SPECIFIC OPERATIONS RISK ASSESSMENTS (SORA) COURSE APPLIED TO UNMANNED AERIAL VEHICLES

CHAPTER V: SORA RISK ASSESSMENT PROCESS

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PRE-SCREENING

- **Can the transaction be considered within the open category?**
- **Can a standard scenario cover the operation?**
- **Is it an operation that cannot be carried out in any case?**
- **Has the competent authority determined that the unmanned aircraft is harmless to the ground risk?**

Operation		Remote pilot competency (age according to MS legislation)	UAS				UAS operator registration
Subcategory	Area of operation (far from aerodromes, maximum height 120 m)		class	MTOM/ Joule (J)	Main technical requirements (CE marking)	Electronic ID/ geo awareness	
A1 Fly over people	You can fly over uninvolved people (not over crowds)	Read consumer info	Privately built	< 250 g	N/a	No	no
			C0		Consumer information, Toy Directive or <19 m/s, no sharp edges, selectable height limit		
		• Consumer info • online training • online test	C1	< 80 J or <900 g	Consumer information, <19m/s, kinetic energy, mechanical strength, lost-link management, no sharp edges, selectable height limit.		
A2 Fly close to people	You can fly at a safe distance from uninvolved people	• Consumer info • online training • online test • theoretical test in a centre recognised by the aviation authority	C2	< 4 kg	Consumer information, mechanical strength, no sharp edges, lost-link management, selectable height limit, frangibility, low-speed mode.	Yes + unique SN for identification	yes
A3 Fly far from people	You should: • fly in an area where it is reasonably expected that no uninvolved people will be endangered • keep a safety distance from urban areas	• Consumer info • online training • online test	C3	< 25 kg	Consumer information, lost-link management, selectable height limit, frangibility.	if required by zone of operations	
			C4		Consumer information, no automatic flight		
			Privately built		N/a		

PROCESS OUTLINE

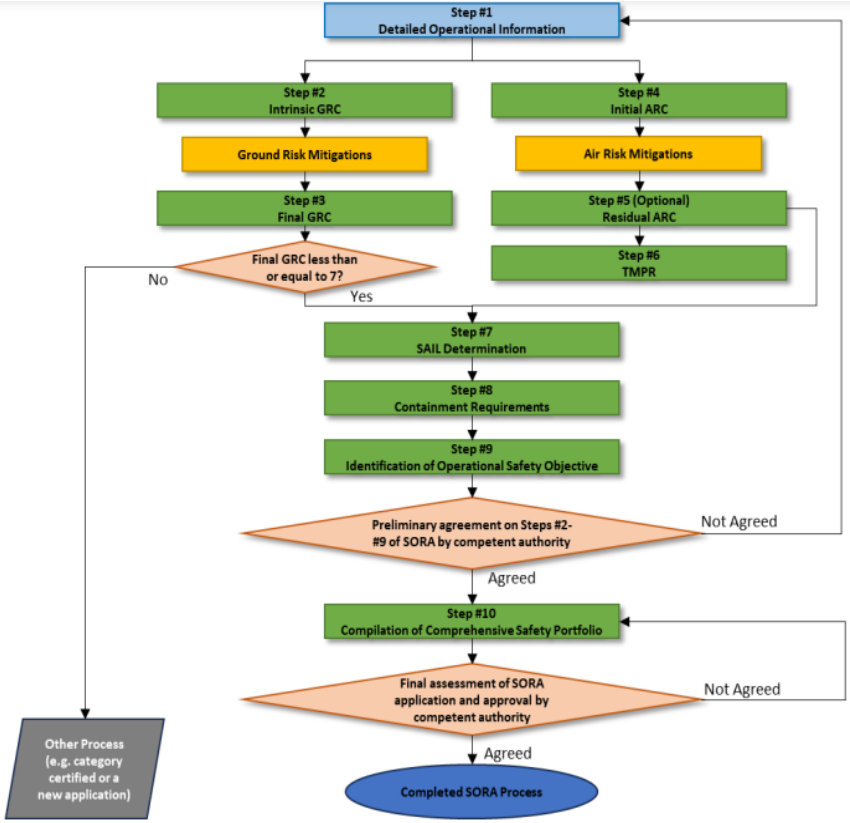
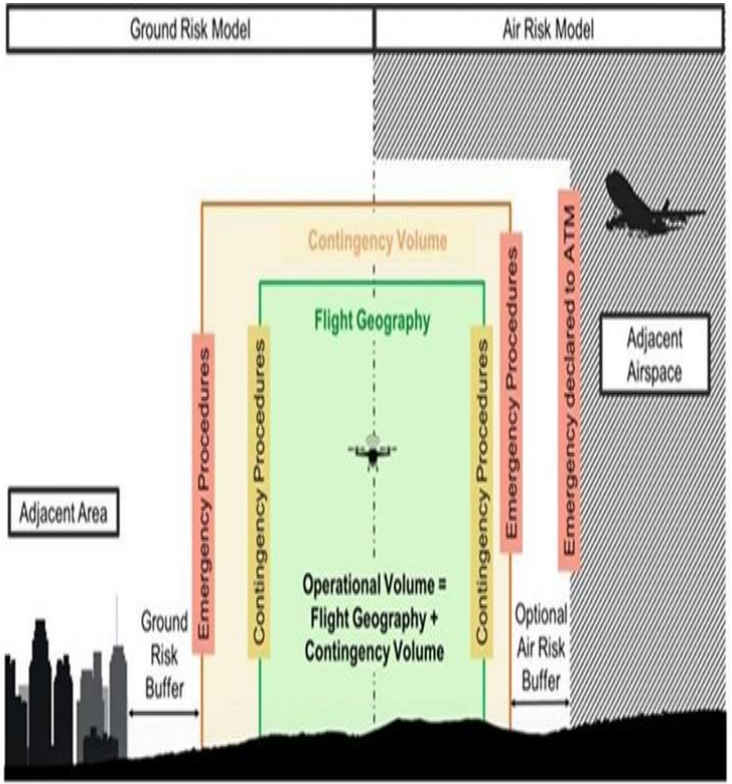


Figure 1 - The SORA process

ROBUSTNESS CONCEPT AND SEMANTIC MODEL

	Low Assurance	Medium Assurance	High Assurance
Low Integrity	Low robustness	Low robustness	Low robustness
Medium Integrity	Low robustness	Medium robustness	Medium robustness
High Integrity	Low robustness	Medium robustness	High robustness



STEP 1 - DESCRIPTION OF THE CONCEPT OF OPERATION (CONOPS)

PILOT TRAINING

TYPE OF ACTIVITY

TYPE OF AIRSPACE

MAXIMUM TAKE-OFF WEIGHT

ZONE TYPE AND SCHEDULE

FLIGHT HEIGHT

TECHNICAL INFORMATION

STEP 2 - DETERMINATION OF THE INITIAL INTRINSIC GROUND IMPACT RISK (GRC)

Intrinsic Ground Risk Index of the UAS				
Maximum dimensions of the UA	1 m	3 m	8 m	>8 m
Expected Typical Kinetic Energy	< 700 J	< 34 KJ	< 1084 KJ	> 1084 KJ
Operational Scenarios				
VLOS/BVLOS over a ground controlled area	1	2	3	4
VLOS over a sparsely populated area	2	3	4	5
BVLOS over a sparsely populated area	3	4	5	6
VLOS over a populated area	4	5	6	8
BVLOS over a populated area	5	6	8	10
VLOS over a crowded area	7			
BVLOS over crowded area	8			

KINETIC ENERGY

$$Ec = \frac{1}{2} mv^2$$

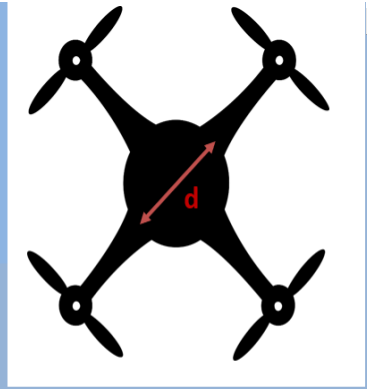
TERMINAL SPEED

$$v_T = \sqrt{\frac{2W}{C_d A \rho}}$$

STEP 2 - DETERMINATION OF THE INITIAL INTRINSIC GROUND IMPACT RISK (GRC)

Kinetic Energy Calculation							
rotary wing							
M	5	W	49,05	N			
Cd	1	Cd	1	Dimensionless	Vt	40,3907121	m/s
d	0,25	A	0,04908739	m2			
p	1,225	p	1,225	kg/m3	Ec	4078,52406	J
ISA Atmosphere		15ºC					
Fixed wing							
W	1,3						
Vmáx	72	km/h	20	m/s			
		Ec	260	J			

Legend:
M= Mass of the aircraft (Kg)
W= Weight of the aircraft N (Newton)
Cd = Aerodynamic drag coefficient (dimensionless)
d = Diameter in plan of the aircraft (in meters)
p= Air density (kg/m^3)
Vt= Terminal or fall velocity (meters/seconds)
Ec= Kinetic energy Joules (J)
Vmax= Maximum speed of the aircraft (meters/seconds)



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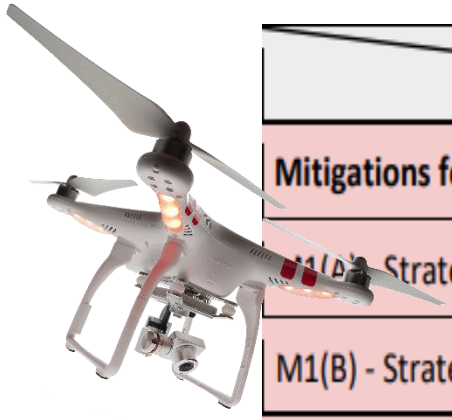
VLOS over a populated area	4	5	6	8
BVLOS over a populated area	5	6	8	10
VLOS over a crowded area	7			
BVLOS over crowded area	8			

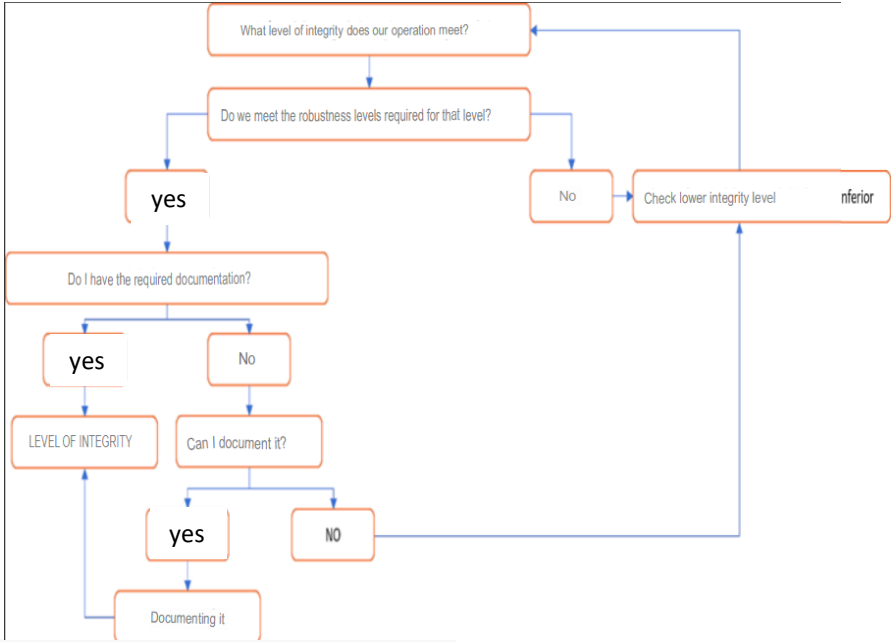
PASO 3 - DETERMINACIÓN DEL RIESGO INTRÍNSECO DE IMPACTO EN TIERRA (GRC) FINAL



	Level of Robustness		
Mitigations for ground risk	**Low**	**Medium**	**High**
M1(A) - Strategic mitigations - Sheltering	-1	-2	N/A
M1(B) - Strategic mitigations - Operational restrictions	N/A	-1	-2
M1(C) - Tactical mitigations - Ground observation	-1	N/A	N/A
M2 - Effects of UA impact dynamics are reduced	N/A	-1	-2

STEP 3 - DETERMINATION OF THE FINAL INTRINSIC GROUND IMPACT RISK (GRC)

INTEGRITY LEVEL SCHEME



+ O - INITIAL GRC

	Level of Robustness		
Mitigations for ground risk	**Low**	**Medium**	**High**
M1(A) - Strategic mitigations - Sheltering	-1	-2	N/A
M1(B) - Strategic mitigations - Operational restrictions	N/A	-1	-2
M1(C) - Tactical mitigations - Ground observation	-1	N/A	N/A
M2 - Effects of UA impact dynamics are reduced	N/A	-1	-2

+ O - GRC FINAL

SAIL determination				
	Residual ARC			
Final GRC	a	b	c	d
≤2	I	II	IV	VI
3	II	II	IV	VI
4	III	III	IV	VI
5	IV	IV	IV	VI
6	V	V	V	VI
7	VI	VI	VI	VI
>7	Category C operation			

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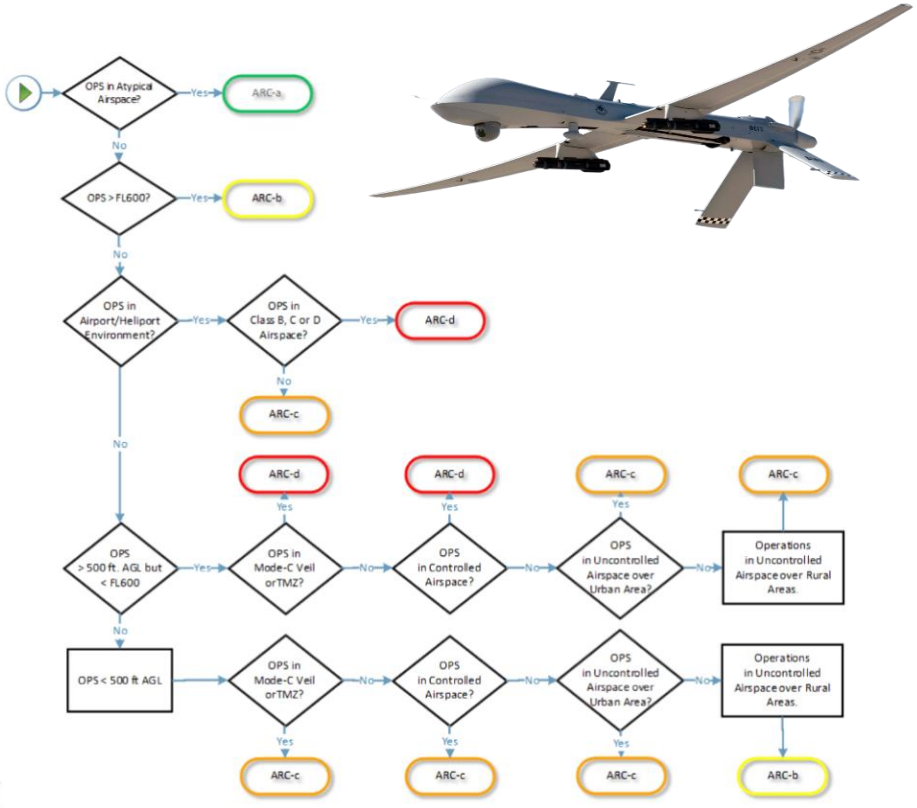
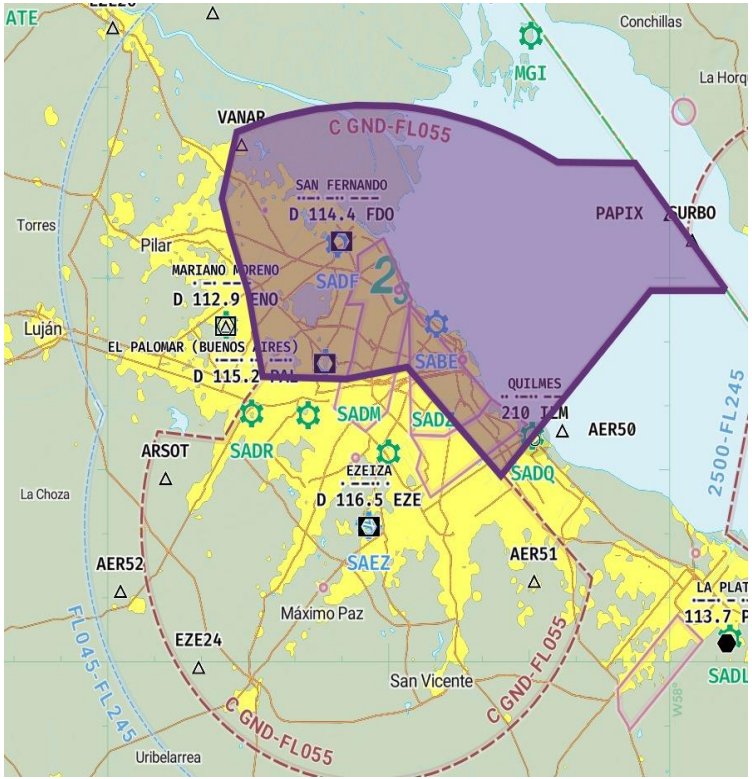
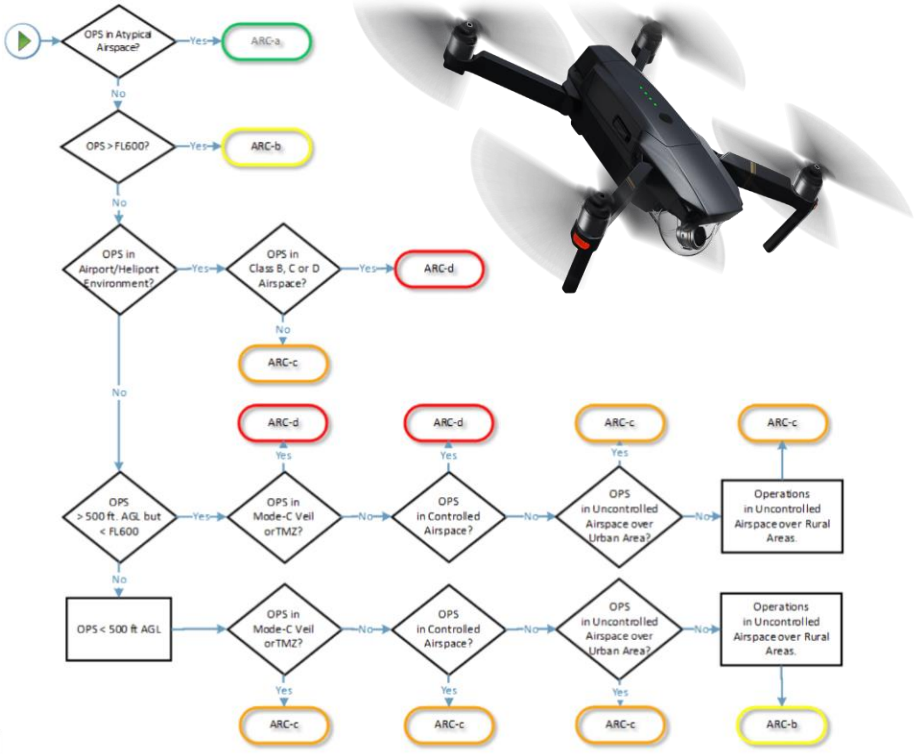
STEP 4 - . INITIAL AIRBORNE COLLISION RISK (ARC) DETERMINATION

	AECs	Espacio Aéreo Operacional	ARC
Operaciones en espacio aéreo por encima de 500 ft	1	Operaciones por encima de 500 ft AGL en un entorno aeroportuario definido en SORA	d
	2	Operaciones por encima de 500 ft AGL en un TMZ	d
	3	Operaciones por encima de 500 ft AGL en espacio aéreo controlado	d
	5	Operaciones en espacio aéreo no controlado fuera de entornos urbanos	c
Otros	11	Operaciones por encima de FL600	b
Operaciones en espacio aéreo por debajo de 500 ft AGL	6a	Operaciones por debajo de 500 ft AGL en un entorno aeroportuario definido en SORA y en espacio aéreo clase B, C o D	d
	6b	Operaciones por debajo de 500 ft AGL en un entorno aeroportuario definido en SORA y en espacio aéreo clase E, F o G sobre entornos urbanos	c
	6c	Operaciones por debajo de 500 ft AGL en un entorno aeroportuario definido en SORA y en espacio aéreo clase F o G fuera de entornos urbanos	b
	7	Operaciones en una TMZ o clase F, G	c
	8	Operaciones en espacio aéreo controlado debajo de 500 ft AGL	c
	9	Operaciones en espacio aéreo controlado debajo de 500 ft AGL, en entornos urbanos	c
	10	Operaciones por debajo de 500 ft AGL en espacio aéreo no controlado y fuera de entornos urbanos	b
Otros	12	Operaciones en espacio aéreo atípico	a



STEP 4 - . INITIAL AIRBORNE COLLISION RISK (ARC) DETERMINATION

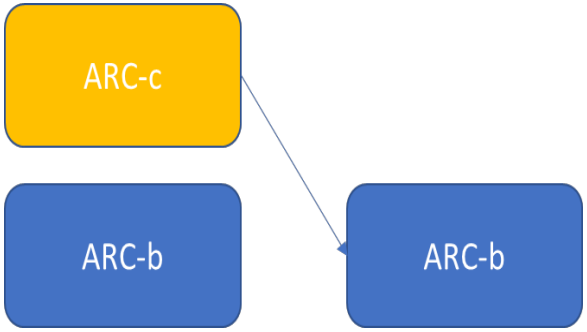




STEP 5 - . FINAL AIRBORNE COLLISION RISK (ARC) DETERMINATION

STRATEGIC MITIGATION

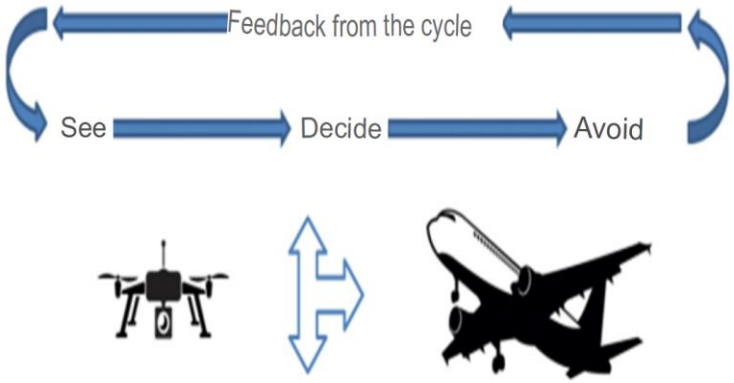
(BEFORE OPERATION)



TACTICAL MITIGATION

(DURING OPERATION)

STEP 6 - TACTICAL MITIGATION PERFORMANCE REQUIREMENTS AND ROBUSTNESS LEVELS (TMPR)



Residual ARC	Tactical Mitigation Performance Requirements (TMPR)	TMPR Level of Robustness
ARC-d	High	High
ARC-c	Medium	Medium
ARC-b	Low	Low
ARC-a	No requirement	No requirement

STEP 6 - TACTICAL MITIGATION PERFORMANCE REQUIREMENTS AND ROBUSTNESS LEVELS (TMPR)

	Function	TMPR Level				
		VLOS	No Requirement (ARC-a)	Low (ARC-b)	Medium (ARC-c)	High (ARC-d)
Tactical mitigation performance requirements (TMPR)	Detect[1]	No Requirement	No Requirement	The expectation is for the applicant's DAA Plan to enable the operator to detect approximately 50 % of all aircraft in the detection volume[2]. This is the performance requirement in the absence of failures and defaults. It is required that the applicant has awareness of most of the traffic operating in the area in which the operator intends to fly, by relying on one or more of the following: • Use of (web-based) real time aircraft tracking services • Use Low Cost ADS-B In /UAT/FLARM[3]/Pilot Aware[3] aircraft trackers • Use of UTM/U-space Dynamic Geofencing[4] • Monitoring aeronautical radio communications (e.g. use of a scanner)[5]	The expectation is for the applicant's DAA Plan to enable the operator to detect approximately 90 % of all aircraft in the detection volume[2]. To accomplish this, the applicant will have to rely on one or a combination of the following systems or services: • Ground based DAA /RADAR • FLARM [3/6] • Pilot Aware [3/6] • ADS-B In/ UAT In Receiver[6] • ATC Separation Services[7] • UTM/U-space Surveillance Service[4] • UTM/U-space Early Conflict Detection and Resolution Service[4] • Active communication with ATC and other airspace users[5]. The operator provides an assessment of the effectiveness of the detection tools/methods chosen.	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable requirements.

[1]For an in-depth understanding of the derivation, please see Annex G. Detection should be done with adequate precision for the avoidance manoeuvre to be effective.
[2]The detection volume is the volume of airspace (temporal or spatial measurement) which is required to avoid a collision (and remain well clear if required) with manned aircraft. It can be thought of as the last point at which a manned aircraft must be detected, so that the DAA system can performance all the DAA functions. The detection volume in not tied to the sensor(s) Field of View/Field of Regard. The size of the detection volume depends on the aggravated closing speed of traffic that may reasonably be encountered, the time required by the remote pilot to command the avoidance manoeuvre, the time required by the system to respond and the manoeuvrability and performance of the aircraft. The detection volume is proportionally larger than the alerting threshold.
[3]FLARM and PilotAware are commercially available (trademarked) products/brands. They are referenced here only as example technologies. The references do not imply an endorsement by the approval authority for the use of these products. Other products offering similar functions may also be used.
[4]These refer to possible future applications of automated traffic management systems for unmanned aircraft in an UTM/U-space environment. These applications may not exist as such today.
[5]If permitted by the authority. May require a Radio-License or Permit.
[6]The selection of systems to aid in electronic detection of traffic should be made considering the average equipment of the majority of aircraft operating in the area. For example: in areas where many gliders are known to operate, the use of FLARM or similar systems should be considered whereas for operations in the vicinity of large commercially operated aircraft, ADS-B IN is probably more appropriate. These refer to possible future applications of automated traffic management systems for unmanned aircraft in an UTM/U-space environment. These applications may not exist as such today. A subscription to these services may be required.
[7]The selection of systems to aid in electronic detection of traffic should be made considering the average equipment of the majority of aircraft operating in the area.

STEP 6 - TACTICAL MITIGATION PERFORMANCE REQUIREMENTS AND ROBUSTNESS LEVELS (TMPR)

	Function	TMPR Level				
		VLOS	No Requirement (ARC-a)	Low (ARC-b)	Medium (ARC-c)	High (ARC-d)
Tactical mitigation performance requirements (TMPR)	Decide	No Requirement	No Requirement	The UAS operator should have a documented de-confliction scheme, in which the UAS operator explains which tools or methods will be used for detection and what the criteria are that will be applied for the decision to avoid incoming traffic. In case the remote pilot relies on detection by someone else, the use of phraseology will have to be described as well. Examples: • The operator will initiate a rapid descend if traffic is crossing an alert boundary and operating at less than 1000ft. • The observer monitoring traffic uses the phrase: 'DESCEND!, DESCEND!, DESCEND!'.	All requirements of ARC-b and in addition: 1. The operator provides an assessment of the human/machine interface factors that may affect the remote pilot's ability to make a timely and appropriate decision. 2. The UAS operator provides an assessment of the effectiveness of the tools and methods utilised for the timely detection and avoidance of traffic. In this context timely is defined as enabling the remote pilot to decide within 5 seconds after the indication of incoming traffic is provided. The UAS operator provides an assessment of the failure rate or availability of any tool or service the UAS operator intends to use.	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable requirements.

STEP 6 - TACTICAL MITIGATION PERFORMANCE REQUIREMENTS AND ROBUSTNESS LEVELS (TMPR)

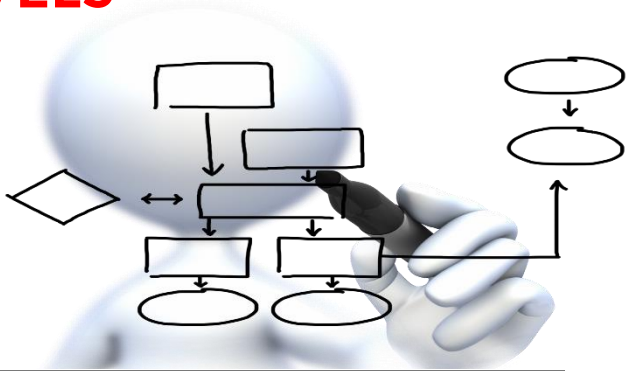
Tactical mitigation performance requirements (TMPR)	Function	TMPR Level				
		VLOS	No Requirement (ARC-a)	Low (ARC-b)	Medium (ARC-c)	High (ARC-d)
	Execute	No Requirement	No Requirement	UAS descending to an altitude not higher than the nearest trees, buildings or infrastructure or ≤ 60 feet AGL is considered sufficient. The aircraft should be able to descend from its operating altitude to the 'safe altitude' in less than a minute.	Avoidance may rely on vertical and horizontal avoidance manoeuvring and is defined in standard procedures. Where horizontal manoeuvring is applied, the aircraft shall be demonstrated to have adequate performance, such as airspeed, acceleration rates, climb/descend rates and turn rates. The following are suggested minimum performance criteria:[10] • Airspeed: ≥ 50 knots • Rate of climb/descend: ≥ 500 ft/min • Turn rate: ≥ 3 degrees per second	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable requirements.

[10] Low End Performance Representative (LEPR) performance requirments for RTCA SC-228 Study 5

STEP 6 - TACTICAL MITIGATION PERFORMANCE REQUIREMENTS AND ROBUSTNESS LEVELS

		TMPR: N/A (ARC-a)	TMPR: Low (ARC-b)	TMPR: Medium (ARC-c)	TMPR: High (ARC-d)
Level of integrity	Criteria	Allowable loss of function and performance of the Tactical Mitigation System: < 1 per 100 Flight Hours (1E-2 Loss/FH)	Allowable loss of function and performance of the Tactical Mitigation System: < 1 per 100 Flight Hours (1E-2 Loss/FH)	Allowable loss of function and performance of the Tactical Mitigation System: < 1 per 1 000 Flight Hours (1E-3 Loss/FH)	Allowable loss of function and performance of the Tactical Mitigation System: < 1 per 100 000 Flight Hours (1E-5 Loss/FH)
	Comments / Notes	*The requirement is considered to be met by commercially available products. No quantitative analysis is required.*	*The requirement is considered to be met by commercially available products. No quantitative analysis is required.*	*This rate is commensurate with a probable failure condition. These failure conditions are anticipated to occur one or more times during the entire operational life of each aircraft.*	*A quantitative analysis is required.*
		TMPR: N/A (ARC-a)	**TMPR: Low (ARC-b)**	**TMPR: Medium (ARC-c)**	**TMPR: High (ARC-d)**
Level of assurance	Criteria	N/A	The operator declares that the tactical mitigation system and procedures will mitigate the risk of collisions with manned aircraft to an acceptable level.	The operator provides evidence that the tactical mitigation system will mitigate the risk of collisions with manned aircraft to an acceptable level.	The evidence that the tactical mitigation system will mitigate the risk of collisions with manned aircraft to an acceptable level is verified by a competent third party.
	Comments / Notes	*N/A*	*N/A*	*N/A*	*N/A*

Table D.3 — TMPR integrity and assurance objectives



Residual ARC	Tactical Mitigation Performance Requirements (TMPR)	TMPR Level of Robustness
ARC-d	High	High
ARC-c	Medium	Medium
ARC-b	Low	Low
ARC-a	No requirement	No requirement

QUESTION TIME!



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