EASA
European Union Aviation Safety Agency

SORA

Specific operation risk assessment

Your safety is our mission.

An Agency of the European Union

Which risks SORA addresses?

Protect from:

- fatal injuries to third parties on ground;
- fatal injuries to third parties in air.

Involved persons

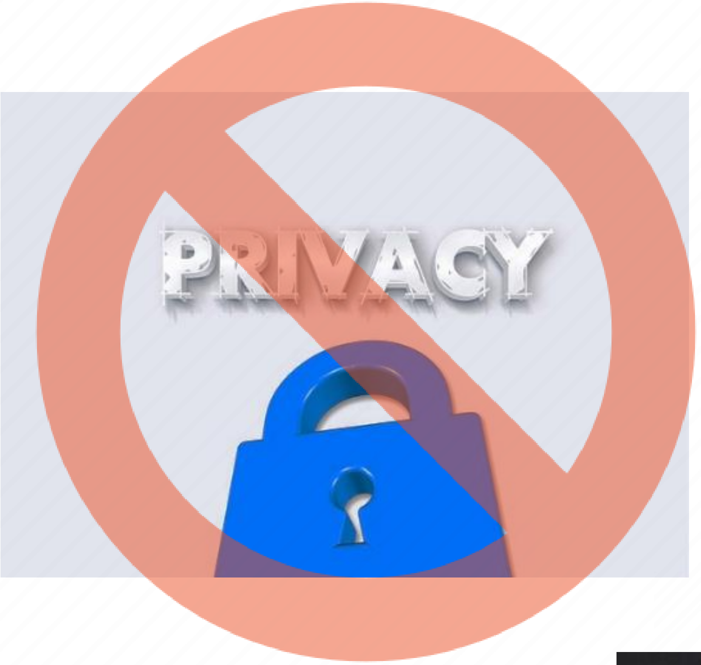
Persons that accepted to take part to the UAS operation

Protected by defining safe operational procedures

Uninvolved persons

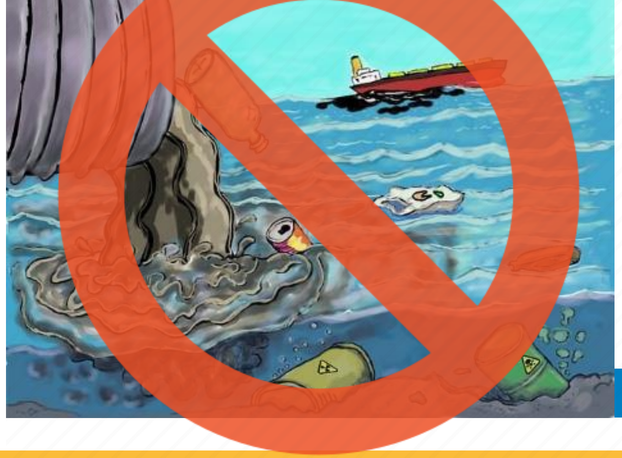
Protected applying mitigations and safety objective derived by SORA

Which risks are not addressed



Risk to industrial infrastructure

Environmental risk



SORA evolution

SORA
2.0

SIMPLIFICATION

NO NEW REQUIREMENTS

FLEXIBILITY

CLARITY

SORA
2.5

Published by JARUS in Jan 2019
Adopted by EASA in Oct 2019

Under consultation until
6 March 2023
http://jarus-rpas.org/jarus-external-consultation-sora-version

Full compatible with SORA 2.0,
except containment, where requirement has been lowered

Who are the SORA actors

Applicant
Seeking for an operational authorisation

After issuance of the operational authorisation →

UAS operator

UAS Manufacturer
Design and/or production

Competent authority (CA)
Issuing the operational authorisation

Competent third party
Assessing evidences: it may be the CA or an entity defined by CA

SORA 2.0 Structure (AMC 1 Art. 11 Reg 2019/947)

- → **Main body**: description of the SORA process
- → **Annex A**: *Conops*, New version was consulted by JARUS in March 2022. Final version in development. It will be renamed into 'Operator manual'
- → **Annex B**: Ground risk mitigations
- → **Annex C**: Air risk strategic mitigations
- → **Annex D**: Air risk tactical mitigations
- → **Annex E**: operational safety objectives

Easy Access Rules for Unmanned Aircraft Systems — *Cover Regulation to Implementing Regulation (EU) 2019/947*

AMC1 Article 11 Rules for conducting an operational risk assessment

ED Decision 2020/022/R

SPECIFIC OPERATIONS RISK ASSESSMENT (SOURCE JARUS SORA V2.0)

EDITION December 2020

1. Introduction

1.1 Preface

(a) This SORA is based on the document developed by JARUS, providing a vision on how to safely create, evaluate and conduct an unmanned aircraft system (UAS) operation. The SORA provides a methodology to guide both the UAS operator and the competent authority in determining whether a UAS operation can be conducted in a safe manner. The document should not be used as a checklist, nor be expected to provide answers to all the challenges related to the integration of the UAS in the airspace. The SORA is a tailoring guide that allows a UAS operator to find a best fit mitigation means, and hence reduce the risk to an acceptable level. For this reason, it does not contain prescriptive requirements, but rather safety objectives to be met at various levels of robustness, commensurate with the risk.

(b) The SORA is meant to inspire UAS operators and competent authorities and highlight the benefits of a harmonised risk assessment methodology. The feedback collected from real-life UAS operations will form the backbone of the updates in the upcoming revisions of the document.

1.2 Purpose of the document

(a) The purpose of the SORA is to propose a methodology to be used as an acceptable means to demonstrate compliance with Article 11 of the UAS Regulation, that is to evaluate the risks and determine the acceptability of a proposed operation of a UAS within the 'specific' category.

(b) Due to the operational differences and the expanded level of risk, the 'specific' category cannot automatically take credit for the safety and performance data demonstrated with the large number of UA operating in the 'open[1]' category. Therefore, the SORA provides a consistent approach to assess the additional risks associated with the expanded and new UAS operations that are not covered by the 'open' category.

(c) The SORA is not intended as a one-stop-shop for the full integration of all types of UAS in all classes of airspace.

(d) This methodology may be applied where the traditional approach to aircraft certification (approving the design, issuing an airworthiness approval and type certificate) may not be appropriate due to an applicant's desire to operate a UAS in a limited or restricted manner. This methodology may also support the activities necessary to determine the associated airworthiness requirements. This assumes that the safety objectives set forth in, or derived from, those applicable for the

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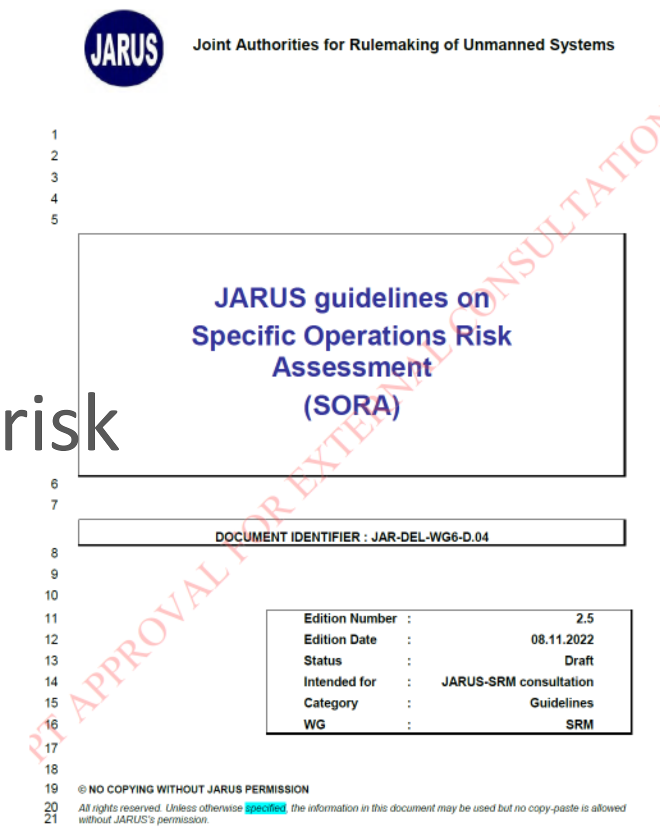
SORA 2.5 structure and differences from 2.0

- → **Main body**: quantitative approach for ground risk + improved containment
- → **Annex A**: no change compared to version published in 2020
- → **Annex B**: Clarification on ground risk mitigations
- → **Annex C, D**: no change (due to lack of time)
- → **Annex E**: functional test based approach added
- → **New Annex F**: quantitative model of the ground risk
- → **New Annex H**: service providers certification
- → **New Annex I**: Glossary


JARUS Joint Authorities for Rulemaking of Unmanned Systems

JARUS guidelines on Specific Operations Risk Assessment (SORA)

DOCUMENT IDENTIFIER : JAR-DEL-WG6-D.04

Edition Number	:	2.5
Edition Date	:	08.11.2022
Status	:	Draft
Intended for	:	JARUS-SRM consultation
Category	:	Guidelines
WG	:	SRM

Robustness levels

Made of 2 elements

level of integrity (i.e. safety gain)

How good the proposed solution is

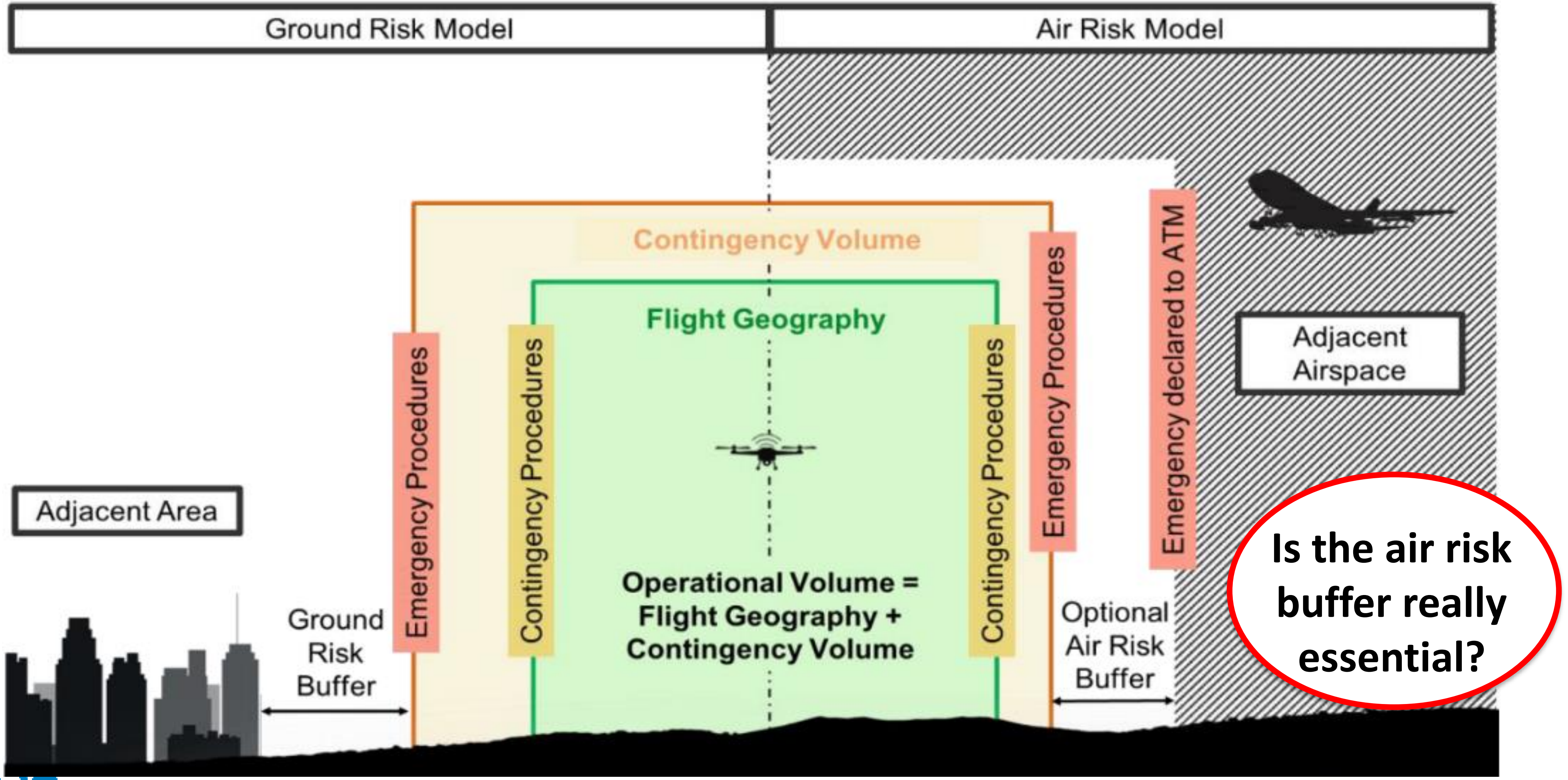
(e.g mitigations, procedures, UA design etc)

level of assurance (i.e. method of proof)

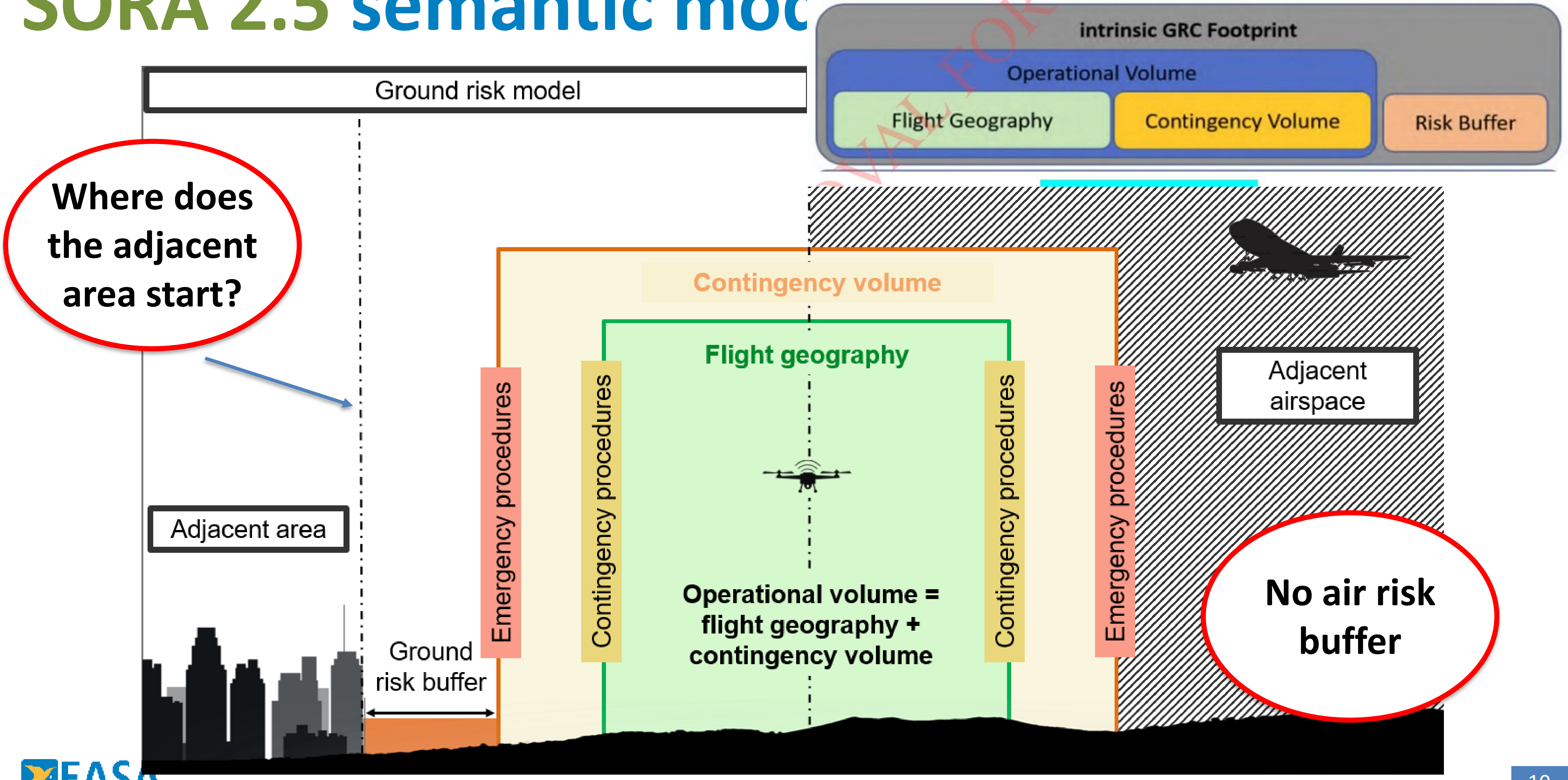
How the achievement of the level of integrity is demonstrated

- **Low**: declarations
- **Medium**: declaration supported by data
- **High**: Verification from the competent authority or entity designated by the competent authority

SORA 2.0 semantic model

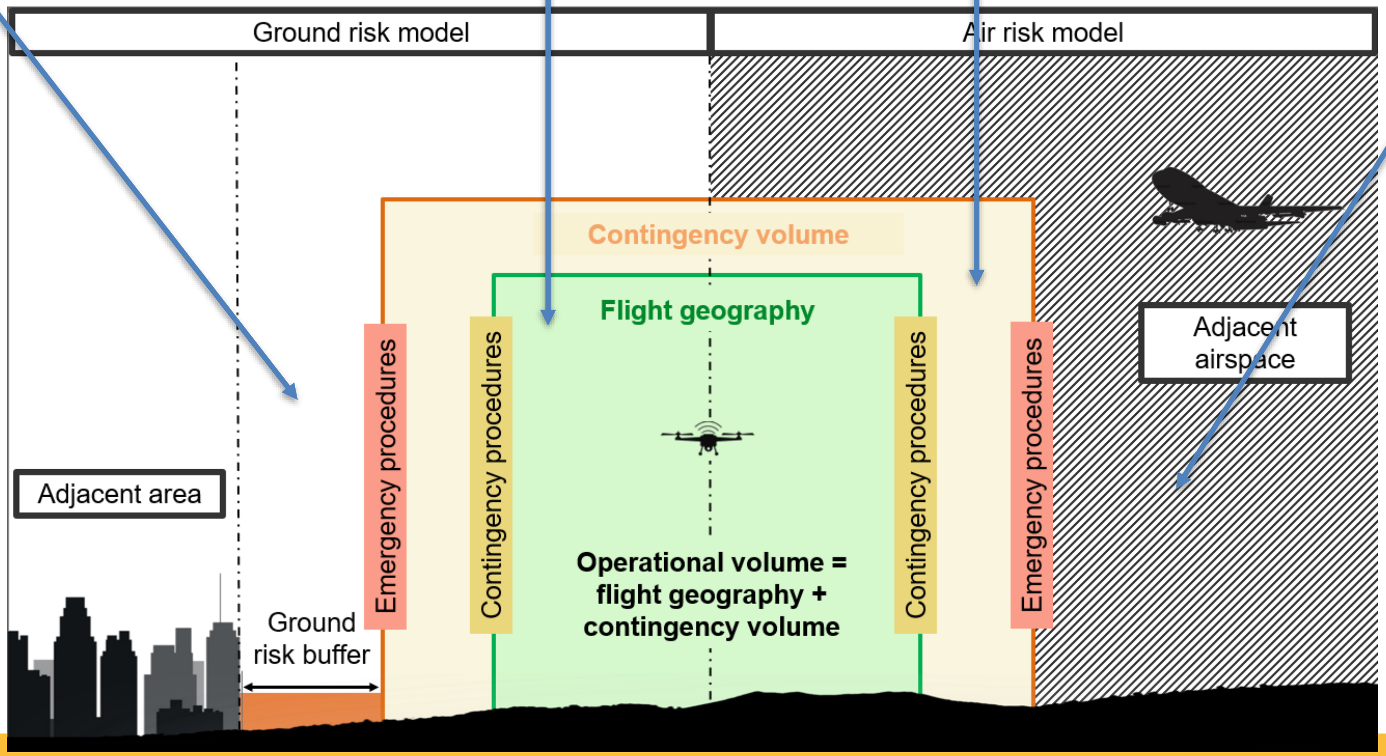


SORA 2.5 semantic model



SORA 2.5 semantic model

Loss of control of the operation (*)	Operation in control		Loss of control of the operation (*)
Emergency situation (unrecovered state)	Normal operation	Abnormal situation (undesired state)	Emergency situation (unrecovered state)
Emergency procedures (land asap or activation of FTS, etc.)	Standard / operationalpProcedures	Contingency procedures (return home, manual control, land on a pre-determined site etc.)	Emergency procedures (land asap or activation of FTS, etc.)
Emergency response plan (plan to limit escalating effect of the loss of control of the operation)			Emergency response plan (plan to limit escalating effect of the loss of control of the operation)



SORA 2.0 Step#1

CONOPS description

- ✓ Applicant to collect and provide the relevant technical, operational and system information needed to assess the risk associated with the intended operation.
- ✓ It is the foundation for all other activities.

What you want to do, where you want to fly, which UAS you intend to use

Outcome

- ✓ Description of the intended operation.
- ✓ Familiarisation with the documents to be provided to the competent authority to apply for the operational authorisation.

SORA 2.0 Step #1 lesson learned

The title (CONOPS) create confusion

→ CONOPS has different meaning in different domains

→ SORA Annex A is also called CONOPS

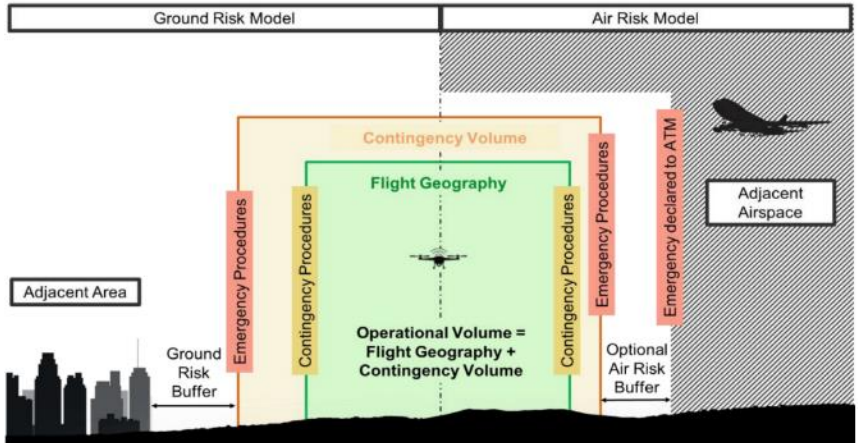
Changes in Step #1 of SORA 2.5

→ Step #1 renamed into 'Documentation of the proposed operation(s)'

→ SORA Annex A renamed in 'operator manual'

NO NEED TO REVISE THE DOCUMENTATION OF OPERATIONS APPROVED USING SORA 2.0 OR PREVIOUSLY APPROVED DOCUMENTATION

SORA Step #2 – Ground risk - Define size of operational area

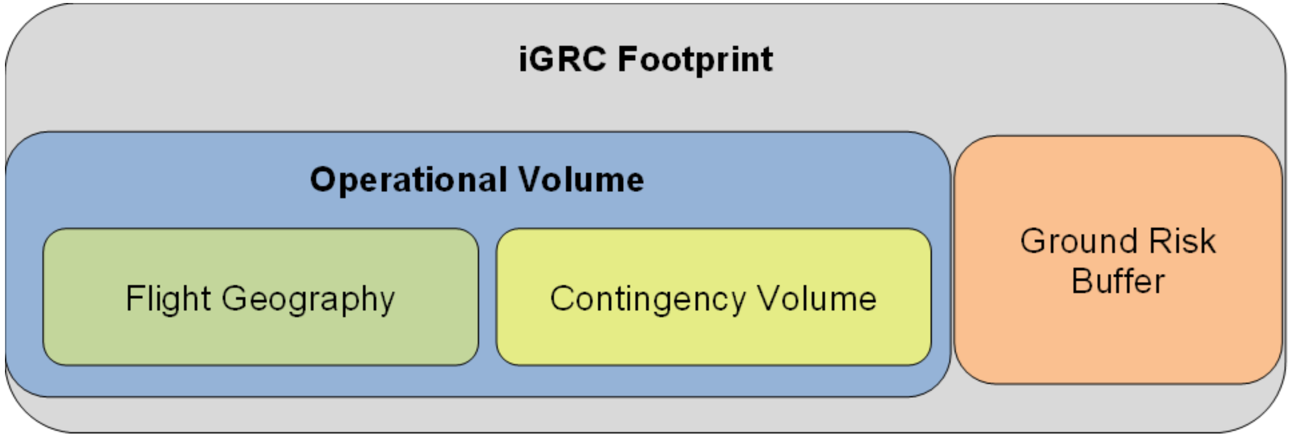


Outcome

a) identification of the size of the footprint;

b) identification of the iGRC (intrinsic ground risk class) of the footprint;

c) Documentation of information and references used to complete this Step.



Initial ground risk class determination

SORA Step #2 – Ground risk - Define size of operational area

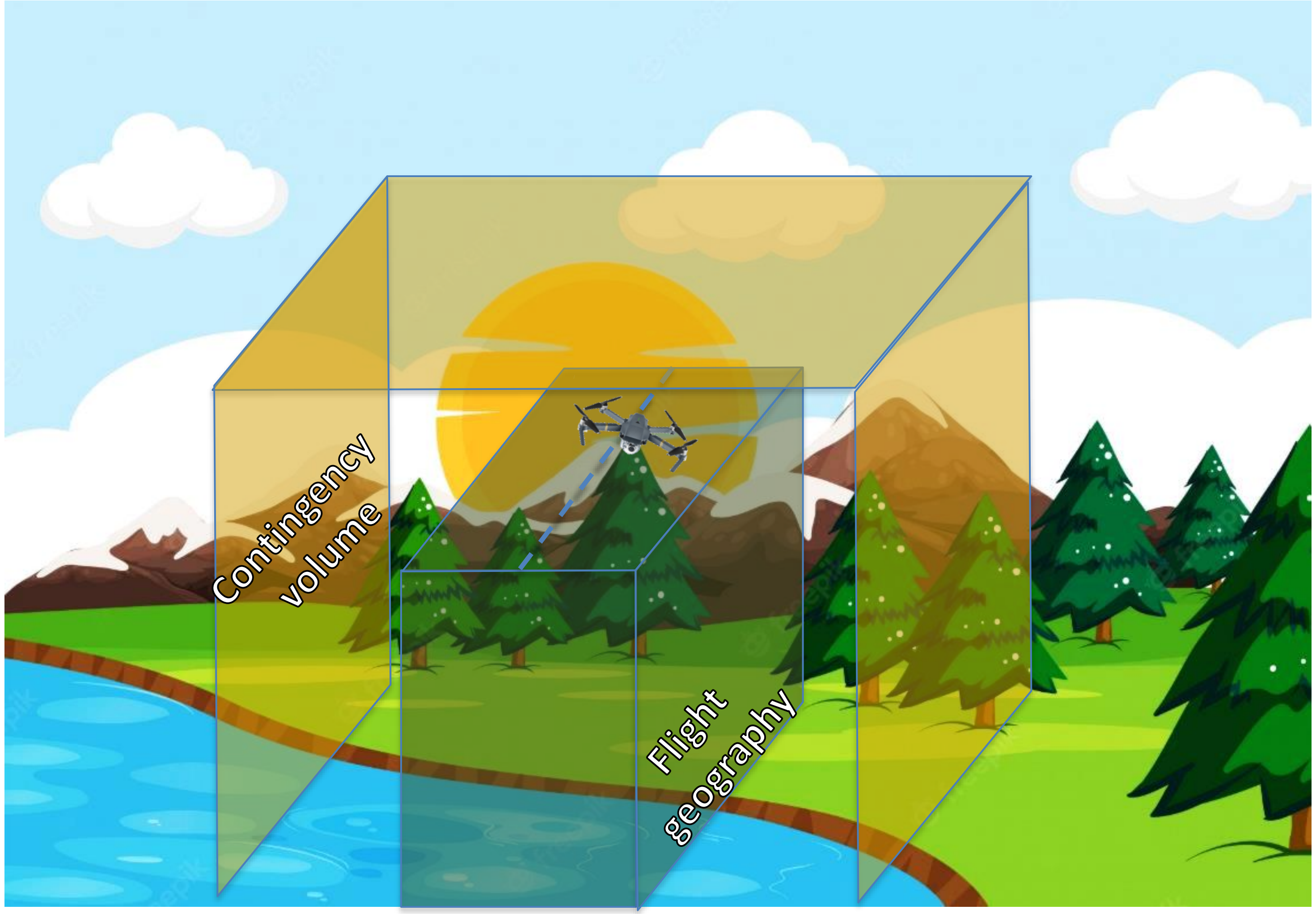
Flight geography: where the drone should fly in normal conditions

Determination of flight geography

Where the operation takes places and:

- Navigation System Error
- Flight Technical Error
- Path Definition Error

SORA Step #2 – Ground risk - Define size of operational area



Contingency volume: where the drone may fly in case of abnormal conditions.

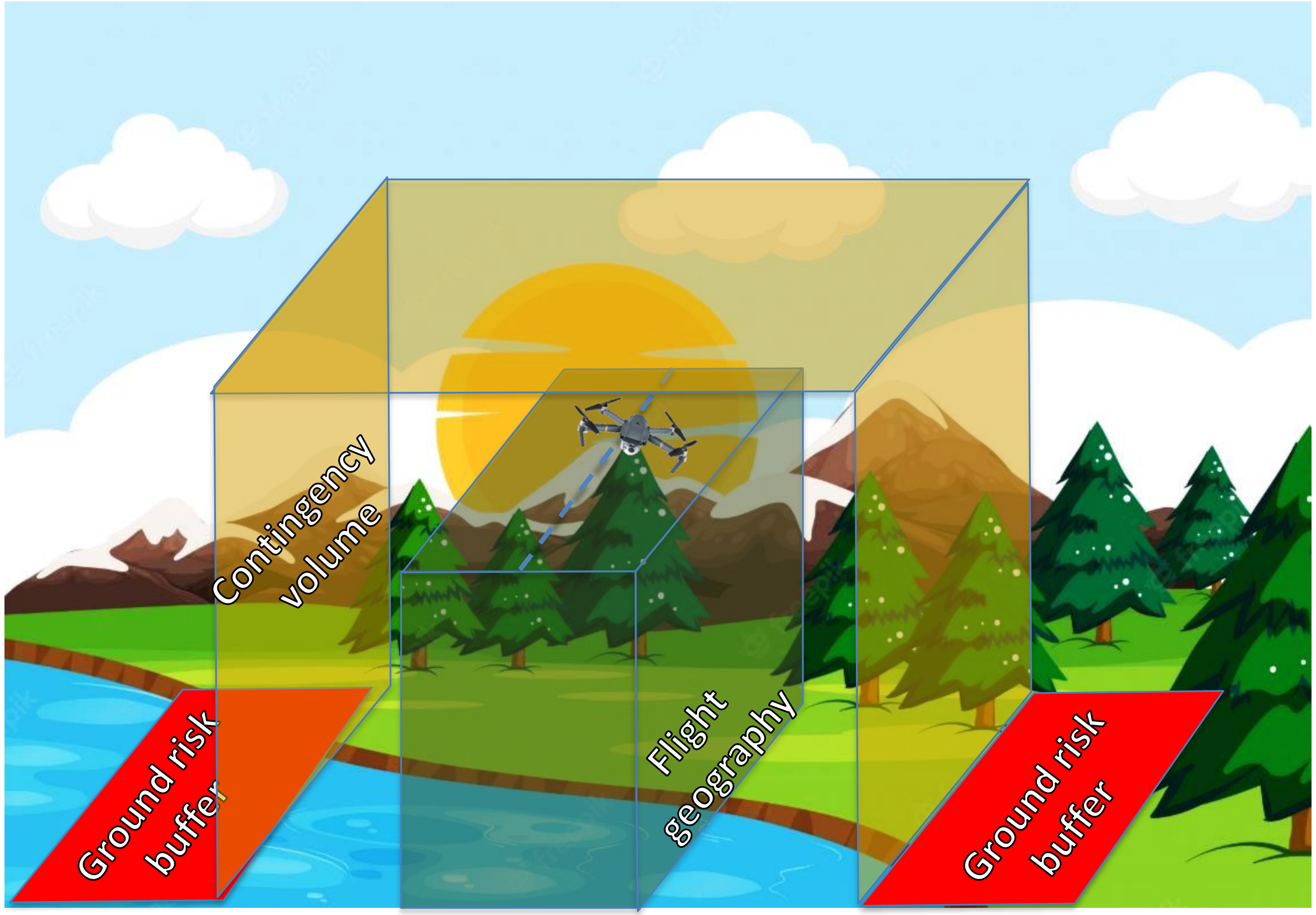
Execution of contingency procedures to immediately return the UA into the flight geography

Determination of contingency volume

Range flew by the drone considering the:

- reaction time
- time to execute contingency manoeuvres

SORA Step #2 – Ground risk - Define size of operational area

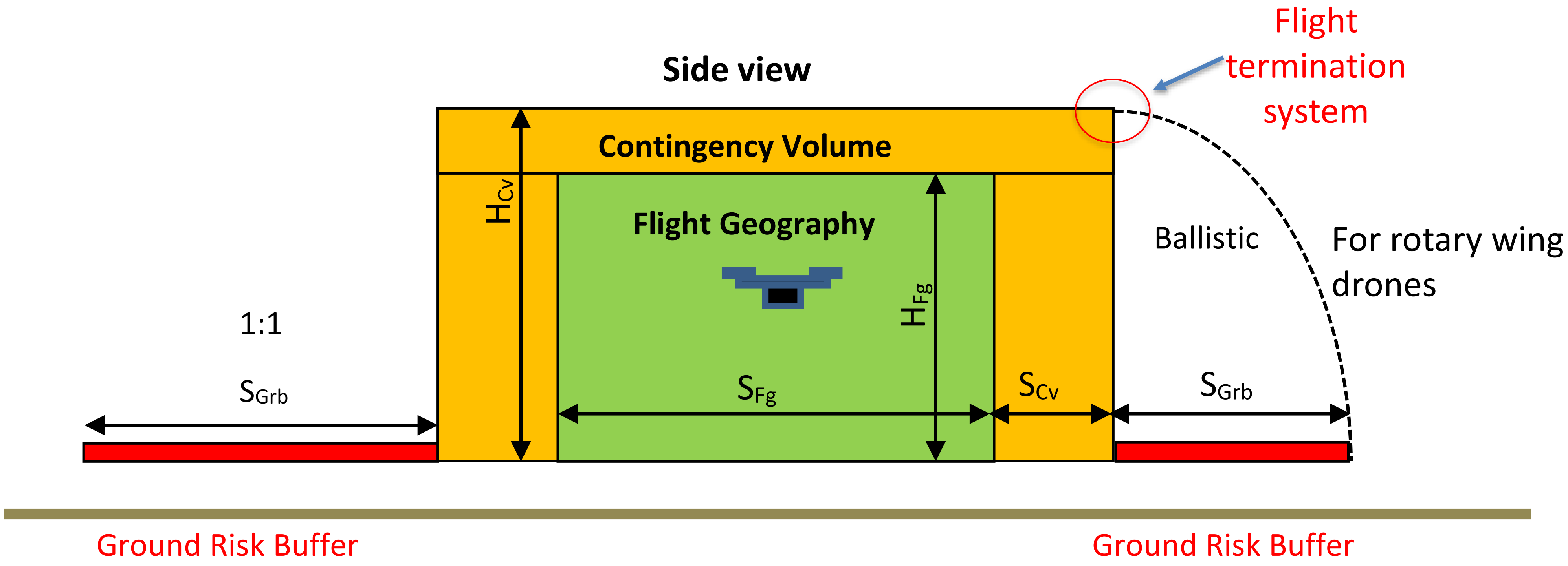


Ground risk buffer: If an operation loses control in a way that the UA exits the operational volume, it shall be contained to end its flight inside the ground risk buffer

<u>**Determination of ground risk buffer**</u>

- 1:1 distance
- Ballistic descend

SORA Step #2 - Determine size of ground risk buffer

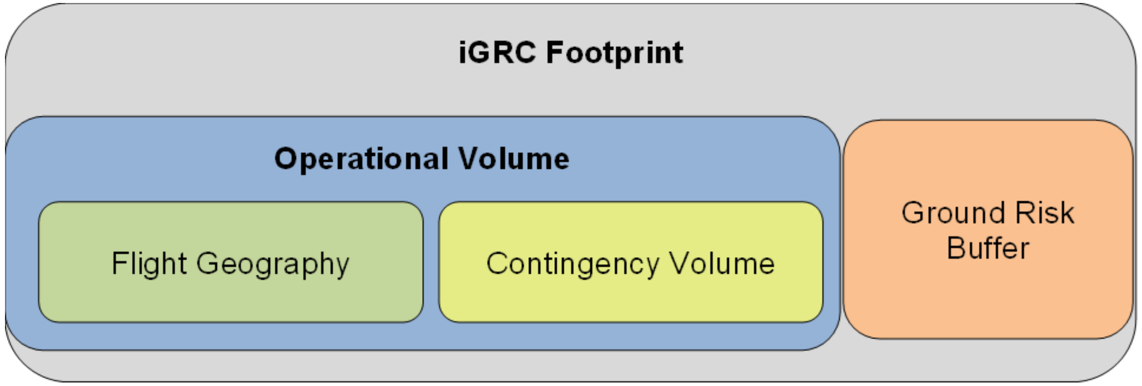


1:1 rule or a more accurate ground risk buffer value may be claimed based on an analysis taking into account malfunctions or failures and the following elements when the containment system is activated:

- Meteorological conditions (e.g. wind),
- UAS latencies
- UA behavior when activating a technical containment measure (e.g. parachute deployment),
- UA performance.

Population density (SORA 2.0)

Identify the maximum population density value of the



- Controlled ground area
  - protected area with negligible probability of presence of uninvolved person

- Sparsely populated
- Populated
- Assembly of people

Fictional example

Manna delivery
MTOM: 23kg
Payload: 2,25kg
Length: 2m

Actual local conditions may be diferent!!!

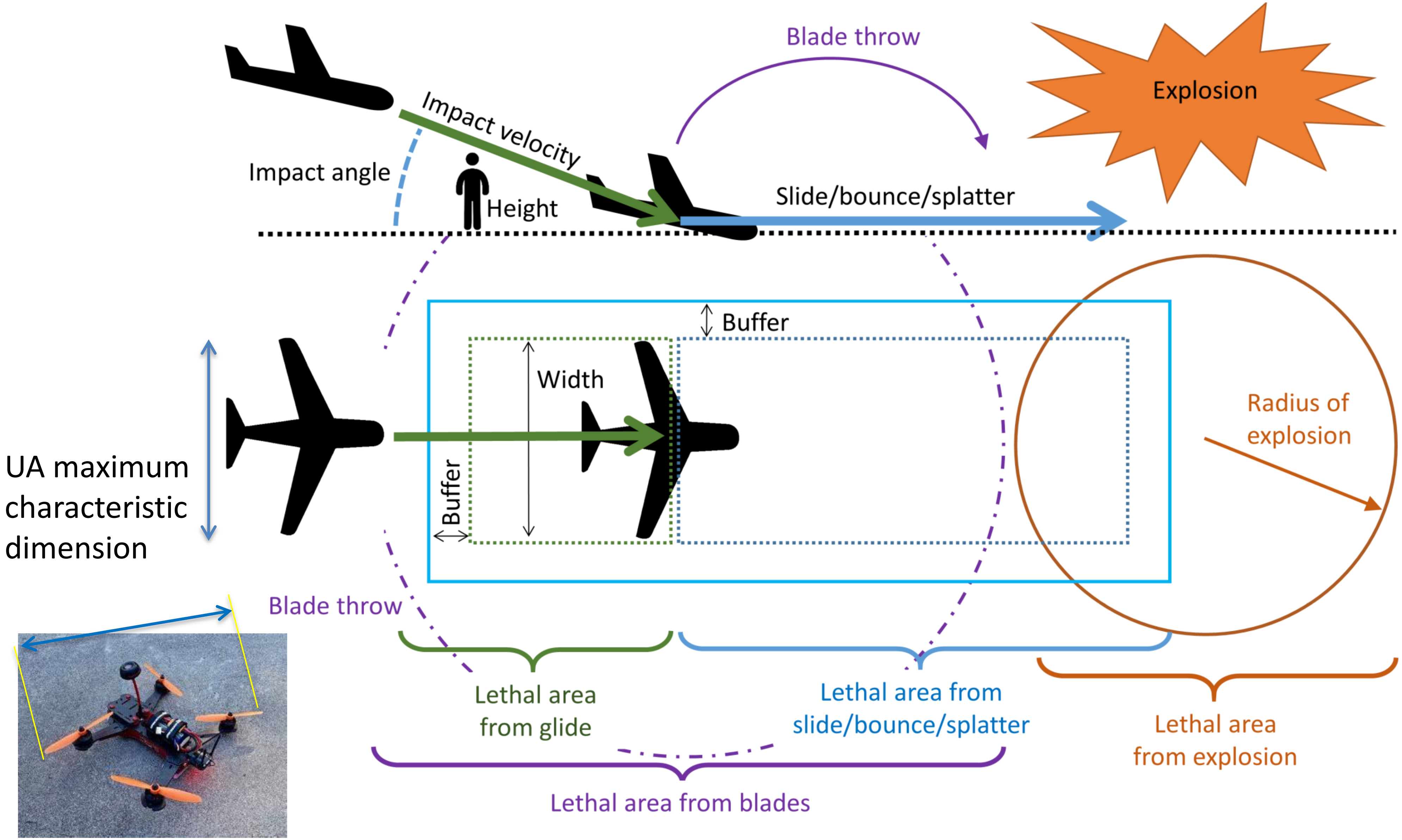
- Sparsely populated area (e.g. max pop density 200 ppl/km^2)
- Populated area (e.g. max pop density 3.000 ppl/km^2)
- Busy open shopping area, assembly of people (e.g. max pop density 250.000 ppl/km^2)

SORA Step #2 - Assessing the ground risk

Is the weight of the drone the main factor?

In case of impact with a person, once the energy transmitted by the drone is higher than a lethal threshold (order of 80J), the most important parameter becomes the size of the drone

SORA Step #2 - Assessing the ground risk



Size of the critical area

SORA 2.0 Step#2

Determination of the intrinsic UAS ground risk class (GRC)

Intrinsic UAS ground risk class				
Max UAS characteristics dimension	1 m / approx. 3 ft	3 m / approx. 10 ft	8 m / approx. 25 ft	>8 m / approx. 25 ft
Typical kinetic energy expected	< 700 J (approx. 529 ft lb)	< 34 kJ (approx. 25 000 ft lb)	< 1 084 kJ (approx. 800 000 ft lb)	> 1 084 kJ (approx. 800 000 ft lb)
Operational scenarios				
VLOS/BVLOS over a controlled ground area[3]	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 an assembly of people	7	Operation not possible in the specific category		
BVLOS over an assembly of people	8			

iGRC table in SORA 2.0

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SORA 2.0 Step #2 lesson learned

1. Qualitative population density values does not help in having an harmonized approach among states
2. It is not clear under which conditions VLOS may play a role in the ground risk determination, what are the requirements for the VLOS bonus?
3. Typical energy difficult to evaluate
4. Very small drones, may reach a GRC of 8
5. Fixed values in the iGRC table: A small increase in the UA dimension (e.g from 3 m to 3.1 m) may classify immediately the UA in the higher GRC
6. The identification of the adjacent area is only required in step 9 and there are no indications on how to calculate its size

SORA 2.5 Step#2

1. Quantitative ground risk assessment

Intrinsic UAS Ground Risk Class						
Maximum UA characteristic dimension		1m / approx. 3ft	3m / approx. 10ft	8m / approx. 25ft	20m / approx. 65ft	40m / approx. 130ft
Maximum cruise speed		*25 m/s*	*35 m/s*	*75 m/s*	*150 m/s*	*200 m/s*
Maximum iGRC population density (ppl/km²)	**Controlled ground area**	1	2	3	4	5
	< 25	3	4	5	6	7
	< 250	4	5	6	7	8
	< 2,500	5	6	7	8	9
	< 25,000	6	7	8	9	10
	< 250,000	7	8	9	10	11
	> 250,000	7	9	**Not part of SORA**		

iGRC table in SORA 2.5

2. VLOS removed and identified as a mitigation for the ground risk (see slide on M1)
3. Typical energy replaced by max cruise speed
4. UAS with max weight <250g and max cruise speed <25m/s are always classified GRC 1
5. Possibility to calculate the actual critical area of the UA and compare with those identified in Annex B

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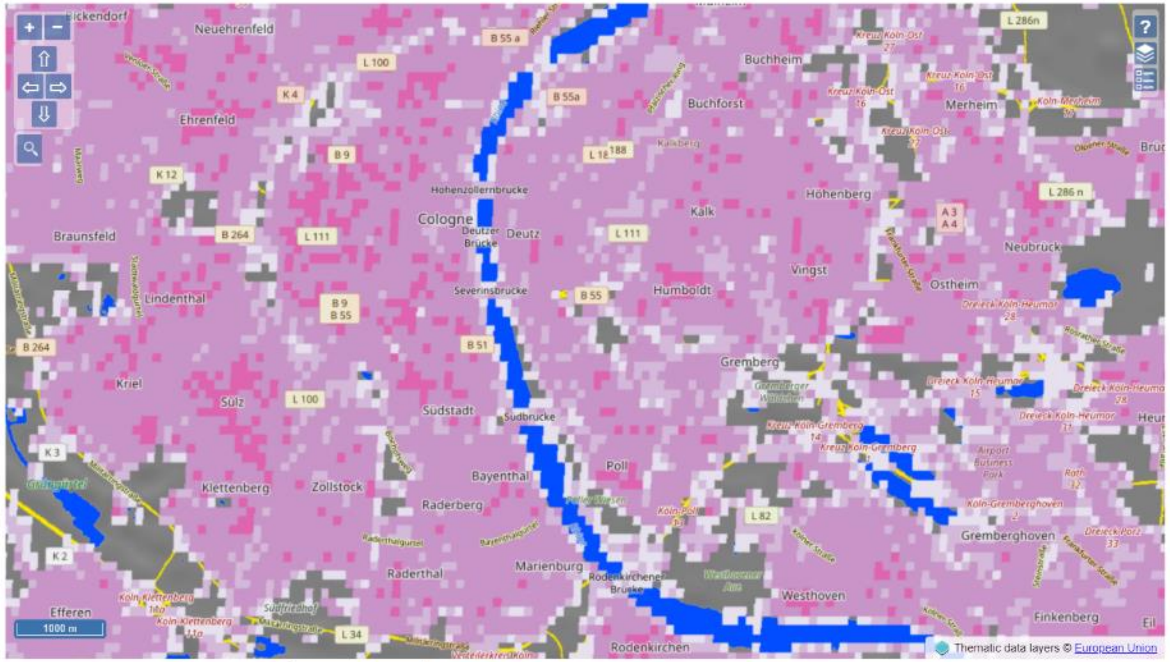
Where can I get the population density data?

- Each state may have their source
- In absence the [Global Human Settlement - Visualisation - European Commission (europa.eu)](#) may be used
- EASA is working to define the minimum requirement for a dynamic population density map service providers



Get a link to share this map: Link to share

Layers selected:

Population - P2022 (res.: 100m): 2020

Base: Markers (when applicable), Country Borders, Shaded reliefs, Land mask, Place names

*Porting of the Degurba model in the GHSL framework (SMOD).

Legend

Degree of Urbanisation

Urban centre (City):
- Urban centre (City)

Urban cluster (Town & suburb):
- Dense and semi-dense urban cluster (Town)
- Suburban or peri-urban cells (Suburb)

Rural grid cells (Rural area):
- Rural cluster (Village)
- Low density rural grid cells (Dispersed rural area) - transparent

Population
- no data (transparent)
- 0 - 5
- 6 - 20
- 21 - 100
- 101 - 300
- 301 - 500
- 501 - 1,000
- 1,000 - Max

Built-up Volume

0 | 50,000 m³ | 100,000 m³

Built-up Surface (10m)

0 | 50 m² | 100 m²

Built-up Surface (100m)

0 | 5,000 m² | 10,000 m²

EASA

How the GRC was calculated in SORA 2.5?

- A more refined ground risk model was developed by JARUS
- New **Annex F** provides all details and justification for the GRC
- Normally, applicants are not required to consult Annex F, unless they would like to propose to the NAA some more sophisticated solutions tailoring the model to their operation

A special thank for leading the development of the ground risk model

Terrence Martin (PhD)
Revolution airspace Australia
Professor at Queensland University of Technology

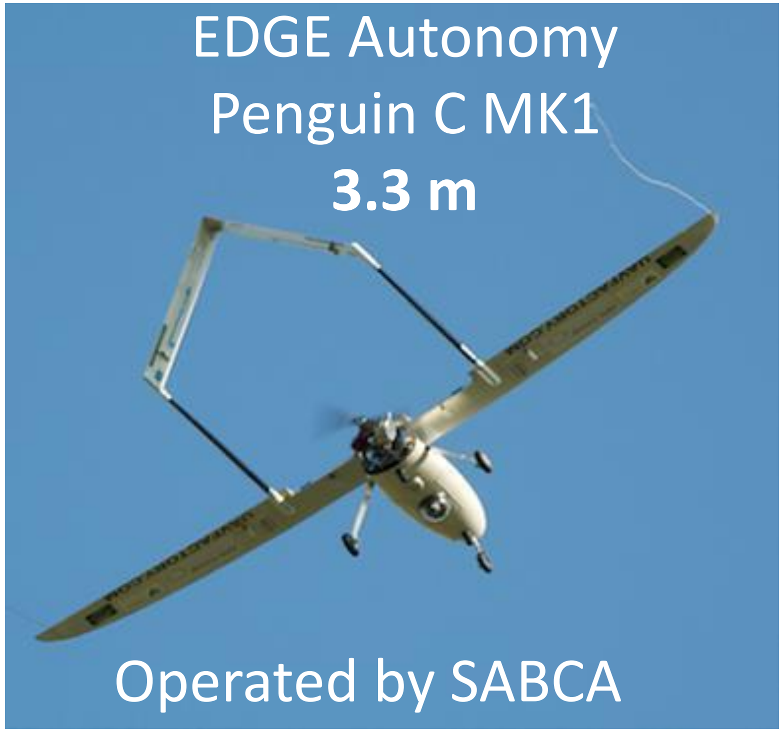
Is there an increase of the iGRC of 1 point between SORA 2.0 and SORA 2.5?

Intrinsic UAS Ground Risk Class						
Maximum UA characteristic dimension		1m / approx. 3ft	3m / approx. 10ft	8m / approx. 25ft	20m / approx. 65ft	40m / approx. 130ft
Maximum cruise speed		*25 m/s*	*35 m/s*	*75 m/s*	*150 m/s*	*200 m/s*
Maximum iGRC population density (ppl/km²)	**Controlled ground area**	1	2	3	4	5
	< 25	3	4	5	6	7
	< 250	4	5	6	7	8
	< 2,500	5	6	7	8	9
	< 25,000	6	7	8	9	10
	< 250,000	7	8	9	10	11
	> 250,000	7	9	**Not part of SORA**		

No if you consider:

- Additional flexibility in applying mitigations in step #3 and Annex B (e.g. shelter)
- Possibility to calculate the actual critical area of the UA (e.g. if using a UA of 4m, maybe the critical area is equivalent to the one of a 3m UA)

SORA 2.5 - Example of calculation actual critical area



Applying Annex F formula for actual critical area it results:

Wingspan	3.3
MTOW	23
Impact speed	32
Impact angle	35
ground friction (friction coeff)	0.65
Coeff of restitution	0.71
Heigh person	1.8
Radius person	0.3
v horizontal	26.21
d glide	2.57
rD	1.95
v non lethal	5.02
t safe	2.13
d slide reduced	25.18
circular end	11.95
Actual Critical Area	**120.18**

Actual critical area is lower than the one identified for a 3m UA in SORA 2.5 Annex B

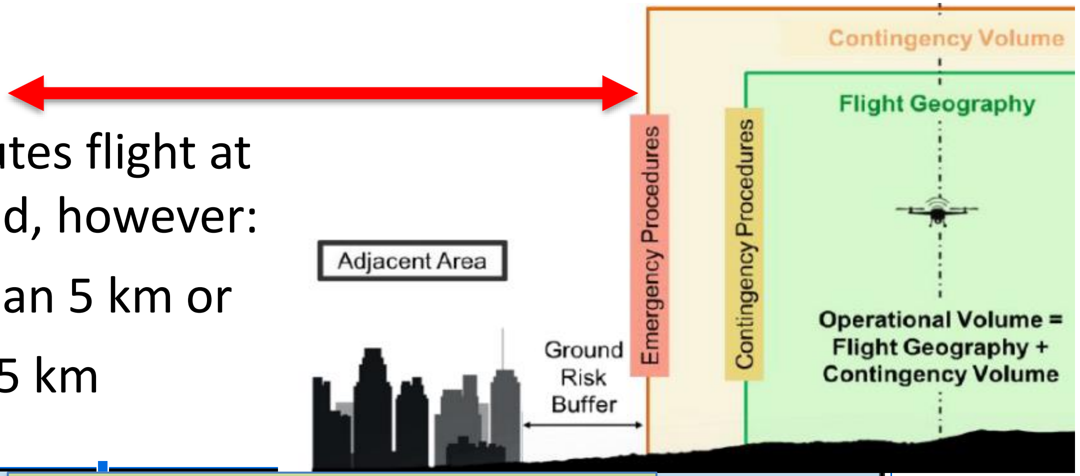
Maximum characteristic dimension (m)	1	3	8	20	40
Critical area (m²)	8	135	1,350	13,500	135,000

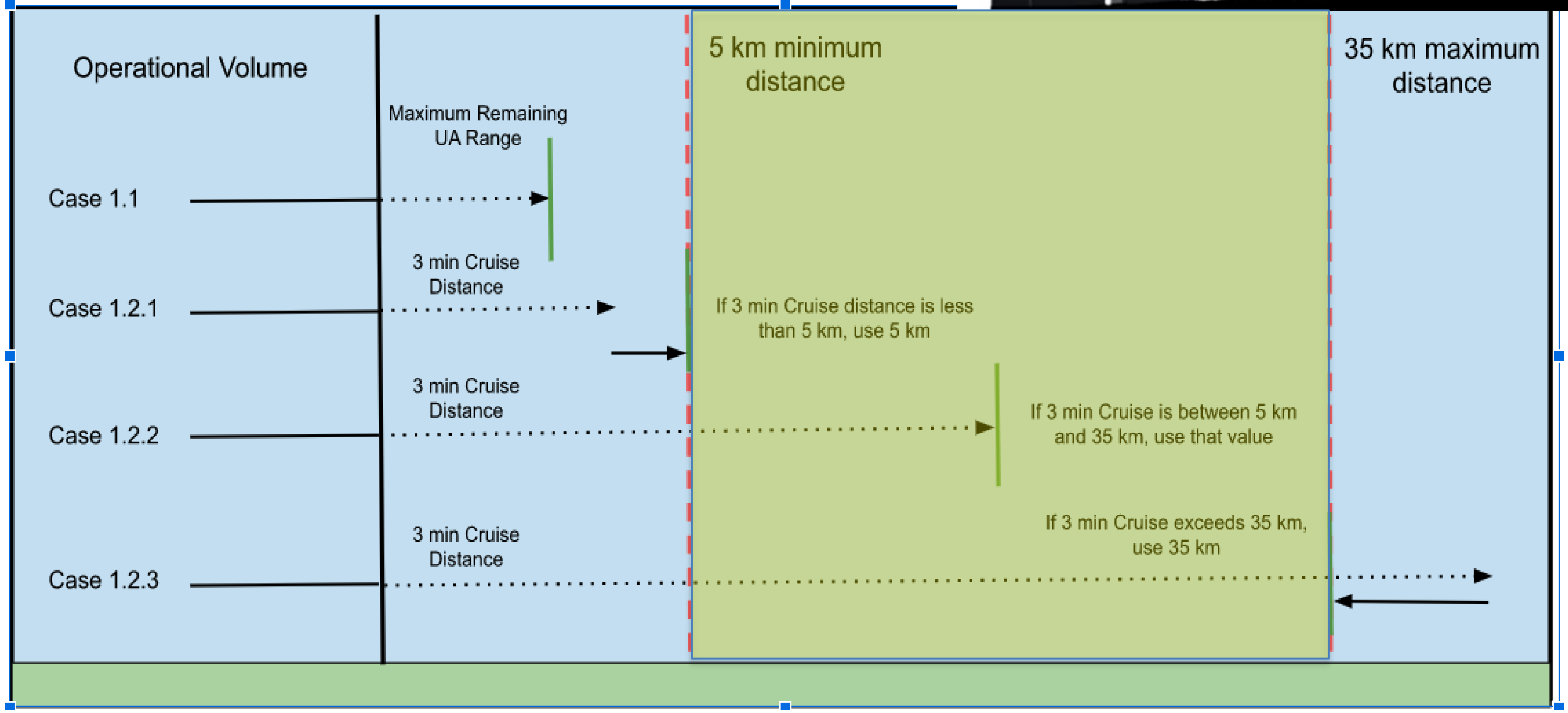
The 3m column can be used!

SORA 2.5 Step #2 – Size of the adjacent area

Range of 3 minutes flight at max cruise speed, however:

- never less than 5 km or
- more than 35 km



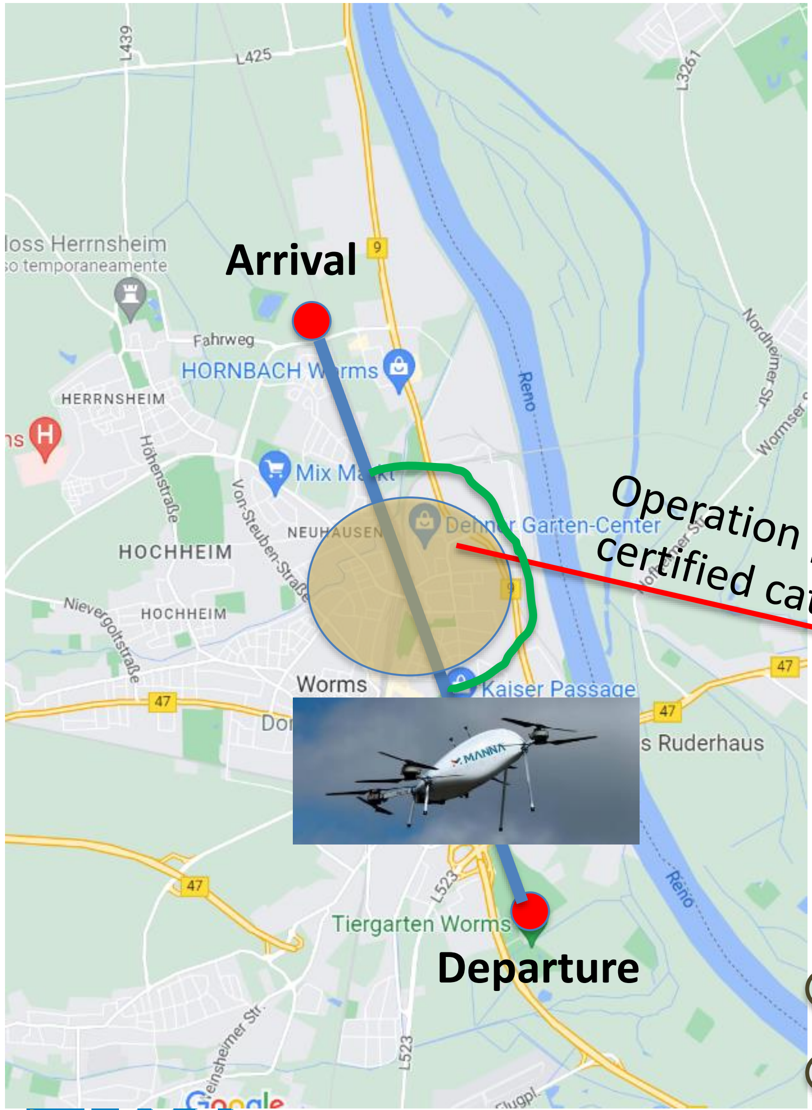


How we reconcile SORA 2.0 with SORA 2.5 iGRC?

Quantitative Population Value (ppl/km2)	< 25	< 250	< 2,500	< 25,000	< 250,000	> 250,000
Qualitative Description	Rural	Sparsely Populated	Suburban	Urban	Dense Urban	Assembly of people 10,000 is the minimum number of people to qualify for assembly of people

Populated area

Fictional example SORA 2.0



Operation possible only in the certified category

Intrinsic GRC 6

Manna delivery

Length: 2m

Intrinsic UAS ground risk class				
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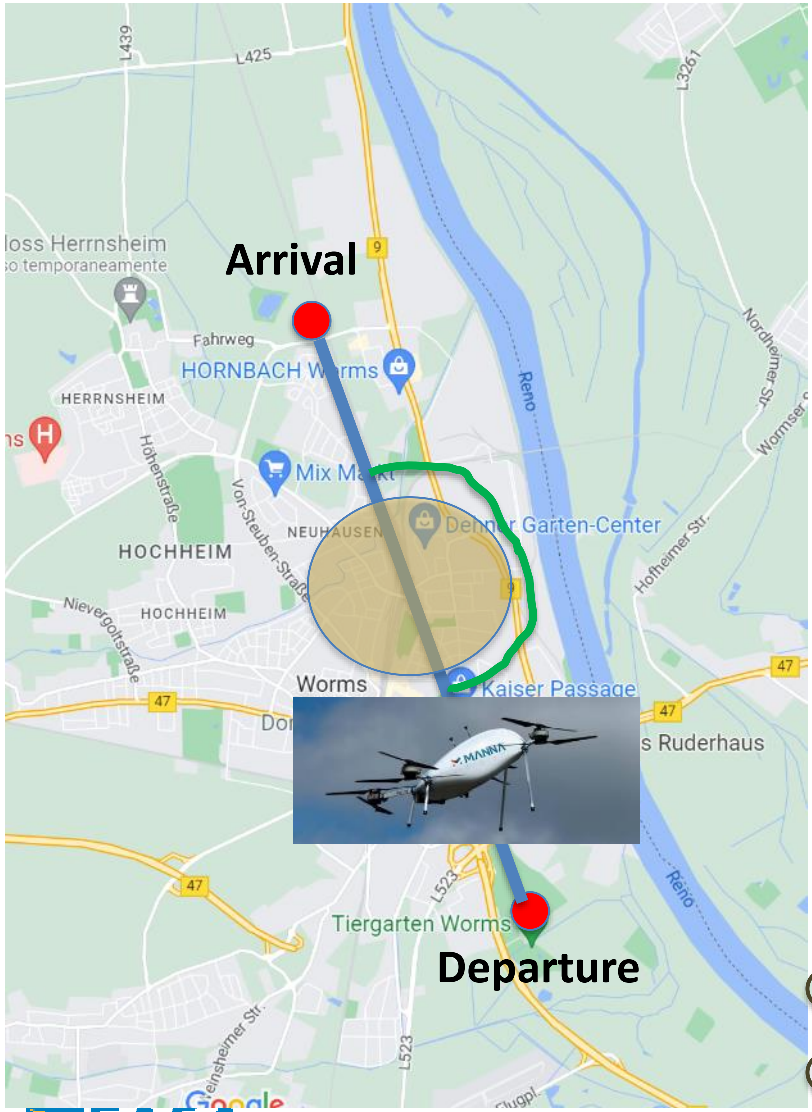
VLOS over an assembly of people	7	Operation not possible in the specific category		
BVLOS over an assembly of people	8			

- Sparsely populated area (e.g. max pop density 200 ppl/km^2)
- Populated area (e.g. max pop density 3.000 ppl/km^2)
- Busy open shopping area, assembly of people (e.g. max pop density 250.000 ppl/km^2)

Fictional example SORA 2.5

Manna delivery
Length: 2m



Intrinsic GRC 7

Intrinsic UAS Ground Risk Class						
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Maximum cruise speed		*25 m/s*	*35 m/s*	*75 m/s*	*150 m/s*	*200 m/s*
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- Populated area (e.g. max pop density 3.000 ppl/km²)
- Busy open shopping area, assembly of people (e.g. max pop density 250.000 ppl/km²)

SORA Step#3 Final GRC Determination

→ Reduce the intrinsic risk of a person being struck by the UA

Outcome

(a) Identification of the mitigations applied to reduce the iGRC for the footprint;

(b) Identification of the applicable mitigations requirements;

(c) Identification of the final GRC;

(d) Collection of information and references used to substantiate the application of the ground risk mitigation(s).

SORA 2.0 Step#3 Final GRC Determination

		Robustness		
Mitigation Sequence	Mitigations for ground risk	Low/None	Medium	High
1	M1 — Strategic mitigations for ground risk[1]	0: None -1: Low	-2	-4
2	M2 — Effects of ground impact are reduced[2]	0	-1	-2
3	M3 — An emergency response plan (ERP) is in place, the UAS operator is validated and effective	1	0	-1
		Declaration	Declaration supported by data	Third party verification

This is possible only for very special cases

<u>For each point of credit the applicant needs to demonstrate a reduction of 1 order of magnitude in the population density at risk</u>

SORA Annex B provides details for the ground risk mitigation requirements

SORA Step#3 – M1 strategic mitigation

Reduce the risk of a person being struck by the UA

Depending on the weight of the drone people may be protected by a **shelter**

Operation may be conducted during **night** when most of people are home

SORA Step#3 – M1 strategic mitigation

- Adjacent area
- Ground risk buffer
- Contingency volume
- Flight geography
- Contingency volume
- Ground risk buffer
- Adjacent area

SORA Step#3 – M1 strategic mitigation

Adjacent area

Ground risk buffer

Contingency volume

Flight geography

Contingency volume

Ground risk buffer

Adjacent area

Modify the flight path to reduce the population density exposed to risk

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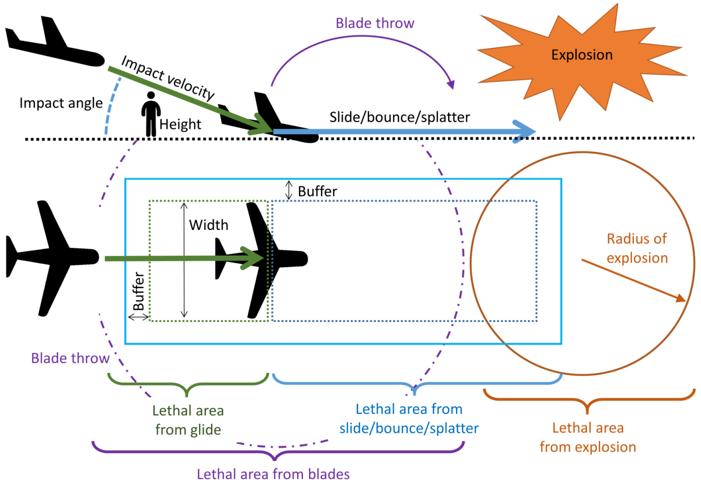
SORA Step#3 – M2 technical mitigation

Several options

Reduce impact energy

Frangibility

Reduce critical area



Stall descend

Spiral descend

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SORA 2.0 Step #3 - Lesson learned

- Reduction of 4 points for M1 high is unrealistic
- Through an emergency response plan is possible to reduce the number of people at risk, only in very special cases
- Annex B is inflexible (e.g. shelter cannot be used for low robustness)

SORA 2.5 Ground risk mitigations

	Level of Robustness		
Mitigations for ground risk	**Low**	**Medium**	**High**
M1(A) - Strategic mitigations for ground risk	**-1**	**-2**	**-3**
M1(B) - Visual Line of Sight (VLOS) - avoid flying over people	**-1**	**N/A**	**N/A**
M2 - Effects of UA impact dynamics are reduced	**0**	**-1**	**-2/-3**

- M3 mitigation removed. Requirement for emergency response plan included in OSO 8
- VLOS is a mitigation meaning that the remote pilot is able to locate people on ground and avoid to fly over people

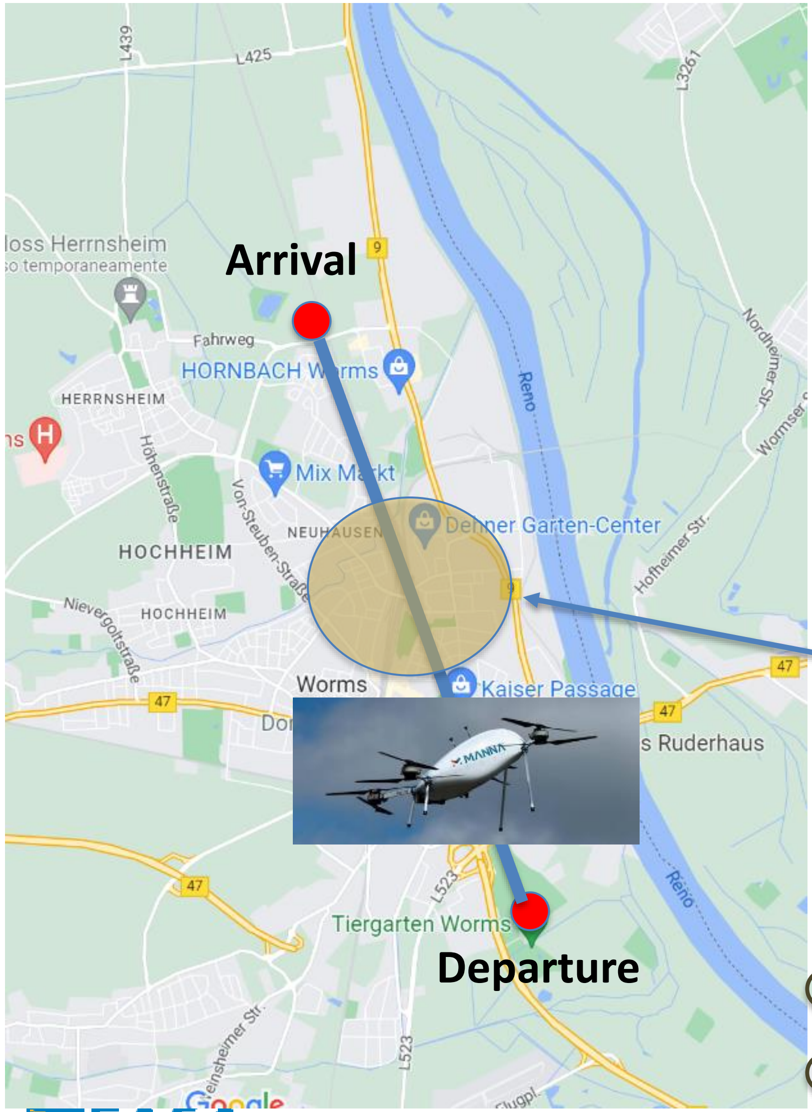
More flexibility in Annex B.
Applicant may propose any approach: the final GRC will be the one resulting from the actual population density at risk in the operational area and the actual critical area

EASA

Fictional example SORA 2.5

Manna delivery
Length: 2m

How to apply M1



How many persons are actually exposed to the risk?

All UAS with a mass<25 kg can use shelter factor (maybe it is possible for higher mass)

No sheltering factor possible here during shop open time

Intrinsic UAS Ground Risk Class							
Maximum UA characteristic dimension		1m / approx. 3ft	3m / approx. 10ft	8m / approx. 25ft	20m / approx. 65ft	40m / approx. 130ft
Maximum cruise speed		25 m/s	35 m/s	75 m/s	150 m/s	200 m/s
Maximum iGRC population density (ppl/km²)	Controlled ground area	1	2	3	4	5
	< 25	3	4	5	6	7
	< 250	4	5	6	7	8
	< 2,500	5	6	7	8	9
	< 25,000	6	7	8	9	10
	< 250,000	7	8			
	> 250,000	7	9	Not part of SORA		

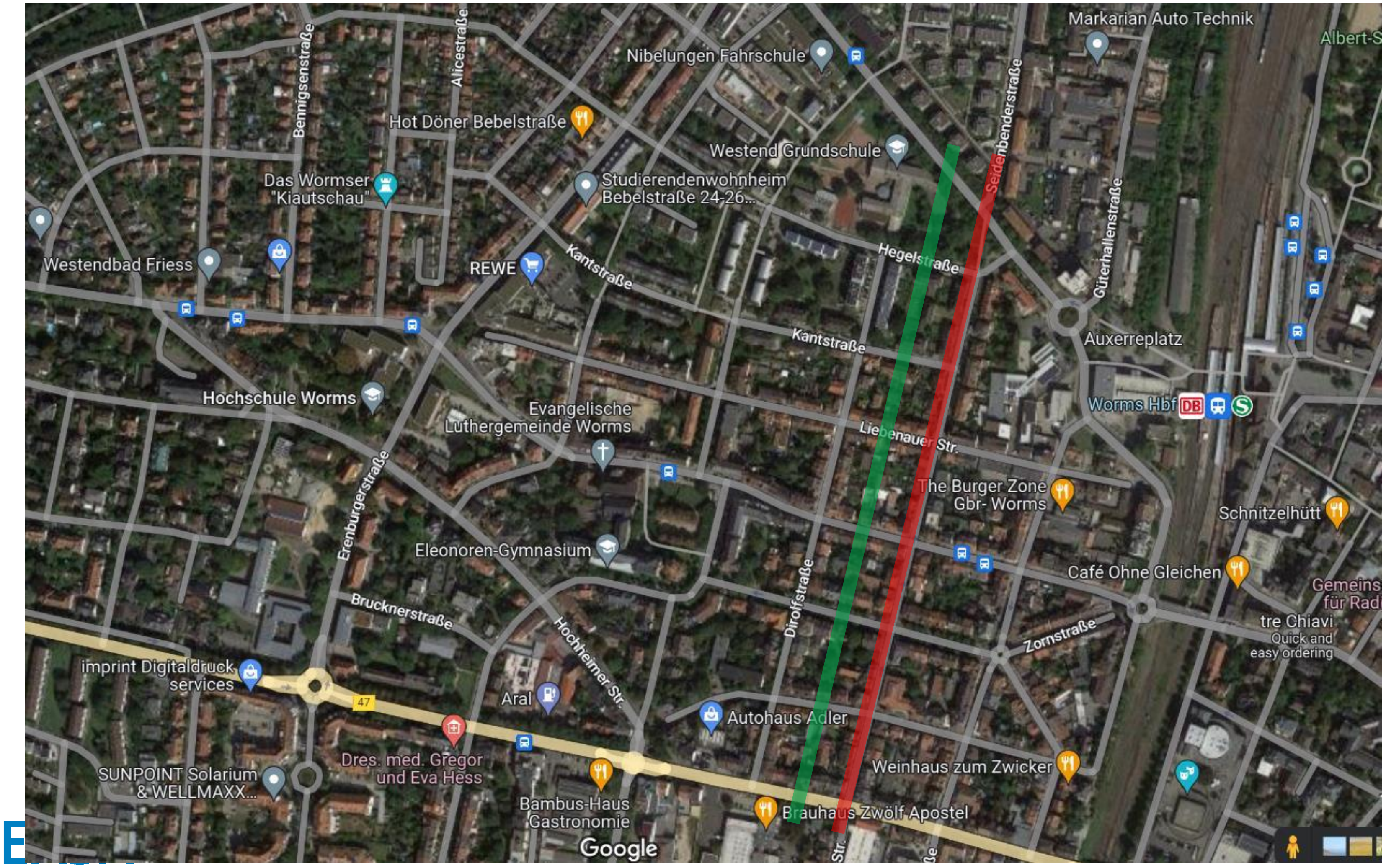
3.000 ppl/km²

- Sparsely populated area (e.g. max pop density 200 ppl/km²)
- Populated area (e.g. max pop density 3.000 ppl/km²)
- Busy open shopping area, assembly of people (e.g. max pop density 250.000 ppl/km²)

EASA

Fictional example SORA 2.5

How to apply M1



To use shelter factor:

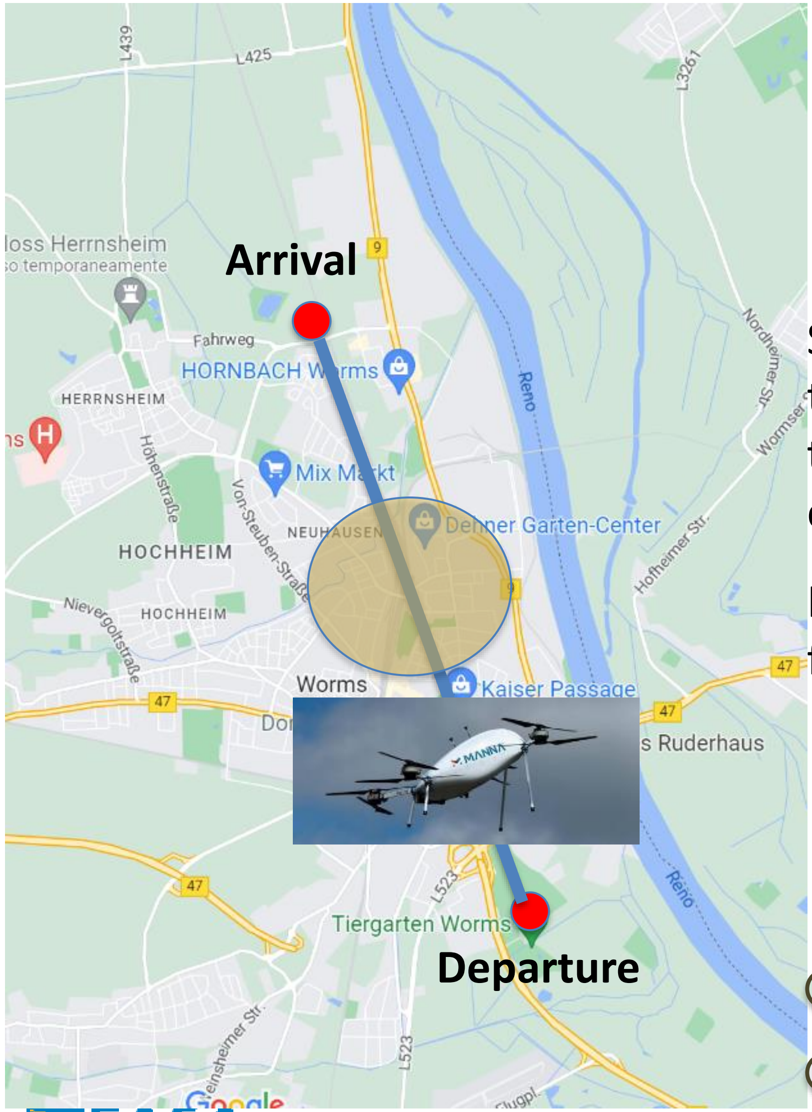
avoid to fly directly over a street where people may be present

Cross street perpendicularly as much as possible ode: bvwlnb

Fictional example SORA 2.5

How to apply M1

Manna delivery
Length: 2m



How many persons are actually exposed to the risk?

Selecting an operational area where the population density at risk is less than 2.500 ppl/km^2, qualifies for 1 credit.

If it is less than 250 ppl/km^2 qualifies for 2 credits and so on

Intrinsic UAS Ground Risk Class						
Maximum UA characteristic dimension		1m / approx. 3ft	3m / approx. 10ft	8m / approx. 25ft	20m / approx. 65ft	40m / approx. 130ft
Maximum cruise speed		25 m/s	35 m/s	75 m/s	150 m/s	200 m/s
Maximum iGRC population density (ppl/km²)	Controlled ground area	1	2			
	< 25	3	4	5	6	7
	< 250	4	5	6	7	8
	< 2,500	5	6	7	8	9
	< 25,000	6	7	8	9	10
	< 250,000	7	8			
	> 250,000	7	9	Not part of SORA		

2.450 ppl/km^2

3.000 ppl/km^2

- Sparsely populated area (e.g. max pop density 200 ppl/km^2)
- Populated area (e.g. max pop density 3.000 ppl/km^2)
- Busy open shopping area, assembly of people (e.g. max pop density 250.000 ppl/km^2)

EASA

SORA 2.0 Step#3 – determination of the final GRC

Intrinsic UAS ground risk class				
Max UAS characteristics dimension	1 m / approx. 3 ft	3 m / approx. 10 ft	8 m / approx. 25 ft	>8 m / approx. 25 ft
Typical kinetic energy expected	< 700 J (approx. 529 ft lb)	< 34 kJ (approx. 25 000 ft lb)	< 1 084 kJ (approx. 800 000 ft lb)	> 1 084 kJ (approx. 800 000 ft lb)
Operational scenarios				
VLOS/BVLOS over a controlled ground area[3]	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 an assembly of people	7	Operation not possible in the specific category		
BVLOS over an assembly of people	8			

M2

M1

Final GRC 4

Length: 2.2m

M1: reduction of the <u>maximum value</u> of population density at risk in the operational area + ground risk buffer

M2: reduction of the critical area (e.g. parachute)

SORA 2.5 Step#3 – determination of the final GRC

Intrinsic UAS Ground Risk Class						
Maximum UA characteristic dimension		1m / approx. 3ft	3m / approx. 10ft	8m / approx. 25ft	20m / approx. 65ft	40m / approx. 130ft
Maximum cruise speed		*25 m/s*	*35 m/s*	*75 m/s*	*150 m/s*	*200 m/s*
Maximum iGRC population density (ppl/km²)	**Controlled ground area**	1	2	3	4	5
	< 25	3	4	5	6	7
	< 250	4	5	6	7	8
	< 2,500	5	6	7	8	9
	< 25,000	6	7	8	9	10
	< 250,000	7	8	9	10	11
	> 250,000	7	9	**Not part of SORA**		

M2

M1

Final GRC 4

Length: 2.2m

M1: reduction of the maximum value of population density at risk in the operational area + ground risk buffer

M2: reduction of the critical area (e.g. parachute)

Assessing the air risk (no change in SORA 2.5)

Step #4

Step #5

See also
SORA Annex C

See also
SORA Annex D

Step #6

Calculate the probability of encountering manned aircraft in the area of operation

If possible reduce the probability of encountering manned aircraft in the area of operation

Ensure that :

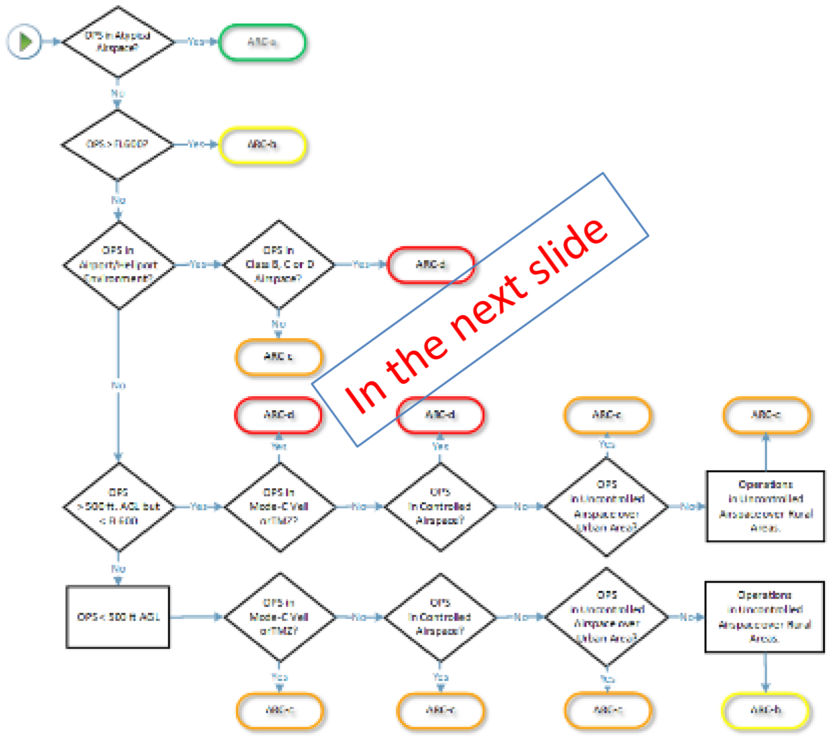
- remote pilot can detect presence of other traffic and have suitable procedures
- UA performances are sufficient to separate it from other traffic in case of encounter

SORA Step#4 Determination of the initial air risk class (ARC)

Outcome

(a) Identification of the probability to encounter a manned aircraft;

(b) Documentation of information and references used to determine the **initial ARC of the operational volume**.



4 air risk classes (ARC)

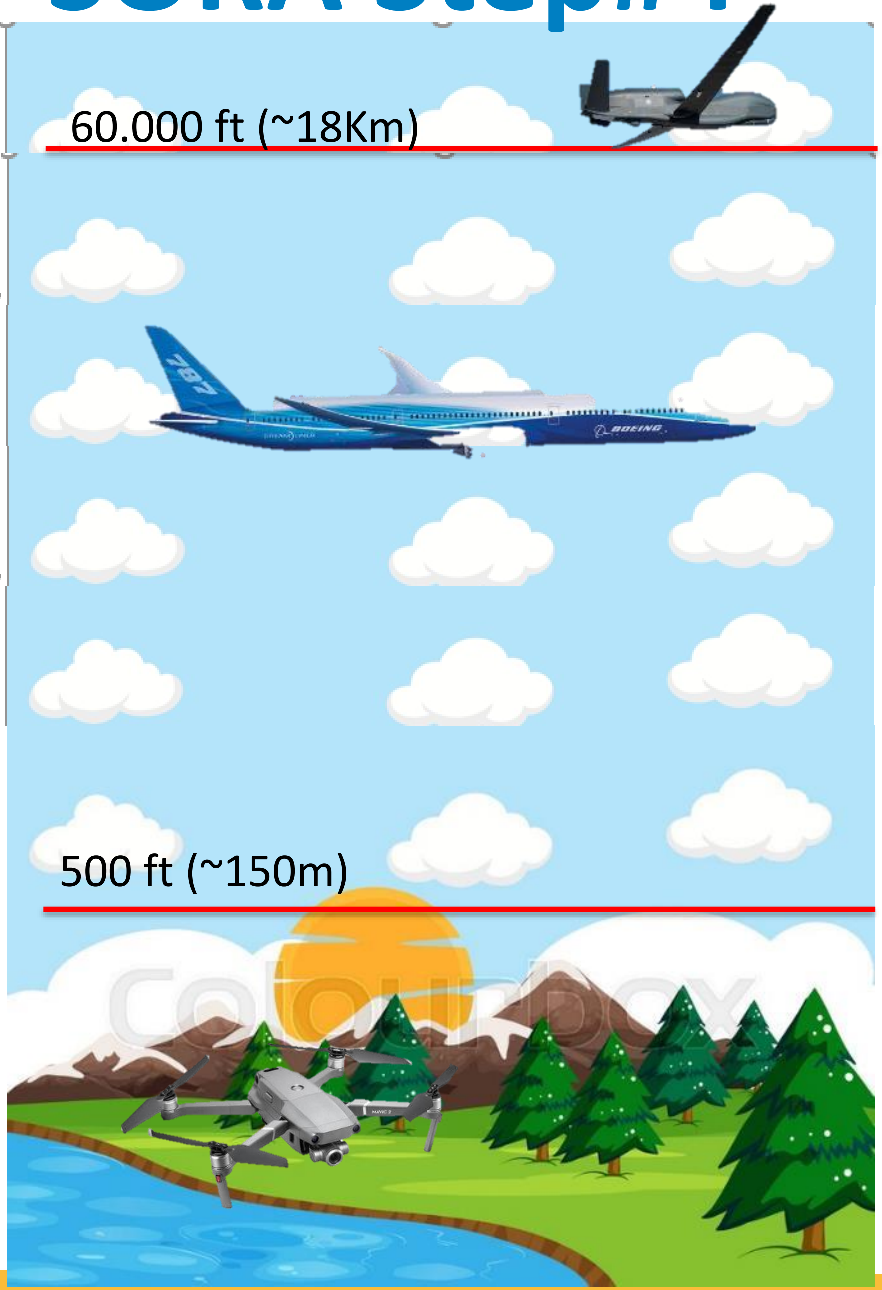
ARC a ← Negligible encounter rate

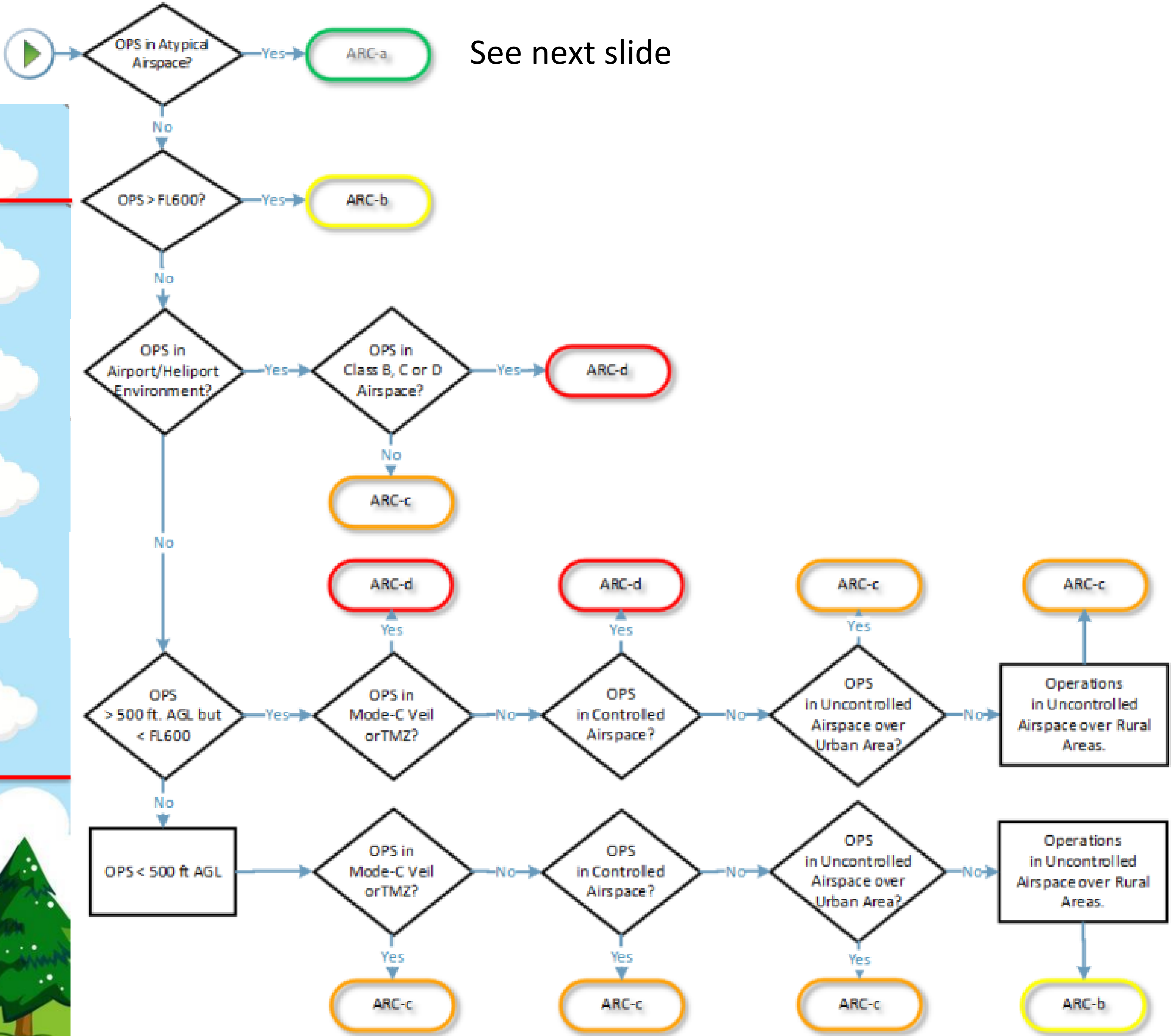
ARC b ← Low encounter rate

ARC c ← Medium encounter rate

ARC d ← High encounter rate

SORA Step#4





See next slide

What is the probability of encountering a manner aircraft?

Proximity of airport
Very high encounter rate
(ARC d)

Urban area
Medium encounter rate
even at low level
(ARC c)

Rural area
Medium encounter rate above 150m (ARC c),
lower below 150m (ARC b)

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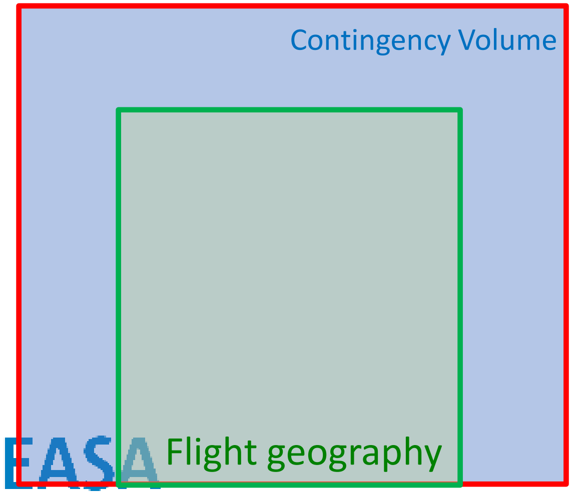
Arc A: Atypical airspace (SORA 2.5 definition)

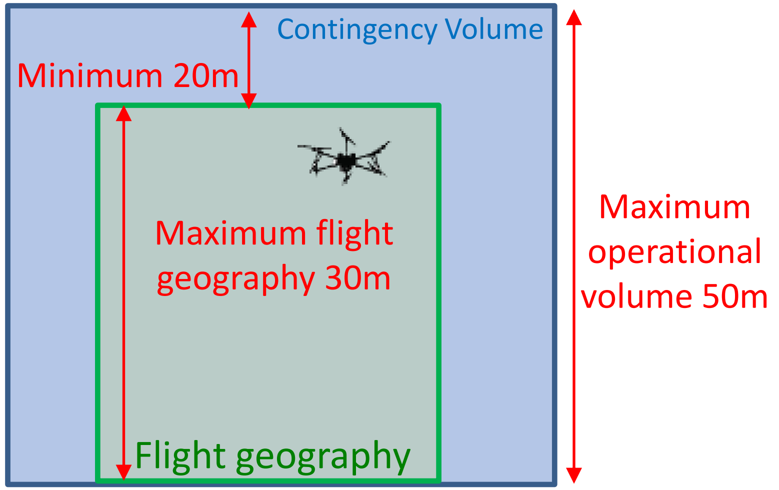
→ Negligible encounter rate

Examples:

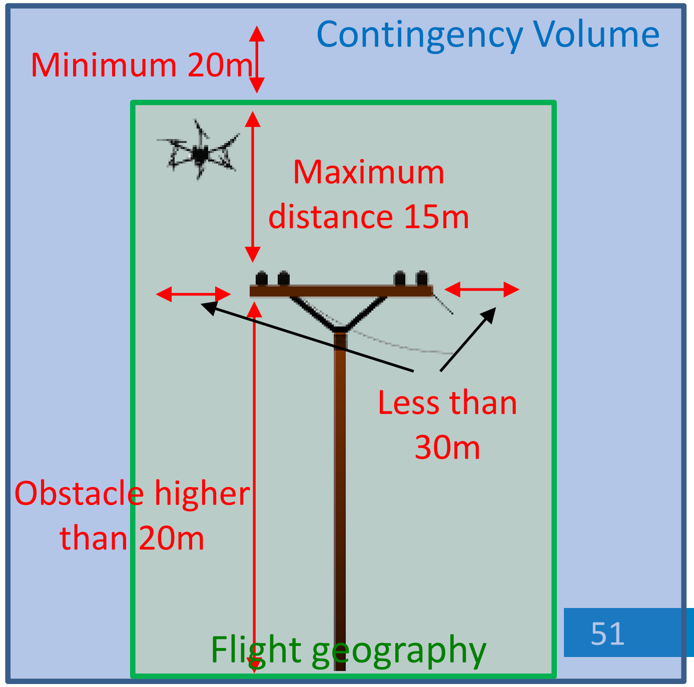
Temporary segregated volume



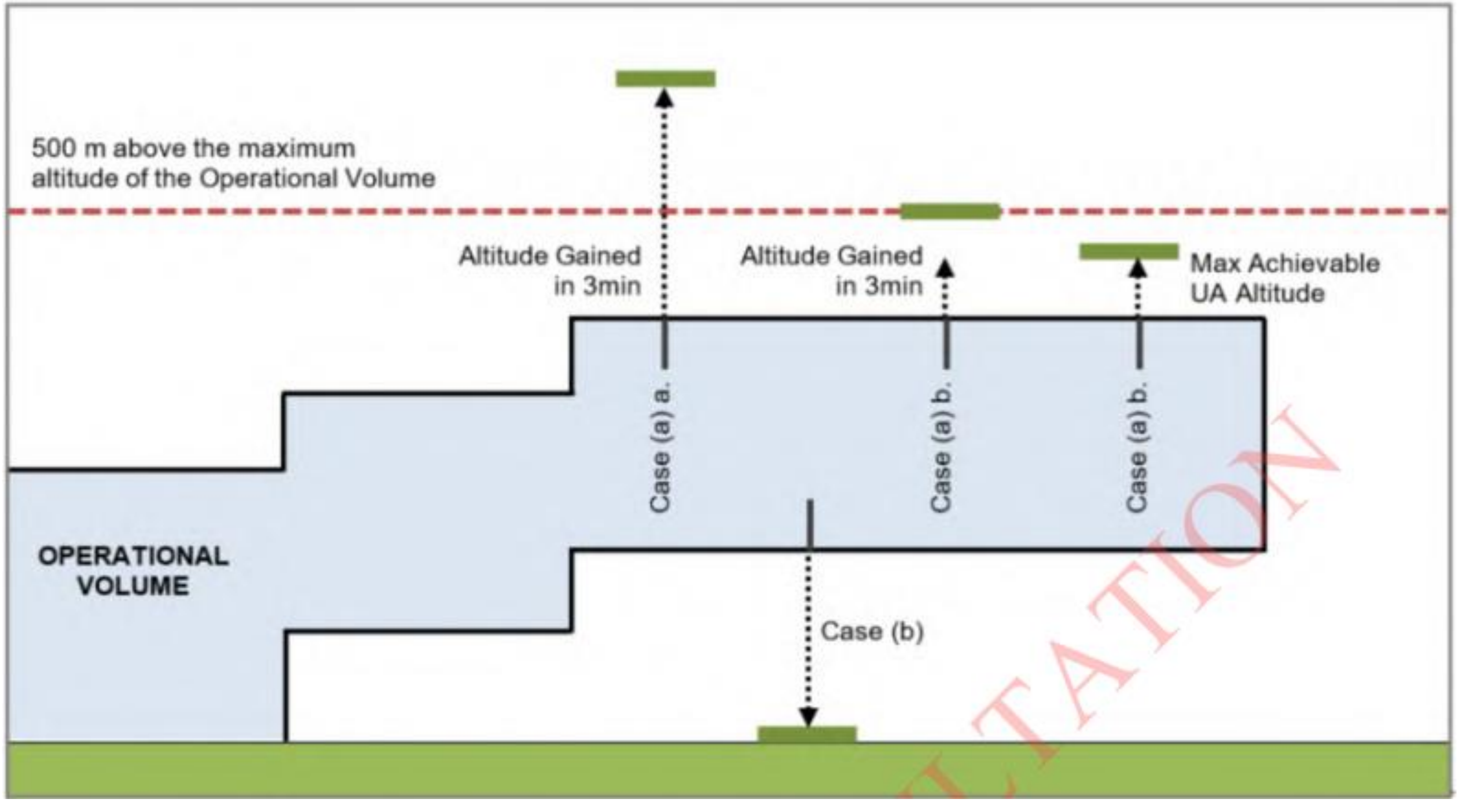
Very low level flights far from aerodromes



Flight shaded by obstacles

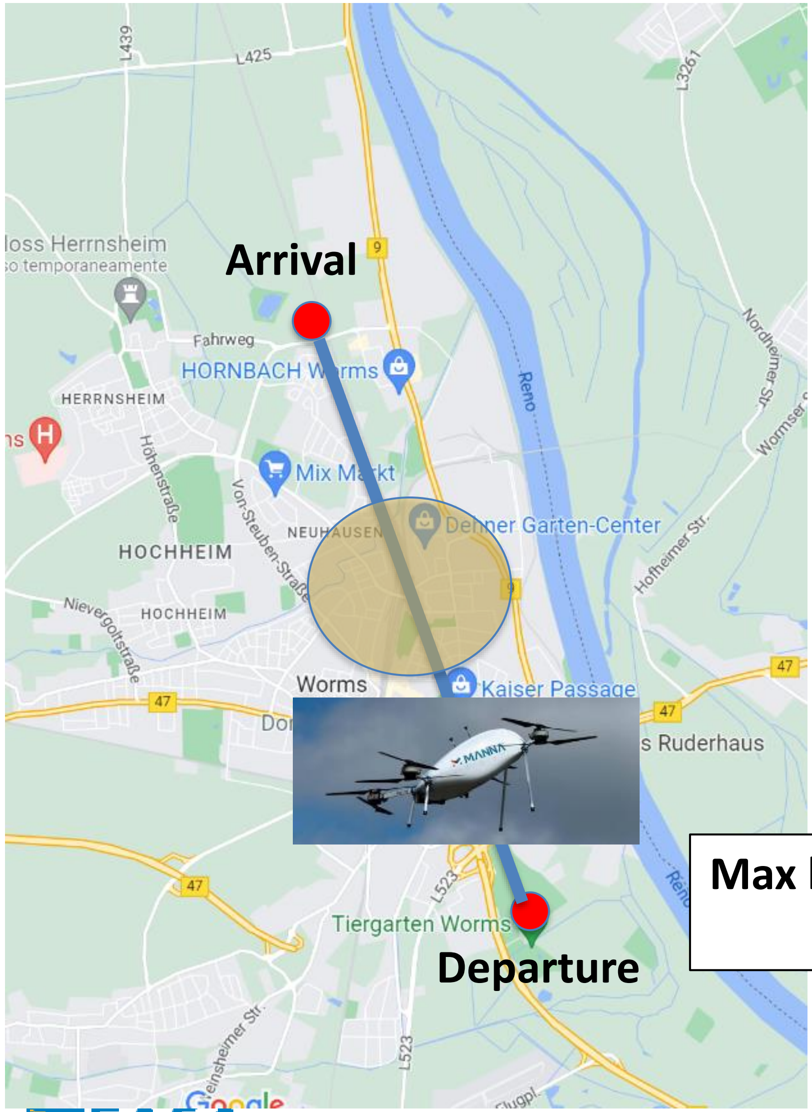


SORA 2.5: step #4 – Adjacent volume determination

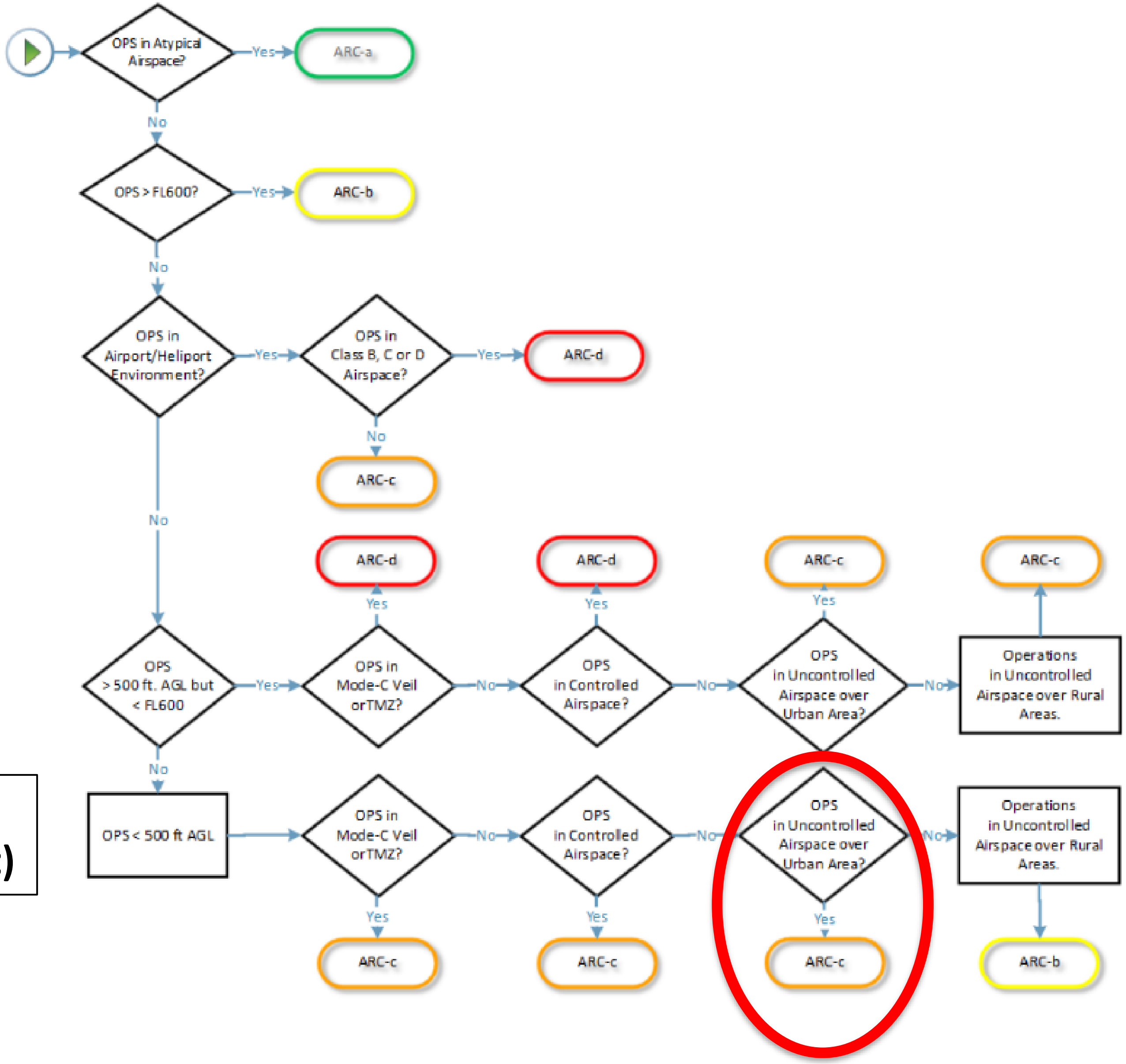


- → Height of adjacent volume:
  - → No less than 500m or
  - → altitude gained in 3 m
  - → Operational volume may also have a lower limit

SORA Step #4 – Determination of iARC



Max height 100m
(330 ft)



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SORA Step#5 - Application of strategic mitigations (optional)

Outcome

(a) Identification of the strategic mitigations applied to reduce the initial ARC in the operational volume.

(b) Identification of the residual ARC.

(c) Documentation of information and references used to support the application of strategic mitigations.

See Annex C for additional information

SORA Step #5 - #6 - Application of mitigations

Mitigations: **Strategic** vs **Tactical**

Strategic

Step #5 (optional)
(Annex C)

- Limit the UAS operation in a portion of airspace or during time when the probability to encounter another aircraft is lower OR
- Demonstrate that the probability to encounter a manned in the operational volume aircraft is lower than the one identified in the initial ARC

Determination of the residual ARC

Harmonisation among EU states needs to be improved

Tactical

Step #6
(Annex D)

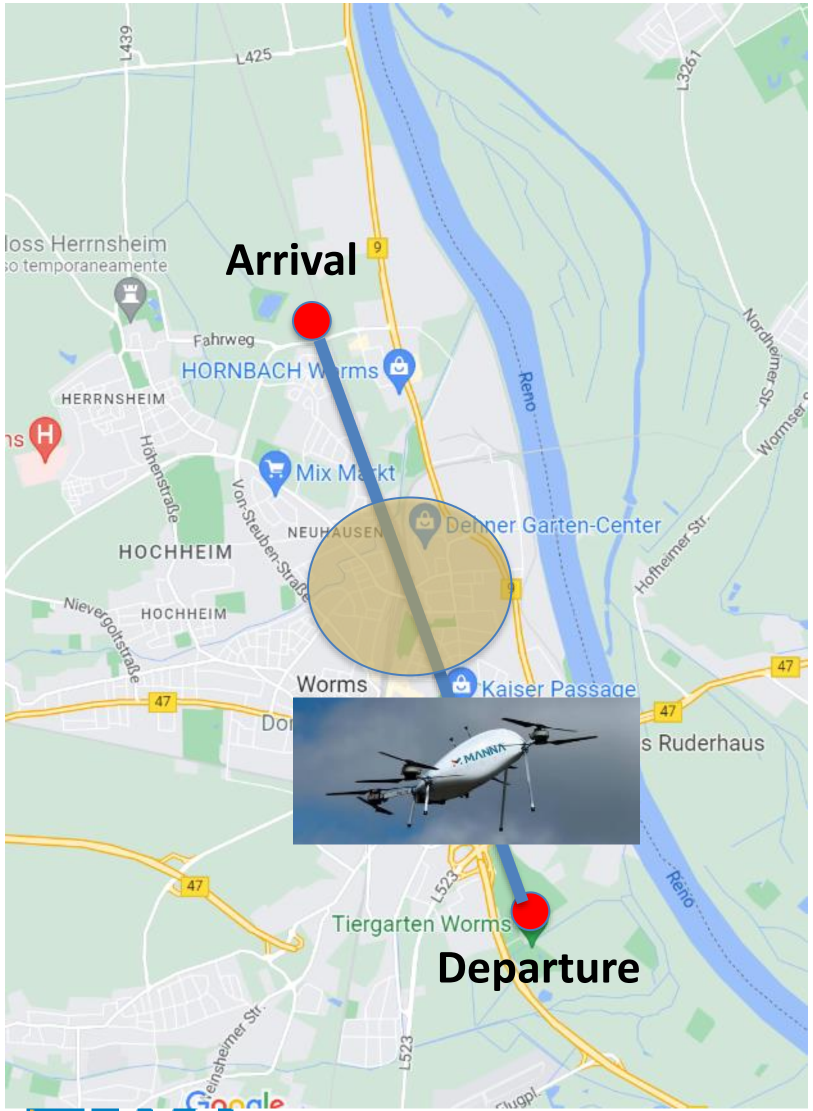
Once the residual ARC is defined, make sure that, in case of encounter another aircraft:

T M P R

- You are able to **detect** the presence of other aircraft
- Your procedures and training are good enough to enable the remote pilot to **decide** how to separate from the other aircraft
- Latency of the command and control link are sufficient to proper **command** the UA
- The drone's performance are good enough to **execute** the separation procedure
- You are able to understand the effectiveness of the action taken through a **feedback loop**

TMPR: Tactical mitigation performance requirements

SORA Step #5 – Strategic mitigations



Initial ARC c

How it is possible to reduce the ARC?

- Ask for a temporary segregated airspace → ARC a
- Conduct the operation during night when there may be less traffic → ARC b
- Use aerial observers to scan the sky
- Conduct the operation in VLOS (however the range will be drastically reduced). This can support the reduction of 1 ARC class (clarification in SORA 2.5)
- Contact the national aviation authority/ traffic service provider to gain data on the traffic in the area

SITUATION WILL CHANGE WHEN WE WILL HAVE AN ACCEPTABLE DETECT AND AVOID SYSTEM (DAA)

What is U-space?

WHY ?

- to enable airspace sharing between manned/unmanned aircraft
- **to ensure safe separation of manned aircraft and drones**
- **to ensure drones can fly safely in the airspace**
- to enable complex and long distance UAS operations (BVLOS)
- to enable Urban Air Mobility

All operations in the U-space are recommended to be classified as ARC b

Volume of airspace

Geographical zone designated by the Member State on the basis of a risk assessment and considering safety, security, environment and privacy

Set of services

Information exchange

DIGITAL- distribution of information and data based on connectivity and internet services

e-conspicuity

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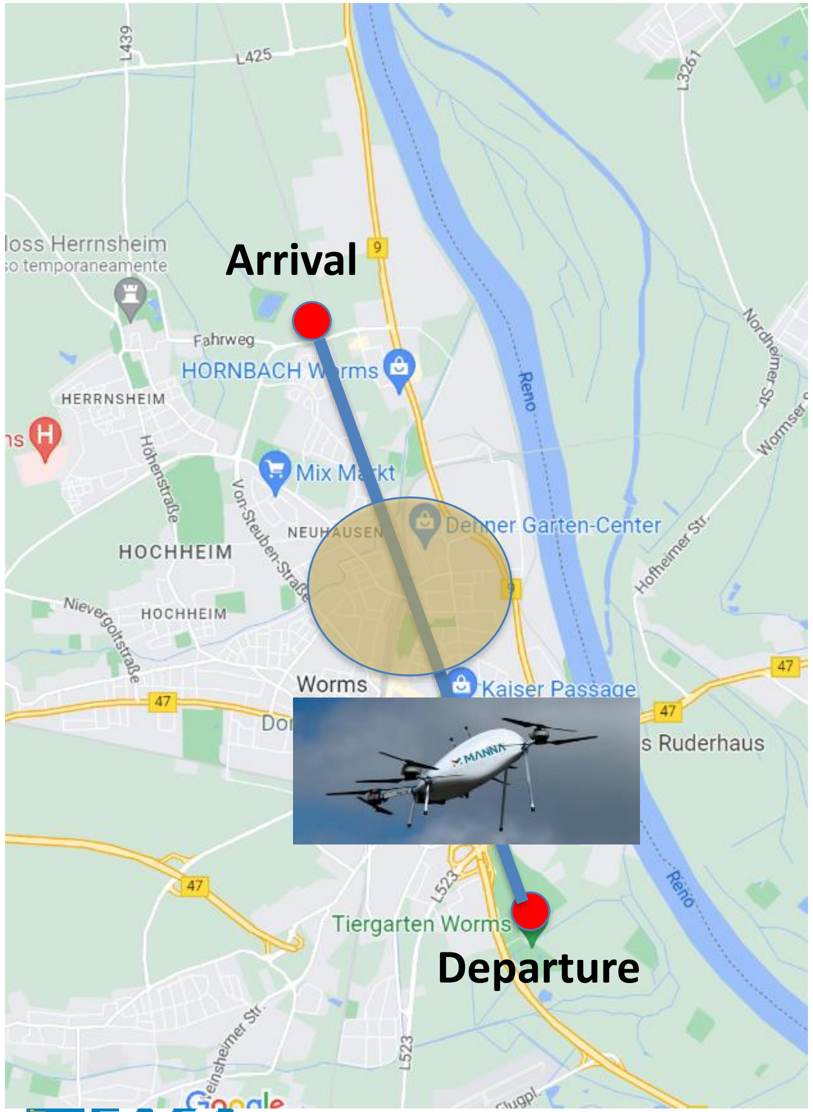
SORA Step #6 – TMPR



- Depending on the final ARC, demonstrate compliance with TMPRs with the applicable level of robustness

Residual ARC	TMPRs	TMPR level of robustness
ARC-d	High	High
ARC-c	Medium	Medium
ARC-b	Low	Low
ARC-a	No requirement	No requirement

Table 4 — TMPRs and TMPR level of robustness assignment

SORA Step#7 SAIL

Outcome

→ Identification of the SAIL.

Final GRC : 4
Residual ARC : b

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	"Certified Category"			

SAIL III

EASA

SORA 2.0 Step #8 OSO identification

Outcome

(a) Definition of the robustness associated to the OSOs

(b) Collection of information and references to be used to show compliance with the OSOs requirements.

→ The applicant is required to show compliance with 24 OSOs with the required Level of robustness (High, Medium or Low) depending on the SAIL

- ✓ UAS technical requirements
- ✓ Remote crew training and human errors
- ✓ Operation procedures
- ✓ Adverse operating conditions

SORA 2.0
Step #8

List of OSOs 1/2

Mandatory LUC

OSO number (in line with Annex E)		SAIL					
		I	II	III	IV	V	VI
	Technical issue with the UAS						
OSO#01	Ensure the UAS operator is competent and/or proven	O	L	M	H	H	H
OSO#02	UAS manufactured by competent and/or proven entity	O	O	L	M	H	H
OSO#03	UAS maintained by competent and/or proven entity	L	L	M	M	H	H
OSO#04	UAS developed to authority recognised design standards[1]	O	O	L	L	M	H
OSO#05	UAS is designed considering system safety and reliability	O	O	L	M	H	H
OSO#06	C3 link performance is appropriate for the operation	O	L	L	M	H	H
OSO#07	Inspection of the UAS (product inspection) to ensure consistency with the ConOps	L	L	M	M	H	H
OSO#08	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#09	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
OSO#10	Safe recovery from a technical issue	L	L	M	M	H	H
	Deterioration of external systems supporting UAS operations						
OSO#11	Procedures are in-place to handle the deterioration of external systems supporting UAS operations	L	M	H	H	H	H
OSO#12	The UAS is designed to manage the deterioration of external systems supporting UAS operations	L	L	M	M	H	H

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SORA 2.0
Step #8

List of OSOs 2/2

OSO number (in line with Annex E)		SAIL					
		I	II	III	IV	V	VI
OSO#13	External services supporting UAS operations are adequate for the operation	L	L	M	H	H	H
	Human error						
OSO#14	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#15	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
OSO#16	Multi-crew coordination	L	L	M	M	H	H
OSO#17	Remote crew is fit to operate	L	L	M	M	H	H
OSO#18	Automatic protection of the flight envelope from human error	O	O	L	M	H	H
OSO#19	Safe recovery from human error	O	O	L	M	M	H
OSO#20	A human factors evaluation has been performed and the human machine interface (HMI) found appropriate for the mission	O	L	L	M	M	H
	Adverse operating conditions						
OSO#21	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#22	The remote crew is trained to identify critical environmental conditions and to avoid them	L	L	M	M	M	H
OSO#23	Environmental conditions for safe operations are defined, measurable and adhered to	L	L	M	M	H	H
OSO#24	UAS is designed and qualified for adverse environmental conditions	O	O	M	H	H	H

ode: bvwlnb

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SORA 2.0 – Step 8 lesson learned

- Is it correct to assess OSOs in Step 8 and only after address containment in Step 9?
  - SORA 2.5: Step 8 (OSO) and Step 9 (containment) swapped
- Why we have 24 OSOs if in Annex E we have only 18?
  - SORA 2.5 list only 18 OSOs as in Annex E
- Which are under the responsibility of operators or manufacturers?
  - SORA 2.5 indicates for which OSOs evidences should be provided by manufacturers, which from operators
- Is the order in which the OSOs are shown the right one?
  - SORA 2.5: order of OSOs follows the order of topics of the operator manual

OSO table in SORA 2.5: renamed Step #9!

- → **No change in intent (text updated for clarification)**
- → Reflects Annex E (e.g. OSOs #8,11,14 and 21 are merged)
- → Reorganised to reflect the order used when developing an OM, according to Annex A

New OSO	Old OSO		SAIL						Operator	Remote pilot	Manufacturer
			I	II	III	IV	V	VI			
OSO# I	OSO#01	Ensure the UAS operator is competent and/or proven	NR	L	M	H	H	H	x		
OSO# II	OSO#02	UAS manufactured by competent and/or proven entity	NR	NR	L	M	H	H			x
OSO# III	OSO#17	Remote crew is fit to operate	L	L	M	M	H	H	x	x	
OSO# IV	OSO#08, #11, #14, #21	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H	x		
OSO# V	OSO#03	UAS maintained by competent and/or proven entity	L	L	M	M	H	H	Crit. 1 Crit. 2		Crit. 1
OSO# VI	OSO#07	Inspection of the UAS (product inspection) to ensure consistency with the ConOps	L	L	M	M	H	H	Crit. 1	Crit. 2	
OSO# VII	OSO#23	Environmental conditions for safe operations are defined, measurable and adhered to	L	L	M	M	H	H	Crit. 2	Crit. 3	Crit. 1
OSO# VIII	OSO#13	External services supporting UAS operations are adequate for the operation	L	L	M	H	H	H	x		
OSO# IX	OSO#16	Multi-crew coordination	L	L	M	M	H	H	Crit. 1 Crit. 3	Crit. 2	
OSO# X	OSO#09, #15, #22	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H		x	
OSO# XI	OSO#19	Safe recovery from human error	NR	NR	L	M	M	H	Crit. 1 Crit. 2	Crit. 2	Crit. 3
OSO# XII	OSO#04	UAS developed to authority recognised design standards	NR	NR	NR	L	M	H			x
OSO# XIII	OSO#05	UAS is designed considering system safety and reliability	NR	NR	L	M	H	H			x
OSO# XIV	OSO#18	Automatic protection of the flight envelope from human error	NR	NR	L	M	H	H			x
OSO# XV	OSO#20	A human factors evaluation has been performed and the human machine interface (HMI) found appropriate for the mission	NR	L	L	M	M	H			x
OSO# XVI	OSO#06	C3 link performance is appropriate for the operation	NR	L	L	M	H	H			x
OSO# XVII	OSO#24	UAS is designed and qualified for adverse environmental conditions	NR	NR	M	H	H	H			x
OSO# XVIII	OSO#10, #12	Safe recovery from a technical issue	L	L	M	M	H	H			x

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SORA Annex E – OSOs examples

TECHNICAL ISSUE WITH THE UAS		Level of integrity		
		Low	Medium	High
OSO #01 Ensure that the UAS operator is competent and/or proven	Criteria	The applicant is knowledgeable of the UAS being used and as a minimum has the following relevant operational procedures: checklists, maintenance, training, responsibilities, and associated duties.	Same as low. In addition, the applicant has an organisation appropriate[1] for the intended operation. Also, the applicant has a method to identify, assess, and mitigate the risks associated with flight operations. These should be consistent with the nature and extent of the operations specified.	Same as medium.
	Comments	*N/A*	*[1] For the purpose of this assessment, 'appropriate' should be interpreted as commensurate with/proportionate to the size of the organisation and the complexity of the operation.*	*N/A*

TECHNICAL ISSUE WITH THE UAS		Level of assurance		
		Low	Medium	High
OSO #01 Ensure that the UAS operator is competent and/or proven	Criteria	The elements delineated in the level of integrity are addressed in the ConOps.	Prior to the first operation, a competent third party performs an audit of the organisation	The applicant holds an organisational operating certificate or has a recognised flight test organisation. In addition, a competent third party recurrently verifies the UAS operator's competences.
	Comments	*N/A*	*N/A*	*N/A*

For each OSO and for each level of integrity, EASA will identify acceptable industry standards or means of compliance

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Annex E: changes in SORA 2.5

- Introduced the possibility to use operational experience to show compliance for the design related OSOs up to SAIL III (using the EASA Functional Test based MoC or FAA Durability & Reliability

SAILs vs Requirements

	Low intrinsic risk	Medium intrinsic risk	High intrinsic risk
	SAIL I and II	SAIL III and IV	SAIL V and VI
	CE Or declaration	Design verification report or declaration	Part 21
Organisation:	SAIL I and II Development of Ops procedures	SAIL III Organisation appropriate for intended ops.	SAIL IV, V and VI LUC or other equivalent certificate required
	SAIL I and II Self declared training	SAIL III and IV Training syllabus available	SAIL V and VI Training provided by third party (e.g. training organisation)

European Aviation Safety Agency

Design verification report

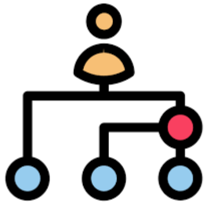
European Aviation Safety Agency

TYPE CERTIFICATE

EASA.E.210

This Type Certificate is issued by EASA, acting in accordance with Regulation ... No. 216/2... on behalf of the European Community, its Member States and of the European ... countries that participate in the activities of EASA under Article 66 of that Regulation and ... accordance with Commission Regulation (EC) No. 748/2012 to

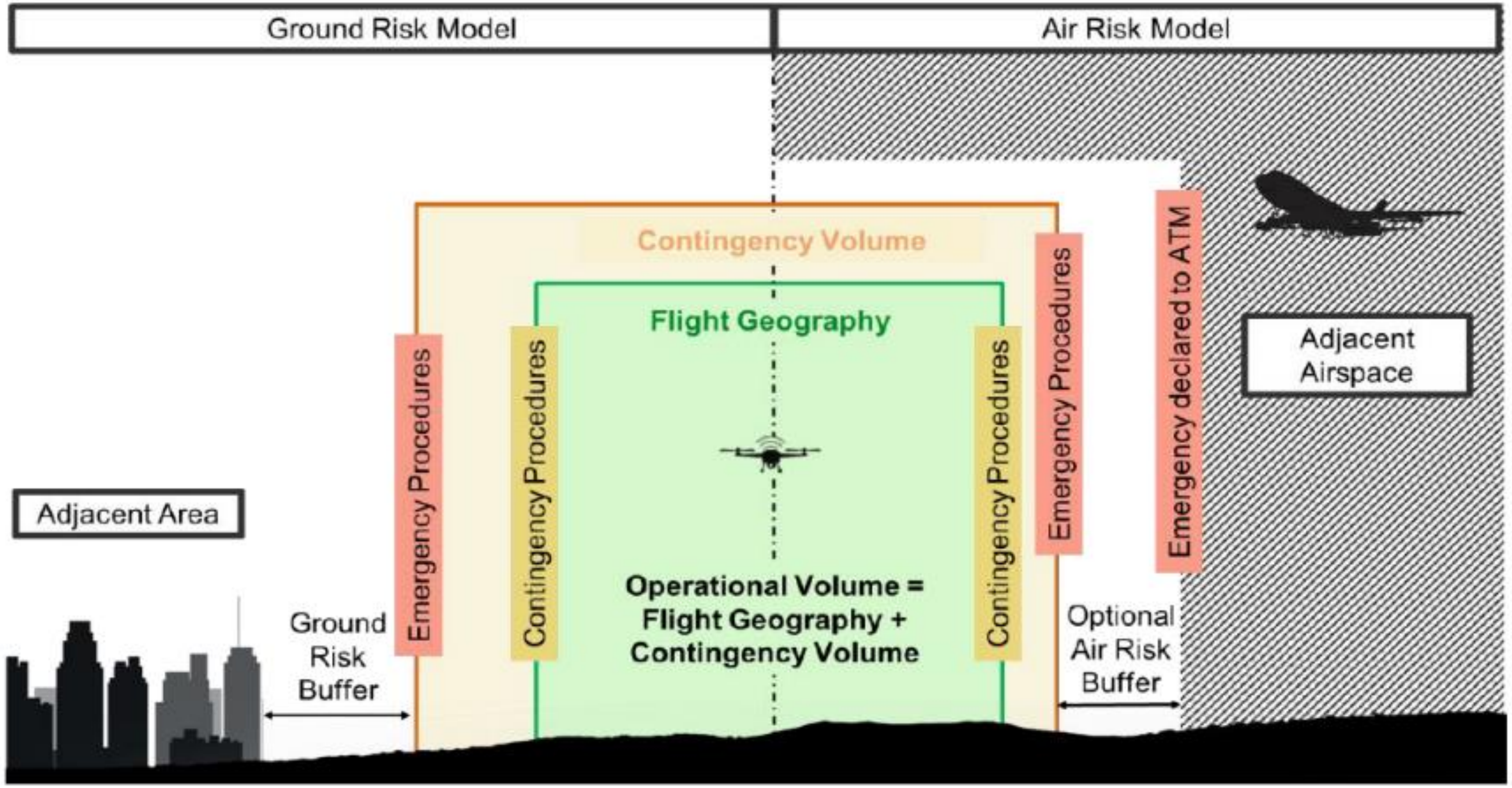
and certifies that the product type design listed below comp... with the applicable Type Certification Basis and environmental protection requirements when ...



SORA 2.0 Step #9

Adjacent Area/Airspace Considerations

- → Step #2 to step #8: assess risk and ensure safety in the operational volume
- → Step #9: assess risk and ensure safety in the adjacent volume



SORA 2.0 Step #9 - Requirements

→ **If the adjacent volume contains**:

(i) assemblies of people, unless the UAS is already approved for operations over assemblies of people; or

(ii) ARC-d unless the residual ARC of the airspace area within the operational volume is already ARC-d;

→ or if the operational volume is in a populated area where:

(i) M1 mitigation has been applied to lower the GRC; or

(ii) operating in a controlled ground area.

Enhanced containment

The probability of the UA leaving the operational volume should be less than 10-4/FH; and no single failure.

Declaration ← Procedures

UAS Design

Or

Declaration ← EASA MoC 2511

DVR

Applicable only in some cases

SORA 2.0 Step #9 - Requirements

→ In all other cases

Basic containment

No probable failure of the UAS or any external system supporting the operation should lead to operation outside the operational volume.

Declaration for :
- adequate procedures and
- using a UAS with no probable failure to exit the operational volume

Some drones with a system to terminate the flight qualifies for basic containment. Since it is not independent, it does not qualify for enhanced containment

SORA 2.0 Step #9 – Lesson learned

- Identification of the size of the adjacent volume not defined
  - SORA 2.5: adjacent area size included in step #2 and adjacent airspace size included in Step #4
- Triggering of the basic/enhanced containment not clear
  - SORA 2.5: triggering rewritten
- Enhanced containment triggering some time too conservative
  - SORA 2.5: different levels of containment identified

SORA 2.5 containment

→ New structure

- → Identification of size of adjacent area (ground risk) included in Step #2
- → Identification of size of adjacent volume (air risk) included in Step #3
- → Definition of the containment requirement in step 8

SORA 2.0	SORA 2.5
Step #1 – CONOPS	Step #1 – Operation description
Step #2 – iGRC	Step #2 – iGRC
Step #3 – Final GRC	Step #3 – Final GRC
Step #4 – iARC	Step #4 – iARC
Step #5 – Residual ARC	Step #5 – Residual ARC
Step #6 – TMPR	Step #6 – TMPR
Step #7 – SAIL	Step #7 – SAIL
Step #8 – OSO	Step #8 – Containment
Step #9 – Containment	Step #9 – OSO
Step #10 – Comprehensive portfolio	Step #10 – Comprehensive portfolio

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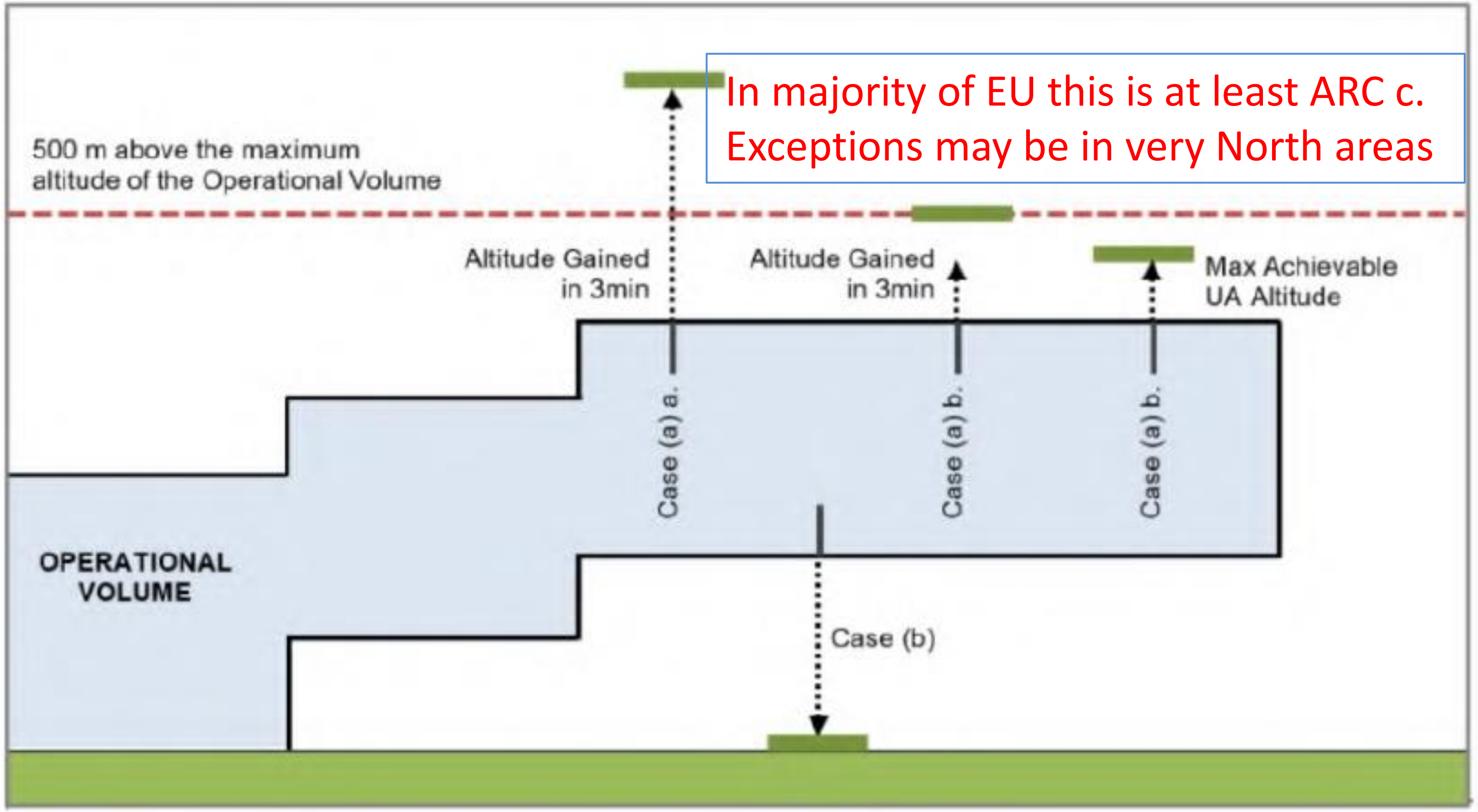
SORA 2.5 Step #8 - Containment

- 5 levels
  - None
  - Low (equal to basic containment of SORA 2.0)
  - Medium (equivalent to MoC SC Light UAS 2511)
  - High (equal to enhanced containment of SORA 2.0)
  - Consult (for corner cases)

None in EU will be only applicable for SAIL V and VI operations

The last 2 levels will be applicable for exceptional cases

SORA 2.5 containment – air risk



Highest Adjacent Airspace	SAIL I, II, III, IV	SAIL V, VI
ARC-a or ARC-b	None	None
ARC-c or ARC-d	Low	None

Not applicable in majority of EU

SORA 2.5 containment

Ground risk

- Assess the GRC of the adjacent area considering the **AVERAGE POPULATION DENSITY**
- Mitigations might be applied to reduce the GRC of the adjacent area.
  - M1 for using the assumption of sheltering;
  - M2 mitigations based on passive designs or inherent UA characteristics, like frangibility, may be used to lower the adjacent area intrinsic GRC.
  - M2 mitigations like parachutes or special descent maneuver may not be used by default.

SORA 2.5 containment

Adjacent area final GRC	SAIL					
	I	II	III	IV	V	VI
≤3	N					
4	L	N				
5	L[1]	L	N			
6	M	M	L	N		
7	H	H	M	L	N	
8	C	C	C	M	L	N
9				C	M	L
10					C	M

This is how in reality the table will look like in EU for majority of cases

SORA 2.5 containment

Adjacent area final GRC	SAIL					
	I	II	III	IV	V	VI
≤3	L	L	L	L		
4	L	L	L	L		
5	L	L	L	L		
6	M	M	L	L		
7			M	L	N	
8				M	L	N
9					M	L
10					C	M

Due to the air risk in EU this will be Low

These are corner cases

This is how in reality the table will look like in EU for majority of cases

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SORA 2.5 containment

Adjacent area final GRC	SAIL					
	I	II	III	IV	V	VI
≤3	L	L	L	L		
4	L	L	L	L		
5	L	L	L	L		
6	M	M	L	L		
7			M	L	N	
8				M	L	N
9					M	L
10					C	M

Due to the air risk in EU this will be Low

These are corner cases

This is how in reality the table will look like in EU for majority of cases

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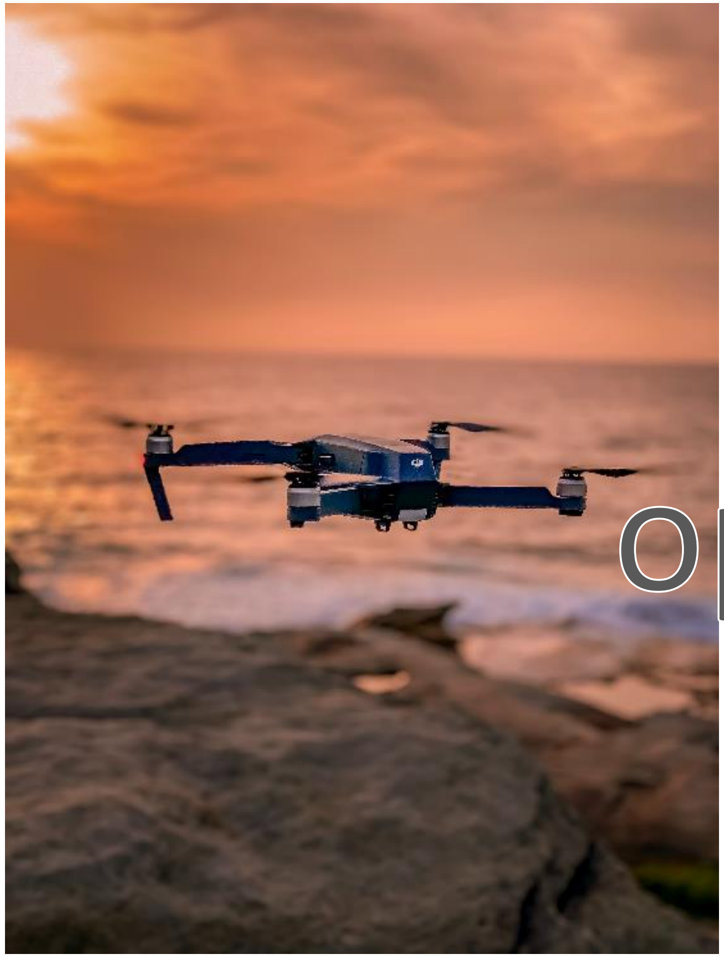
SORA Step #10

→ Comprehensive Safety Portfolio

To be provided
to the NAA

EASA



The applicant is now ready to apply for an operational authorisation and become a UAS operator!

European Union Aviation Safety Agency

Your safety is our mission.

An Agency of the European Union

What is a UAS operation in the specific category?

- A UAS operation is a flight activity performed by a UAS operator using a drone, covered by one operational authorisation.
- It may consist in one or multiple flights, even in different locations and with different purposes.
- Flights belong to the same operation as long as they are conducted:
  - with a drone with similar characteristics
  - in areas having same or lower final GRC and residual ARC
  - Applying the same mitigations (unless final GRC and residual ARC may be reached without mitigations)

SORA Step#3 – M1 strategic mitigation

Ground risk buffer

Contingency volume

Flight geography

Contingency volume

Ground risk buffer

Modify the flight path to reduce the population density exposed to risk

EASA