR.1353 (g) (2) or (g) (3), the operating procedures for disconnecting the battery from its charging source must be furnished. (h) Information on the total quantity of usable fuel for each fuel tank and the effect on the usable fuel quantity as a result of a failure of any pump, must be furnished. (i) Procedures for the safe operation of the UAV's systems and equipment, both in normal use and in the event of malfunction, must be furnished. In particular, emergency recovery capability procedures and data link loss strategy must be stated in the UAV System Flight Manual.
1587	USAR.1587 Performance information See AMC.1587 and AMC.1587 (f) Unless otherwise presented, performance information must be provided over the altitude and temperature ranges required by USAR.45 (b) and for intended UAV configuration, engine configuration and weight ranges required by USAR 25. All performance shall based on a minimum engine performance. If other engine performance is used, the flight manual shall state such. (a) The following information must be furnished: (1) The stalling speeds V_{SO}, and V_{S1} with the landing gear and wing flaps retracted, defined for the weight ranges required by USAR.25 and the effect on these stalling speeds at maximum bank angles allowed by the flight control system ; (2) The steady rate and gradient of climb with all engines operating, determined under USAR.69 (a); (3) The landing distance, determined under USAR.75 for each airfield altitude and standard temperature and the type of surface for which it is valid; (4) The effect on landing distance of operation on other than smooth hard surfaces, when dry and when wet, determined under USAR.45 (g); and (5) The effect on landing distance of runway slope and 50% of the headwind component and 150% of the tailwind component. (6) The limitations on the flight performance imposed by the flight envelope protection as defined in USAR.334. (b) In addition to sub-paragraph (a), the steady angle of climb/descent determined under USAR.77 must be furnished.

	(c) In addition to sub-paragraph (a) and paragraph (b) the following information must be furnished: (1) The take-off distance, determined under USAR.53 and the type of surface for which it is valid; (2) The effect on take-off distance of operation on other than smooth hard surfaces, when dry and when wet, determined under USAR.45 (g); (3) The effect on take-off distance of runway slope and 50% of the headwind component and 150% of the tailwind component; (4) For multi-engine powered UAV, the one or more engine(s) inoperative take-off climb/descent gradient, determined under USAR.66; (5) For multi-engined UAV, the en-route rate and gradient of climb/descent with one or more engine(s) inoperative, determined under USAR.69 (b); and (6) For single-engine UAV, the glide performance determined under USAR.71. (d) In addition to paragraph (a), the following information must be furnished: (1) The accelerate-stop distance determined under USAR.55; (2) Not applicable (3) Not applicable (4) The effect on accelerate-stop distance, take-off distance and, if determined, take-off run, of operation on other than smooth hard surfaces, when dry and when wet, determined under USAR.45 (g); (5) The effect on accelerate-stop distance, take-off distance and, if determined, take-off run, of runway slope and 50% of the headwind component and 150% of the tailwind component; (6) Not applicable. (7) The en-route gradient of climb/descent with one engine inoperative, determined under USAR.69 (b); (8) The effect, on the en-route gradient of climb/descent with one or more engine(s) inoperative, of 50% of the headwind component and 150% of the tailwind component; (9) Not applicable (10) The relationship between IAS and CAS determined in accordance with USAR.1323 (b) and (c); and (11) The altimeter system calibration required by USAR.1325 (e). (e) Engine performance data shall be provided and maximum power performance data for takeoff shall be specifically stated. (f) Flight Planning Performance data shall be provided.
1589	USAR.1589 Loading information The following loading information must be furnished: (a) The weight and location of each item of equipment that can easily be removed, relocated, or replaced and that is installed when the UAV was weighed under USAR.25.

	(b) Appropriate loading instructions for each possible loading condition between the maximum and minimum weights established under USAR.25, to facilitate the centre of gravity remaining within the limits established under USAR.23.
U1591	USAR.U1591 Data link information The data link information furnished in the UAV System Flight Manual must meet the requirements of USAR.1611, USAR.1613 (a) and USAR.1615 (c).

subpart H –COMMAND AND CONTROL DATA LINK

<table>
<tr><th colspan="2">COMMAND AND CONTROL DATA LINK</th></tr>
<tr><td>U1601</td><td>USAR.U1601 General

See AMC.1601

(a) The UAV System communication system consists of the following subsystems:

(1) the command and control data link subsystem,

(2) the ATC communication subsystem,

(3) the payload data link subsystem.

The present subpart H only covers the command and control data link subsystem. ATC communication and payload data link are regulated by Operation materials.

(b) A UAV System must include a command and control data link (a radio-frequency link, for example) for control of the UAV with the following functions:

(1) Transmittal of UAV crew commands from the UCS to the UAV (uplink), and

(2) Transmittal of UAV status data from the UAV to the UCS (downlink). This status data must include, to the appropriate extent, navigational information, response to UAV crew commands, and equipment operating parameters in accordance with subpart I requirements.</td></tr>
<tr><td>U1603</td><td>USAR.U1603 Command and control data link architecture

The command and control data link architecture must ensure that there is no single failure that could lead to a Hazardous or more serious event.</td></tr>
<tr><td>U1605</td><td>USAR.U1605 Electromagnetic interference and compatibility

See AMC.1605 and AMC.1605 (b)

(a) The command and control data link must be protected against electromagnetic interference (EMI).

(b) Each command and control data link must be protected in such a way to prevent electromagnetic vulnerability (EMV).

(c) The command and control data link electromagnetic compatibility (EMC) must meet USAR.1431.

(d) The command and control data link, as system must comply with USAR.1309 requirement.

(e) The command and control data link must be designed to be protected against electrostatic, lightning and EME hazards at a level agreed with the Certifying Authority.</td></tr>
<tr><td>U1607</td><td>USAR.U1607 Command and control data link performance and monitoring

See AMC.1607 (a)

(a) The effective maximum range of each command and control data link must be stated in the UAV System Flight Manual, for a range of altitudes up to the maximum operating altitude as defined in USAR.1527, and for a range of availability levels agreed by Certifying Authority for the uplink and for the downlink

(b) For each command and control data link, the effective maximum range which may include a safety margin to be agreed by the Certifying Authority must be displayed in the UCS for a specific availability level</td></tr>
</table>

	for both uplink and downlink on request of the UAV crew. The corresponding availability level must be displayable on UAV crew request at the appropriate position on the UCS display. (c) For each command and control data link, the integrity of the uplink and downlink must be continuously monitored at a refresh rate consistent with safe operation. (d) Maximum range cues must be provided in the UCS on UAV crew request or automatically in case of a likely breakdown of the command and control data link. (e) Intervisibility information must be displayed in the UCS and warning cues provided to the UAV crew in order to prevent a total loss of command and control data link.
U1611	USAR.U1611 Command and control data link latency (a) Time delays in the command and control data link (namely 'latency') shall be specified in the UAV System Flight Manual as a function of all relevant conditions. (b) The command and control data link latency must not lead to an unsafe condition, considering all probable environmental conditions and envisaged type of operations and must be agreed by the Certifying Authority.
U1613	USAR.U1613 Command and control data link loss strategy See AMC.1613 (a), AMC.1613 (b) and AMC.1613 (c) (a) A command and control data link loss strategy must be established, approved and presented in the UAV System Flight Manual taking into account the emergency recovery capability as defined in USAR.1412. (b) The command and control data link loss strategy shall include an autonomous reacquisition process in order to try to re-establish in a short reasonable time the command and control data link. (c) There must be an alert for the UAV crew, via a clear and distinct aural and visual signal, for any total loss of the command and control data link.
U1615	USAR.U1615 Command and control data link antenna maskings (a) For all UAV attitudes and orientations relative to the signal source within the design envelope, the UAV antenna margin must be consistent to maintain a sufficient link budget for safe operation. (b) The masking must be stated in the UAV System Flight Manual. (c) Warning cues shall be provided to the UAV crew in case of approaching masking attitudes in order to prevent a total loss of command and control data link.
U1617	USAR.U1617 Command and control data link switchover function See AMC.1617 (a), AMC.1617 (b) and AMC.1617 (c) (a) The operation that consists of performing the transfer of the UAV command and control from one data link channel to another channel within the same UCS is called "switchover". (b) The switchover of a command and control data link shall not lead to an unsafe situation. (c) The UAV must be under continuous positive control at all times during switchover and when changing data links from the same UCS or it shall be shown that no positive control will not lead to unsafe conditions.

subpart I – UAV CONTROL STATION

	GENERAL
U1701	USAR.U1701 General See AMC.1701 and AMC.1701 (e) (a) The UAV control station (UCS) of a UAV System is the facility or device from which the UAV is remotely controlled. A UAV System may be comprised of more than one UCS. (b) The design of a UCS must facilitate the command and control of the UAV by the UAV crew for safe operations as agreed by the Certifying Authority. (c) When the UCS is to be used on a moving platform, the Certifying Authority may require establishing a Special Condition. (d) It must be shown using the UAV system safety analysis according to USAR.1309 that all identified hazards within the UCS have been reduced to a level consistent with safe operation of the system. (e) The UAV control station must be designed and its performance established by test for operation over the complete target environment as determined by an Environmental Life Cycle analysis. This analysis shall take into account the full range of operational and non-operational (storage, transportation, etc) environments.
U1702	USAR.U1702 UCS infrastructure (a) The physical parameters (e.g. size, temperature, power supply, earth bonding, maximum capacity, …) deemed as essential for flight safety and that define the infrastructure suitable for the UCS must be stated in the UAV System Flight Manual. (b) Where the UCS infrastructure is part of the UAV System to be certified, its design must comply with the parameters prescribed in USAR.1702 (a)
U1703	USAR.U1703 UAV crew work place (a) The UCS and its equipment must allow each UAV crew at work place to perform their duties without unreasonable concentration or fatigue. (b) The UAV crew work place conditions (temperature, humidity, vibration, noise, heat emissions, …) must not hamper safe execution of the flights.
1704	USAR.U1704 Minimum UAV crew The minimum UAV crew must be established so that it is sufficient for safe operation considering (a) The workload on individual UAV crew members taking into account at least the following tasks: (1) Operation and monitoring of all essential UAV System elements, (2) Navigation, (3) Flight path control, (4) Communications, (5) Compliance with airspace, air traffic, and air traffic control requirements, (6) Command decisions including Crew resource management, (b) The accessibility and ease of operation of necessary controls.

U1705	USAR.U1705 UAV crew work place lights The UAV crew work place lights must (a) Make each indicator, data display, information, markings, placard and control easily readable and discernible; (b) Be installed so that their direct rays, and rays reflected from any surface, are shielded from the UAV crew's eyes;
U1707	USAR.U1707 Communication system See AMC.1707 (a) and AMC.1707 (c) (a) For those UAV Systems that require more than one UAV crew member in the UCS, or whose operation will require communication with more than one UAV crew member, the UCS must be evaluated to determine if the UAV crew, when at their work places, can converse without difficulty under the actual UCS environment. If the UCS design includes provisions for the use of communication headsets, the evaluation must also consider conditions where headsets are being used. If the evaluation shows conditions under which it will be difficult to converse, an intercommunication system must be provided. (b) If the communication equipment that is installed incorporates transmit switches, these switches must be such that when released, they return from the "transmit" to the "off" position. (c) If provisions for the use of communication headsets are provided, it must be demonstrated that the UAV crew will receive all aural warnings under the actual UCS noise conditions when any headset is being used.
U1709	USAR.U1709 Voice recorders See AMC.1709 and AMC.1709 (e) (a) The UCS must be equipped with a voice recorder agreed by the Certifying Authority and must be installed so that it will record the following : (1) Voice communications transmitted from or received in the UCS. (2) Voice communications in the UCS. (3) Voice communications of UAV crew using the UCS's interphone system. (4) Voice or audio signals introduced into a headset or speaker. (b) The recording requirements of sub-paragraph (a) (2) must be met by installing an area microphone, located in the best position for recording voice communications originating at UAV crew work place and voice communications of other ground staff when directed to those stations. The microphone must be so located and, if necessary, the preamplifiers and filters of the recorder must be so adjusted or supplemented, so that the intelligibility of the recorded communications is as high as practicable when recorded under UCS noise conditions and played back. Repeated aural or visual play-back of the record may be used in evaluating intelligibility. (c) Where more than three UAV crew members are involved in the ground station (1) A channel must be dedicated to each boom, mask, headset or speaker used at each UAV crew work place. (2) A channel must be dedicated to each area microphone. (d) Each UCS voice recorder must be installed so that

	(1) It receives its electric power from the control station bus that provides the maximum reliability for operation of the voice recorder. (2) There is an aural or visual means for pre-flight checking of the recorder for proper operation. (e) Universal time reference signal must be recorded on a special track of the voice recorder.
U1711	USAR.U1711 UCS data recorder See AMC.1711 and AMC.1711 (a) If required by the Certifying Authority, the installation of data recorder in the UCS must comply with the following: (a) The UCS must be equipped with a data recorder that continuously record all the data transmitted via the command and control data link and the status of the UCS. (b) The storage capacity of the data recorder must be compatible with the record of the three last flight hours or compatible with the maximum duration of flight for which the certification is requested, which ever is lower. (c) The time basis used by the data recorder must be synchronised with an uniform time basis, and, (1) the downlink data must be labelled and recorded with the time basis at which they have been generated in the UAV, (2) the uplink data must be labelled and recorded with the time basis at which they have been generated in the UCS, (3) A reference to Air Traffic Control time must be recorded. (d) Time basis of the required UAV System recorders shall allow a post synchronisation of all recorded data or information with an accuracy better than half a second between any of the recorders. (e) The UCS should provide a function that is able to read the data recorder for post-flight operation.
U1717	USAR.U1717 UCS electrical systems (a) Each electrical system in the UCS must be : (1) free from hazards in itself, in its method of operation, and in its effects on other parts of the UCS (2) so designed that the risk of electrical shock is reduced to a minimum. (3) designed to be protected against electrostatic, lightning and EME hazards. (b) The total electrical heat emission must be taken into account in the design of the UCS
U1719	USAR.U1719 UCS power supply (a) The UCS power supply must be designed such that the operations in normal and failure conditions shall not lead to an unsafe condition. (b) The minimum UCS power supply consistent with sub-paragraph (a) must be stated in the UAV System Flight Manual.
U1720	USAR.U1720 Automated Mission Planning See AMC.1720 Automated mission planning calculations must not lead to unsafe conditions.

	DATA DISPLAYED IN THE UAV CONTROL STATION
U1721	USAR.U1721 Arrangement and visibility See AMC.1721 (a) Each flight, navigation, powerplant and UAV status data must be clearly arranged and visible to UAV crew as required or UAV crew selectable. (b) For each multi-engined UAV, identical powerplant data must be available and located so as to prevent confusion as to which engine the data relates. (c) Data required for safe operation of the system must be grouped appropriately and located within the normal scan pattern of the UAV crew. (d) If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all lighting conditions. (e) All displays, indications and warnings must be visible under all UCS lighting conditions.
U1722	USAR.U1722 Part-time data display See AMC.1722 Many UAV System parameters or status indications are required in subpart H and I to be displayed, yet they may be only necessary or required in certain phases of flight. (a) When parameters are not displayed full-time, flight safety must not be impaired. (b) Part-time displays of UAV System parameters or status indicators must be shown not to create an unsafe conditions.
U1723	USAR.U1723 Flight and navigation data (a) The following are the minimum required flight and navigational data that must be displayed at all times in the control station at an update rate consistent with safe operation: (1) indicated airspeed, (2) pressure altitude and related altimeter setting, (3) heading or track, (4) UAV position: the UAV position must be continuously displayed on a map at a scale selectable by the UAV crew at a level of detail to ensure safe flight. (5) where semi-automatic flight control modes as defined in USAR.1329 are activated, the commanded flight or navigation parameters sent to the UAV must be displayed in the UCS. (b) Considering USAR.1722, the following are the minimum required flight and navigational data that shall be selectable or available when queried by the UAV crew for display in the control station at an update rate consistent with safe operation : (1) airspeed limitations identified under USAR.1505 to USAR.1513, (2) sideslip angle, (3) free air temperature, (4) A speed warning device for

	(i) Turbine engine-powered UAV; and (ii) Other UAV for which V_{MO}/M_{MO} and V_D/M_D are established under USAR.335 (b) (2) and USAR.1505 (c) if V_{MO}/M_{MO} is greater than 0.8 V_D/M_D. The speed warning device must give effective aural warning (differing distinctively from aural warnings used for other purposes) to the UAV crew whenever the speed exceeds that agreed by the Certifying Authority. The upper limit of the production tolerance for the warning device may not exceed the prescribed warning speed. The lower limit must be set to minimise nuisance warnings. The need for or the exact setting of this speed warning device may nevertheless consider the existence of high speed protections maintained by the flight control system, when it may be shown that the UAV is prevented from reaching such speeds. (5) UAV position: (i) the UAV position relative to the LOS data link transmitter/receiver must be also displayed in terms of range and bearing ; (ii) the deviation between the planned ground track and the actual flightpath of the UAV. (6) UAV attitude in terms of roll and pitch, (7) vertical speed, (8) time (hours, minutes, seconds), (9) navigation systems status, (10) UAV identification in accordance with USAR.1883 (b), where multiple UAV are being operated. (11) Wind direction and speed at UAV level, if only track data is displayed to the UAV crew.
U1725	USAR.U1725 Powerplant data (a) The following are the minimum required powerplant data that must be displayed at all times in the control station at an update rate consistent with safe operation: (1) remaining fuel quantity, (2) an indicating means to indicate the good functioning of each engine. (b) For the following data, they are only required to be displayed full time if the system is not capable of providing a warning to the UAV crew if a safe range is exceeded. (1) For reciprocating engine-powered UAV. In addition to the powerplant data required by sub-paragraph (a), the following powerplant data are required: (i) RPM for each engine. (ii) manifold pressure for each altitude engine and for each engine with a controllable propeller. (2) For turbine engine-powered UAV. In addition to the powerplant data required by sub-paragraph (a) , the following powerplant data are required: (i) gas temperature for each engine. (ii) speed of the rotors with established limiting speeds for each engine.

(3) For turbojet/turbofan engine-powered UAV. In addition to the powerplant data required by sub-paragraphs (a) and (b)(2), the following powerplant data are required:

(i) For each engine, thrust or a parameter that can be related to thrust, including free air temperature if needed for this purpose.

(ii) For each engine with a thrust reverser, an indication to the UAV crew of the thrust reverser position.

(4) For turbopropeller-powered UAV In addition to the powerplant data required by sub-paragraphs (a) and (b)(2), the following powerplant data is required: torque for each engine.

(c) Considering USAR.1722, the following are the minimum required powerplant data that shall be selectable or available when queried by the UAV crew for display in the control station at an update rate consistent with safe operation:

(1) For all UAV:

(i) oil pressure for each engine, except for engines where the design does not include a separate lubrication device;

(ii) oil temperature for each engine, except for engines where the design does not include a separate lubrication device;

(iii) oil quantity for each oil tank which meets the requirements of USAR.1337(d), except for engines where the design does not include a separate lubrication device.

(2) For reciprocating engine-powered UAV. In addition to the powerplant data required by sub-paragraph (a), (b)(1) and (c)(1), the following powerplant data are required:

(i) induction system air temperature for each engine equipped with a preheater and having induction air temperature limitations that can be exceeded with preheat.

(ii) cylinder head temperature for each air-cooled engine with cowl flaps;

(iii) fuel pressure for pump fed engines.

(iv) For each turbocharger installation:

- If limitations are established for either carburettor (or manifold) air inlet temperature or exhaust gas or turbocharger turbine inlet temperature, data must be furnished for each temperature for which the limitation is established unless it is shown that the limitation will not be exceeded in all intended operations.

- If its oil system is separate from the engine oil system, oil pressure and oil temperature must be provided.

(v) coolant temperature for each liquid-cooled engine.

(3) For turbine engine-powered UAV. In addition to the powerplant data required by sub-paragraph (a), (b)(2) and (c)(1) , the following powerplant data are required:

(i) fuel flow for each engine.

(ii) fuel low pressure warning means for each engine.

(iii) fuel low level warning means for any fuel tank that should not be depleted of fuel in normal operations.

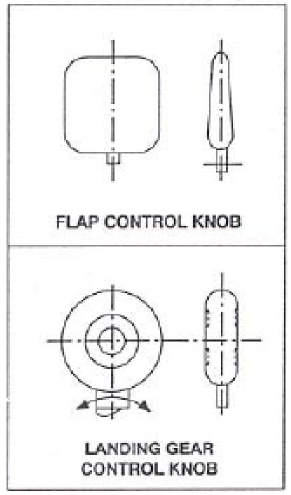
	(iv) oil low pressure warning means for each engine. (v) An indicating means to indicate the functioning of the powerplant ice protection system for each engine. (vi) For each engine, a means to indicate the contamination of the fuel strainer or filter (required by USAR 997) before it reaches the capacity established in accordance with USAR.997(d). (vii) For each engine, a means to indicate the contamination of the oil strainer or filter (required by USAR.1019), if it has no bypass, before it reaches the established capacity. (viii) An indicating means to indicate the functioning of any heater used to prevent ice clogging of fuel system components. (4) For turbopropeller-powered UAV In addition to the powerplant data required by sub-paragraphs (a), (b)(2), (b)(4), (c)(1) and (c)(3), the following powerplant data is required: a position indicating means to indicate to the UAV crew when the propeller blade angle is belowthe flight low pitch position, for each propeller, unless it can be shown that such occurrence is highly improbable.
U1726	USAR.U1726 Data display of equipment required by Operations regulation The data and status of equipment required by Operation regulation must be capable of display in the UCS as agreed by the Certifying Authority.
U1727	USAR.U1727 Electronic data display See AMC.1727 and AMC.1727 (b) (a) Electronic data display systems must (1) Meet the arrangement and visibility requirements of USAR.1721; (2) Be easily legible under all the lighting conditions encountered by the workstation considering the expected electronic display brightness level at the end of an electronic display indicator's useful life. Specific limitations on display system useful life must be addressed in the instructions for continued airworthiness requirements of USAR.1529; (3) Incorporate sensory cues for the UAV crew that are easily comprehensible, and (4) Incorporate visual displays of indicators or data display markings, required by USAR.1831 to USAR.1843, or visual displays that alert the UAV crew to abnormal operational values or approaches to established limitation values, for each parameter required to be displayed in USAR. (b) The electronic display systems, including their subsystems and installations, and considering other UAV systems, must be designed so that one display of information essential for continued safe flight and landing will remain available to the UAV crew after any single failure or probable combination of failures.
U1728	USAR.U1728 Data link data display, warnings and indicators Data link data display, warnings and indicators must meet the requirements of USAR.1607.
U1729	USAR.U1729 Fuel quantity and oil quantity data (a) Fuel quantity and consumption data. There must be means to indicate to the UAV crew the rate of fuel consumption and the quantity of usable fuel in each tank during flight. A calibrated scale in appropriate units and clearly marked to indicate those units, must be used. In addition (1) Tanks with interconnected outlets and airspaces may be considered as one tank and need not display separate data; and

	(2) No fuel quantity data is required for an auxiliary tank that is used only to transfer fuel to other tanks if the relative size of the tank, the rate of fuel transfer and operating instructions are adequate to (i) Prevent overflow; and (ii) Give to the UAV crew a prompt warning if a transfer malfunction occurs. (b) Oil quantity data. There must be a means to indicate in the UCS the quantity of oil in each tank in flight, if there is an oil transfer system or a reserve oil supply system.
U1730	USAR.U1730 Automatic take-off system or automatic landing system data For UAV equipped with an automatic take-off system or an automatic landing system or both, the following data must be continuously displayed to the UAV crew during the respective flight phases in compliance with USAR.1490 (d) (a) the UAV flightpath, (b) the deviation between the UAV flightpath and the planned flightpath. For landing the standard slope is as defined in USAR.75.
CONTROLS	
U1731	USAR.U1731 General See AMC.1731 (a) Each control in the UCS must be located and (except where its function is obvious) identified to provide convenient operation and to prevent confusion and inadvertent operation. (b) The controls must be located and arranged so that the UAV crew, when at their workstation have full and unrestricted movement of each control without interference from either their clothing or the UCS structure. (c) The control system must be designed so that the controls needed for continued safe flight and landing remain available to the UAV crew in normal, abnormal and emergency conditions.
U1732	USAR.U1732 Safety critical controls (a) The design, location and accessibility of safety critical controls (i.e. requiring immediate action of the UAV crew) must be compatible with a rapid and precise reaction of the UAV crew during emergency operation. (b) Where the interface with UAV crew is based on a “pull down menus” architecture, (1) the controls that necessitate a prompt reaction of the UAV crew must be accessible at the first level of the pull down menus, (2) otherwise, safety critical controls in the UCS must have dedicated knobs or levers. (c) Safety critical controls must be designed to prevent the possibility of confusion and subsequent inadvertent operation.
U1733	USAR.U1733 Conventional controls and indicators (a) Where conventional flying controls and indicators are employed, the form, the location and layout must ensure safe operation. (b) For each conventional indicators in the UCS (1) When markings are on the cover glass of the indicator, there must be means to maintain the correct alignment of the glass cover with the face of the dial,

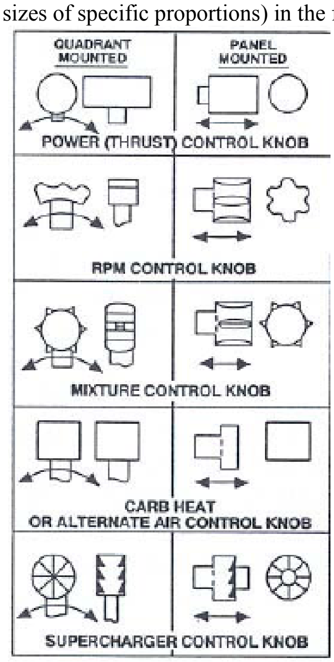
(2) Each arc and line must be wide enough and located to be clearly visible to the UAV crew,

(3) All related indicators must be calibrated in compatible units.

(c) If conventional flap and landing gear control knobs are used by the UAV crew, they must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure:



(d) If conventional powerplant control knobs are used by the UAV crew, they must conform to the general shapes (but not necessarily the exact sizes of specific proportions) in the following figures:



U1735	USAR.U1735 Motion and representation of controls UCS controls must be designed so that they, or their representations, operate intuitively for the UAV crew. The representation of these controls must be similar to conventional flight controls that exist in manned aircraft.
U1741	USAR.U1741 UCS flight controls (a) The UCS flight controls are those used by the UAV crew to operate the UAV with the semi-automatic mode of control as defined in USAR.1329 (b) The design of UCS flight controls must allow the UAV crew to rapidly and easily change the following flight parameters of the UAV (1) heading or track, (2) altitude, and, (3) airspeed.
U1742	USAR.U1742 Flight termination system control When the UAV is equipped with a flight termination system, (a) Its controls are safety critical controls as defined in USAR.1732. (b) Its controls must be arranged and identified such that they are readily available and accessible. The use of these controls must be intuitive and minimise the possibility of confusion and subsequent inadvertent operation. (c) Two distinct actions of the UAV crew are required to initiate the flight termination command.
U1743	USAR.U1743 Fuel controls (a) There must be a means readily available to allow the UAV crew to rapidly shut off, in flight, the fuel to each engine individually. (b) In addition, there must be means to (1) Prevent inadvertent operation of each shut-off valve; and (2) Allow appropriate UAV crew to reopen each valve rapidly after it has been closed. (c) Where fitted, fuel tank selector must (1) Require a separate and distinct action to place the selector in the “OFF” position; and (2) Have the tank selector designed to operate so that it is impossible for the selector to pass through the “OFF” position when changing from one tank to another.
U1745	USAR.U1745 Fuel jettisonning control (a) Where existing, the fuel jettisoning valve must be designed to allow UAV crew to close the valve during any part of the jettisoning operation. (b) There must be an indication compliant with USAR.1831, adjacent to the jettison control to warn the UAV crew against jettisoning fuel while any means (including flaps, slots and slats) of changing the airflow across or around the wings is in use, unless it is shown that using such means does not adversely affect fuel jettisoning. (c) Fuel jettisoning control must be designed to prevent inadvertent operation

U1747	USAR.U1747 Air induction control Each automatic alternate air induction door must have an override means accessible to the UAV crew.
U1751	USAR.U1751 Engine and APU controls The controls necessary to perform all functions in normal, abnormal and emergency modes must be provided to the UAV crew taking into account the level of automation substantiated by the flight control system.
U1753	USAR.U1753 Ignition switches See AMC.1753 (b) (a) Ignition switches must control each ignition circuit on each engine. (b) There must be means readily available to the UAV crew to quickly shut off all ignition circuits on multi-engine UAV. (c) Ignition switches must have safeguards to prevent inadvertent operation.
U1755	USAR.U1755 Mixture controls When mixture control is provided, there shall be a separate control for each engine. Each mixture control must be designed to prevent confusion and inadvertent operation. (a) The controls must be grouped and arranged to allow (1) Separate control of each engine; and (2) Simultaneous control of all engines. (b) The control must require a separate and distinct operation to move the control towards lean or shut-off position.
U1757	USAR.U1757 Propeller speed and pitch controls (a) Where propeller speed or pitch controls exist, they must be grouped and arranged to allow (1) Separate control of each propeller; and (2) Simultaneous control of all propellers. (b) The controls must allow ready synchronisation of all propellers on multi-engine UAV.
U1759	USAR.U1759 Propeller feathering controls Where propeller feathering controls exist, it must be possible to feather each propeller separately. Each control must have means to prevent inadvertent operation.
U1761	USAR.U1761 Turbine engine reverse thrust and propeller pitch settings below the flight regime For turbine engine installations, each control for reverse thrust and for propeller pitch settings, where existing, below the flight regime must have means to prevent its inadvertent operation. The means must have a positive lock or stop at the flight idle position and must require a separate and distinct operation by the UAV crew to displace the control from the flight regime (forward thrust regime for turbojet powered UAV).
U1763	USAR.U1763 Carburettor air temperature controls Where existing, there must be a separate carburettor air temperature control for each engine.
U1765	USAR.U1765 Shut-off controls (a) For each UAV function that can be shut-off from the UCS, there must be a means to prevent inadvertent operation of the shut-off control. In addition, there must be a means to restore the function after it has been shut-off.

	(b) For fuel shut-offs control, the requirement is addressed in USAR.1743. (c) For ignition shut-off control, the requirement is addressed in USAR.1753
U1769	USAR.U1769 "Abort" control for automatic take-off system or automatic landing system See AMC.1769 Where a UAV System is equipped with an automatic take-off system or an automatic landing system there must be a means readily available to the UAV crew to rapidly abort the take-off phase or the landing phase in compliance with USAR.1492
INDICATORS AND WARNINGS	
U1785	USAR.U1785 Warning, caution and advisory information colour code The warning, caution or advisory information installed in the UCS, must, unless otherwise approved by the Certifying Authority, be (a) Red, for warning information (information indicating a hazard which may require immediate corrective action); (b) Amber, for caution information (information indicating the possible need for future corrective action); (c) Green, for safe operation information; and (d) Any other colour, including white, for information not described in sub-paragraphs (a) to (c), provided the colour differs sufficiently from the colours prescribed in sub-paragraphs (a) to (c) to avoid possible confusion. (e) Effective under all probable UCS lighting conditions.
U1787	USAR.U1787 UAV automatic diagnostic and monitoring See AMC.1787 (a) (a) The UCS must include an automatic diagnostic and monitoring capability for the status of the UAV System and provide to the UAV crew appropriate warning indication. (b) Guidance for corrective actions shall be provided either automatically or in the UAV System Flight Manual.
U1788	USAR.U1788 Degraded modes of operation warning The UCS must be configured to ensure that the UAV crew is informed of any abnormal or emergency mode, including cases in which there is an automatic switching to an alternate mode of operation.
U1789	USAR.U1789 Low speed warning (a) There must be a clear and distinctive low speed warning in the UCS, with the flaps and landing gear in any normal position in straight and turning flight, in accordance with the following (1) It should not be possible to command from the UCS speed values lower than the minimum steady flight speed (except take-off and landing) allowed by the flight envelope protection maintained by the flight control system. (2) Adequate low speed cues and warning should be provided in the UCS when approaching the stalling speed or $V_{min\ DEMO}$ if the stalling is not to be demonstrated. (3) During the tests required by USAR.201 the low speed warning must begin at a speed exceeding the stalling spped or $V_{min\ DEMO}$ (if the stalling is not to be demonstrated) by a margin of not less than 5 knots and must continue as long as the condition is true.

	(4) When following the procedures of USAR.1585, the low speed warning must not occur during a take-off with all engines operating, a take-off continued with one engine inoperative or during an approach to landing. (b) The low speed warning must be furnished by a device that will give clearly distinguishable indication. A visual low speed warning device that requires the attention of the UAV crew within the UCS is not acceptable by itself.
U1790	USAR.U1790 UAV mode of control indicator There must be a means in the UCS to indicate to the UAV crew the active mode of control of the flight control system. If semi-automatic mode is engaged, a specific indicator must be activated in clear view of the UAV crew.
U1791	USAR.U1791 Wing flaps position indicator Where a UAV is equipped with wing flaps, there must be a wing flap position indicator in the UCS
U1793	USAR.U1793 Landing gear position indicator and warning See AMC.1793 (b) (a) Position indicator. If a retractable landing gear is used, there must be a landing gear position indicator in the UCS to inform the UAV crew that each gear is secured in the extended (or retracted) position. (b) Landing gear warning. If a retractable landing gear is used, an aural or equally effective landing gear warning devices must be provided to inform the crew of an imminent landing without the gear fully extended and locked. (c) Landing gear controlled by an automatic landing system (see USAR.1492) must comply with (a) and (b).
U1795	USAR.U1795 Pressurised compartment indicator See AMC.1795 Where a UAV is equipped with a pressurised compartment, there must be a warning to indicate when the safe pressure differential is exceeded.
U1797	USAR.U1797 Fuel pumps warning Where a UAV is equipped with fuel pumps, if both the main pump and emergency pump operate continuously, there must be a means to indicate to the UAV crew a malfunction of either pump.
U1799	USAR.U1799 Air induction indicator Where a UAV is equipped with an air induction door, each alternate air induction door must have a means to indicate to the UAV crew when it is not closed.
U1801	USAR.U1801 Battery discharge warning See AMC.1801 There must be means to warn the UAV crew if malfunctioning of any part of the electrical system is causing the continuous discharge of any battery which is relevant for safe flight.
U1803	USAR.U1803 Indicators for power-assisted valves in the powerplant See AMC.1803 For power-assisted valves in the powerplant, there must be a means in the UCS to indicate to the UAV crew when the valve (i) is in the fully open or fully closed position (ii) is moving between the fully open and fully closed position.

U1805	USAR.U1805 Shut off valves indicator Where a UAV is equipped with power operated shut off valves they must have means to indicate to the UAV crew when the valve has reached the selected position
U1809	USAR.U1809 UAV electrical systems warning and indicator See AMC.1809 (a) There must be a means to give immediate warning to the UAV crew of a failure of any UAV electrical power generating device. (b) A means must exist in the UCS to indicate to the UAV crew the electric power system quantities essential for safe operation (c) A warning which is unambiguous and clearly distinguishable to the UAV crew shall be immediately provided for any UCS power supply failure which could result in an unsafe condition in any phase of UAV flight, including landing and take off.
U1811	USAR.U1811 De-icer boot system indicator If certification with ice protection provisions is desired and a de-icer boot system is installed there must be means to indicate to the UAV crew that the de-icer boot system is functioning normally.
U1813	USAR.U1813 Hydraulic systems indicator There must be a means to indicate to the UAV crew the pressure in each hydraulic system which supplies two or more primary functions.
U1817	USAR.U1817 Fire protection warning If action by the UAV crew is required to prevent or extinguish fire (e.g. equipment shut-down or actuation of a fire extinguisher) in the UAV, quick acting means must be provided to immediately alert the UAV crew in the UCS.
U1819	USAR.U1819 Pitot heat indicator If a pitot heating system is installed to meet the requirements specified in USAR.1323 (b), an indication system must be provided to indicate to the UAV crew when that pitot heating system is not operating.
U1821	USAR.U1821 UCS Power distribution indicator See AMC.1821 Each UCS power distribution circuit must have an indicator in the UCS to indicate when power is below safe minimum.
U1825	USAR.U1825 Flight control system lock warning If there is a device on the UAV to lock the flight controls as mentioned in USAR.679, the UAV crew must be warned when the device is engaged.
U1827	USAR.U1827 Flightpath deviation warning Where automatic flight control modes as defined in USAR.1329 are activated, a warning must be displayed when excessive deviation from the pre-programmed flightpath occurs. The acceptable deviation shall be agreed with the Certifying Authority.
U1829	USAR.U1829 UAV safety status indication An indication must be provided in the UCS which shows the safety status of the UAV so approaching ground staff can be notified if the UAV is in an unsafe state (e.g. radiation hazard present, laser energized, etc.).

	INFORMATION, MARKINGS AND PLACARDS
U1831	USAR.U1831 General Each information, markings and placard displayed in the UCS prescribed in USAR.1541 (a) must be (a) continuously displayed in a conspicuous place relative to the object, indicator or data it is assumed to be associated with; and (b) easily interpreted unambiguously by the UAV crew.
U1835	USAR.U1835 Airspeed data (a) If required to maintain safe flight, each airspeed data must be marked as specified in sub-paragraph (b), with the marks located at the corresponding indicated airspeeds. (b) The following markings must be made: (1) For the never-exceed speed V_{NE}, a red line. (2) For the caution range, a yellow band extending from the red line specified in sub-paragraph (1) to the upper limit of the green band specified in sub-paragraph (3) . (3) For the normal operating range, a green band with the lower limit at V_{S1} with maximum weight and with landing gear and wing flaps retracted, and the upper limit at the maximum structural cruising speed V_{NO} established under USAR.1505 (b). (4) For the flap operating range, a white band with the lower limit at V_{S0} at the maximum weight and the upper limit at the flaps-extended speed V_{FE} established under USAR.1511. (5) For multi-engine powered UAV, for the speed at which compliance has been shown with USAR.69 (b) relating to rate of climb, at maximum weight and at sea-level, a blue line. (6) For multi-engine powered UAV, for the maximum value of minimum control speed (one or more engine inoperative) determined under USAR.149 (b), V_{MC}, a red line. (c) If V_{NE} or V_{NO} vary with altitude, there must be means to indicate to the UAV crew the appropriate limitations throughout the operating altitude range. (d) Sub-paragraphs (b) (1) to (b) (3) and sub-paragraph (c) do not apply to UAV for which a maximum operating speed V_{MO}/M_{MO} is established under USAR.1505 (c). For those UAV System there must either be a maximum allowable airspeed indication showing the variation of V_{MO}/M_{MO} with altitude or compressibility limitations (as appropriate), or a red line marking for V_{MO}/M_{MO} must be made at lowest value of V_{MO}/M_{MO} established for any altitude up to the maximum operating altitude for the UAV. (e) There must be an airspeed indication in clear view of the UAV crew and as close as practicable to the airspeed indicator. This indication must list (1) The operating manoeuvring speed, Vo; (2) The maximum landing gear operating speed V_{LO}; and (3) For multi-engine-powered UAV, the maximum value of the minimum control speed (one or more engine inoperative) determined under USAR.149 (b), V_{MC}.

U1837	USAR.U1837 Magnetic heading or track data See AMC.1837 Where magnetic heading or track is displayed in the UCS, it must be automatically compensated for deviation.
U1839	USAR.U1839 Powerplant and auxiliary power unit data For each required powerplant and auxiliary power unit, data shall be available in the UCS, as appropriate to the type of powerplant. (a) Each maximum and if applicable, minimum safe operating limit must be marked with a red radial or a red line; (b) Each normal operating range must be marked with a green arc or green line not extending beyond the maximum and minimum safe limits; (c) Each take-off and precautionary range must be marked with a yellow arc or a yellow line; and (d) Each engine, auxiliary power unit or propeller range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.
U1841	USAR.U1841 Oil quantity data Each oil quantity data displayed in the UCS must be marked in sufficient increments to indicate readily and accurately the quantity of oil.
U1843	USAR.U1843 Fuel quantity data A red line must be marked on each data displayed in the UCS at the calibrated zero reading, as specified in USAR.1337 (b)(1).
U1845	USAR.U1845 Control markings See AMC.1845 (e)(2) (a) Every control, switch, knob or lever in the UCS must be plainly marked as to its function and method of operation. (b) Each remote control, as defined in USAR.1741, must be suitably marked. (c) For powerplant fuel controls (1) Each fuel tank selector control must be marked to indicate the position corresponding to each tank and to each existing cross feed position; (2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on or near the selector for those tanks; (3) The conditions under which the full amount of usable fuel in any restricted usage fuel tank can safely be used must be stated adjacent to the selector valve for that tank; and (4) Each valve control for any engine of a multi-engine UAV must be marked to indicate the position corresponding to each engine controlled. (5) For fuel jettisonning control, see USAR.1745 (b). (d) Usable fuel capacity must be marked as follows: (1) For fuel systems having no selector controls, the usable fuel capacity of the system must be indicated near the fuel quantity data displayed in the UCS

	(2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control. (e) For accessory, auxiliary and emergency controls (1) If retractable landing gear is used, the indicator required by USAR.1793 must be marked so that the UAV crew can, at any time, ascertain that the wheels are secured in the extreme positions; and (2) Each emergency control must be red and must be marked as to method of operation. (3) No control other than an emergency control shall be this colour.
U1849	USAR.U1849 Operating limitations indications (a) There must be an indication in clear view of the UAV crew stating in the UCS that the UAV must be operated in accordance with the UAV System Flight Manual; (b) There must be an indication in clear view of the UAV crew that specifies the kind of operations to which the operation of the UAV is limited or from which it is prohibited under USAR.1525.
<u>MISCELLANEOUS</u>	
U1881	USAR.U1881 UAV hand over between two UCS See AMC.1881 (b), AMC.1881 (c) and AMC.1881 (d) Where the UAV System is designed for UAV hand over between two UCS: (a) The in-control UCS must be clearly identified to all UAV crew members. (b) Positive control must be maintained during handover. (c) The command and control functions that are transferred during handover must be approved by the Certifying Authority and defined in the UAV System Flight Manual. (d) Handover between two UCS must not lead to unsafe conditions. (e) The in-control UCS must have the required functionality to accommodate emergency situations.
U1883	USAR.U1883 Command and control of multiple UAV Where a UCS is designed to command and control multiple UAV, the following requirements apply: (a) The minimum UAV crew must be established so that it is sufficient for safe operation of each vehicle in compliance with USAR.1704 and emergency conditions. (b) The UAV data shall be displayed in the UCS in a manner that prevents confusion and inadvertent operation. (c) The UAV controls must be available to the UAV crew for each UAV of which it has command and control in a manner that prevents confusion and inadvertent operation. (d) All indicators and warnings must be available to the UAV crew for each UAV in a manner that prevents confusion and inadvertent operation.
U1885	USAR.U1885 UAV handover within the same UAV control station See AMC.1885 (b) and AMC.1885 (d) Where the UCS has more than one workstation designed for controlling the UAV:

	(a) The in-control workstation must be clearly identified to all UAV crew members. (b) Positive control must be maintained during handover. (c) The command and control functions that are transferred during handover must be approved by the Certifying Authority and defined in the UAV System Flight Manual. (d) Handover within the same UAV control station must not lead to unsafe conditions. (e) The in-control workstation must have the required functionality to accommodate emergency situations.
U1887	USAR.U1887 Multiple UAV monitoring Where the UCS is designed to monitor multiple UAV, there must be a means to clearly indicate to the UAV crew the UAV over which it has command and control.

Appendix C

Basic Landing Conditions

Appendix C

Basic Landing Conditions

C23.1 Basic landing conditions

Condition	Tail wheel type: Level landing	Tail wheel type: Tail-down landing	Nose wheel type: Level landing with inclined reactions	Nose wheel type: Level landing with nose wheel just clear of ground	Nose wheel type: Tail-down landing
Reference section	23.479(a)(1)	23.481(a)(1)	23.479(a)(2)(i)	23.479(a)(2)(ii)	23.481(a)(2) and (b)
Vertical component at c.g.	nW	nW	nW	nW	nW
Fore and aft component at c.g.	KnW	0	KnW	KnW	0
Lateral component in either direction at c.g.	0	0	0	0	0
Shock absorber extension (hydraulic shock absorber)	Note (2)	Note (2)	Note (2)	Note (2)	Note (2)
Shock absorber deflection (rubber or spring shock absorber)	100%	100%	100%	100%	100%
Tyre deflection	Static	Static	Static	Static	Static
Main wheel loads (both wheels) V_r	(n-L)W	(n-L)Wb/d	(n-L)Wa'/d'	(n-L)W	(n-L)W
Main wheel loads (both wheels) D_r	KnW	0	KnWa'/d'	KnW	0
Tail (nose) wheel loads V_f	0	(n-L)Wa/d	(n-L)Wb'/d'	0	0
Tail (nose) wheel loads D_f	0	0	KnWb'/d'	0	0
Notes	(1), (3), and (4)	(4)	(1)	(1), (3), and (4)	(3) and (4)

NOTE (1)
K may be determined as follows: K=0.25 for W=1361 kg (3,000 pounds) or less; K=0.33 for W=2722 kg (6,000 pounds) or greater, with linear variation of K between these weights.

NOTE (2)
For the purpose of design, the maximum load factor is assumed to occur throughout the shock absorber stroke from 25% deflection to 100% deflection unless otherwise shown and the load factor must be used with whatever shock absorber extension is most critical for each element of the landing gear.

NOTE (3)
Unbalanced moments must be balanced by a rational conservative method.

NOTE (4)
L is defined in USAR.725(b).

NOTE (5)
n is the limit inertia load factor, at the c.g. of the UAV, selected under USAR.475 (d), (f), and (g).

Appendix D

Wheel Spin-Up Loads

(a) The following method for determining wheel spin-up loads for landing-conditions is based on NACA T.N. 863. However, the drag component used for design may not be less than the drag load prescribed in USAR.479 (b).

$$F_{H\,max} = \frac{1}{r_e}\sqrt{\frac{2I_w\,(V_H - V_C)\,n\,F_{V\,max}}{t_z}}$$

where :
FH max = maximum rearward horizontal force acting on the wheel (in pounds);
re = effective rolling radius of wheel under impact based on recommended operating tyre pressure (which may be assumed to be equal to the roiling radius under a static load of njWe) in feet;
IW = rotation mass moment of inertia of rolling assembly (in slug feet);
V_H = linear velocity of UAV parallel to ground at instant of contact (assumed to be 1.2 V_{S0}, in feet per second);
V_C = peripheral speed of tyre, if pre-rotation is used (in feet per second) (there must be a positive means of pre-rotation before pre-rotation may be considered);
n = effective coefficient of friction (0.80 may be used);
FV max = maximum vertical force on wheel (pounds = njWe, where We and nj) are defined in USAR.725;
tz = time interval between ground contact and attainment of maximum vertical force on wheel (seconds). However, if the value of FH max, from the above equation exceeds 0.8 FV max, the latter value must be used for FH max.

(b) This equation assumes a linear variation of load factor with time until the peak load is reached and under this assumption, the equation determines the drag force at the time that the wheel peripheral velocity at radius re equals the UAV velocity. Most shock absorbers do not exactly follow a linear variation of load factor with time. Therefore, rational or conservative allowances must be made to compensate for these variations. On most landing gears, the time for wheel spin-up will be less than the time required to develop maximum vertical load factor for the specified rate of descent and forward velocity. For exceptionally large wheels, a wheel peripheral velocity equal to the ground speed may not have been attained at the time of maximum vertical gear load. However, as stated above, the drag spin-up load need not exceed 0.8 of the maximum vertical loads.

(c) Dynamic spring-back of the landing gear and adjacent structure at the instant just after thewheels come up to speed may result in dynamic forward acting loads of considerable magnitude. This effect must be determined, in the level landing condition, by assuming that the wheel spin-up loads calculated by the methods of this appendix are reversed. Dynamic spring-back is likely to become critical for landing gear units having wheels of large mass or high landing speeds.

Appendix F

Test Procedure for Self-Extinguishing Materials in accordance with USAR.1359
(a) Conditioning. Specimens must be conditioned to 21° ± 3°C (70° ± 5°F), and at 50% ± 5% relative humidity until moisture equilibrium is reached or for 24 hours. Only one specimen at a time may be removed from the conditioning environment immediately before subjecting it to the flame. (b) Specimen configuration. (1) Not applicable; (2) Not applicable (3) When showing compliance with USAR.1359 (c) for materials used in electrical wire and cable insulation, the wire and cable specimens must be the same size as used in the UAV. In the case of fabrics, both the warp and fill direction of the weave must be tested to determine the most critical flammability condition. When performing the tests prescribed in sub-paragraphs (d) and (e) of this Appendix, the specimen must be mounted in a metal frame so that; (i) in the vertical tests of sub-paragraph (d), the two long edges and the upper edge are held securely; (ii) in the horizontal test of sub-paragraph (e), the two long edges and the edge away from the flame are held securely; (iii) the exposed area of the specimen is at least 5 cm (2 in) wide and 30 cm (12 in) long, unless the actual size used in the UAV is smaller; and (iv) the edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen but must be representative of the actual cross-section of the material or part installed in the UAV. When performing the test prescribed in sub-paragraph (f) of this Appendix, the specimen must be mounted in a metal frame so that all four edges are held securely and the exposed area of the specimen is at least 20 cm by 20 cm (8 in by 8 in). (c) Apparatus. Except as provided in sub-paragraph (e) of this Appendix, tests must be conducted in a draft-free cabinet in accordance with Federal Test Method Standard 191 Method 5903 (revised Method 5902) which is available from the General Services Administration, Business Service Centre, Region 3, Seventh and D Streets SW. Washington, D.C. 20407, or with some other approved equivalent method. Specimens which are too large for the cabinet must be tested in similar draft-free conditions. (d) Vertical test. A minimum of three specimens must be tested and the results averaged. For fabrics, the direction of weave corresponding to the most critical flammability conditions must be parallel to the longest dimension. Each specimen must be supported vertically. The specimen must be exposed to a Bunsen or Tirrill burner with a nominal 9.5 mm (3/8 in) inner diameter tube adjusted to give a flame of 38 mm (1½ in) in height. The minimum flame temperature measured by a calibrated thermo-couple pyrometer in the centre of the flame must be 843°C (1550°F). The lower edge of the specimen must be 19 mm (3/4 in) above the top edge of the burner. The flame must be applied to the centre line of the lower edge of the specimen. For materials covered by USAR.853 (f), the flame must be applied for 60 seconds and then removed. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with sub-paragraph (h) of this Appendix must be measured to the nearest 2.5 mm (1.10 in). (e) Horizontal test. A minimum of three specimens must be tested and the results averaged. Each specimen must be supported horizontally. The exposed surface when installed in the UAV must be face down for the test. The specimen must be exposed to a Bunsen burner or Tirrill burner with a nominal 9.5 mm (3/8 in) inner diameter tube adjusted to give a flame of 38 mm (1½ in) in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 843°C (1550°F). The specimen must be positioned so that the edge being tested is 19 mm (¾ in) above the top of, and on the centre line of, the burner. The flame must be applied for 15 seconds and then removed. A

minimum of 25 cm (10 in) of the specimen must be used for timing purposes, approximately 38 mm (1½ in) must burn before the burning front reaches the timing zone, and the average burn rate must be recorded.

(f) Forty-five degree test. Not applicable.

(g) Sixty-degree test. A minimum of three specimens of each wire specification (make and size) must be tested. The specimen of wire or cable (including insulation) must be placed at an angle of 60° with the horizontal in the cabinet specified in sub-paragraph (c) of this appendix with the cabinet door open during the test or placed within a chamber approximately 0.6 m (2 ft) high by 0.3 m by 0.3 m (1 ft by 1 ft), open at the top and at one vertical side (front), that allows sufficient flow of air for complete combustion but is free from drafts. The specimen must be parallel to and approximately 15 cm (6 in) from the front of the chamber. The lower end of the specimen must be held rigidly clamped. The upper end of the specimen must pass over a pulley or rod and must have an appropriate weight attached to it so that the specimen is held tautly throughout the flammability test. The test specimen span between lower clamp and upper pulley or rod must be 61 cm (24 in) and must be marked 20 cm (8 in) from the lower end to indicate the centre point for flame application. A flame from a Bunsen or Tirrill burner must be applied for 30 seconds at the test mark. The burner must be mounted underneath the test mark on the specimen, perpendicular to the specimen and at an angle of 30° to the vertical plane of the specimen. The burner must have a nominal bore of 9.5 mm (3/8 in), and must be adjusted to provide a 76 mm (3 in) high flame with an inner cone approximately onethird of the flame height. The minimum temperature of the hottest portion of the flame, as measured with a calibrated thermocouple pyrometer may not be less than 954°C (1750°F). The burner must be positioned so that the hottest portion of the flame is applied to the test mark on the wire. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with sub-paragraph (h) of this appendix must be measured to the nearest 2.5 mm (1 10 in). Breaking of the wire specimen is not considered a failure.

(h) Burn length. Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discoloured, nor areas where material has shrunk or melted away from the heat source.

Appendix G

Instructions for continued airworthiness

G.1 General

(a) This appendix specifies requirements for the preparation of instructions for continued airworthiness as required by USAR.1529.

(b) The instructions for continued airworthiness for each UAV System must include the instructions for continued airworthiness for each engine and propeller (hereinafter designated 'products'), for each appliance required by USAR, and any required information relating to the interface of those appliances and products with the UAV System. If instructions for continued airworthiness are not supplied by the manufacturer of an appliance or product installed in the UAV System, the instructions for continued airworthiness for the UAV System must include the information essential to the continued airworthiness of the UAV System.

G.2 Format

(a) The instructions for continued airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

G.3 Content

The contents of the manual or manuals must be prepared in a language acceptable to the Certifying Authority. The instructions for continued airworthiness must contain the following manuals or sections, as appropriate and information:

(a) (I) UAV Maintenance Manual or section

(1) Introduction information that includes an explanation of the UAV's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A description of the UAV and its systems and installations including its engines, propellers, and appliances.

(3) Basic control and operation information describing how the UAV components and systems are controlled and how they operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of access panels for inspection and servicing, locations of lubrication points, lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and levelling information.

(b) (II) Ground segment and command and control data link (UCS – launch and landing elements) Maintenance Manual or section

(1) Introduction information that includes an explanation of the ground segment's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A description of the ground segment and its systems and installations including UCS, launch and landing elements and command and control data link.

(3) Basic control and operation information describing how the ground segment components and systems are controlled and how they operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of access panels for inspection and servicing,

locations of lubrication points, lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and levelling information.

(c) Maintenance Instructions

(1) Scheduling information for each part of the UAV System and its engines, auxiliary power units, propellers, accessories, instruments, and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances, and work recommended at these periods. However, reference may be made to information from an accessory, instrument, or equipment manufacturer as the source of this information if it is shown that the item has an exceptionally high degree of complexity requiring specialised maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross reference to the airworthiness limitations section of the manual must also be included. In addition, an inspection programme that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the UAV System must be included.

(2) Trouble-shooting information describing probable malfunctions, how to recognise those malfunctions, and the remedial action for those malfunctions.

(3) Information describing the order and method of removing and replacing products and parts with any necessary precautions to be taken.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, weighing and determining the centre of gravity, lifting and shoring, and storage limitations.

(d) Diagrams of structural access plates and information needed to gain access for inspections when access plates are not provided.

(e) Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified.

(f) Information needed to apply protective treatments to the structure after inspection.

(g) All data relative to structural fasteners such as identification, discard recommendations, and torque values.

(h) A list of special tools needed.

(i) Not applicable

G.4 Airworthiness Limitations section

The instructions for continued airworthiness must contain a section titled airworthiness limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure required for type certification. This section must also set forth to review the approved Design Usage Spectrum (see USAR.17) on a regular basis as specified by the Certifying Authority. If required by the Certifying Authority the Design Usage Spectrum should be updated. If the instructions for continued airworthiness consist of multiple documents, the section required by this paragraph must be included in the principal manual. This section must contain a legible statement in a prominent location that reads: The airworthiness limitations section is approved and variations must also be approved.

BOOK 2 - ACCEPTABLE MEANS OF COMPLIANCE (AMC)

A – GENERAL

AMC.17
Design usage spectrum The Applicant uses this information as the basis for assumptions underpinning fatigue and damage tolerance and associated individual UAV tracking. The design usage spectrum is therefore necessary for producing and maintaining the Fatigue Type Record or equivalent document. The applicant also uses the design usage spectrum to identify any gross deviation between design assumptions and service usage. The design usage spectrum is descriptive, rather than prescriptive. The design usage spectrum contains a breakdown of the typical Sortie Profiles Codes (SPCs) or any equivalent for the UAV type in each of its roles and at each typical operating location. SPCs or any equivalent are expressed in terms of height, time, speed, mass and configuration data, which are derived from recorded sortie information. The initial issue of the design usage spectrum should be produced as early as possible in the project life cycle and should be reviewed and updated throughout the life of type.

AMC.19
Special military modes of operation The methodology used to substantiate USAR.19 should include consideration of potential system failures in both the inactive special modes and the normal system.

B – FLIGHT

AMC.21
Proof of compliance

During flight test, the variability in measurement of a desired performance parameter shall be less than 5%, accounting for flight test practice tolerances and instrumentation accuracies.

Critical items affected by weight should have a tolerance between +5% and -1%.

AMC.55
Accelerate-stop Distance or Critical Field Length

UAV crew and system response delays should be considered as part of the Accelerate-stop distance or Critical Field Length calculation. For example, if an arresting hook deployment requires activation from the UCS, latencies associated with this command may affect Accelerate-stop distance or Critical Field Length.

AMC.171
Longitudinal and lateral stability and response

(a) Accuracy
The UAV shall be capable to maintain the desired flight parameters in smooth air with a sufficiently small static error, to be agreed by the Applicant and the Certifying Authority. This should be demonstrated by model-based analyses and verified by flight tests, for the following parameters, throughout the normal flight envelope:

(1) Attitude: pitch and roll angles

(2) Airspeed, heading or track, turn rate, and altitude.

(b) Transient response

It shall be demonstrated for the entire flight envelope that :

(1) Pitch and Roll response following an abrupt command input or gusts, are suitably damped so as not to cause exceedance of the:

(i) Limit load factor

(ii) Maximum torque allowed by the control surface actuators

(2) Transition to a selected altitude, or engagement of an altitude hold function should not cause a deviation (overshoot) of the commanded value by a tolerance greater than 3 times the tolerance agreed with the authorities under paragraph (a).

(3) Transition to a selected heading or engagement of a heading hold function should not cause transient deviation (overshoot) of the commanded value by a tolerance greater than 3 times the tolerance agreed with the authorities under paragraph (a).

(4) Transition to a selected airspeed or selection of an airspeed hold function, within the permissible flight envelope protection, should not cause the air speed to:

(i) Fall below the minimum allowed air speed

(ii) Exceed V_{NE}.

AMC.235
Operations on unpaved surfaces (1) Consideration should also be given to the relationship of the position of the engine intakes to the operating surface to establish whether there is any risk of damage from the ingestion of foreign objects, i.e. FOD. (2) The following leaflets contained within the UK MoD Defence Standard 00-970 give additional guidance on the operation from surfaces other than smooth hard runways: Defence standard 00-970 part 1 section 4 leaflets 48, 49, 50, 51, 52 and 53.

AMC.283
Launch safety trace Ballistic footprint, rocket misalignment errors, poor catapult launch performance, poor engine performance, flight control failures, etc., should be considered as part of the hazard analysis to determine the launch safety trace.

C – STRUCTURE

AMC.301

Loads

(a) Static qualification evidence is usually in the form of a static type record (STR) or equivalent national document. The STR or equivalent document comprises a general arrangement and description of the UAV, a summary of static design assumptions and/or criteria, a summary of critical loading, shear force, bending moment, torque and mass distributions, and a summary of static reserve factors. The static evidence must normally list all relevant supporting stress and test reports and calculation files. For modern designs, evidence may have been obtained from aerodynamic and loads models (such as finite element models (FEM)) and so it may be beneficial to maintain and update these models through the life of the type, in the same manner as the STR document itself or equivalent document. The scope of the STR or equivalent document , in terms of the structural components to be covered, should match the list of items of structure whose failure would be catastrophic.

(b) The following ultimate crash load factors should be used to protect people and structure on the ground in the event of a failure:

	Longitudinal		Vertical		Lateral	
	Fwd	Aft	Up	Down	Left	Right
(1) Internal fuel tanks (2/3 full)	9	1.5	2	4.5	1.5	1.5
(2) Installations of other items that could injure ground personnel	9	1.5	2	4.5	1.5	1.5

Notes: 1. The specified load factors will act separately or in combination, whichever produces the most critical loading.
2. The longitudinal, vertical, and lateral directions of load factor refer to the major aircraft axes (F.S., B.L., W.L.) and the loads will be applied in planes parallel to these axes.

AMC.307

Proof of Structure

In deciding the need for and the extent of testing including the load levels to be achieved the following factors will be considered by the Certifying Authority.

(a) The confidence which can be attached to the constructors' overall experience in respect to certain types of UAV in designing, building and testing UAV.

(b) Whether the UAV in question is a new type or a development of an existing type having the same basic structural design and having been previously tested, and how far static strength testing can be extrapolated to allow for development of the particular type of UAV.

(c.) The importance and value of detail and/or component testing including representation of parts of structure not being tested, and

(d) The degree to which credit can be given for operating experience.

Analyses including finite element models used in place of tests must be demonstrated to be reliable for the structure under evaluation and the load levels that have to be covered. This would normally be provided by correlation with experimental results on the same structure or through comparison with other known and accepted methods and results or through a combination of both.

If the structure or parts thereof are outside the manufacturer's previous experience, the manufacturer should establish a strength test programme. In the case of a wing, wing carry through, fuselage and empennage this will usually involve ultimate load testing or structural analysis conducted in a rational and conservative manner.

When ultimate load static tests are conducted it is recommended that preliminary tests to limit load and back to zero are performed first, in order to demonstrate that no detrimental permanent deformation has taken place. During the ultimate test however, the limit load need not be removed provided that continuous readings of strains and deflections of the structure are measured at an adequate number of points, and also provided that a close examination of the structure is maintained throughout the tests with particular emphasis being placed upon close observation of the structure at limit load for any indications of local distress, yielding buckles, etc.

Static testing to ultimate load may be considered an adequate substitute for formal stress analysis where static loads are critical in the design of the component. In cases where a dynamic loading is critical, dynamic load tests may be considered equivalent to formal stress analysis. An example of components on which dynamic loading is usually critical is the landing gear and the landing gear structure of a UAV. The same yield criteria apply to dynamic tests as to static tests.

Where proof of structure is being shown by an ultimate load test, the test article should conform to the same design specifications as the production article.

The manufacturer should ensure through his quality assurance organisation that the strength (e.g. material properties and dimensions) of the component tested conservatively represents the strength of the components used in production.

Test correction factors should be used to allow for process and material variability during production. This may be expected particularly when wood or composite-material is used. This factor may be varied according to the coefficient of variation that the manufacturer is able to show for his product (see Table 1).

TABLE 1
Test factor [Tf] vs. Coefficient of Variation [Cv%]

Cv%	5	6	7	8	9	10	12	14	15	20
Tf	1 00	1 03	1 06	1 10	1 12	1 15	1 22	1 30	1 33	1 55

Definition of Coefficient of Variation

For a population with mean M and standard deviation [sigma], the coefficient of variation expressed as a percentage, Cv%, is defined by:

Cv% = 100 * [sigma]/M

AMC.321 (c)

Flight Loads - General

For UAV with an Md less than 0.5 the effects of compressibility are unlikely to be significant.

AMC.333 (c)

Flight envelope

This AMC gives guidance on the gust values to be used for classes of UAV Systems that will be operated for extended periods below 10,000ft.

(i) Positive (up) and negative (down) gusts of 66 fps at V_C should be considered at altitudes between sea level and 20 000 ft. The gust velocity may be reduced linearly from 50 fps at 20 000 ft to 25 fps at 50 000 ft; and

(ii) Positive and negative gusts of 25 fps at V_D should be considered at altitudes between sea level and 20 000 ft. The gust velocity may be reduced linearly from 25 fps at 20 000 ft to 12.5 fps at 50 000 ft..

AMC.341 (b)

Gust Loads Factors

An appropriate technique for selecting the gust load factor should be selected from those provided in ESDU data sheet 04024.

AMC.343 (b)

Design Fuel Loads

Fuel carried in the wing increases the inertia relief on the wing structure during manoeuvres and gusts which results in lower stresses and deflections. However, if the wing fuel tanks are empty the inertia load of the wing is reduced which, depending on the particular design, may lead to an increase of the bending stresses in the wing structure itself and in the wing attachments. In order not to over stress the UAV's structure the maximum weight of the UAV without any fuel in the wing tanks should therefore be established, taking into account the applicable manoeuvre and gust loadings.

AMC.345 (d)

High Lift Devices

The effect of propeller slipstream on the extended flaps may be limited to the flap area behind the propeller circle area.

AMC.371

Gyroscopic and Aerodynamic Loads

The aerodynamic loads specified in USAR.371 include asymmetric flow through the propeller disc. Experience has shown that the effects of this asymmetric flow on the engine mount and its supporting structure are relatively small and may be discounted, if propellers are installed having diameters of 2.74 m (9 ft) or less.

AMC.393 (a)

Loads parallel to hinge lines

On primary control surfaces and other movable surfaces, such as speedbrakes, flaps (in retracted position) and all-moving tailplanes the loads acting parallel to the hinge line should take into account the effect of wear and axial play between the surface and its supporting structure. Compliance may be shown by analysis or by test.

AMC.393 (b)

Loads parallel to hinge lines

For control surfaces of a wing or horizontal tail with a high dihedral angle and of a V-tail configuration the K-factor may be calculated as follows:

$$K = 12 \times \sqrt{4 - \left(\frac{3}{1 + \mathrm{Tan}^2 \nu}\right)}$$

where :
ν = dihedral angle measured to the horizontal plane
As a simplification the following K-factors may be assumed:
for dihedral angles up to ±10° K = 12
and for dihedral angles between 80° and 90° K = 24

AMC.441

Manoeuvring loads – Vertical surfaces

(a) If a manoeuvre analysis is used to predict the manoeuvring loads on the yaw control surfaces, the time for sudden deflection from neutral position to the stops or vice-versa should be measured.

(b) For UAV where the horizontal tail is supported by the vertical tail, the tail surfaces and their supporting structure including the rear portion of the fuselage should be designed to withstand the prescribed loadings on the vertical tail and the rolling moment induced by the horizontal tail acting in the same direction.

(c) For T-tails, in the absence of a more rational analysis, the rolling moment induced by sideslip or deflection of the vertical rudder may be computed as follows:

$$Mr = 0 \cdot 3S_h \frac{\rho_o}{2} \beta V^2 b_h$$

where:
Mr = induced rolling moment at horizontal tail (Nm)
S_h = area of horizontal tail (m2)
b_h = span of horizontal tail (m)
β = effective sideslip angle of vertical tail (radians)

AMC.443

Gust Loads - Vertical Surfaces

For UAV where the horizontal tail is supported by the vertical tail, the tail surfaces and their supporting structure including the rear portion of the fuselage should be designed to withstand the prescribed loading on the vertical tail and the rolling moment induced by the horizontal tail acting in the same direction.

For T-tails, in the absence of a more rational analysis, the rolling moment induced by gust load may be computed as follows:

$$Mr = 0 \cdot 3S_h \frac{\rho_o}{2} VUb_h K_{gt}$$

where:
Mr = induced rolling moment at horizontal tail (N.m)
S_h = area of horizontal tail (m²)
B_h = span of horizontal tail (m)
U = gust velocity (m/s) as specified in USAR.333(c)
K_{gt} = gust alleviation factor of vertical tail as specified in USAR.443(c)

In computing 'S_h' and 'b_h' the horizontal tail root has to be assumed on a vertical plane through the centreline of the UAV fuselage.

AMC.471

General

Where a UAV System is designed to be re-used after a hard emergency parachute landing as defined in USAR.U290, consideration should be given to the requirements in USAR.473 through USAR.499.

AMC.481

Tail-down landing conditions

Where iy cannot be determined by more rational means, a value of: iy = 0.225 LR may be used.
LR in this case to be taken as the overall length of the fuselage without rudder.
In designing the tail skid, side loads should be accounted for in addition to the vertical load determined as above.

AMC.570

General

(1) An example of fatigue evaluation guidance may be obtained from DS 00-970 Part 1 section 3 supplements 34, 35, 36, 37, 38, 40 and 41.

(2) Fatigue Qualification evidence - Fatigue qualification evidence is usually in the form of a fatigue type record (FTR) or equivalent national document. The initial issue of the FTR or equivalent document generally consists of a single Part 1, which comprises a statement of the fatigue and/or damage tolerance principles used and a summary of fatigue and/or damage tolerance analyses for each item of structure whose failure would be catastrophic. The FTR or equivalent document also lists all relevant reports and may be supported by computer models. The scope of the fatigue evidence should be determined by the list of structure whose failure would be catastrophic. Furthermore, because both usage and

fatigue evidence evolve significantly over the life of a UAV type, the FTR or equivalent document should be developed in due course to incorporate additional sections, as follows:

Part 2 – Reassessment in light of Service usage and fatigue test results.

Part 3 – A reassessment of examination requirements shown to be necessary in Part 2.

Part 4 – A life extension document (as required).

AMC.572

Fatigue evaluation: metallic pressurised compartment structures, metallic fuselage, wing, empennage and associated structures

1- In assessing the possibility of serious fatigue failures, the design should be examined to determine probable points of failure in service. In this examination, consideration should be given, as necessary, to the results of stress analysis, static tests, fatigue tests, strain gauge surveys, test of similar structural configurations, and service experience. Locations prone to accidental damage or to corrosion should also be considered.

Unless it is determined from the foregoing examination that the normal operating stresses in specific regions of the structure are of such a low order that serious damage growth is extremely improbable, repeated load analysis or tests should be conducted on structure representative of components or subcomponents of the wing (including canard and tandem wings, winglets and control surfaces), empennage, their carry-through and attaching structures, fuselage and pressurised cabin, landing gear, and their related primary attachments. Test specimens should include structure representative of attachment fittings, major joints, changes in section, cut-outs and discontinuities. Service experience has shown that special attention should be focused on the design details of important discontinuities, main attachment fittings, tension joints, splices, and cut-outs such as windows, doors, and other openings. Any method used in the analyses should be supported, as necessary, by tests or service experience. The nature and extent of tests on complete structures or on portions of the primary structure will depend upon evidence from applicable previous design and structural tests, and service experience with similar structures. The scope of the analyses and supporting test programmes should be agreed with the Certifying Authority.

2- The use of the following stress levels should be taken as sufficient evidence, in conjunction with good design practices to eliminate points of stress concentration, that structural items have adequate safe-life design :

Material used	Allowable normal stress level of maximum limit load
- Glass rovings in epoxy resin	25 daN/mm2
- Carbon fibre rovings in epoxy resin	40 daN/mm2
- Wood	According to ANC-18*
- Aluminium Alloy	Half of rupture tensile strength
- Steel Alloy	Half of rupture tensile strength

*ANC-18 is the ANC Bulletin 'Design of wood aircraft structures'; issued June 1944 by the Army-Navy-Civil Committee on Aircraft Design Criteria (USA).

Higher stress levels should need further fatigue investigation using one or a combination of the following methods:
a. Fatigue tests, based on a realistic operating spectrum.
b. Fatigue computation, using strength values which have been proved to be sufficient by fatigue tests of specimens or components.

For conventional metallic (2024, 6061, steel) or composite structural item identified as flight critical structure, if the limit tensile stress levels does not exceed 50% of the ultimate allowable for the material then no further fatigue assessment is required. The limit tensile stress level must take into account any stress concentrations in the wing lower spar booms and attachment fittings, wing struts and lower wing-fuselage carry through structures.

AMC.573 (a) (1) & (3)

Damage tolerance and fatigue evaluation of structure – composite airframe structure

In addition to the guidance material described in AMC .603 the following procedure may be adopted for residual strength tests of structure with built-in barely visible damages (BVID) and visible damages. Tests should be performed up to limit load level, then the visible damages may be repaired without substantially exceeding the original strength or characteristics of the type design and the test should be continued up to at least* ultimate load level in order to validate the BVID in the unrepaired structure.

* Experience has shown that continuation of testing to rupture should be considered in order to identify failure modes. Extrapolation by analysis of residual strength tests would not normally be acceptable for further development of the UAV .

AMC.573 (a) (4)

Damage tolerance and fatigue evaluation of structure – composite airframe structure

The safe life of components which are to be cleared by inspection should be demonstrated to be at least half of the Specified Life under the Design Spectrum.

AMC.573 (b)

Damage tolerance and fatigue evaluation of structure – Metallic airframe structure

The damage-tolerance evaluation of structure is intended to ensure that, if serious fatigue, corrosion, or accidental damage occurs within the operational life of the UAV , the remaining structure can withstand reasonable loads without failure or excessive structural deformation until the damage is detected. Design features which should be considered in attaining a damage-tolerant structure include the following:

– Multiple load path construction and the use of crack stoppers to control the rate of crack growth, and to provide adequate residual static strength;

– Materials and stress levels that, after initiation of cracks, provide a controlled slow rate of crack propagation combined with high residual strength. For single load path discrete items, such as control surface hinges, wing spar joints or stabiliser pivot fittings the failure of which could be Catastrophic, it should be clearly demonstrated that cracks starting from material flaws, manufacturing errors or accidental damage including corrosion have been properly accounted for in the crack propagation estimate and inspection method;

– Arrangements of design details to ensure a sufficiently high probability that a failure in any critical structural element will be detected before the strength has been reduced below the level necessary to withstand the loading conditions specified in USAR.573(b) so as to allow replacement or repair of the failed elements.

AMC.595 (a)

Limit load factor

The free drop height formula used to demonstrate USAR.595 (a) (2) should be the following :

$$h = \frac{Vzd^2}{2g}$$

where:

- Vzd is the maximum descent velocity of the UAV under parachute,
- g is the acceleration due to gravity (m/s2).

However, the free drop height should not be less than 0.234 m.

D - DESIGN AND CONSTRUCTION

AMC 601

General

The following FAA advisory circulars and policy documents may be applicable for UAV designed to USAR and may be sighted by the Applicant in their certification evidence.

AC 20-107A Composite Aircraft Structure
AC 21-26 Quality Control for the Manufacture of Composite Structures
AC 20-53A Protection of Airplane Fuel Systems Fuel Vapor Ignition due to Lightning
AC 20-66A Vibration and Fatigue Evaluation of Airplane Propellers
AC 20-135 Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards and Criteria
AC 20-136 Protection of Aircraft Electrical/Electronic Systems Against the indirect Effects of Lightning
AC 21-31 Quality Control for the Manufacture of non metallic Compartment Interior Components
AC 23-2 Flammability Test
AC 23-20 Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems
AC 23.629-1A Means of Compliance with section 23.629 Flutter
AC 145-6 Repair Stations for Composite and Bonded Aircraft Structures

> For Information
AC 29.2C MG8 Substantiation of Composite Rotorcraft Structure
AC 35.37-1 Guidance Material for Fatigue Limit Tests and Composite Blade Fatigue Substantiation

> FAA Policy Documents Applicable to Part 23 Aircraft
PS-ACE100-2-18-1999 Temperature differential between Wet Glass Transition.
PS-ACE100-2005-10038 Bonded Joints and Structures
PS-ACE100-2004-10030 Substantiation of Secondary Composite Structures
PS-ACE100-2001-006 Static Strength of Composite Airplane Structure

AMC 603 (a)

Material and Workmanship for metallic UAV Structure

An acceptable means of compliance, but not the only means, of showing compliance with the provisions of USAR regarding airworthiness type requirements for metallic UAV structures can be found in FAA advisory circular AC23-13A.

AMC 603 (b)

Material and Workmanship Composite UAV Structure

1 *Purpose*. This AMC sets forth an acceptable means, but not the only means, of showing compliance with the provisions of USAR regarding airworthiness type certification requirements for composite UAV structures, involving fibre-reinforced materials, e.g. carbon (graphite), boron, aramid (Kevlar), and glass-reinforced plastics. Guidance information is also presented on associated quality control and repair aspects. This AMC material is adapted from the structural content of FAA Advisory Circular AC 20.107A, dated 25 April 1984. The individual USAR paragraphs applicable to each AMC paragraph are listed in Table 1 of this AMC.

2 *Definitions*

2.1 *Design Values*. Material, structural element, and structural detail properties that have been determined from test data and chosen to assure a high degree of confidence in the integrity of the completed structure (see USAR.613(b)).

2.2 *Allowables*. Material values that are determined from test data at the laminate or lamina level on a probability basis (e.g. A or B base values).

2.3 *Laminate* level design values or allowables. Established from multi-ply laminate test data and/or from test data at the lamina level and then established at the laminate level by test validated analytical methods.

2.4 *Lamina* level material properties. Established from test data for a single-ply or multi-ply singledirection oriented lamina layup.

2.5 *Point design*. An element or detail of a specific design which is not considered generically applicable to other structure for the purpose of substantiation (e.g. lugs and major joints). Such a design element or detail can be qualified by test or by a combination of test and analysis.

2.6 *Environment*. External, non-accidental conditions (excluding mechanical loading) separately or in combination, that can be expected in service and which may affect the structure (e.g. temperature, moisture, UV radiation and fuel).

2.7 *Degradation*. The alteration of material properties (e.g. strength, modulus, coefficient of expansion) which may result from deviations in manufacturing or from repeated loading and/or environmental exposure.

2.8 *Discrepancy*. A manufacturing anomaly allowed and detected by the planned inspection procedure. They can be created by processing, fabrication or assembly procedures.

2.9 *Flaw*. A manufacturing anomaly created by processing, fabrication or assembly procedures.

2.10 *Damage*. A structural anomaly caused by manufacturing (processing, fabrication, assembly or handling) or service usage. Usually caused by trimming, fastener installation or foreign object contact.

2.11 *Impact Damage*. A structural anomaly created by foreign object impact.

2.12 *Coupon*. A small test specimen (e.g. usually a flat laminate) for evaluation of basic lamina or laminate properties or properties of generic structural features (e.g. bonded or mechanically fastened joints).

2.13 *Element*. A generic element of a more complex structural member (e.g. skin, stringers, shear panels, sandwich panels. joints, or splices).

2.14 *Detail*. A non-generic structural element of a more complex structural member (e.g. specific design configured joints, splices, stringers, stringer runouts, or major access holes).

2.15 *Subcomponent*. A major three-dimensional structure which can provide complete structural representation of a section of the full structure (e.g. stub-box, section of a spar, wing panel, wing rib, body panel, or frames).

2.16 *Component*. A major section of the airframe structure (e.g. wing, body, fin, horizontal stabiliser) which can be tested as a complete unit to qualify the structure.

3 General

3.1 This AMC is published to aid the evaluation of certification programmes for composite applications and reflects the current status of composite technology. It is expected that this AMC will be modified periodically to reflect technology advances.

3.2 The extent of testing and/or analysis and the degree of environmental accountability required will differ for each structure depending upon the expected service usage, the material selected, the design margins, the failure criteria, the data base and experience with similar structures, and on other factors affecting a particular structure. It is expected that these factors will be considered when interpreting this AMC for use on a specific application.

4 Material and Fabrication Development

4.1 To provide an adequate design data base, environmental effects on the design properties of the material system should be established.

4.2 Environmental design criteria should be developed that identify the most critical environmental exposures, including humidity and temperature, to which the material in the application under evaluation may be exposed. This is not required where existing data demonstrate that no significant environmental effects, including the effects of temperature and moisture, exist for material systems and construction details, within the bounds of environmental exposure being considered. Experimental evidence should be provided to demonstrate that the material design values or allowables are attained with a high degree of confidence in the appropriate critical environmental exposures to be expected in service. The effect of the service environment on static strength, fatigue and stiffness properties should be determined for the material system through tests (e.g. accelerated environmental tests, or from applicable service data). The effects of environmental cycling (i.e. moisture and temperature) should be evaluated. Existing test data may be used where it can be shown directly applicable to the materialsystem.

4.3 The material system design values or allowables should be established on the laminate level by either test of the laminate or by test of the lamina in conjunction with a test-validated analytical method.

4.4 For a specific structural configuration of an individual component (point design), design values may be established which include the effects of appropriate design features (holes, joints, etc.).

4.5 Impact damage is generally accommodated by limiting the design strain level.

5 Proof of Structure – Static

5.1 The static strength of the composite design should be demonstrated through a programme of component ultimate load tests in the appropriate environment, unless experience with similar designs, material systems and loadings is available to demonstrate the adequacy of the analysis supported by subcomponent tests, or component tests to agreed lower levels.

5.2 The effects of repeated loading and environmental exposure which may result in material property degradation should be addressed in the static strength evaluation. This can be shown by analysis supported by test evidence, by tests at the coupon, element or subcomponent level, or alternatively by relevant existing data.

5.3 Static strength structural substantiation tests should be conducted on new structure unless the critical load conditions are associated with structure that has been subjected to repeated loading and environmental exposure. In this case either :

a. The static test should be conducted on structure with prior repeated loading and environmental exposure, or

b. Coupon/Element/Subcomponent test data should be provided to assess the possible degradation of static strength after application of repeated loading and environmental exposure, and this degradation accounted for in the static test or in the analysis of the results of the static test of the new structure.

5.4 The component static test may be performed in an ambient atmosphere if the effects of the environment are reliably predicted by subcomponent and/or coupon tests and are accounted for in the static test or in the analysis of the results of the static test.

5.5 The static test articles should be fabricated and assembled in accordance with production specifications and processes so that the test articles are representative of production structure.

5.6 When the material and processing variability of the composite structure is greater than the variability of current metallic structures, the difference should be considered in the static strength substantiation by :

a. Deriving proper allowables or design values for use in the analysis, and the analysis of the results of supporting tests, or
b. Accounting for it in the static test when static proof of structure is accomplished by component test.

5.7 Composite structures that have high static margins of safety may be substantiated by analysis supported by subcomponent, element and/or coupon testing.

5.8 It should be shown that impact damage that can be realistically expected from manufacturing and service, but not more than the established threshold of detectability for the selected inspection procedure, will not reduce the structural strength below ultimate load capability. This can be shown by analysis supported by test evidence, or by tests at the coupon, element or subcomponent level.

6 Proof of Structure – Fatigue/Damage Tolerance

6.1 The evaluation of composite structure should be based on the applicable requirements of USAR.573(a). The nature and extent of analysis or tests on complete structures and/or portions of the primary structure will depend upon applicable previous fatigue/damage tolerant designs, construction, tests, and service experience on similar structures. In the absence of experience with similar designs, approved structural development tests of components, sub components, and elements should be performed. The following considerations are unique to the use of composite material systems and should be observed for the method of substantiation selected. When selecting the damage tolerance or safe life approach, attention should be given to geometry inspectability, good design practice, and the type of damage/degradation of the structure under consideration.

6.2 Damage Tolerance (Fail-Safe) Evaluation

6.2.1 Structural details, elements, and subcomponents of critical structural areas should be tested under repeated loads to define the sensitivity of the structure to damage growth. This testing can form the basis for validating a no-growth approach to the damage tolerance requirements. The testing should assess the effect of the environment on the flaw growth characteristics and the no-growth validation. The environment used should be appropriate to the expected service usage. The repeated loading should be representative of anticipated service usage. The repeated load testing should include damage levels (including impact damage) typical of those that may occur during fabrication, assembly, and in service, consistent with the inspection techniques employed. The damage tolerance test articles should be fabricated and assembled in accordance with production specifications and processes so that the test articles are representative of production structure.

6.2.2 The extent of initially detectable damage should be established and be consistent with the inspection techniques employed during manufacture and in service. Flaw damage growth data should be obtained by repeated load cycling of intrinsic flaws or mechanically introduced damage. The number of cycles applied to validate a no-growth concept should be statistically significant, and may be determined by load and/or life considerations. The growth or no growth evaluation should be performed by analysis supported by test evidence, or by tests at the coupon, element or sub component level.

6.2.3 The extent of damage for residual strength assessments should be established. Residual strength evaluation by component or sub component testing or by analysis supported by test evidence should be performed considering that damage. The evaluation should demonstrate that the residual strength of the structure is equal to or greater than the strength required for the specified design loads (considered as ultimate). It should be shown that stiffness properties have not changed beyond acceptable levels. For the no-growth concept, residual strength testing should be performed after repeated load cycling.

6.2.4 An inspection programme should be developed consisting of frequency, extent, and methods of inspection for inclusion in the maintenance plan. Inspection intervals should be established such that the damage will be detected between the time it initially becomes detectable and the time at which the extent of damage reaches the limits for required residual strength capability. For the case of no-growth design concept, inspection intervals should be established as part of the maintenance programme. Inselecting such intervals the residual strength level associated with the assumed damage should be considered.

6.2.5 The structure should be able to withstand static loads (considered as ultimate loads) which are reasonably expected during the completion of the flight on which damage resulting from obvious discrete sources occur (i.e. uncontained engine failures, etc.). The extent of damage should be based on a rational assessment of service mission and potential damage relating to each discrete source.

6.2.6 The effects of temperature, humidity, and other environmental factors which may result in material property degradation should be addressed in the damage tolerance evaluation.

6.3 Fatigue (Safe-Life) Evaluation. Fatigue substantiation should be accomplished by component fatigue tests or by analysis supported by test evidence, if necessary, accounting for the effects of the appropriate environment. The test articles should be fabricated and assembled in accordance with production specifications and processes so that the test articles are representative of production structure. Sufficient component, subcomponent, element or coupon tests should be performed to establish the fatigue scatter and the environmental effects. Component, subcomponent and/or element tests may be used to evaluate the fatigue response of structure with impact damage levels typical of those that may occur during fabrication, assembly, and in service, consistent with the inspection procedures employed. The component fatigue test may be performed with an as-manufactured test article if the effects of impact damage are reliably predicted by sub component and/or element tests and are accounted for in the fatigue test or in analysis of the results of the fatigue test. It should be demonstrated during the fatigue tests that the stiffness properties have not changed beyond acceptable levels. Replacement lives should be established based on the test results. An appropriate inspection programme should be provided.

7 Proof of Structure – Flutter. The effects of repeated loading and environmental exposure on stiffness, mass and damping properties should be considered in the verification of integrity against flutter and other aeroelastic mechanisms. These effects may be determined by analysis supported by test evidence, or by tests of the coupon, element or subcomponent level.

8 Additional Considerations

8.1 Impact Dynamics. Not applicable.

8.2 Flammability. (See appropriate USAR requirements in Table 1 of this AMC.)

8.3 Lightning Protection. (See appropriate USAR requirements in Table 1 of this AMC.)

8.4 Protection of Structure. Weathering, abrasion, erosion, ultraviolet radiation, and chemical environment (glycol, hydraulic fluid, fuel, cleaning agents, etc.) may cause deterioration in a composite structure. Suitable protection against and/or consideration of degradation in material properties should be provided for and demonstrated by test.

8.5 Quality Control. An overall plan should be established and should involve all relevant disciplines (i.e. engineering, manufacturing and quality control). This quality control plan should be responsive to special engineering requirements that arise in individual parts or areas as a result of potential failure modes, damage tolerance and flaw growth requirements, loading, inspectability, and local sensitivities to manufacture and assembly.

8.6 Production Specifications. Specifications covering material, material processing, and fabrication procedures should be developed to ensure a basis for fabricating reproducible and reliable structure. The discrepancies permitted by the specifications should be substantiated by analysis supported by test evidence, or tests at the coupon, element or subcomponent level.

8.7 Inspection and Maintenance. Maintenance Manuals should include appropriate inspection, maintenance and repair procedures for composite structures.

8.8 Substantiation of Repair. When repair procedures are provided in maintenance documentation, it should be demonstrated by analysis and/or test, that methods and techniques of repair will restore the structure to an airworthy condition.

TABLE l
AMC paragraphs and related USAR texts

	AMC paragraph	USAR paragraph
1	Purpose	None
2	Definitions	None
3	General	None
4	Materials and Fabrication	603 , 605 , 613 , 619
5	Proof of structure static	305 , 307
6	Proof of structure – Fatigue/damage tolerance	573
7	Proof of structure – Flutter	629
8	Additional considerations	
8.1	Impact dynamics	601, 783 , 787, 963
8.2	Flammability	850, 863, 865, 903, 967, 1121, 1181, 1183, 1189, 1191, 1193
8.3	Lightning protection	867, 863, 954
8.4	Protection structure	1529
8.5	Quality control	
8.6	Production specifications	603, 605

AMC 607 (b)

Fasteners

Locking devices of fasteners installed in engine compartments or other compartments affected by temperature and/or vibration should be of a type and material which is not influenced by such temperatures encountered under normal operating conditions.

AMC 609

Protection of structure

Adequate corrosion prevention and control practices should be in place for uniform surface corrosion, pitting, galvanic, crevice, filiform, exfoliation, inter-granular, fretting, high temperature oxidation (hot corrosion), corrosion fatigue, and stress corrosion cracking.
Corrosion prevention systems should remain effective during the service life, including the mitigation of environmentally assisted cracking. Specific corrosion prevention and control measures, procedures, and processes should be identified and established commensurate with the operational and maintenance capability.
The finish system should provide adequate corrosion protection for specific parts, surfaces of similar and dissimilar materials, and attaching parts and fasteners.

AMC 611

Accessibility provisions

(1) Non-destructive inspection aids may be used to inspect structural elements where it is impracticable to provide means for direct visual inspection if it is shown that the inspection is effective and the inspection procedures are specified in the Maintenance Manual required by USAR.1529.

(2) For inspections repeated at short intervals (such as pre-flight or daily inspections) the means of inspection should be simple, e.g. visual with the aid of easily removable or hinged access panels. However, for inspections required only a few times, for example once or twice in the lifetime of the UAV some disassembly of structure, e.g. deriveting a small skin panel may be acceptable.

AMC.613

Metallic strength properties and design values

Material specifications should be those contained in documents accepted either specifically by the Certifying Authority or by having been prepared by an organisation or a person which the Certifying Authority accepts has the necessary capabilities.
Such specifications are for example:
1 Mil–HDBK–5 'Metallic Materials and Elements for Flight Vehicle Structure'
2 Mil–HDBK–17 'Plastics for Flight Vehicles'
3 Mil–HDBK–23 'Composite Construction for Flight Vehicles'
4 ANC–18 'Design of Wood Aircraft Structures'
In defining design properties the material specification values must be modified and/or extended as necessary by the designer to take account of manufacturing practices (e.g., methods of construction, forming, machining and subsequent heat treatment). For composite structure AMC.603 contains guidance information relevant to the requirements of USAR.613.

AMC.629

Flutter

Compliance with the rigidity and mass balance criteria (pages 4-12), in Airframe and Equipment Engineering Report No. 45 (as corrected) "Simplified Flutter Prevention Criteria" (published by the Federal Aviation Administration) may be accomplished to show that the UAV is free from flutter, control reversal, or divergence if

(1) V_D/M_D for the UAV is less than 482 km/h (260 knots) (EAS) and less than Mach 0.5;

(2) The wing and aileron flutter prevention criteria, as represented by the wing torsional stiffness and aileron balance criteria, are limited to use to UAV without large mass concentrations (such as engines, floats, or fuel tanks in outer wing panels) along the wing span; and

(3) The UAV

(i) Does not have a T-tail or other unconventional tail configurations;

(ii) Does not have unusual mass distributions or other unconventional design features that affect the applicability of the criteria; and

(iii) Has fixed-fin and fixedstabiliser surfaces.

AMC.629 (j)

Flutter

The total backlash should be no greater than 0.2 degree for controls on the outer 50% of a flying surface, and 1 degree for inboard controls. Larger backlash is allowable if it is shown by rational analysis that control surface backlash will not lead to flutter.

AMC.631

Bird strike

Consideration should be given in early stages in the design to the installation of items in essential services, such as control system components, and items which, if damaged, could cause a hazard, such as electrical equipment. As far as practicable, such items should not be installed immediately behind areas liable to be struck by birds.
Compliance with this section by provision of redundant structure and protected location of control system elements or protective devices such as splitter plates or energy absorbing material is acceptable.

AMC.671

Control systems – General

In designing and manufacturing primary control systems attention should be given to minimise friction in the systems and to avoid jamming and interference with other parts in operation, due to vibration and accelerations.

AMC.683

Operation tests

One method, but not the only one, for showing compliance with the requirements of USAR.683 is as follows:
Conduct the control system operation tests by operating the controls with the entire system loaded so as to correspond to the limit control forces established by the regulations for the control system being tested. The following conditions should be met:

(1) Under limit load, check each control surface for travel and detail parts for deflection. This may be accomplished as follows:

(i) Support the control surface being tested while positioned at the neutral position.

(ii) Load the surface using loads corresponding to the limit control forces established in the regulations.

(iii) Load the controls until the control surface is just off the support.

(iv) Determine the available travel which is the amount of movement of the surface from neutral when the control is moved to the system stop.

(v) Remove the surface load and command the surface position back to neutral. The resulting mechanical set (offset) from initial neutral position should be no greater than 1 percent of the total control system travel or the maximum value considered safe by modeling system response.

(vi) The minimum control surface travel from the neutral position in each direction being measured should be 10 percent of the control surface travel measured with no load on the surface. Regardless of the amount of travel of the surface when under limit load, the UAV should have adequate flight characteristics as specified in paragraph USAR.141. Any derivative UAV of a previous Type Certificated UAV need not exceed the control surface travel of the original UAV; however, the flight characteristics should be flight tested to ensure compliance.

(2) Under limit load, no signs of jamming or of any permanent set of any connection, bracket, attachment, etc., may be present.

(3) Friction should be minimised so that the limit control forces and torques specified by the regulations may be met.

AMC.693

Joints

The specification for elastomeric bearings should be those contained in documents accepted specifically by the Certifying Authority. Such a specification is, for example "MIL-B-85598 General Specification for Elastomerics".

AMC.729 (g)

Equipment located in the Landing Gear Bay

In showing compliance with this requirement, consideration should include the effects that likely damage from hazards arising from other items of equipment such as high brake temperature and external sources such as slush, water and tyre burst/loose tyre tread will have on equipment/systems located on the landing gear or in the landing gear bay that are essential to continued safe flight and landing.

AMC.735 (c)

Brakes

As specified in the requirement, the pressure on the wheel brake must not exceed the pressure that is specified by the brake manufacturer. The requirement does not specify how the force that is applied to the braking command is transmitted to the brakes. This means may be mechanical, hydraulic or some other system, such as an electronic control system. By clarifying the applicability of the requirements to the force applied to the wheel brake assembly, it can be applied to any braking system that is included in the UAV design.

AMC.863

Flammable fluid fire protection

Designer should consider a means to ventilate and drain leaked flammable fluids and vapors.

AMC.865

Fire protection of flight controls, engine mounts and other flight structure

Engine mounts or portions of the engine mounts that are not constructed of fire proof material should be shielded to provide an equivalent level of safety to that provided by the use of fireproof materials. Care should be taken that any shielding does not invalidate the type certification of the engine.

AMC.867 (a)

Electrical bonding and protection against lightning and static electricity

The latest edition of the following documents should provide guidance as to acceptable means of compliance for USAR.867:

(a) SAE International standard ARP5412, "Aircraft Lightning Environment and Related Test Waveforms"

- This document describes the lightning environment, applicable to both direct (physical) and indirect (electromagnetically coupled) lightning effects.

(b) MIL-STD-464, "Electromagnetic Environmental Effects Requirements for Systems"

- This document provides requirements and guidance with regard to lightning, bonding, grounding, and static electricity.

(c) NATO STANAG 3614, "Electromagnetic Environmental Effects (E3) Requirements for Aircraft Systems and Equipment"

- This document is similar in scope to MIL-STD-464.

(d) RTCA, Inc. standard DO-160, "Environmental Conditions and Test Procedures for Airborne Equipment"

- This document describes equipment-level testing against direct lightning effects, indirect lightning effects and static-electric discharge from human contact.

- The direct lightning-effects test is limited in purview to externally-mounted airborne equipment (such as antennas, exterior lights, and exposed fuel-quantity probes). This test does not encompass aircraft structure, mechanical devices (such as fuel filler caps), or any item protected by a covering which is part of the aircraft itself.

- The indirect lightning-effects test applies principally to aircraft with metallic skin.

(e) AEP-29 (NATO STANAG 3856), "Protection of Aircraft, Crew, and Subsystems in Flight Against Electrostatic Charges"

- This document provides guidance with regard to precipitation static effects upon aircraft in flight.

(f) UK Ministry of Defence Defence Standard 59-113 - Lightning Strike ProtectionRequirements for Service Aircraft.

AMC.881 (a)

Parachute design

Where tests are carried out to demonstrate the compliance with USAR.881 (a), the following requirements must be met. There shall be no failure to meet any of the requirements during the tests of this AMC. In case of failure, the cause must be found, corrected and all affected tests repeated.

(a) Environmental tests
Three drops must be made at the minimum speed of the UAV flight envelope protection as defined in USAR.334 under the following parachute assembly preconditionning :

(1) Preconditionning for 16h at not less than +93.3°C, stabilise to ambient and test drop,

(2) Preconditionning for 16h at not greater than –40°C, stabilise to ambient and test drop,

(3) Preconditionning for not less than continuous 400h with a 889.6 N (200 lbf) or greater load applied to compress the pack in manner similar to that most likely to be encountered in actual use. Test drop must be made within 1h after removing the load.

(b) Strength tests
Tests may be conducted for either a complete parachute assembly or separate components. There shall be no evidence of material, stitch, or functional failure that will affect airworthiness. The same canopy, harness, component and riser(s) must be used for all strength tests. Three drops must be carried out with the following characteristics :

(1) Test weight is 1.2 times the maximum UAV take-off weight

(2) Test speed is 1.2 times the maximum speed of the UAV flight envelope protection as defined in USAR.334.

(3) Where easily detachable hardware (such as snap and ring) is used to attach the canopy or riser(s) to the harness, a cross connector must be used and one of the drops shall be with only one attachment engaged to test the cross connector and hardware.

(c) Functional tests
For all functional tests, the maximum allowable opening time for parachute canopies is 3s + 0.022s for every kg of maximum UAV take-off weight in excess of 113.4 Kg (250lb). Alternatively, altitude loss instead of time may be measured and the maximum allowable altitude loss may be calculated as follow : 91.4 m + 0.67m for every kg of maximum UAV take-off weight in excess of 113.4 Kg.

(1) There shall be a minimum of 48 drops with a weight not more than the maximum UAV take-off weight and a speed at the time of pack opening in the range of the flight envelope protection as defined in USAR.334. The parachute canopy must be functionally open within the maximum allowable time from the time of pack opening.

(2) A minimum of 5 drops shall be made to demonstrate the parachute opening within the maximum allowable time + 1s from the time of pack release :

(i) with a weight not more than the maximum UAV take of weight,

(ii) at the minimum airspeed of the UAV flight envelope protection,

(iii) with three twists in the same direction (360° each) purposely packed in the suspension lines adjacent to the lowest attachment point to the canopy.

E – POWERPLANT

AMC.901
Installation It is assumed that UAV Systems are designed with an automatic engine control (i.e. engine is controlled via FCS) with a direct UAV crew involvement as a Special Condition only. In case of semi-automatic or manually controlled engine(s), Special Conditions apply for: (1) data to be transmitted and displayed to the UAV crew. (2) set up of the UCS (i.e. levers, controls, etc.) which should be agreed with the Certifying Authority. The level of integration of engine control functions into the FCS should be agreed with the Certifying Authority.

AMC.903 (a)
Engines and auxiliary power units Ingestion of hail, rain and foreign objects risk qualification and bird strike and ingestion risk qualification may be based on EASA CS-E790 and EASA CS E-800 or any equivalent qualification agreed by the Certifying Authority.

AMC.903 (f)
Engines and auxiliary power units APU qualification may be based on EASA CS-APU or any equivalent qualification agreed by the Certifying Authority.

AMC.905 (d)
Propellers Compliance with 905(d) may be based on EASA CP-P-210 requirement or equivalent document agreed with the Certifying Authority.

AMC.905 (e)
Propellers Ice shed from the forward fuselage and the wings may cause significant damage to pusher propellers that are very close to the fuselage and well back from the UAV nose. Similarly, ice shed from the wing may cause significant damage to wind mounted pusher propellers. Account should be taken of these possibilities. The term 'during any operating condition' may require tests also for intentional, or temporary unintentional entry into icing conditions. This may also be shown by analysis or a combination of both.

AMC.905 (g)
Propeller In most pusher propeller installations, the engine exhaust gases pass through the propeller disc. Many factors affect the temperature of these gases when they contact the propellers and propeller tolerance to these gases varies with propeller design and materials.

AMC.907 (a)
Propeller Vibration The definition of a conventional fixed pitch wooden propeller should be taken to include a propeller with a wooden core and a simple cover of composite material, but not a propeller where the load carrying structure is composite and the wood simply provides the form.

AMC.909 (a)

Turbo charger systems

Compliance with 909(a)(1) may be based on EASA CP-E-440 requirement or equivalent document agreed with the Certifying Authority.

AMC.909 (d) (1)

Turbo charger systems

Intercooler mounting provisions should have sufficient strength to withstand the flight and ground loads for the UAV as a whole in combination with the local loads arising from the operation of the engine.

AMC.934

Turbojet and turbofan engine thrust reverser system tests

Compliance with USAR.934 may be based on EASA CS-E 650 and EASA CS-E 890 or equivalent document approved with the Certifying Authority.

AMC.939 (c)

Powerplant operating characteristics

Inlet Airflow Distortion Limits. The engine shall not surge, stall, flameout, or incur any damage with the steady state or time variant inlet distortion (pressure, temperature, or any combination of both) shown herein. The aerodynamic interface plane shall be identified on the engine configuration and envelope figure. Where exhaust nozzle backpressure effects on the engine affect tolerance of the engine to inlet air pressure variation, the effect shall be specified in the engine system specification. Engine stability and performance assessments shall use the methodology and inlet distortion descriptors defined in ARP 1420 and AIR 1419 (or other acceptable standards) for total pressure and temperature distortion. Temperature distortion methodology and concurrent distortion shall be specified herein.

AMC.959 (a)

Unusable fuel supply

The term 'most adverse fuel feed condition' is not intended to include radical or extreme manoeuvres not likely to be encountered in operation. Judgement should be used in determining what manoeuvres are appropriate to the type of UAV being tested. A tank that is not needed to feed the engine under all flight conditions should be tested only for the flight regime for which is was designed (e.g. cruise conditions). Tests for this kind of tank should include slips and skids to simulate turbulence. Suitable instructions on the conditions under which the tank may be used should be provided in a placard or in the UAV System Flight Manual. Analyse the fuel system and tank geometry to determine the critical manoeuvres for the specific tanks being considered, e.g. main, auxiliary, or cruise tanks and conduct only those tests considered applicable to the UAV being tested. Particular attention should be directed towards the tank or cell geometry and orientation with respect to the longitudinal axis of the UAV and location of supply ports. Care should be taken in planning how the critical altitude manoeuvres are tested so that the test procedure does not result in unconservative unusable fuel. The test manoeuvres should be selected using good judgement with regard to the kind of manoeuvres the UAV under test will be subjected to in operation. Ground tests using equipment which accurately simulate the UAV fuel system and in-flight inertial effects may be considered acceptable. The quantity of fuel to be used for the tests should be sufficient for determination of unusable fuel by allowing the manoeuvres described herein to be performed. The manoeuvres are to be repeated until first evidence of engine malfunction. Repeated manoeuvres may result in fuel refilling some bays or tanks; therefore, minimum fuel should be used. For the tests, a malfunction will be considered when engine roughness, partial or total loss of power, fuel pressure loss of below minimum, or fuel flow fluctuations are experienced. To assure the most conservative unusable fuel supply value for each tank, another tank should be selected at the first indication of fuel interruption. The fuel remaining in the test tank at the time of malfunction should be drained, measured and recorded as unusable fuel. If header tanks (small tanks that accumulate fuel from one or more fuel tanks and supply the engine directly) are utilised, the fuel remaining in the header tank should be added to the unusable fuel but would not be shown on the fuel gauge marking. All tests should be conducted at a minimum practical weight or weight determined to be critical for the UAV being tested. The flight testing of a single-engine UAV with a one-tank system requires a separate temporary fuel system to supply the engine after fuel starvation occurs

AMC.961

Fuel system hot weather operation

Any fuel system that uses aviation gasoline is considered conductive to vapour formation. However a fuel system having a fuel pump with suction lift, is more critical with respect to vapour formation. Critical operating conditions which need to be considered during evaluation of hot weather tests should include at least the maximum fuel flow, high angles of attack, maximum fuel temperature, etc. The weight of the UAV should be the weight with critical fuel level and the ballast necessary to maintain the centre of gravity within allowable limits. The critical fuel level in most cases would be low fuel; however, in some cases, full fuel may be critical. A flight test is normally necessary to complete the hot weather operation tests, however, if a ground test is performed, it should closely simulate flight conditions. Several methods of heating the fuel are available, such as circulating hot water or steam through a heat exchanger placed in the fuel tank to increase the fuel temperature, placing black plastic or other material on the fuel tanks in bright sunlight, or blowing hot air over the fuel tank. The fuel should not be agitated or handled excessively during the heating operation. The heating process should be completed in the shortest time period possible without causing excessive local temperature conditions at the heat exchanger. Raise the temperature of the fuel to the critical value as follows :

– For aviation gasoline, 43 °C – 0 to + 3 °C (110° F – 0 to + 5° F)
– For turbine fuel, 43 °C – 0 to + 3 °C (110° F – 0 to + 5° F)
– For automobile gasoline, 43 °C – 3 to + 0 °C (110° F – 5 to + 0° F)

Testing should commence immediately after the fuel temperature reaches its required value. The desirable outside air temperature measured 1.2 to 1.8 m (4 to 6 feet) above the runway surface should be at least 29 °C (85° F). If tests are performed in weather cold enough to interfere with the test results, steps should be taken to minimise the effects of cold temperature. This may be accomplished by insulating fuel tank surfaces, as appropriate, fuel lines, and other fuel system components from the cold air to simulate hot-day conditions. The take-off and climb should be made as soon as possible after the fuel in the tank reaches the required test temperature, and the engine oil temperature should be at least the minimum recommended for take-off. The airspeed in the climb should be the same as that used in demonstrating the requirements of USAR.65, except the UAV should be at minimum weight with a critical quantity of fuel in the tanks. Power settings should be maintained at the maximum approved levels for take-off and climb to provide for the maximum fuel flow. The climb should be continued to the maximum operating altitude approved for the UAV. If a lower altitude is substantiated, appropriate limitations should be noted in the UAV System Flight Manual. The following data should be recorded :

– Fuel temperature in the tank
– Fuel pressure at the start of the test and continuously during climb noting any pressure failure, fluctuation, or variations
– Main and emergency fuel pump operation, as applicable
– Pressure altitude
– Ambient air temperature, total or static as applicable
– Airspeed
– Engine power, i.e. engine pressure ratio, gas generator speed, torque, rpm, turbine inlet temperature, exhaust gas temperature, manifold pressure, and fuel flow, as appropriate
– Comments on engine operation
– Fuel quantities in the fuel tank(s) during take-off
– Fuel vapour pressure (for automobile gasoline only), determined prior to test
– Fuel grade or designation, determined prior to test

A fuel pressure failure is considered to occur when the fuel pressure decreases below the minimum prescribed by the engine manufacturer or the engine does not operate satisfactorily. The emergency fuel pump(s) should be inoperative if being considered for use as backup pump(s). This test may be used to establish the maximum pressure altitude for operation with the pump(s) off. If significant fuel pressure fluctuation occurs during testing of the critical flight condition but pressure failure does not occur, additional testing should be considered to determine that pressure failure may not occur during any expected operating mode. Also, the fuel system should be evaluated for vapour formation during cruise flight at maximum approved altitude in smooth air at low to moderate power setting and low fuel flow and idling approach to landing. The hot weather tests may have to be repeated if the critical tank cannot be positively identified. Any limitations on the outside air temperature as a result of hot weather tests should be included in the UAV System Flight Manual.

AMC.967
Fuel tank installation There should be no external fuel leakage from the fuel system during normal operating conditions including ground refuelling.

AMC.973
Fuel tank filler connection (1) The UAV, including external tanks, should be capable of being refuelled to any intermediate quantity or to the UAV capacity and automatically shut off without external power applied to the UAV. (2) The ground refueling adapter should be isolated from fuel pressure during all flight phases. (3) The engine and engine feed-lines should not be subjected to the pressures imposed on the refueling system during refueling. (4) The fuel system tubing and components should be electrically bonded to eliminate static charge accumulation, provide controlled current return paths, and provide lightning protection. (5) A bonding receptacle should be provided adjacent to each refueling receptacle/port for bonding the refueling nozzle to the UAV. The bonding receptacle should be located no more than 41 inches from the gravity filler opening and no closer than 12 inches from fuel tank vent openings or filler cap openings.

AMC.975
Fuel tank vents and carburettor vapour vents Pressure relief for fuel thermal expansion should be provided for all closed plumbing segments.

AMC.993
Fuel system lines and fittings (1) Clearance between all fuel system hoses and tubing should be provided to prevent contact with surrounding components, hardware, and structure during all fuel transfer and refueling operations on the ground and in-flight. Fuel lines should be supported so that the lines will not deflect out of position as a result of internal pressure or aircraft maneuvers. Fuel lines which may be subjected to damage due to maintenance, cargo handling, personnel traffic, or normal aircraft use should be protected. (2) The use of magnesium, cadmium, and copper on parts that come in contact with fuel should be avoided.

AMC.995
Fuel valves and controls Controls and switches readily accessible to the ground staff necessary to meet the safety levels of AMC.1309 should be considered (e.g. emergency fuel cut-off switch).

AMC.997
Fuel strainer or filter Depending on operating weather conditions likely to be encountered and unless means are provided in the fuel system to prevent the accumulation of ice on the filter, a means must be provided automatically to maintain the fuel flow if ice clogging of the filter occurs.

AMC.999
Fuel system drains In the event of a wheels-up or collapsed skid landing, it should be possible to defuel each tank through the normal fuel servicing adapters or by suction through accessible openings in each tank.

AMC.1001
Fuel jettisoning system Effect of fuel dump onto extended landing gear wheels and brakes should be considered.

AMC.1011 (b)
Oil System – General The minimum allowable usable oil capacity can be determined from the endurance and the maximum allowable oil consumption. For either wet or dry sump engines, the maximum allowable fuel/oil supply ratio is equal to the minimum obtainable fuel/oil consumption ratio. This is expressed mathematically as follows: Capacity Oil Usable Allowable Minimum   Consumptio Oil Specific Allowable Maximum --- ≈ --- Capacity Fuel Usable Allowable Maximum   Consumptio Fuel Specific Obtainable Minimum Therefore, for both wet and dry sump engines, fuel/oil supply ratio equal to or less than the minimum obtainable fuel/oil consumption ratios are considered acceptable. For multi engine installations, unless an adequate oil reserve is provided, the endurance of a multi-engined UAV employing a fuel crossfeed system or common fuel tank should be established on the basis that 50% of the specific total initial fuel capacity provided for a shutdown engine will be available to the other engine. The engine power levels to be considered for a multi engine UAV having a crossfeed system are those that will allow maximum published endurance with both engines operating and adjusted as necessary (including mixture setting) to complete safely the flight with one engine inoperative after 50% of the fuel supply is consumed.

AMC.1045
Cooling test procedures for turbine engine-powered UAV Analysis and ground tests data may be considered by the Certifying Authority to assess the extent of flight testing to be carried out.

AMC.1045 (b)
Cooling test procedures for turbine engine-powered UAV For the cooling tests, a temperature is 'stabilised' when its rate of change is less than 1°C (2° F) per minute.

AMC.1047
Cooling test procedures for reciprocating engine-powered UAV (a) Analysis and ground tests data may be considered by the Certifying Authority to assess the extent of flight testing to be carried out. (b) For the cooling tests, a temperature is 'stabilised' when its rate of change is less than 1°C (2° F) per minute.

AMC.1091
Air induction system The maximum allowable shear, axial, and overhung moment loads at the engine inlet flange should be specified in the engine specification for static (1g) conditions. The allowable loads at the engine inlet flange should also be specified for the maximum allowable manœuvre loads as defined in Figure 1 (combined linear and angular effects) of USAR.333.

AMC.1093

Induction system icing protection

Pre-heaters should not be only solution for carb icing prevention as small resistive heating elements placed on carb butterfly valves (surface on which ice is most likely to form) has been shown to be effective in minimizing ice formation; additionally, de-icing fluid has also been shown to, when added to fuel, greatly minimize carb butterfly ice formation.

AMC.1093 (b)

Induction system icing protection

Icing conditions may be defined using the EASA CS-definitions document.

AMC.1095 (a)

Carburettor deicing fluid flow rate

A rate of fluid flow for independant carburettor de-icing fluid, expressed in kg per hour, should not be less than 1.13 times the square root of the maximum continuous power of the engine

AMC.1141 (e)

UAV Powerplant controls: general

The effects of combination of failures should be assessed.

AMC.1143

Engine controls

(a) USAR.1143 (g) states that the UAV should be capable to continue safe flight or the maximum severity of the resulting failure is Major in case of engine control separation at the metering device

(b) When linkage separation occurs, the fuel control should go to a setting that will allow to maintain level flight in the cruise configuration.

AMC 1147

Mixture controls

When mixture linkage separation occurs, the mixture control should go to a full rich setting.

AMC.1189 (a) (5)

Shut-off means

The catastrophic amount of flammable fluid for this requirement should be established as 1 l (one quart).

AMC.1191 (e)

Firewalls

(a) Compliance with the criteria for fireproof materials or components must be shown as follows:

(1) The flame will have the following characteristics:

(i) Temperature 1100°C ± 80°C

(ii) Heat Flux Density 116 KW/m2 ± 10 KW/m2 (116 KW/m2 +/- 10 KW/m2 to 1191)

(2) Sheet materials approximately 25 cm (10 in) square must be subjected to the flame from a suitable burner.

(3) The flame must be large enough to maintain the required test temperature over an area approximately 12.7 cm (5 in) square.

(4) Withstand the application of heat by a flame, for a period of 15 minutes without any failure that would create a hazard to the UAV.

(b) The following materials with the minimum thickness as shown may be used in firewalls or shrouds without being tested as required by this paragraph:

(1) Stainless steel sheet, 0.38 mm (0.015 in) thick.

(2) Mild steel sheet (coated with aluminium or otherwise protected against corrosion) 0.45 mm (0.018 in) thick.

(3) Terne plate, 0.45 mm (0.018 in) thick.

(4) Monel metal, 0.45 mm (0.018 in) thick.

(5) Titanium sheet, 0.41 mm (0.016 in) thick.

(c) Firewall fittings may be constructed of steel or copper base alloy without being tested.

AMC.1193

Cowling and nacelle

Components in an engine nacelle or in the fuselage should be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway.

F – EQUIPMENT

AMC.U1307
Thermal analyses and or tests should be conducted to demonstrate the thermal environment for critical avionics or electronics is maintained at or below the design limitations for ground and flight operations.

AMC.1309 (b)

System Design and Analysis

(1) Introduction

(a) This AMC describes an acceptable means for showing compliance with the requirements of USAR.1309 (b), and sets a severity reference system and a probability reference system for UAV System failure conditions in order to identify the risks deemed to be acceptable. While USAR.1309 does not apply specifically to UAV engine, the most feared events, severity reference system, probability reference system, and risk reference system defined in paragraphs (2) through (5) below apply to all aspects of the UAV System, including the engine integration to the UAV propulsion system. While structural aspects are covered by subpart C and D, this AMC considers probable structural failures which have an effect on system safety and UAV system failures which affect UAV flight structure integrity.

A failure condition is defined as a condition having an effect on either the UAV System, people (including UAV crew, maintainers and third parties) or property on the ground, either directly or consequentially, which is caused or contributed to by one or more failures, considering flight phase and relevant adverse operational or environmental conditions or external events. Failure conditions are classified in accordance to subparagraph (3) (c) hereunder and are identified during FHA process at UAV System level and then at UAV subsystem level (except for UAV powerplant systems provided as part of the certificated engine and except for UAV flight structure, as stated in USAR.1309 (f)).

(b) The compliance with USAR.1309 should be demonstrated by the approach as defined in "SAE ARP 4761 - Guidelines and methods for conducting the safety assessment process on civil airborne systems and Equipment" based on iterative approach through FHA, PSSA, SSA and CCA at UAV System level, then at UAV subsystem level. Alternatively, a similar approach could be used employing the tasks/products itemized in MIL-STD-882 to ensure hazards are identified and design requirements and management controls implemented to prevent mishaps.

The application of ARP 4761 process, whether using ARP 4761 products and/or MIL-STD-882 tasks/products, should be tailored by the Applicant according to the novelty, complexity and severity, and should be submitted for approval to the Certifying Authority.

The FHA consists of:

(i) identifying all the functions at the level under study (aerial vehicle - payloads, etc.) and its interfaces (UCS - data link, etc.),

(ii) identifying and describing the failure conditions associated with these functions, and,

(iii) determining the effects and the severity of these failure conditions.

The FHA should include – but not be limited to – consideration of the failure conditions in Appendix A of FAA Advisory Circular 23-1309-1C.

The PSSA and SSA addresses all significant failure conditions identified in the FHA and aims at justifying their compliance with the quantitative safety objectives set in subparagraphs (5) (a), (5) (c) and (5) (d) hereunder and qualitative Fail-Safe criteria –no single failure shall lead to a catastrophic effect. However, in certain cases, such as engine failure during limited risk time or some mechanical failures, where it can be reasonably shown that these failures are extremely improbable, account may be taken of their probability of occurrence and/or of experienced engineering judgement based upon the application of sound design techniques.

The assessment of the probability of a failure condition may be either qualitative or quantitative. A quantitative analysis is intended to supplement qualitative methods based on engineering and operational judgement. A quantitative analysis is often used for catastrophic or hazardous failure conditions of systems that are complex, that have sufficient service experience to help substantiate their safety, or that have attributes that differ significantly from those of conventional systems.

(c) The evaluation of each failure condition should take account of:

(i) the failure of equipment or other functions performed by the subsystem, other functions or equipment's performed by the subsystem,

(ii) the failure of functions performed by subsystems in interface,

(iii) factors external to the system,

(iv) corrective actions taken by UAV crew or performed automatically,

(v) the flight phase of the UAV, and flight duration,

(vi) the possibility of hidden failures.

(d) In the process to identify and assess the failure conditions at each subsystem level, the SSA should take into account the results of the Failure Modes, Effects Analysis (FMEA) and /or Failure Mode and Effect Summary (FMES) carried out for the design of UAV equipment.

(e) The need for Common Causes Analysis process as described within the SAE ARP 4761 (Common Mode Analysis, Zonal Safety Analysis and Particular risks analysis) should be tailored relatively to the specificity of the UAV System.

(2) Most feared events

(a) The applicant should identify the following failure conditions at UAV System level

(i) uncontrolled flight and/or uncontrolled crash, which can potentially result in fatalities.

An uncontrolled flight (including flight outside of pre-planned or contingency flight profiles/areas) and/or uncontrolled crash is defined as a condition resulting from one or a combination of failure conditions that result in loss of UAV control and / or manoeuvrability.

The consequences of failure conditions identified leading to flight outside of pre-planned or contingency flight profiles/areas may also be mitigated by additional regulations and requirements approved by the Certifying Authority. This statement does not imply that such failure conditions need not to be assessed during the FHA process.

(ii) controlled-trajectory termination or forced landing potentially leading to the loss of the air vehicle, but which can reasonably be expected to avoid fatalities.

A controlled-trajectory termination or forced landing is defined as a condition resulting from one or a combination of failure conditions that prevents the UAV from landing on its planned main landing site although UAV control and / or manoeuvrability is maintained.

(iii) landing of the UAV on a predefined site where it can be reasonably expected that fatality will not occur.

A forced landing on a predefined site where it can be reasonably expected that fatality will not occur is defined as a condition resulting from one or a combination of failure conditions that prevents the UAV from landing on its planned main landing site although the UAV is controllable and manoeuvrable and can also able perform a forced landing on a predefined area that as far as is reasonably practicable has been cleared of people.

(b) The failure condition assessment should be carried out by using tools proposed in ARP 4761 as:

(i) a fault Fault Tree Analysis (FTA) approach with emphasis on the minimal cuts/cut sets of the basic events forming the most feared event,

(ii) a reliability block diagram (RBD) approach accepted by the Certifying Authority.

(3) Severity reference system

(a) In international airworthiness codes applicable to manned aircraft, a crash is considered as catastrophic, whether or not it occurs above a populated area since it is likely to result in numerous fatalities.

(b) Adaptation of these codes to UAV System context must take into account the fact that a UAV carries no passenger or crew. The consequences of an event in terms of casualties are therefore not to be considered with respect to the aircraft occupants, but with respect to people (including UAV crew, maintainers and third parties) or property on the ground.

(c) On the basis of this analysis, the following definitions are adopted by USAR to qualify the severity of failure conditions. These severity definitions are listed in order of likely impact to people with the highest impact being catastrophic and the lowest being minor. When quantifying the severity of the failure the criteria that closest fits the situation should be selected.

(i) Catastrophic: Failure conditions that result in a worst credible outcome of at least uncontrolled flight (including flight outside of pre-planned or contingency flight profiles/areas) and/or uncontrolled crash, which can potentially result in a fatality.
Or
Failure conditions which could potentially result in a fatality to UAV crew or ground staff.

(ii) Hazardous: Failure conditions that either by themselves or in conjunction with increased crew workload, result in a worst credible outcome of a controlled-trajectory termination or forced landing potentially leading to the loss of the UAV where it can be reasonably expected that a fatality will not occur.
Or
Failure conditions which could potentially result in serious injury to UAV crew or ground staff.

(iii) Major: Failure conditions that either by themselves or in conjunction with increased crew workload, result in a worst credible outcome of an emergency landing of the UAV on a predefined site where it can be reasonably expected that a serious injury will not occur.
Or
Failure conditions which could potentially result in injury to UAV crew or ground staff.

(iv) Minor: Failure conditions that do not significantly reduce UAV System safety and involve UAV crew actions that are well within their capabilities. These conditions may include a slight reduction in safety margins or functional capabilities, and a slight increase in UAV crew workload.

(v) No safety effect: Failure conditions that have no effect on safety.

(4) The probability level reference system applicable to USAR is the following:

(a) Extremely Improbable: occurrence less than 10^{-6} per flight hour,

(b) Extremely Remote: occurrence between 10^{-5} and 10^{-6} per flight hour,

(c) Remote: occurrence between 10^{-4} and 10^{-5} per flight hour,

(d) Probable: occurrence between 10^{-3} and 10^{-4} per flight hour,

(e) Frequent: occurrence more than 10^{-3} per flight hour.

For systems and equipment used only in certain phases of flight (e.g., landing gear), a probability reference of "per flight" instead of "per flight hour" may be used at the discretion of the Certifying Authority (see FAR AC23.1309-1C).

(5) Risk reference system

(a) The safety objectives should ensure that systems and equipment design will allow the UAV System to achieve an acceptable safety level. A rational and acceptable inverse relationship should exist between the Average Probability per Flight Hour and the severity of failure condition effects. The relationship between probability and severity of failure condition effects is as follows :

		Catastrophic	Hazardous	Major	Minor	No safety effect
Frequent	$> 10^{-3}$/h					
Probable	$< 10^{-3}$/h					
Remote	$< 10^{-4}$/h					
Extremely Remote	$< 10^{-5}$/h					
Extremely Improbable	$< 10^{-6}$/h					

(hatched)	Unacceptable
	Acceptable

(b) This matrix therefore should apply to each individual failure condition of each UAV subsystem forming the UAV System.

(c) Where, exceptionally, the current state of the art does not permit the attainment of the individual objectives stated in sub-paragraph (a), it should be shown that

(i) at UAV System level, the combination of all catastrophic failure conditions is characterised by an occurrence of 10^{-5} per flight hour or less (with the calculation method subject to Certifying Authority agreement), and,

(ii) the design and construction utilise well-proven methods.

(d) Where the technology and architecture used do not permit the attainment of the objectives stated in subparagraph (5) (a) and (5) (c), the UAV System type certification should be dealt on a case by case basis, subject to the Certifying Authority agreement, either through operational restrictions or through a rationale justifying lesser value (e.g. considering UAV weight or/and kinetic energy at impact) based upon the risk to third parties.

(6) Software development assurance levels

(a) The software integrated in UAV System should perform their intended function with a level of confidence in safety that complies with the requirements set by this paragraph. A software safety program should include identification of the software rigor required for safety criticality elements (e.g., safety integrity level as described in IEC 61805), provide software development assurance evidence of safe software engineering (e.g, RTCA/DO-178B for software and RTCA/DO-254 for firmware), and analyze safe use within the context of hardware design (e.g, using guidelines in the US DoD Joint Software System Safety Committee Software System Safety Handbook, MIL-STD-882, and/or STANAG 4404).

(b) The software life cycle assurance process agreed with the Certifying Authority should be demonstrated with the approach defined in RTCA DO- 178B / ED-12B "Software considerations in airborne systems and equipment certification", especially with annex A for the process objectives and outputs by software level. If equivalent standards are provided, a Plan for Software Airworthiness should be provided and agreed with the Certifying Authority in order to present how the quoted standards will be applied.

(c) The software level should be based upon the contribution of software to potential failure conditions as determined with Development Assurance Level (DAL) derived from FHA, PSSA, SSA analysis as described in subparagraph (1) (b). The DAL allocation in USAR for system and portion of the system architecture is as follows:

<table>
<tr><th colspan="2" rowspan="2">DAL allocation for system and each portion of the system architecture</th><th colspan="2">Degree of redundancy</th></tr>
<tr><th>Single failure/errors</th><th>Double failure/errors

two or more independent/dissimlar portions</th></tr>
<tr><td rowspan="5">Failure Conditions Classification</td><td>Catastrophic</td><td>DAL B</td><td>DAL B for the system and,
DAL C for each portion</td></tr>
<tr><td>Hazardous</td><td>DAL C</td><td>DAL C for the system and,
DAL D for each portion</td></tr>
<tr><td>Major</td><td>DAL D</td><td>DAL D for the system and,
DAL D for each portion</td></tr>
<tr><td>Minor</td><td>DAL E</td><td>DAL E</td></tr>
<tr><td>No Safety Effect</td><td colspan="2">DAL E</td></tr>
</table>

(d) For non-airborne non-flight critical softwares, the software life cycle assurance process should comply with RTCA DO-278 / ED-109 « Guidelines for communication, navigation, surveillance, and air traffic management (cns/atm) systems software integrity assurance », especially with Section 3 for the process objectives and outputs by software level. If equivalent international standards are provided, a Plan For Software Airworthiness should be provided and agreed with the Certifying Authority in order to present how the quoted standards will be applied.

(e) In case of new hardware development with use of PLD (programmable logic device), development assurance level process should be agreed with the Certifying Authority by use of a specific Special Condition.

AMC.1325(e)

Static pressure measuring device

The system error, in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding measuring device calibration error, should not exceed ±9 m (± 30 ft) per 185 km/h (100 knot) speed for the appropriate configuration in the speed range between 1.3 V_{SO} with flaps extended and 1.8 V_{S1} with flaps retracted. However, the error need not be less than ±9 m (± 30 ft).

AMC.1329(e)

Flight control system

The Applicant should consider failure condition loads on the UAV and failure conditions which cause unacceptable deviations from in the intended flight path.

AMC.1329(i)

Flight control system

Consideration should be given to FAA Advisory Circular 25.672-1, "Active Flight Controls" dated 15 Nov 1983, or equivalent means as approved by the Certifying Authority.

AMC.1329(j)
Flight control system

Provisions should be made for determining the status of the continuous built-in-test function and alerting the UAV crew of degradation of the system as appropriate.

AMC.1351 (a) (2)
Electrical Systems and Equipment, General

If compliance is shown by electrical measurements, the procedures should include sufficient testing to show that the electrical systems meet the requirements of USAR.1351. When laboratory tests of the electrical system are conducted

(1) The tests may be performed on a mock-up using the same generating equipment used in the UAV;

(2) The equipment should simulate the electrical characteristics of the distribution wiring and connected loads to the extent necessary for rated test results; and

(3) Laboratory generator drives should simulate the actual prime movers on the UAV with respect to their reaction to generator loading, including loading due to faults.'

AMC.1357 (a)
Circuit protective devices

Circuits essential for continued safe operation should have a redundant circuit per USAR.1309.

AMC.1361
Master switch arrangement

Controls and switches readily accessible to the ground staff necessary to meet the safety levels of AMC.1309 should be considered (e.g. an emergency stop switch).

AMC.1412 (a)(2)
Emergency recovery capability

This emergency recovery capability may include, for instance,

(1) An automatic pre-programmed course of action to reach a predefined site where it can be reasonably expected that fatality will not occur, or,

(2) An automatic flight profile to regain link (return home course), or,

(3) An automatic orbit pattern around a pre-defined waypoint.

AMC.1412 (e)
Emergency recovery capability

Where explosives are used as part of the flight termination system:

(a) A Master Armament Safety Switch should be provided for the UAV crew which can isolate all armament of explosive device circuits from all A.C. and D.C electrical supplies.

(b) Only explosive devices approved by the Certifying Authority should be used.

(c) Explosive devices should be installed as to be easily accessible and should not require excessive handling during installation.

(d) Particular attention should be paid to protecting the insulation of circuits connected to explosives.

AMC.1459
UAV onboard flight recorders On board flight recorders should comply with EUROCAE ED-112 or ETSO-C124a or any equivalent standard.

AMC.1485
Environmental Control System (ECS) (a) Due consideration should be given to the cooling of avionic equipment, pressurisation requirements, bleed air and ducting systems and thermal management in the design of the ECS. (b) The ECS design (including emergency equipment and/or auxiliary methods) should provide an acceptable pressure environment for equipment affecting safety of flight. (c) Normal and emergency pressurization requirements and status should be indicated in the UCS. (d) Bleed air or other compressed air duct system should be monitored for leaks and structural integrity. Hot air leaking from damaged ducting should not cause ignition of any flammable fluids or other materials or cause damage to safety-critical equipment. Shutdown capability, with a UCS advisory or warning, should be provided when a potentially damaging or fire-producing leak occurs. The sensors for the leak detection system should recover their required leak detection function following exposure to a leak. (e) The UAV thermal management system should be stable for all flight conditions and environments. The mass flow and delivery temperature of cooling medium should be sufficient for the air vehicle heat loads and provide the necessary thermal stability to ensure safety-of-flight.

AMC.1490 (f)(2)
General (a) The size of the convergence window and associated tolerances should be defined with the Certifying Authority based on the tailoring of manned aircraft reference documents such as EASA CS-AWO.

G – OPERATING LIMITATIONS AND INFORMATION

AMC.1587
Performance information (a) Performance information should be provided for each UAV aircraft and engine configuration. If appropriate, a Drag Index System or an equivalent system approved by the Certifying Authority should be used. For estimated performance data, fuel flows should be increased by 5 percent. For flight tested performance data, this factor should not be used if approved by the Certifying Authority. If it is included, it should not exceed 5 percent. (b) Dry/wet runway (1) Runway conditions should be referenced to STANAG 3634 – Runway Friction and Braking Conditions. (2) For example, "dry runway" means a runway with braking and directional control that are not reduced – whether the runway is actually "dry" or not.

AMC.1587 (f)
Performance information The performance parameters should include, but not limited to; Climb performance (time, distance and fuel to climb, best climb speeds), Cruise performance (Specific Range, Specific Endurance, Best Cruise speed and altitude, Best Endurance Speed and Altitude), One Engine Inoperative Climb and Cruise performance, Divert Performance, Descent performance, etc.

H – COMMAND AND CONTROL DATA LINK

AMC.1601

General

(a) Command and control information consists of commands and parameters transmitted to the UAV(s) from the UCS(s), and transmission of all relevant operating parameters required for operation of the system from the UAV(s) to the UCS(s). In this context, commands to the UAV include any parameter that is necessary to enable the operation of the system.

(b) Command and control information transmitted to the UAV from the UCS (transmitted via the 'uplink') should be shown to enable positive control of the UAV during all normal operations, and transmitted at a rate consistent with safe operation.

(c) Command and control information transmitted from the UAV (transmitted via the 'downlink'), should be shown to enable positive control of the UAV during all normal operations, and transmitted at a rate consistent with safe operation.

(d) Bandwidth and the latency of the overall communications system are to be considered when determining transmission rates consistent with safe operation. It should be noted that the terms 'uplink' and 'downlink' do not imply only a line of sight radio frequency channel, but include any configuration of any type(s) of communication device(s) capable of transmitting the required information.

(e) It should be shown that a remote communications system is sufficient and robust enough to allow the safe operation of the system.

(f) Reference should be made to STANAG 4586 for the design and assessment of the UAV communications system, including matters such as command formats and confirmation.

(g) Any ATC communications system should be shown as compliant with USAR 1301 and 1309 as installed equipment.

(h) Any payload data link system related to a safety-of-flight critical component (for instance an electro-optical pan-tilt-zoom payload) should be shown to be compliant with USAR part H and USAR 1309.

(i) The functionality of payload data links with no safety of flight impact need not to be assessed under USAR 1601.

(j) Where data is to be transmitted to a location other than the UCS (such as a remote viewing terminal), it should be shown that the communications paths used will not interfere with safe operation of the system.

AMC.1605

Electromagnetic interference and compatibility

It should be shown that there is no interference (i.e. EMI/EMC, EME etc) with the command and control link by the ATC communication link, any data link, or other UAV systems, for all possible combinations of paths for both uplinks and downlinks. RTCA DO-160 and other relevant standards should be considered in design and compliance assessment.

AMC.1605 (b)

Electromagnetic interference and compatibility

(a) Where multiple radiofrequency links are used for redundancy or for specific function such as local control for launch and landing elements, operating frequency should be chosen such as to rule out the possibility of mutual interference.

(b) Spread spectrum techniques may be effective in reducing mutual interference. Spread-spectrum communications are those in which the frequency of both the transmitted RF signal and the intended RF receiver are rapidly and identically varied. This is done to minimize disruption from other transmitters, as well as to prevent detection by or disruption to non-system RF receivers.

AMC.1607 (a)
Command and control data link performance and monitoring The maximum data link range depends on the data link frequency, the availability, the BER (bit error rate) for digital link, the relevant climate area parameters, the UAV altitude, etc…

AMC.1613 (a)
Command and control data link loss strategy The pre-programmed flight path should be stored in the UAV to provide resilience to communication/data link anomalies.

AMC.1613 (b)
Command and control data link loss strategy The autonomous reacquisition process should be able to try to re-establish a command and control data link to the original or any other available UCS.

AMC.1613 (c)
Command and control data link loss strategy (1) Total loss of the command and control data link means that the data link has become degraded to a point that an emergency condition exists under USAR.1412 and USAR.1607 (c). (2) The UCS should predict and display the geographic position of the UAV flying without data link communications, based on the UAV Mission Plan, progress before losing the link, and the input link loss strategy

AMC.1617 (a)
Command and control data link switchover function This operation is also called "changeover".

AMC.1617 (b)
Command and control data link switchover function A UAV System may have multiple data links, some capable of UAV command and control, some capable of transferring payload information, and some capable of both. The protocols for data link switchover should be examined for every possible command and control switchover scenario, including scenarios where multiple UAVs are being controlled from a single UAV control station. Specific emphasis should be given to determination and indication of which data link has actual control of the UAV.

AMC.1617 (c)
Command and control data link switchover function Positive control is the practice of the command and control data link to mediate a transfer of control to the new controlling command and control data link for before severing the control connection to the UAV. I.e. The entity wishing to transfer control can not terminate the connection to the UAV until the entity wishing to gain control has acknowledged the connection and required level of control.

I – UAV CONTROL STATION

AMC.1701
General

(a) It is assumed that regulatory requirements associated with occupational safety and health, fire safety, electrical safety, radiation safety etc, any effect on the UCS and/or the UAV crew are under national law. As one or more of these factors have a direct impact on airworthiness and may lead to an emergency situation, these factors should be included in the airworthiness assessment of the system. Any failure condition leading to UAV crew or ground staff injury or death is included under the AMC.1309 definitions of severity levels.

The design of the UCS should therefore take into account all relevant hazards and include mitigation techniques such as fire detection/suppression systems, emergency lighting, emergency egress, etc. that may have an impact on flight safety as deemed appropriate and agreed with the Certifying Authority.

(b) When considering the design of the UAV control station, guidance can be obtained from Defence standard 00-25 Human Factors for Designers of Systems.

AMC.1701 (e)
General

Reference for these environments are provided by MIL-STD-810 or any equivalent standard approved by the Certifying Authority.

AMC.1707 (a)
Communication system

Particular consideration should be given to communication intensive operations such as UAV handover (USAR.1881) and other operations where UAV crew may not be co-located in the same UCS.

AMC.1707 (c)
Communication system

For those installations where all warnings are not provided through the radio/audio equipment, consideration should be given to the UAV crew ability to hear and recognise warnings when headsets are used, including noise cancelling headsets.

AMC.1709
Voice recorders

(a) The storage capacity of the voice recorder should be compatible with the record of the maximum duration of flight for which certification is requested.

(b) The voice recorder should be designed to prevent unauthorised or unintentional editing.

AMC.1709 (e)
Voice recorders

For instance, the GPS time signal can be used for this purpose.

AMC.1711
UCS data recorder

(a) The data recorder should be compatible with the UAV System's classification guide and security procedures.

(b) The data recorder should be designed to prevent unauthorised or unintentional editing.

AMC.1711 (a)

UCS data recorder

(a) Primary mission data should include but not be limited to;
- Mission plans and updates
- Air vehicle commands

(b) System data should include but not be limited to;
- Data link up link commands
- Data link down link air vehicle data, to include;
  - Airspeed
  - Altitude
  - Vertical acceleration
  - Magnetic heading
  - Pitch attitude
  - Roll attitude
  - Engine performance data
  - Control surface position
  - Sense and avoid data
  - Internal parameters associated with autonomous functions
  - System health data

(c) Consideration should be given to any unique design or operational features of the UAV to determine whether any relevant dedicated parameters should be recorded.

(d) Guidance on data recorders can be obtained from

(1) EUROCAE MOPS ED-112 (Minimum Operational Performance Specification for Crash Protected Airborne Recording Systems), or,

(2) Air Force Instruction (AFI) 63-1401, Aircraft Information Program and Air Force Handbook (AFH) 63-1402, Aircraft Information Program.

AMC.1720

Automated Mission Planning

The intent of USAR.1720 is to ensure that safety critical calculations in mission planning wherever they are performed, are properly assessed by hazard analysis and where applicable software design assurance level application.

(a) All of the UAV mission planning sub-systems that influence the safe operation of the UAV system (in particular those that provide aerodynamic performance predictions, UAV manoeuvre commands or flight profile waypoints) should be verified, such that none of the UAV limits or performance capabilities are exceeded.

(b) The verification process should range and type check UAV crew data entries against the UAV limits and performance capabilities.

(c) The automated mission planning sub-systems should be compliant with USAR.1309

AMC.1721

Arrangement and visibility

(a) The intention of USAR is to give system designers maximum flexibility to innovate safely. The selection of system data for display, and the nature of those displays, is a key safety factor. This AMC gives guidance on the categorization and assessment of data for display.

(b) 'Data' in this context means any system information required for the operation of the system, and includes, but is not limited to, information concerning navigation, flight management, system performance, cautions and warnings.

(c) In this context, USAR has three broad categories of system data:

(1) Data that is essential for the safe operation of the system and which must be displayed to the UAV crew at all times and at a refresh rate consistent with safe operation. Full-time display is mandatory for this category of data.

(2) Data where continuous display is not essential to safe operation but to which UAV crew access on demand is essential. Full-time display is not mandatory for this category of data (i.e. part-time display is an option).

(3) Data to which UAV crew display access on demand is not essential to safe operation but is nevertheless possible. Full-time display is not mandatory for this category of data (i.e. part-time display is an option).

(d) Data automatically monitored by the system that will result in a caution or warning when specified conditions are met or parameters exceeded is subject to the requirements of USAR 1787. The display of a caution or warning itself is not subject to USAR 1722 [1723,25….] but the data used to generate the warning (for instance airspeed) may be also subject to full or part-time display.

(e) Given the diverse nature of UAV systems, it is difficult to prescribe a definitive list of data for which full-time display would be mandatory, and for which part-time or no display would be appropriate. Hence, each UAV system should be analysed to determine which data shall be displayed full-time, and which data shall be displayed part-time. This analysis and its results should be approved by the Certifying Authority.

AMC.1722

Part-time display

If it is desired to inhibit some parameters from full-time display, an equivalent level of safety to full-time display should be demonstrated. Criteria to be considered include the following :

(a) Continuous display of the parameter is not required for safety of flight in all normal flight phases.

(b) The parameter is automatically displayed in flight phases where it is required.

(c) The inhibited parameter is automatically displayed when its value indicates an abnormal condition, or when the parameter reaches an abnormal value.

(d) Display of the inhibited parameter can be manually selected by the UAV crew without interfering with the display of other required information.

(e) If the parameter fails to be displayed when required, the failure effect and compounding effects must meet the requirements of USAR.1309. The analysis is to clearly demonstrate that the display(s) of data is consistent with safe operation under all probable operating conditions.

(f) The automatic, or requested, display of the inhibited parameter should not create unacceptable clutter on the display; simultaneous multiple "pop-ups" must be considered.

(g) If the presence of the new parameter is not sufficiently self-evident, suitable alerting must accompany the automatic presentation.

AMC.1727

Electronic data display system

Colour Standardisation

(1) Although colour standardisation is desirable, during the initial certification of electronic displays colour standards for symbology were not imposed. At that time the expertise did not exist within industry, nor did sufficient service experience exist, to rationally establish a suitable colour standard.

(2) In spite of the permissive CRT colour atmosphere that existed at the time of initial EFIS certification programmes, an analysis of the major certifications to date reveals many areas of common colour design philosophy; however, if left

unrestricted, in several years there will be few remaining common areas of colour selection. If that is the case, information transfer problems may begin to occur that have significant safety implications. To preclude this, the following colours are being recommended based on current-day common usage.

(3) The following depicts acceptable display colours related to their functional meaning recommended for electronic display systems.

(i) Display features should be colour coded as follows:

Warnings	Red
Flight envelope and system limits	Red
Cautions, abnormal sources	Amber/Yellow
Earth	Tan/Brown
Engaged modes	Green
Sky	Cyan/Blue
ATOL deviation pointer	Magenta
Flight director bar	Magenta/Green

(ii) Specified display features should be allocated colours from one of the following colour sets:

	Colour Set 1	**Colour Set 2**
Fixed reference symbols	White	Yellow*
Current data, values	White	Green
Armed modes	White	Cyan
Selected data, values	Green	Cyan
Selected heading	Magenta**	Cyan
Active route/flight plan	Magenta	White

* The extensive use of the colour yellow for other than caution/abnormal information is discouraged.

** In colour Set 1, magenta is intended to be associated with those analogue parameters that constitute 'fly to' or 'keep centred' type information.

(iii) Precipitation and turbulence areas should be coded as follows:

Precipitation	0-1	mm/hr	Black
	1-4	"	Green
	4-12	"	Amber/Yellow
	12-50	"	Red
	Above 50	"	Magenta
Turbulence		"	White or Magenta

(iv) Background colour: (Grey or other shade) — Background colour may be used to enhance display presentation.

(4) When deviating from any of the above symbol colour assignments, the manufacturer should ensure that the chosen colour set is not susceptible to confusion or colour meaning transference problems due to dissimilarities with this standard. The Certifying Authority should be familiar with other systems in use and evaluate the system specifically for confusion in colour meanings. In addition, compatibility with electro-mechanical instruments should be considered.

(5) The Certifying Authority does not intend to limit electronic displays to the above colours, although they have been shown to work well. The colours available from a symbol generator/display unit combination should be carefully selected on the basis of their chrominance separation. Research studies indicate that regions of relatively high colour confusion exist between red and magenta, magenta and purple, cyan and green, and yellow and orange (amber). Colours should track with brightness so that chrominance and relative chrominance separation are maintained as much as possible. Requiring the UAV crew to discriminate between shades of the same colour for symbol meaning in one display is not recommended.

AMC.1727 (b)
Electronic data display

It must be shown that the transition of displayed information from one display screen to another must not lead to an unsafe situation.

AMC.1731
General

The compliance with USAR.1732 to USAR.1769 may also be demonstrated by the use of modern synthetic interface based on the representation of controls on electronic display systems related to convenient man-machine interface.

AMC.1753 (b)
Ignition switches

For example by grouping the switches or by a single master ignition control.

AMC.1769
"Abort" control for automatic take-off system or automatic landing system

The Automatic take-off and landing "abort" control is a safety critical control as defined in USAR.1732

AMC.1787 (a)
Automatic diagnostic and monitoring

Compliance with USAR.1787 (a) should address instances where the actual UAV parameters are substantially different from the commanded value such as airspeed, geospatial location, altitude, etc…

AMC.1793 (b)
Landing gear position and warning

As a minimum, the following aural or equally effective landing gear warning devices should be provided:

(1) A device that functions continuously when one or more engine settings are beyond the power or thrust settings normally used for landing approach without the landing gear fully extended and locked. If there is a manual shut-off for the warning device prescribed in this paragraph, the warning system must be designed so that, when the warning has been suspended, subsequent retardation of any engine power or thrust to or beyond the setting for normal landing approach will activate the warning device.

(2) A device that functions continuously when the wing flaps are extended beyond the maximum approach flap position, using a normal landing procedure, without the landing gear fully extended and locked. There may not be a manual shut-off for this warning device. The system for this device may use any part of the system (including the aural warning device) for the device required in sub-paragraph (1).

AMC.1795
Pressurised compartment indicator

There should be an indicator in the UCS to display

(1) the pressure differential

(2) the compartment pressure altitude, and,

(3) the rate of change of compartment pressure altitude.

AMC.1801
Battery discharge warning Special attention should be given to batteries used for engine restart in flight.

AMC.1803
Powerplant power assisted valves The required means to indicate the valve position may be – a system which senses directly that the valve has attained the position selected, or – other indications in the UCS which give the UAV crew a clear indication, that the valve has moved to the selected position. Although a continuous display indicator would enable compliance with these requirements the alternative use of lights showing the fully open and fully closed position or transit of the valves are also acceptable means of compliance.

AMC.1809
UAV electrical systems warning and indicator There should be an indicator to inform the UAV crew about (a) the available electric power (including power storede in batteries) (b) the actual power consumption, and, (c) the electrical power required for safe flight.

AMC.1821
Power distribution indicator Safe minimums are a function of the minimum power needed for safe flight versus the distributions of this power over the distinguished circuits. Note that one sole circuit may be inadequate to provide all power needed for safe flight.

AMC.1837
Magnetic heading or track data The primary intent of the USAR.1837 is to deal with deviation caused by the UAV. However, the Certifying Authority should consider Special Conditions during the taxi, launch and landing phase of UAV.

AMC.1845 (e) (2)
Control markings 1- Reciprocating engine mixture control and turbine engine condition levers incorporating fuel stopcocks, or fuel stopcocks themselves, are considered to be emergency controls since they provide an immediate means to stop engine combustion. 2- Where emergency control interface is based upon electronic data display system, deviation from red colour assignment should be allowed if the Applicant is able to ensure that the chosen colour is not susceptible to confusion. The Certifying Authority should be familiar with other systems in use and evaluate the system specifically for confusion in colour meanings. In addition, compatibility with electro-mechanical instruments should be considered.

AMC.1881 (b)
UAV hand over between two UCS (1) Positive control is the practice of the UCS to mediate a transfer of control to the new controlling UCS for before severing the control connection to the UAV. I.e. The entity wishing to transfer control can not terminate the connection to the UAV until the entity wishing to gain control has acknowledged the connection and required level of control. (2) The transition time during which the UAV is not under the control of any UCS must be assessed in order to demonstrate that UAV hand over procedure does not lead to any unsafe situation.

AMC.1881 (c)
UAV hand over between two UCS A specific description of the synchronisation procedure in each UCS should be presented in the UAV System Flight Manual.

AMC.1881 (d)
UAV hand over between two UCS Particular attention should be given to UCS settings during control handover to ensure operating parameters are identical before and after handover.

AMC.1885 (b)
UAV handover within the same UAV control station Positive control is the practice of the UCS to mediate a transfer of control to the new controlling workstation for before severing the control connection to the UAV. I.e. The entity wishing to transfer control can not terminate the connection to the UAV until the entity wishing to gain control has acknowledged the connection and require level of control.

AMC.1885 (d)
UAV handover within the same UAV control station Particular attention should be given to UCS settings during control handover to ensure operating parameters are identical before and after handover.