ENCLOSURE 4

(WG III Report)

4 OPERATIONS MAINTENANCE AND LICENSING

4.1 Methodology used by WG III

4.1.1 Scope

TheJAA/EUROCONTROL UAV Task Force Working Group II (WG III) has been tasked to analyse the operations, maintenance and licensing regulatory material relating to the operation of UAVs, within Europe, in all classes of airspace.

The following persons have participated in the activities of WG III

Name	Country	Organization	Affiliation
Lex Risseeuw (Chair)	Netherlands	EURO UVS	ADSE
Catherine Barthélemy (Backup Chair)	France	EURO UVS	EADS-S&DE ISR
Hans Brants	Netherlands	USICO/EURO UVS	NLR
Luca Cistriani	Italy	EURO UVS	METEOR
Denis Jeandel	France	EURO UVS	EDT
Lars Sundlin	Sweden	EURO UVS	LFV
Philippe Bataillé	France	DGAC	DGAC/STNA
Winfried Wrasse	Germany	AECMA	EADS
Thomas Breitkreuz	Germany	AECMA	EADS
Vicky Brennan	United Kindom	EURO UVS	Praxis Critical Systems Limited
Brian Orr	United Kingdom	EURO UVS	Praxis Critical Systems Limited
Gregory Edwards	USA	FAA	AEU –100 Brussels

This chapter proposes a concept (i.e. an outline and guiding principles, not draft regulations) for civil UAV regulations on operations maintenance and licensing, with a justification and recommendations for future work.

4.1.2 Approach

WG-III used three ways to identify significant issues for UAVs on operations, maintenance and licensing that might need further action before drafting regulations:

1. Brainstorm about particularities of UAVs that might not yet have been sufficiently addressed in existing regulations for manned aircraft
2. A review of existing regulations on operations, maintenance and licensing , notably the JAR-OPS, JAR-FCL, JAR-145/147 and 66 as well the applicable ICAO annexes (1, 2, 6, 10,11 and 18. This review can be found in appendix 1
   The relation between the applicable ICAO annexes and the JARs can be found below
3. A review of the available EASA regulatory material.

The following table illustrated the material that has been analysed and indicated which working group has handled the analysis.

ICAO Annex		JAR reference	Working Group
01	Personnel Licensing	FCL 1, 2, 3, 4 STDs	WG III Chapter 7
02	Rules of the Air		WG III
03	Meteorological Service for International Air Navigation		Refers to services provided – no special arrangements required for UAV operations.
04	Aeronautical Charts		Refers to services provided – no special arrangements required for UAV operations.
05	Units of Measurement to be Used in Air and Ground Operations		Not Applicable for UAV systems as it refers to services provided?
06	Operation of Aircraft	OPS1, 3, AWO	WG III Chapter 10
07	Aircraft Nationality and Registration Marks		WG I or II
08	Airworthiness of Aircraft	21, 22, 23, 25, 26, 27, 29, 39, APU, E, MMEL/MEL, P, TSO, VLA 145, 147, 66	WG II Airworthiness WG III Chapter 8 (Maintenance)
09	Facilitation		Refers to services provided – no special arrangements required for UAV operations.
10	Aeronautical Telecommunications		Refers to services provided – no special arrangements required for UAV operations.
11	Air Traffic Services		WG III
12	Search and Rescue		Refers to services provided – no special arrangements required for UAV operations.
13	Aircraft Accident and Incident Investigation		Refers to services provided – no special arrangements required for UAV operations.
14	Aerodromes		Refers to services provided – no special arrangements required for UAV operations.
15	Aeronautical Information Services		Refers to services provided – no special arrangements required for UAV operations.
16	Environmental Protection	36	WG II
17	Security: Safeguarding International Civil Aviation Against Acts of Unlawful Interference		WG I
18	The Safe Transport of Dangerous Goods by Air		WG III

Table 4-2 Summary of Documents Reviewed

While reviewing the existing regulations the Working Group was aware that these could not be explicitly applied to UAVs because these regulations were established for other purposes. However, these documents were considered to be the best source of requirements for aircraft operations and hence a useful means (but not the only means) to quickly identify issues that should be considered for UAV operations.

After reviewing the existing regulatory material for aircraft maintenance it was concluded that the existing regulations could be applied to UAVs unchanged. Therefore maintenance issues are not discussed in this document.

The three approaches yielded a series of issues that are identified in appendix 2. In Appendix 2 each issue is elaborated as follows:

1. Reference for manned aircraft
   Here references of that specific topic to the existing regulations are stated;
2. Summary of referenced requirements for manned aircraft
   In this summary the specific topic is defined in such a way that it is unambiguous what the specific topic is dealing with
3. Discussion of the issue
   Here the issue is discussed in relation to UAV operations.

4. Recommendations
   Recommendations for drafting regulations for UAVs if possible within the scope of the WG III activities are formulated here.

In the following section the 25 issues identified in Appendix 2 are grouped and summarized into 8 topics. The way in which the topics have been clustered is shown in the table below:

			4.2.1 Collision avoidance	4.2.2 Equipment	4.2.3 Flight rules	4.2.4 Licenses and ratings	4.2.5 Emergency procedures	4.2.6 Operator certification	4.2.7 Responsibilities and handover	4.2.8 Other identified topics
1	Medical fitness	L				X				
2	Licenses and ratings	H				X				
3	Synthetic flight instruction	L								X
4	Age	L				X				
5	Experience	L				X				
6	Training	M								X
7	Theoretical knowledge, skill and examination	M				X				
8	Crew composition	M							X	
9	Responsibilities and handover	M							X	
10	Multiple type ratings	L				X				
11	Collision avoidance	H	X							
12	Recorders	L		X						
13	Alternates	H					X			
14	Low visibility operations	L								X
15	Circuit protection	L		X						
16	Windshield wipers	L		X						
17	Equipment	H		X						
18	First aid equipment	L		X						
19	Performance	M								X
20	Signals	L			X					
21	Unlawful interference	L			X					
22	Interception	L			X					
23	Operator certification	H						X		
24	Flight rules	H			X					
25	Termination and tracking	M					X			

4.2 Topics

4.2.1 Collision Avoidance

4.2.1.1 Introduction

This section seeks to lay out a basis for future European UAV 'collision avoidance requirements'. The analysis evaluates those aspects of current aircraft operating standards (from JAA and ICAO), which are impacted by the advent of UAV operations. It outlines those aspects, of the UAV operational concepts, that appear to align with the current regulations and indicated where there appears to be a need for appropriate updating.

The approach taken relates the collision avoidance requirements to the ICAO airspace 'classes' and proposes suitable provisions for safe UAV operations.

Finally there is a formal identification of the 'issues' that appear to require some adaptations, clarifications, or changes, to the current regulations and would need to be actioned by an appropriate organisation. At this stage of the analysis no actions are specifically assigned to any of these bodies; however, there is an underlying assumption that further analysis will be undertaken and suitable action taken, in due course. To facilitate this follow-up action the 'issues' from this section and others have been collated at Appendix 2 to this document.

4.2.1.2 Current Situation

The rules and regulations for aircraft operations in the ECAC region were established in an era before the operation of unmanned 'flying machines' became an issue. Whilst the regulations don't specifically exclude the operation of these aircraft, there is a presumption of manned flight. However, it is equally true that the regulations were conceived in an era when aircraft were operating more slowly, airspace less congested and where collision avoidance technology was nothing more than visual lookout for VFR flights and procedural separation - based on a pressure altimeter and aircraft speed/direction/time across a fixed route structure for IFR flights.

The advent of UAV is not alone in bringing into question the safety implications of the 'see and be seen' principle and the fallibility of the human in the cockpit is now a matter of wider debate. New conflict detection tools are being promoted: primary / secondary radar are now widely used by the ATS, in all classes of airspace, for both VFR and IFR flights; and an Airborne Collision and Avoidance System (ACAS), currently TCAS II, is being mandated for certain types of flight. UAV operations may promote the introduction of additional 'collision avoidance' technologies, which may also have application for manned aircraft

4.2.1.2.1 Future UAV Operations

With the increase of the air traffic, the risk of in-flight collisions will increase unless the methods of operations and the performance of supporting equipment are improved (e.g., by Collision Avoidance Systems).

Like manned aircraft, UAVs shall maintain a safe distance from other aircraft such that there is no need for collision avoidance manoeuvring as defined in Annex 2. This "proximity distance" (between the vehicles) applies for Visual Meteorological Conditions (VMC); for controlled flights under Instrument Meteorological Conditions (IMC) larger distances may apply. The proximity distance is comparable to the 500 ft "near miss" as defined by the US FAA, but could be larger.

Aircraft pilots shall always maintain situational awareness to other aircraft, regardless airspace class. They achieve this by long range and short-range surveillance. This also applies to UAV pilots.
Long range surveillance is mainly provided by (lightweight) transponders (in the future: ADS-B). Short-range surveillance requires heavier equipment that is capable to provide more accurate last second information to avoid a collision; presently only the bigger UAVs can carry this. Short-range surveillance equipment may be pointing, scanned and / or co-operating with the long-range equipment and use different wavelength sensors.

Safe collision avoidance manoeuvres will require manoeuvre intent information to be exchanged between the vehicles. A short-range communication system is required for this purpose.

4.2.1.2.2 Airspace Classes and service Provision

In considering changes in the provisions for conflict avoidance it is prudent to look at the current conflict avoidance requirements, which are defined in accordance with an ICAO classification of airspace. ICAO Annex 11 defines Class A as the most restrictive type of airspace where the separation of aircraft is assured principally by the air traffic 'control' service with mandatory instructions from the controller to separate and sequence the air traffic. Each of the lower categories gives progressively more autonomy to the aircraft and reduces the ATC service to 'traffic advisories' and 'flight information'. The most relaxed regime, Class G, requires that the aircraft take only a 'flight information service' when flying IFR.

The following paragraphs and the associated table indicate, by classes of airspace, how aircraft operations could be adapted to accommodate UAV operations.

4.2.1.2.3 Class A, B, C, D and E (IFR) Airspace

In future UAV aircraft can be expected to operate routinely in Class A through E airspace; however the mode of UAV operation will vary significant based on the role of the UAV and it's size/weight/performance. Refer to Section ___ for the characteristics of the different types of UAV.

4.2.1.2.3.1 Class 0[1] UAVs in Class A, B, C, D and E (IFR) Airspace

It would appear that small, light UAVs operating close to the surface are likely to have least impact on ATC operations across Classes A to E. Provided they do not operate from controlled aerodromes and avoid (to the maximum extent possible) the ATC patterns for controlled airports their impact should be manageable by the air traffic service - the deconfliction from helicopters presents the only major issue.

Low/light/slow UAV operations would have the following constraints:

- The aircraft performance and navigation capabilities shall be adequate enough to predict, with significant accuracy, the route and track of the aircraft and to assure that it cannot deviate into traffic patterns or reserved airspace;
- The UAV 'operator' must be in continuous radio communication with the ATS agency and the responses of the UAV aircraft shall be prompt and predictable. The UAV operator and UAV aircraft must be able to comply with all aspect of an ATC clearance;
- Collision avoidance technologies shall be available to ensure an adequate 'safety net' - equivalent to flight crew monitoring in a conventional aircraft. Acting as a first level of fallback in the event of an error in the ATS service provision.

4.2.1.2.3.2 Class 1-3 UAVs Conforming with Behaviour of Manned Aircraft (Class A, B, C, D and E (IFR) Airspace)

The most challenging types of UAV operations will occur where manned and unmanned operations have to co-exist in the same airspace and potentially on the same runways. Such aircraft would operate IFR and need to behave in a consistent manner and have equivalent performance characteristics to manned aircraft.

The constraints on this type of operation are:

- **Airframe Performance**. Unmanned aircraft would have to operated at compatible airspeed and rates of climb/descent as manned aircraft;

[1] Class 0 is defined as MTOW< 25 kgs, range< 10nms and ceiling 1000 ft

- **Air/ground communications**. Unmanned aircraft would have to be operated (by an 'operator') able to maintain the same continuous communication with the ATS provider and be a responsive to the instruction/clearances/requests as the pilot located in the cockpit;
- **Navigation Performance**. Unmanned aircraft should provide the same navigation performance, including the ability to adjust heading , speed, route – exactly as a manned aircraft;
- **Collision Avoidance**. Although the primary responsibility for separation of aircraft lies in the air traffic control service – there is a need to provide an equivalence with the 2nd level of safety protection, as provided by the flight crew.

4.2.1.2.3.3 Class 1-3 UAVs Unable to Conform to the Behaviour of Manned Aircraft (Class A, B, C, D and E (IFR) Airspace)

This scenario in complex European airspace is likely to meet with significant opposition; however, provided airspace complexity and density of aircraft operations are consistent – there are likely to be no significant impediments. The constraints for this type of operations are as follows:

- **Airspace design.** The airspace design would need to include SIDs, STARs and routings that have the minimum impact on conventional aircraft operations.[2]
- **Airframe Performance**. Unmanned aircraft would have to operated is accordance with the airspace design and defined procedures;
- **Air/ground communications**. As in the previous para, unmanned aircraft would have to maintain the same continuous communication, with the ATS provider, and be as responsive to the instruction/clearances/requests, as the pilot located in the cockpit;
- **Navigation Performance**. As in the previous para, unmanned aircraft must provide consistent navigation performance, including the ability to adjust heading , speed, route etc;
- **Collision Avoidance**. As in the previous para – there is a need to provide 'collision avoidance' capabilities equivalent to the 2nd (even 3rd level) of safety protection provided by the flight crew.

4.2.1.2.4 UAV Class 0-3 in Class E (VFR), F and G Airspace

UAV operations can be expected to operate routinely in Class F and G airspace; however adequate demonstration will be required to prove that adequate conflict avoidance can be achieved.

Sparely Populated Areas – Low Traffic Density (Class E (VFR), F and G Airspace)

In sparsely populated areas (over oceans, desert, remote areas etc) where there is a minimal level of aerial activity is may be possible to operate certain types of UAV based on a 'notification and co-ordination system'. Such a basis for operations would be subject to formal approval (or dispensation) by the Airspace Regulator and would require the full co-ordination with airspace users and other airspace operators. It would be possible to demonstrate the achievement of an appropriate level of safety based on these procedural measures. UAVs would have priority and manned flights would be operated so as to avoid published tracks, routes and areas – or would accept responsibility for visual separation.

4.2.1.2.4.1 UAV Class 0-3 in Areas of Significant Air Operations (Class E (VFR), F and G Airspace)

In Class F and G airspace where there are more that a few manned aircraft operating the UAV can operate in one of two modes:

[2] There is an assumption that UAVs may need specific SIDs and STARs; however in cruise flight the performance may be consistent with manned aircraft.

- Under close-control of a ground agency with adequate surveillance information to effect separation:
- Using airborne 'collision avoidance' technology. Suitable technologies are under development[3] and are expected to give conflict detection and avoidance which is equal to, or better than, can be achieved with human pilot operations. The development, testing and approval procedures for 'collision avoidance' technologies are procedural issues that require early action.

4.2.1.2.5 Summary of Flight Requirements for UAV Operations by Airspace Class

The following table summarises the 'conflict avoidance requirements', for UAV Operations, by relationship with the ICAO Airspace Classes.

[3] E.g. In the US-led Environmental Research Aircraft and Sensor Technology (ERAST) Programme.

Table xxxx: SUMMARY OF FLIGHT REQUIREMENTS FOR UAV OPERATIONS BY AIRSPACE CLASS

Class	Type of Flight	Separation provided	Service provided	Speed Limits	Radio Comms requirements	Subject to an ATS Clearance	UAV Operations		
							Radio Comms	Able to comply with a clearance	Remarks
A	IFR	All aircraft	ATC Service	Not analysed (at this stage)	Continuous 2-way	Yes	Essential	Essential	
B	IFR	All aircraft	ATC Service		Continuous 2-way	Yes	Essential	Essential	Compatible and consistent aircraft performance
B	VFR	All aircraft	ATC Service		Continuous 2-way	Yes	Essential	Essential	AND
C	IFR	IFR from IFR IFR from VFR	ATC Service		Continuous 2-way	Yes	Essential	Essential	Consistent navigation Performance
C	VFR	VFR from IFR	1)ATC Service for separation from IFR 2) VFR/VFR 'traffic info and 'traffic avoidance' advice on request.		Continuous 2-way	Yes	Essential	Essential	AND
D	IFR	IFR from IFR	ATC Service, 'traffic info' about VFR flights (and 'traffic avoidance' advice on request.)		Continuous 2-way	Yes	Essential	Essential	Continuous communications and prompt action to clearance and instructions
D	VFR	Nil	IFR/VFR and VFR/VFR 'traffic info' (and 'traffic avoidance' advice on request.)		Continuous 2-way	Yes	Essential	Essential	AND
E	IFR	IFR from IFR	ATC service and as far as practical 'traffic info about VFR flights.		Continuous 2-way	Yes	Essential	Essential	Approved 'collision avoidance' systems
E	VFR	Nil	Traffic information as far as practical.		No	No	Not required	N/a	Close control
F	IFR	IFR from IFR as far as practical	Air traffic advisory; flight information service.		Continuous 2-way	No	Essential	N/a	OR
F	VFR	Nil	Flight information service.		No	No	Not required	N/a	Priority to UAV
G	IFR	Nil	Flight information service.		Continuous 2-way	No	Not required	N/a	OR
G	VFR	Nil	Nil		No	No	Not required	N/a	Approved 'Collision Avoidance' systems

4.2.1.3 Recommendations for Update for Current Regulations

A review of the current regulation has highlighted the following references that need review and updating to specifically include UAV operations

	Source	**Para**	**Section Title**	**Action Proposed**
1.	Annex 11	3.4	Separation minima.	Requires review and updating
2.	Annex 11	3.7	Air traffic control clearances	Requires review and updating
3.	JAR-OPS	1.395	Ground proximity detection	Requires review and updating
4.	JAR-OPS	1.398	Use of Airborne Collision Avoidance System (ACAS)	Requires review and updating
5.	JAR-OPS	1.660	Altitude alerting system	Requires review and updating
6.	JAR-OPS	1.665	Ground proximity warning system	Requires review and updating
7.	JAR-OPS	1.668	Airborne Collision Avoidance System	Requires review and updating
8.	Annex 2	3.1	Protection of persons and property.	Requires review and updating
9.	Annex 2	3.2	Avoidance of collisions.	Requires review and updating

4.2.1.4 Collision Avoidance 'Issues' Associated with UAV operations

The following 'issues', relating to 'collision avoidance' have been identified and may need resolution by the responsible bodies:

1. Need to define the Required Navigation Performance (RNP) standards for UAV operations in Class A-E airspace.
    - The choice of required equipment (in the Aerial Vehicle as well as the Control Station) is dependent on the defined RNP
2. Need to define the Required Communication Performance (RCP) standards for UAV operations in Class A-E airspace.
    - The choice of required equipment (in the Aerial Vehicle as well as the Control Station) is dependent on the defined RCP
3. Need to Minimum Aviation System Performance Standards (MASPS) for airborne 'collision avoidance' systems. (Note: the MASPS may be applicable to manned and unmanned aircraft).
    - This needs to be looked into by avionics experts in order to determine the MASPS and required equipment
4. Need to develop Minimum Operational Performance Standards (MOPS) for UAV 'control station'
    - Airworthiness standards for MOPS need to be developed

4.2.2 Equipment

4.2.2.1 Introduction

Appendix 2 identified several requirements addressing equipment that shall be installed on board aircraft depending on the types of operations: Recorders (#12) ,Circuit Protection (#15), Windshield Wipers (#16), Equipment (#17) and Fist Aid Equipment (#18)

4.2.2.2 Current situation

ICAO Annex 6 and the JAR–OPS provide requirements for equipment for flight, navigation and communication during day VFR, night VFR and IFR operations: an operator shall not operate an aeroplane

- by day in accordance with Visual Flight Rules (VFR) unless it is equipped with the flight equipment as listed in Appendix 2.
- in accordance with Instrumental Flight Rules (IFR) or by night unless it **additionally** has the flight equipment as listed in Appendix 2:
- specific types of aeroplanes unless equipped with airborne weather radar equipment whenever it is being operated at night or in instrument meteorological conditions in areas where thunderstorms or other potentially hazardous weather conditions, detectable with airborne weather radar, may be expected to exist along the route.
- unless it is equipped with a pressure altitude reporting SSR transponder, and any other SSR transponder capability required for the route being flown.
- under IFR, or under VFR over routes that cannot be navigated by reference to visual landmarks, unless the aeroplane is equipped with radio communication and navigation equipment in accordance with the requirements of air traffic services in the area(s) of operation.
  The radio equipment shall comprise not less than two independent radio communication systems.
  The navigation equipment shall comprise not less than one VOR receiving system, one ADF system and one DME and, if required, one ILS or MLS, one Marker Beacon receiving system, an Area Navigation System. There shall be an additional DME (or VOR or ADF) system if navigation is based only on DME (or VOR or ADF) signals.
  The navigation equipment shall comply with the Required Navigation Performance (RNP) Type for operation in the airspace concerned. VHF communication equipment, ILS Localiser and VOR receivers to be operated in IFR shall comply with the FM immunity performance standards

These requirements are summarized in the table below.

			A	B			C			D			E			F			G		
			I	I	V		I	V		I	V		I	V		I	V		I	V	
					D	N		D	N		D	N		D	N		D	N		D	N
	Basic equipment		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Altimeter	CS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Airspeed indicator	CS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Compass	CS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Engine instruments	CS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Additional equipment for IFR operations																					
	Flight Instrumentation																					
1	Outside air temperature indicator	CS	X	X			X			X			X			X			X			
2	Gyroscopic turn and bank indicator + slip indicator	CS	X	X			X			X			X			X			X			
3	Artificial horizon (power supply independent of itm 2)	CS	X	X			X			X			X			X			X			
4	Directional gyroscope	Aerial Vehicle	X	X			X			X			X			X			X			
5	Vacuum and/or voltage indicator (for 2,3 and 4)	CS	X	X			X			X			X			X			X			
6	Heated pitot tube	Arial Vehicle	X	X			X			X			X			X			X			
7	Vertical speed indicator	CS	X	X			X			X			X			X			X			
	Navigation Equipment																					
8	Automatic direction finding (ADF)	CS	X	X			X			X			X			X			X			
9	VHF navigation installation	CS	X	X			X			X			X			X			X			
14	Distance measuring equipment (DME)	CS	X	X			X			X			X			X			X			
	Communication Equipment																					
10	VHF communication installation (primary set)	CS and AV	X	X			X			X			X			X			X			
11	VHF communication installation (secondary set)	CS and AV	X	X			X			X			X			X			X			
12	Air traffic control (ATC) transponder	Aerial Vehicle	X	X			X			X			X			X			X			
13	Altitude reporting	AV	X	X			X			X			X			X			X			
	Additional requirements																					
	Flight Data Recorder	CS or AV depending on autonomy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15	Navigation lighting and landing light installation for flight at night	AV																				
	GPWS	AV																				

UAVs, with the exception of close control from the ground or from an airborne operator, will not operate VFR.. Other UAV operations are always executed under an IFR Flight Plan..

4.2.2.3 Future UAV Operations

Apart from the above mentioned equipment additional equipment requirements for communication relay, data link and collision avoidance must be included, fulfilling the airworthiness requirements from WG II.

4.2.3 Flight Rules

4.2.3.1 Introduction

This section lays out a basis for future European UAV operations compliance with the ICAO Flight Rules. The analysis evaluates those aspects of the current ICAO flight rules, which are impacted by the advent of UAV operations. It outlines those aspects, of UAV operational concepts, that appear to align with the current regulations and indicated where there appears to be a need for appropriate updating.
At the end of the section there is a formal identification of the 'issues' that appear to require some adaptations, clarifications, or changes, to the current regulations and would need to be actioned by an appropriate organisation. At this stage of the analysis no actions are specifically assigned to any of these bodies; however, there is an underlying assumption that further analysis will be undertaken and suitable action taken, in due course. To facilitate this follow-up action the 'issues' from this section and others have been collated at Appendix 2 to this document.

4.2.3.2 Context of Flight Rules Analysis

There is a significant overlap between the analysis of the UAV impact of the 'flight rules' and the analysis to be found in the other sections of this document. In effect the 'flight rules' regulation indicated just how the regulations are to be applied.
Flight rules brings together aspects of:

- Collision Avoidance
- Equipment
- Licences and ratings
- Emergency procedures
- Operator certification
- Responsibilities and handover

4.2.3.3 Current Situation

The rules and regulations for aircraft operations in the ECAC region were established many decades ago and although they continue to be adapted to take account of new concepts and technologies (e.g. ACAS) they have remained relatively stable. The ICAO flight rules provide the fundamental codes of practices to ensure the maximum level of interoperability for all modes of flight and provide a pragmatic approach to air safety that, provided conventions are followed, will reduce risk, if not eliminate it.
The flight rules provide basic principles which apply to all types of flying machines from balloons and gliders to massive airliners and super-sonic aircraft. They also apply equally to both civil and military aircraft types. They are also globally applicable, though some national variations are published in the supplements to ICAO Annex 2.
Current UAV operations are conducted with a full regard of the 'rules of the air' and for unmanned flights in segregated airspace (and exceptionally outside) the principles of the rules have been followed to the maximum extend possible.

4.2.3.4 Advent of UAV Operations

UAV operations have been based on the premise that they should comply with the current regulations to the maximum extent possible and much of the early research has been based on the development of procedures and technologies to make this possible.

Although unmanned flight will lack the visual acquisition capabilities of a manned aircraft and this provide a challenge in the 'collision avoidance' requirements. However the remainder of the rules can be met with high degrees of compliance.

4.2.3.5 Summary of the Applicable Rules and indications of Compliance

4.2.3.5.1 Structure of the ICAO Flight Rules

Flight rules are to be found in ICAO Annex 2. The flight rules break down into four distinct groups:

- Applicability;
- General Rules; (i)
- IFR Rules; (ii)
- VFR Rules; (ii)

Notes:

(i) These rules apply to all flights irrespective of aircraft type, mode of flight (rotary/fixed-wing or powered/unpowered), type of flight (OAT/GAT), types of airspace, etc;

(ii) Note the Rules for IFR and VFR are based on the class of airspace – see the table in Section 4.2.1.

4.2.3.5.2 UAV Operations - Applicability of Flight Rules

The general rules on applicability appear in Chapters 2 of ICAO Annex 2 and are just as relevant to UAV operations as to other types of air operation.
In order to explicitly accommodate UAV operations Chapter 2 will require maintenance only in the area of 'pilot-in-command' (Annex 2 Ch 2 paras 2.3 and 2.4. UAVs will invariably need to have a suitably trained, qualified person and licensed person to operate the flight. These aspects are dealt with in Section 4.2.4 under 'Licensing and Ratings'.

4.2.3.5.2.1 UAV Operations – General Flight Rules

The general rules appear in Chapters 3 of ICAO Annex 2 and are just as relevant to UAV operations as to other types of air operations.
Chapter 3 deals with:

- Protection of Persons and Property (Annex 2, Ch 3 para 3.1) includes rules for:
  - Negligent or reckless operation of aircraft.
  - Cruising levels
  - Dropping or spraying
  - Towing
  - Parachute descent
  - Aerobatic flight
  - Formation flights
  - Violation of prohibited airspace

UAV Compliance:
All of these regulations are applicable and can be complied with by UAV operators.

- Avoidance of Collisions (Annex 2, Ch 3 para 3.2) includes rules for:
  - Proximity to other aircraft
  - Right-of-way

- Lights to be displayed
- Simulated instrument flight
- Operation in the vicinity of an aerodrome
- Water operations

UAV Compliance:
UAVs are unlikely to be involved in 'simulated instrument fight'; however all of these regulations are applicable and can be complied with by UAV operators.

- Flight Plans (Annex 2, Ch 3 para 3.3) includes rules for:
  - Flight plan submission
  - Flight plan contents
  - Flight plan completion
  - Flight plan changes and closing.

UAV Compliance:
UAVs operations will need to be published by all appropriate means. For the foreseeable future they will invariably be covered by NOTAM action; however having surmounted other impediments to IFR/VFR flights, the compliance with flight planning rules will present no additional difficulties.
All of these regulations are applicable and can be complied with by UAV operators.

- Signals (Annex 2, Ch 3 para 3.4) includes rules for:
  - Distress signals
  - Urgency signals
  - Visual signal to warn about entering a Restricted/Prohibited/danger Area
  - Signal for Aerodrome traffic
  - Marshalling signals

Distress / Urgency Signals
These rules are predicated on maintaining the safety and operational effectives of the crew in a manner aircraft. UAV operation can provide a equivalence to the rules for the declaring and handling of a malfunctioning UAV. These distress/urgency calls may only be appropriate where there is a risk to persons on the ground.
UAV Compliance with Distress Signal Rules:
The safety provisions for UAV malfunctions are expected to exceed the requirements in ICAO Annex 2 Ch 3

Visual Signals – Reserved Airspace
The visual signals which warn about active airspace reservations appear to be an anachronism, which can only relate to very low and slow aircraft operating without radios and in good visibility. They are no more relevant to UAVs than they are to any military fast-jet or any conventional civil air transport aircraft,
***UAV Compliance with* Visual Signals – Reserved Airspace Rules**
The safety provisions for UAV operating close to 'reserved airspace' - (Restricted/ Prohibited/ Danger Area or Controlled) are expected to exceed the requirements in ICAO Annex 2 Ch 3

Signals for Aerodrome Traffic
The visual signals provide various communications media relevant to aircraft (or an airport) temporarily or permanently without radio. As with the visual signal

previously discussed, they appear to be an anachronism, which can only relate to quite primitive air operations. As with the previous visual signals they are no more relevant to UAVs than they are to any military fast-jet or any conventional civil air transport aircraft,

***UAV Compliance with* Signal Rules for Aerodrome Traffic**

The safety provisions for UAV at aerodrome are expected to exceed the requirements in ICAO Annex 2 Ch 3

- **Time**
  All agencies in air operation need to operate on a consistent time datum. This can be UTC or local time depending on local regulations. UAV operation can comply with any regulations in this area.

UAV Compliance Time Rules
The 'time' synchronisation for UAV operations can fully meet the requirements in ICAO Annex 2 Ch 3

- **Air Traffic Control Service**
  The rules for the ATC service include:
  - ATC Clearances
  - Adherence to Flight Plan
  - Position reporting
  - Termination of Control
  - Communications

In order to fly IFR UAVs must avail them selves of the ATC service as outline in the table to be found in section 4.2.1. In order to comply with these rules UAV operations must have the necessary communication performance, navigation capabilities and crew competence to benefit from the ATC service.
UAV Compliance with ATC service Rules
The rules for Air Traffic Control service contained in ICAO Annex 2 Ch 3 para 3.6 need no specific amendment for UAV operations; however the UAV community need to develop the technologies and procedures to ensure that both UAV and pilot/operator can partake in the ATC service without any perceptible difference by the service provider.

- **Unlawful Interference Rules**
  The rules for handling Unlawful Interference as defined in ICAO Annex 2 - Rules of the Air relate more to the behaviour by and responses to manned aircraft that are being interfered with.
  There is an assumption that UAV systems are designed, constructed and operated in a manner that they cannot be taken over directly by a human being – analogous to a hijack. However the navigation and communication systems must also be protected. See issue at the end of this section.
  UAV Compliance with Unlawful Interference *Rules*
  The rules for Unlawful Interference in manned aircraft need not apply to UAV however the security and integrity of the UAV systems effectively must obviate the potential for unlawful interference.

- **VMC Visibility and Distance from Cloud Minima**
  The rules for visibility and distance from cloud minima vary by Class of airspace and type of aircraft. They can be applied to UAV's being operated in visual sight of the operator be that on the ground, or from a chase plane. However the range from the operator is short.
  UAV Compliance with Visibility and Distance from Cloud Minima
  The rules for Visibility and Distance from Cloud Minima can be complied with by UAV in the limited circumstances mentioned above.

4.2.3.5.2.2 UAV Operations – VFR Rules

The VFR rules appear in Chapters 4 of ICAO Annex 2 and cover aspects including:

- Terrain Clearance
- Day/ night operations
- Speed limitations
- Altitude limitations
- Avoidance of built up area
- Compliance with an ATC clearance
- Communication requirements

As defined in the previous paragraph UAVs, with the exception of close control from the ground or from an airborne operator, will not operate VFR.

UAV Compliance with VFR requirements

To the limited extent that VFR flight are feasible they can be conducted in accordance with the VFR Rules.

4.2.3.5.2.3 UAV Operations – IFR Rules

The IFR rules appear in Chapters 5 of ICAO Annex 2 and cover aspects including:

- Terrain Clearance/ minimum flight levels
- IFR/VFR and VFR/IFR transitions
- Obtaining and complying with an ATC clearance
- Cruising levels
- Communication requirements
- Position reporting
- Navigation requirements
- Equipment requirements

IFR will be the normal mode of flight for future UAV operations. The IFR Rules enforce significant requirements on operators of UAV in terms of the communication, navigation and avionics requirements.

UAV Compliance with IFR requirements

UAV must be designed equipped and operated in order that the Instrument Flight Rules are complied with and that the presence of unmanned aircraft shall not incur additional risks for other aircraft operators, nor impose additional workload on controllers.

4.2.3.6 Recommendations for Update for Current Regulations

A review of the current regulation has highlighted it

	Source	**Para**	**Section Title**	**Action Proposed**
1.	Annex 2	2.3 and 2.4	Responsibility for compliance with the rules of the air	The concept of pilot-in-command need to be amplified to include the pilot/operator of the UAV, who will assume all responsibilities.
2.	Annex 2	3.	General rules	Requires review and updating
3.	Annex 2	3.4 App 1	Signals	Certain aspects of visual signals may not be appropriate.
4.	Annex 2	3.9	VMC visibility and distance from cloud minima.	Requires review and updating
5.	Annex 2	4.	Visual flight rules	Requires review and updating.
6.	Annex 2	5.	Instrument flight rules.	Requires review and updating
7.	Annex 2	5.1	Rules applicable to all IFR flights	Requires review and updating
8.	Annex 2	5.2	Rules applicable to IFR flights within controlled airspace	Requires review and updating
9.	Annex 2	5.3	Rules applicable to IFR flights outside controlled airspace	Requires review and updating

4.2.3.7 Flight Rules 'Issues' Associated with UAV operations

The following 'issues', relating to 'flight rules' have been identified and may need resolution by the responsible bodies:

A. Need to define Standard Operating Procedures for UAV operations at airports to ensure that the inability to read, or make, visual signal does not have additional safety implications.

B. Need to define the Required Navigation Performance (RNP) standards for UAV operations for each class of airspace.

C. Need to define the Required Communication Performance (RCP) standards for UAV operations in receipt of an ATC service for each class of airspace.

D. UAV navigation systems shall be designed and operated in a manner such that the flight profile of the aircraft cannot be unlawfully interfered with.

E. Flight control and data communications systems shall be designed and operated in order that the operation of the aircraft cannot be assumed by a 3rd-party for an illegal purposes. Fully automated self-defence measures in the aircraft shall ensure that in the event of corrupt or interrupted ground instructions that there will be an autonomous behaviour that will ensure a safe termination of the flight.

4.2.4 Licences and Ratings

4.2.4.1 Introduction

To enable international UAV operations with privileges similar to those of manned aviation operations, the crewmembers that perform UAV operations shall accept responsibilities and obligations similar to those of the crew of manned aircraft.

The ICAO Annex 1 states: "A person shall not act as a flight crewmember of an aircraft unless a valid licence is held showing compliance with the specifications of this Annex and appropriate to the duties to be performed by that person. The licence shall have been issued by the State of Registry of that aircraft or by any other Contracting State and rendered valid by the State of Registry of that aircraft." Licences issued on basis of the JAR-FCL are based on this Annex 1. Article 29 of the Convention on International Civil Aviation requires that the flight crewmembers carry their appropriate licences on board every aircraft engaged in international air navigation.

4.2.4.2 Current situation

In the world of manned aviation, JAR-FCL matches with defined airworthiness standards, training requirements and facilities synchronised accordingly and harmonised with corresponding operational requirements. The JAR-FCL system guides individuals ab initio to their license and up to a certain type specific rating: the JAR-FCL "delivers" a type rated pilot to an operator, whereupon the operator "only" has to adopt this pilot to his organisation in accordance with the requirements of the JAR-OPS 1. The operator will train and authorise, by a conversion course, the pilot for his appointed tasks, e.g., as a commander. All basic skills and type-specific knowledge that he needs is specified in the JAR-FCL, the use of these skills in a specific organisation are in the JAR-OPS.

4.2.4.3 Future UAV operations

In the world of unmanned aviation, there is no defined airworthiness standard, nor standardised "type" criteria. UAV systems using the same air vehicle may be different in system structure, operational use, environments and degree of freedom. This diversity may cause skills and operational knowledge to be applicable to a specific system only and make it impracticable to establish generally applicable requirements like those in the JAR-FCL. It may even be that only

the UAV operator can assess whether skills and knowledge are sufficient to operate the system. Because of the varied UAV world, but the limited number of system and operators, most of the skill and operational training could be performed within the operational requirements (JAR-OPS) and a basic aviation and UAV generic system training within the JAR-FCL system.

An UAV commander/pilot do not have to meet the same medical requirements as a flying pilot. To perform the safety tasks the circumstances (Activities, environmental, human factor situation) are very similar to a flight controller. Therefore a medical ability similar to theirs could be sufficient. For a technician there are no differences as the ground operations are concerned compared to a manned aircraft technician functions.

UAV operation is exposed in the same way as a manned system for Human Performance influence. UAV system, as well as manned system, has to be designed and operated within the field of Human limitations and performance. In flight operations CRM (Crew resource management) is a inseparable component in a safe operation. Procedures and training in this aspect is essential for safety reason but also for the effectiveness of an operation. Certain efforts have to be done to implement the specific UAV conditions into training and operation as well as for designing systems.

Appendix 2 identifies the following issues that may need further consideration: Medical fitness, Licenses and ratings, Synthetic flight instruction, Age, Experience, Training, Theoretical knowledge, skill and examination, Crew composition, Multiple type ratings.

Several details have to be discussed and considered regarding applicable and needed conformity with existing JAR-FCL as relevant parts with specific UAV influence that should be added. Among these could following be;

- At what level of required theoretical and practical skill level should UAV enter JAR-FCL to be accepted by other regulations with major impact, e g FARs.
- Certain crew and technician functions, which exactly have to be discussed, should have a UAV license.
- The theoretic base for such a license is the same as for a manned aircraft license, excluded certain part that are not applicable for UAV systems. Added to that base knowledge a generic UAV system block, covering UAV specific fundamental facts, possibilities and limitations.
- The base requirements should be stated within JAR-FCL system that should compromise knowledge needed for crewmembers and check functions and procedures how to within JAR-OPS obtain certain system skill and ratings.
- A license could be issued as a result of approved basic training and subsequent type system training. Procedures for that should be stated in JAR-FCL.
- Minimum experience and recurrent requirements should be discussed.
- Provisions in the procedures for an UAV license should enable individuals with “normal” license to convert to a UAV rating.

Appendix 3 contains further considerations with respect to JAR FCL and JAR-OPS.

4.2.5 Emergency Procedures

4.2.5.1 Introduction

Operating procedures can be defined as written instructions that, when followed, will minimise deviations from design or operating intent. One hundred years of manned aviation has yielded an immense amount of scenarios and situations that pilots should deal with, but which all assume that pilot is on board the aircraft and able to assess the situation and take the necessary

actions. The scenarios and situations for unmanned aircraft may be similar to those for manned aircraft or specific to unmanned aircraft only, but in any case the operating procedures shall be adapted to be performed by pilot that is not on board the aircraft.

This chapter identifies the emergency procedures that are specific to UAVs and those that are applicable to manned aircraft as well but shall be dealt with differently by UAV pilots.

4.2.5.2 Current situation

JAR 25.1585 requires operating procedures for –

(1) Normal procedures peculiar to the particular type or model encountered in connection with routine operations;
(2) Non-normal procedures for malfunction cases and failure conditions involving the use of special systems or the alternative use of regular systems; and
(3) Emergency procedures for foreseeable but unusual situations in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe.

Such normal, non-normal and emergency procedures are addressed in Chapter 3 as result of the airworthiness certification of the system. Procedures not directly related to airworthiness or not under the control of the crew, must not be included in the AFM, nor must any procedure that is accepted as basic airmanship.

The abnormal and emergency procedures that are not directly related to airworthiness shall be in the Operations Manual (OM) (Ref. JAR-OPS 1.1045 and Appendix 1 to JAR-OPS 1.1045). The OM shall contain the abnormal and emergency procedures and duties assigned to the crew, the appropriate checklists, the system for use of the checklists and the necessary co-ordination procedures between flight and cabin crew.
The JAR-OPS lists the events for which the OM shall provide abnormal or emergency procedures; some of these may not be applicable to UAV operations, e.g., exceeding cosmic radiation limits. The JAR-OPS will not provide procedures for events that are unknown to manned aircraft, e.g., loss of flight control data link.

4.2.5.3 Future UAV operations

Appendix 2 yields that UAV operations need dedicated procedures for alternate landing areas, signals and interception.

Selection and use of alternate landing areas when the UAV is unable to reach or land at the destination, e.g., because of a technical failure or because the weather at the landing side is below specific minima. Like the airfields for manned aircraft, the alternate areas for UAVs shall be free of population and be of a size that is sufficient for the UAV to make a safe landing.

Signals to the crew to communicate that the crew shall undertake specific action or signals by the crew to communicate that it needs specific assistance. These signals may be communicated by radiotelegraphy, data link, rockets, shells or flares, specific motions of the aeroplane, switching on and off of specific aircraft lights, or by a signalman. Although UAVs may be unable to see the visual signals, a human observer on the ground can perform this role if he can inform the UAV pilot about these signals or directly intervene in the UAVs flight path.

Like a manned aircraft, a UAV may be intercepted by another aircraft, e.g., after an unauthorised border crossing. It may be difficult for the UAV to detect that he is intercepted and to observe the visual signals from the intercepting aircraft. The worst case is that the intercepting aircraft shoots down the intercepted UAV and does this over uninhabited area. This may be acceptable and need no dedicated design features or procedures.

Hence for these topics UAVs can be dealt with the same way as manned aircraft.

ICAO Annex 2 sets requirements for flight termination onboard unmanned free balloons and devices on board that permit continuous tracking of the balloon.

Recommendations:

- The requirement as set in ICAO Annex 2, to activate the flight termination devices for unmanned free balloons shall be reconsidered.
- Pilots of manned aircraft shall plan their flight such that they never land in inhabited area, even in case of an emergency. Similarly, the use of a flight termination device shall not cause a landing of a UAV in inhabited area.
- Emergency procedures for UAVs are developed to protect people on the ground
- UAV's should plan alternates as for manned aviation
- Flight Termination Device (if installed) is only to be used as a last means to prevent the UAV from uncontrolled crashing into the ground.

4.2.6 Operator Certification

4.2.6.1 Introduction and Current Situation

When an operator wants to operate an aircraft for commercial use he shall comply with the aviation requirements for such operations ICAO/JAA and EC 2407(Economics).
In manned aviation when issuing an Air Operator Certificate the regulatory authority has established that the operator fulfils the requirements as set for the proposed operation:
1) flight operations, 2) the maintenance system, 3) crew training and 4) ground operations (refer to appendix 2).
The operator also must show to the regulatory authority that by means of a quality assurance system he will consistently fulfil the set requirements.
At present only the JAA requirements for the qualification of operators dealing with commercial transport have been defined. Operational requirements for aerial work as well as general aviation are nonexistent in JAA context.

4.2.6.2 Operator certification for UAVs

Considering the equivalence principle an operator intending to operate UAVs should also be in the possession of an Air Operator Certificate for UAV operation.
In the current situation the existing JAR-OPS requirements do not include UAV operations (refer to appendix 3), however the certification of UAV operators should include similar requirements and practices as those for manned aviation in order to be equivalent.
There is a broad scope of different kind of operations with UAVs comparable to Aerial Work activities in manned aviation. By lack of applicable JAA requirements for aerial work the CASR requirements for aerial work operations can be used as a starting point instead.
CASR distinguishes the following types of aerial work activities:

- Aerial filming
- Agriculture
- Construction
- Emergency and medical services
- Fire fighting
- Freight
- Law enforcement
- Observation and patrol
- Stock mustering
- Survey

The requirements for these aerial work activities for manned aircraft shall be analysed and if suitable be adapted to UAVs.

4.2.7 Responsibilities and Handover

WG I, with special attention to multiple UAVs controlled by one control station and multiple control stations in control of one or more UAVs in conjunction with each other is responsible for this area. At the same time the handover from one control station to another control station must be dealt with taking the responsibilities (to be determined) for the commander into account
The assignment of responsibilities also has legal impacts as stated in annex 13.

4.2.8 Other identified Topics

Apart from the items covered in the previous section, appendix 2 identifies other topics of medium and low priority: training, theoretical knowledge, skill and examination, performance, synthetic flight instruction and low visibility operations.
These are not elaborated in the sections above because it is not expected that these topics yield an extensive discussion.