

SORA – En metod för riskanalys inom UAS

Seminarium AOC helikopter och Specialiserad flygverksamhet
(SPO) flygplan och helikopter

2023-11-22

Transportstyrelsen och sektionen för Helikopter & Allmänflyg
Tobias Fridarve

Innehåll

- När blir UAS-verksamheten tillståndspliktig?
- Riskanalys enligt SORA (Specific Operations Risk Assessment)

Regler

INCORPORATED AMENDMENTS

IMPLEMENTING RULES (IRs) (COMMISSION REGULATIONS)

Incorporated Commission Regulation	Regulation amendment	Applicability date ¹
Regulation (EU) 2019/947	Initial issue	31/12/2020
Regulation (EU) 2020/639	Amendment 1	2/6/2020
Regulation (EU) 2020/746	Amendment 2	6/6/2020
Regulation (EU) 2021/1166	Amendment 3	5/8/2021
Regulation (EU) 2022/425	Amendment 4	4/4/2022

DELEGATED RULES (DRs) (COMMISSION REGULATIONS)

Incorporated Commission Regulation	Regulation amendment	Applicability date
Regulation (EU) 2019/945	Initial issue	1/7/2019
Regulation (EU) 2020/1058	Amendment 1	9/8/2020

AMC & GM TO IRs (ED DECISIONS)

Incorporated ED Decisions	AMC/GM Issue No, Amendment No	Applicability date
ED Decision 2019/021/R	Issue 1	11/10/2019
ED Decision 2020/022/R	Issue 1, Amendment 1	18/12/2020
ED Decision 2022/002/R	Issue 1, Amendment 2	10/2/2022

Note: To access the official versions, please click on the hyperlinks provided above.

EU-regler för UAS började gälla
1 januari 2021



JARUS
Joint Authorities
for Rulemaking
on Unmanned
Systems



Drönarflygning delas i tre kategorier beroende på flygningens risknivå

Öppen Låg risk



- CE märkt drönare
- C-klassad drönare
- Lägre än 120m
- Under 25kg
- Inom synhåll (VLOS)
- Inte flyga på ett sätt som utgör en risk för andra luftfartyg, människor, djur, miljö eller egendom.
- Avstånds begränsad i förhållande till personer som inte är involverade i flygningen

Specifik Medelrisk Tillståndspliktig



Högre än 120m

Över människor



Utom synhåll



Certifierad Hög risk Tillståndspliktig



TAXI

passagerare



>3m eller 34kj
& Över
folksamling



Farligt gods

När blir UAS-verksamheten tillståndspliktig?

När man inte längre kan flyga enligt den öppna kategori, t.ex.:

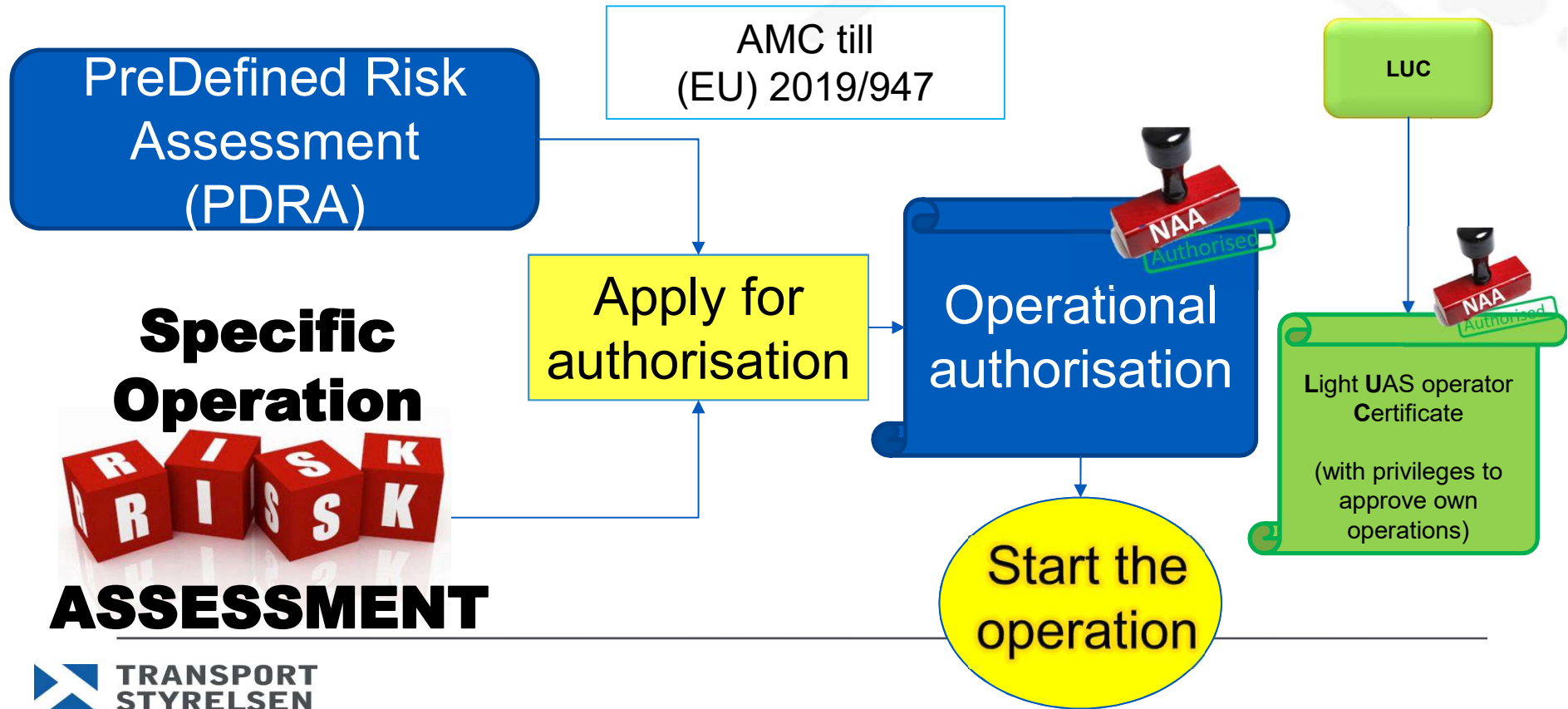
- När man flyger utom synhåll
- När man flyger högre än 120 m
- När man släpper föremål från luften
- När drönaren är tyngre än 25 kg
- När man flyger på avstånd mindre än 150 m där folk kan finnas med drönare över 4 kg
- När man flyger över människor med drönare över 900 g

Specifika



**Tillstånd i den specifika kategorin ges av Transportstyrelsen
baserat på en riskanalys**

Specifika kategorin



SORA – Riskanalys enligt tio steg

- Steg #1 Concept of Operation (ConOps) / “Operation description” enligt SORA 2.5
- Steg #2 Determination of the intrinsic UAS ground risk class (GRC)
- Steg #3 Final GRC determination
- Steg #4 Air risk assessment
- Steg #5 Air risk classification and strategic mitigations
- Steg #6 Tactical mitigation performance requirement (TMPR) and robustness levels
- Steg #7 SAIL determination
- Steg #8 Identification of Operational Safety Objectives (OSOs)
- Steg #9 Adjacent area/airspace considerations
- Steg #10 Comprehensive safety portfolio (Compliance with mitigations and OSOs)

Samordning internt hos Transportstyrelsen gällande de delar som berör luftrummet (steg #4-6)

- Sektionen för helikopter och allmänflyg (Sloh)
- **Sektionen för luftrum och flygplatser (SLia)**

Steg #1

Concept of Operation (ConOps)

‘Operation description’
(SORA 2.5)

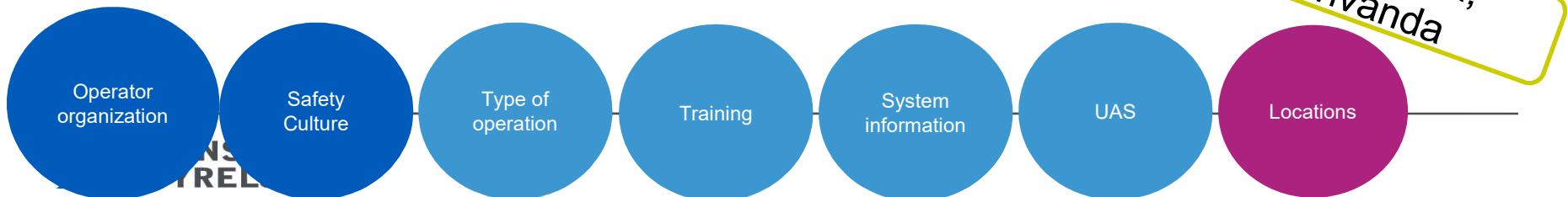
CONOPS beskrivning

- ✓ Den sökande beskriver relevant information om system, tekniska delar och operativa procedurer som behövs för att bedöma risken i samband med den avsedda operationen.
- ✓ Det är grunden för alla andra aktiviteter.

Vad du vill göra, vart du vill flyga,
vilken UAS tänker du använda

Resultat

- ✓ Beskrivning av den avsedda operationen.

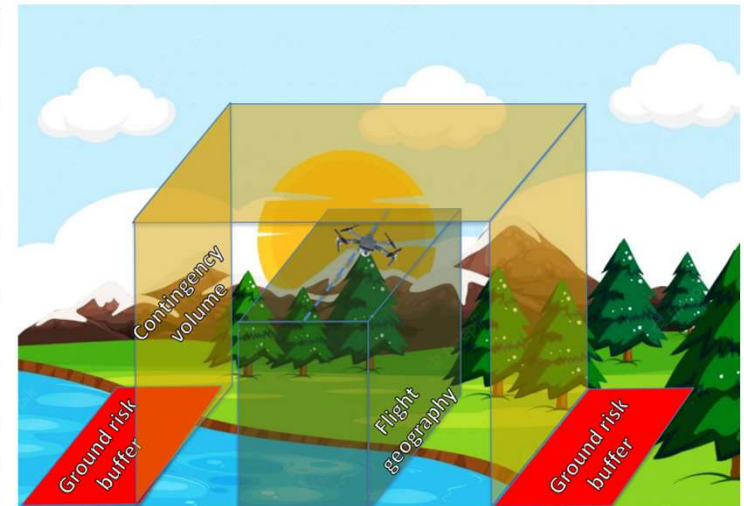


Step #2

Determination of the intrinsic UAS Ground Risk Class (iGRC)

Max UAS characteristics dimension	Intrinsic UAS ground risk class			
	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			
BVLOS over an assembly of people	8			

Table 2 — Determination of the intrinsic GRC



iGRC = 5

Steg #3

Final GRC determination

iGRC = 5

Mitigation Sequence	Mitigations for ground risk	Robustness		
		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

Table 3 — Mitigations for final GRC determination

	Intrinsic UAS ground risk class			
	1 m / approx. 3 ft	3 m / approx. 10 ft	8 m / approx. 25 ft	>8 m / approx. 25 ft
Max UAS characteristics dimension	< 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)
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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			
BVLOS over an assembly of people	8			

Table 2 — Determination of the intrinsic GRC

- M1: minskning av maxvärdet på befolkningstäthet i det operativa området (verksamhetsområde + markrisikbuffert)
- M2: minskning av det kritiska området (t.ex. fallskärm)
- M3: ERP (Emergency Response Plan)

Final GRC = 3
(5-1-1=3)

Steg #3 (mitigeringar)

Exempel M2 (fallskärm)

				M2		
Criteria	Required robustness	Requirement	Criterion description	Reference	Motivation	Text in manual
Criterion #1 (Technical design)	Medium	Integrity	(a) Effects of impact dynamics and post impact hazards ¹ are significantly reduced although it can be assumed that a fatality may still occur. (b) When applicable, in case of malfunctions, failures or any combinations thereof that may lead to a crash, the UAS contains all the elements required for the activation of the mitigation. (c) When applicable, any failure or malfunction of the proposed mitigation itself (e.g. inadvertent activation) does not adversely affect the safety of the operation.			
Criterion #1 (Technical design)	Medium	Integrity Comment	<i>1 Examples of post impact hazards include fires and the release of high-energy parts.</i>			
Criterion #1 (Technical design)	Medium	Assurance	The applicant has supporting evidence to claim that the required level of integrity is achieved. This is typically ² done by means of testing, analysis, simulation ³ , inspection, design review or through operational experience.			
Criterion #1 (Technical design)	Medium	Assurance Comment	<i>2 The use of industry standards is encouraged when developing mitigations used to reduce the effect of ground impact. 3 When simulation is used, the validity of the targeted environment used in the simulation needs to be justified.</i>			
Criterion #2 (Procedures, if applicable)	Medium	Integrity	Any equipment used to reduce the effect of the UA impact dynamics is installed and maintained in accordance with the manufacturer's instructions. ⁴			

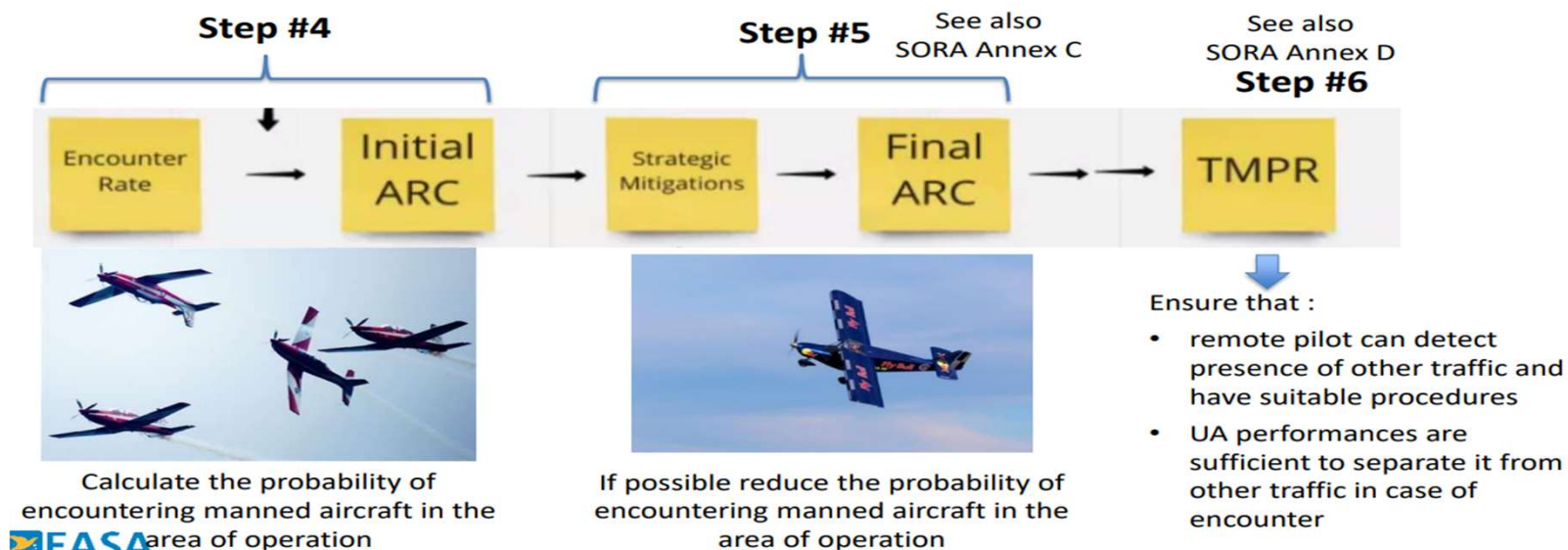
Valj nivå på robustness

Beskrivning av VAD som ska uppvisas

Beskrivning av nivån på det som ska uppvisas (deklaration, stödande bevis, ...)

Steg #4, #5 och #6

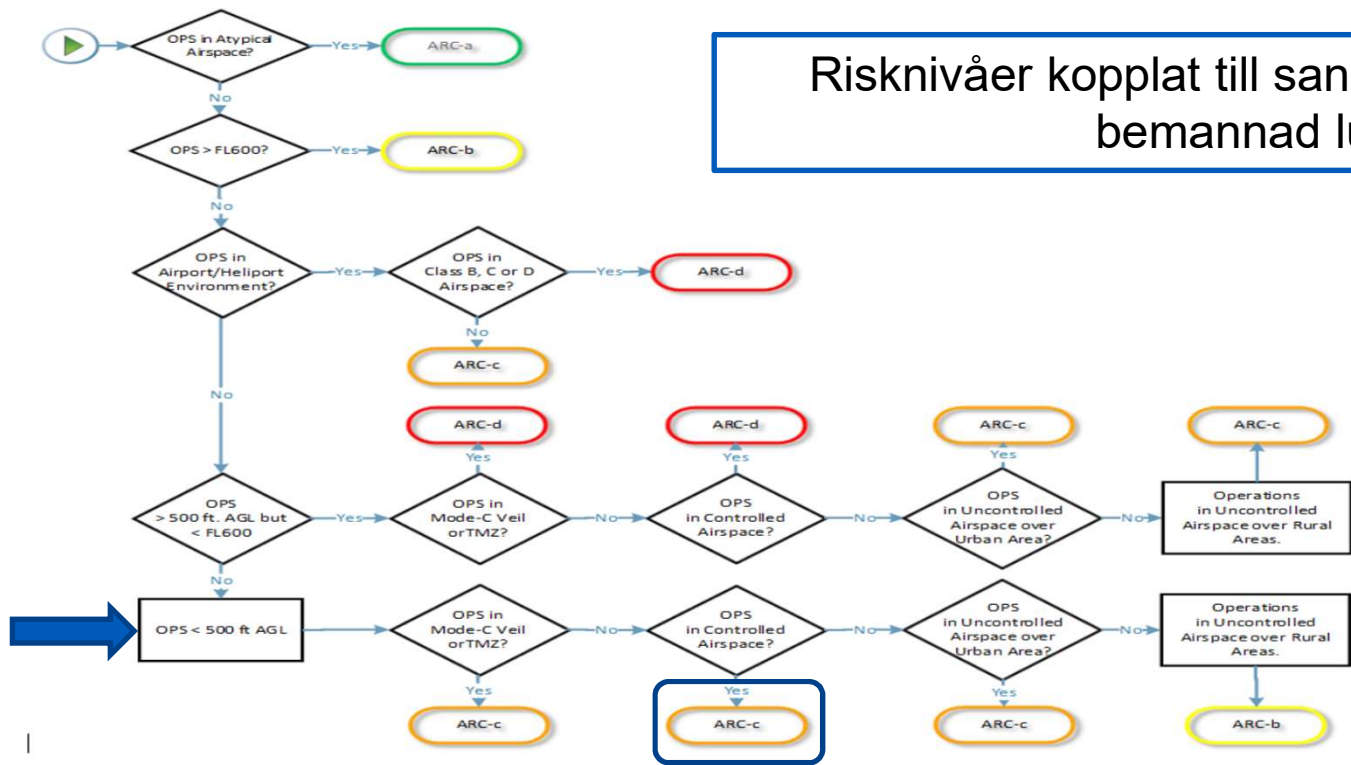
Air risk assessment - Air risk classification and strategic mitigations - Tactical mitigation performance requirement (TMPR) and robustness levels



Steg #4 Initial Air Risk Class

Initial Air Risk Class (iARC)

Riskenivåer kopplat till sannolikheten att möta bemannad luftfart



Steg #5 Strategic mitigations

Steg #6 Tactical mitigations

Strategisk mitigering kan vara:

- Upprätta avtal med ATS om att upprätta en sektor
- Flyga lågt
- Flyga en viss tid

Strategic mitigations are applied before take off and reduce the risk of an encounter

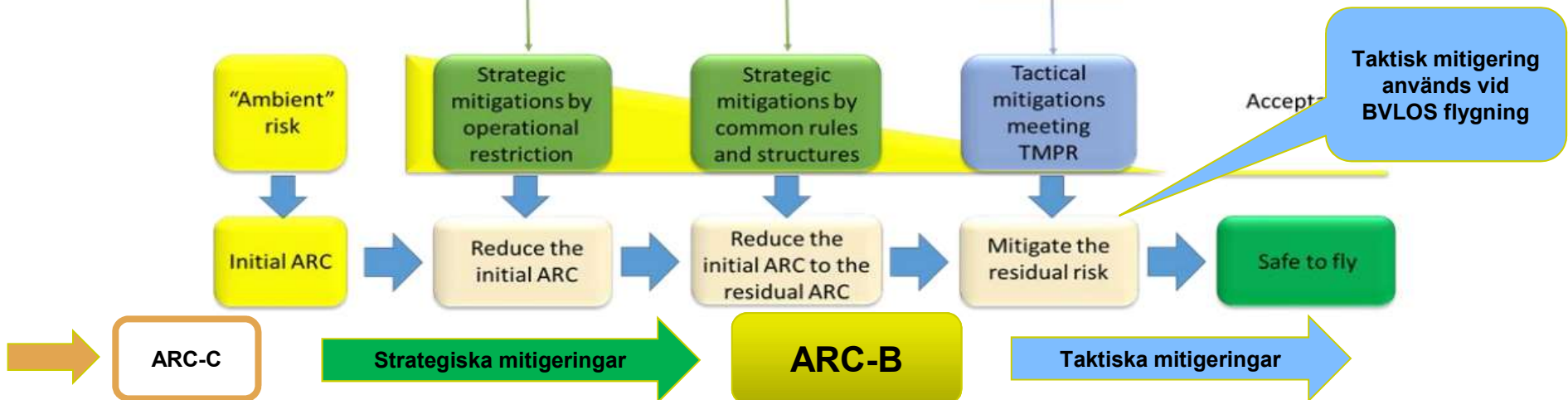
Strategic mitigations under operator's control

Strategic mitigations not under operator's control

Tactical mitigations are applied after take off and reduce the risk of an encounter evolving into an NMAC*

Taktisk mitigering kan vara:

- Flyga VLOS
- Begära klarering
- System för att se andra luftfartyg



Steg #7 SAIL determination

Safety Assurance Integrity Level

ARC-B

Final GRC = 3

Final GRC	Residual ARC			
	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	Certifierade kategorin			

SAIL II

Step #8 Operational Safety Objectives (OSOs)

Identification of Operational Safety Objectives (OSOs)

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

Optional
Low
Medium
High

- **Technical issue with the UAS**
OSO #1-10
- **Deterioration of external systems supporting UAS operations**
OSO #11-13
- **Human error**
OSO #14-20
- **Adverse operating conditions**
OSO #21-24

Steg #8 Operational Safety Objectives (OSOs)

Exempel OSO #3 UAS maintained by competent and/or proven entity

OSO	Criteria	Required robustness	Criterion description	Operatör			Compliant Y/N	TS TS Comment
				Reference	Motivation	Text in manual		
OSO #03	TECHNICAL ISSUE WITH THE UAS			OSO #03 UAS maintained by competent and/or proven entity				
OSO #03				Integrity requirements				
OSO #03		Low	(a) The UAS maintenance instructions are defined, and, when applicable, cover the UAS designer's instructions and requirements.					
OSO #03			(b) The maintenance staff is competent and has received an authorisation to carry out UAS maintenance.					
OSO #03			(c) The maintenance staff use the UAS maintenance instructions while performing maintenance.					
OSO #03				Assurance requirements				
OSO #03	Criterion #1 Procedure	Low	(a) The maintenance instructions are documented					
OSO #03			(b) The maintenance conducted on the UAS is recorded in a maintenance log system.					
OSO #03			(c) A list of the maintenance staff authorised to carry out maintenance is established and kept up to date.					
OSO #03	Criterion #2 Training	Low	A record of all the relevant qualifications, experience and/or training completed by the maintenance staff is established and kept up to date.					
OSO #03								

Beskrivning av VAD som ska uppvisas

Beskrivning av nivån på det som ska uppvisas (deklaration, stödande bevis,...)

Steg #9 Adjacent area/airspace considerations

Adjacent area/airspace considerations

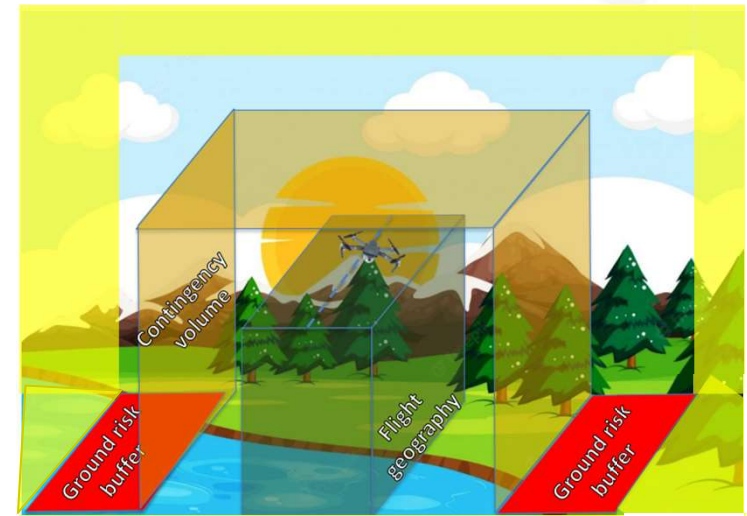
Steg #2 till steg #8

Omhändertar riskerna för att garantera säkerhet i den **operativa volymen**

Steg #9

Omhändertar riskerna för att garantera säkerhet för den **angränsande volymen**

**Enhanced eller Basic
Containment**



Steg #9 – Enhanced Containment



- 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



Ska vara ett oberoende system

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

Applicable only in some cases

DVR

Steg #9 – Basic containment

→ 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

Steg #10 Comprehensive safety portfolio

Comprehensive safety portfolio
(Compliance with mitigations and OSOs)

- Den samlade dokumentationen som uppvisar omhändertagandet av operationen till den nivå som framkommit vid den genomförda riskanalysen (mitigeringar, OSOs,...)

PDRA - Ansökan

Application process in case of PDRA

Topic	Level of Assurance	PDRA provision	Compliance	Assurance
Level of human intervention	Low	1.1 No autonomous operations: the remote pilot should have the ability to maintain control of the UA, except in case of loss of the command and control (C2) link.	N/A	I declare that the UAS always allow the remote pilot to take control of the UA
	low	1.2 The remote pilot should operate only one UA at a time.	Operation manual at para xx indicates that remote pilot operates only one UA at a time	I declare....
	medium	1.3 The remote pilot should not operate from a moving vehicle.	Operation manual at para xx indicates that remote pilot cannot operate from a moving vehicle	I declare.... evidence can be found in appendix y to this document
	low	1.4 The remote pilot should not hand over the control of the UA to another command unit.	...	I declare....
UA range limit	Low	1.5 Launch/recovery: at VLOS distance from the remote pilot, if not operating from a safe prepared area. Note: "safe prepared area" means a controlled ground area that is suitable for the safe launch/recovery of the UA.	I declare....
	Low	1.6 in flight: 1.6.1 If no AOs are employed: the UA is not operated further than 1 km (or other distance defined by the competent authority) from the remote pilot. Note: The remote pilot's workload should allow the remote pilot to continuously scan the airspace.	N/A: AOs are employed	I declare....
	medium	1.6.2 If AOs are employed: the range is not limited as long as the UA is not operated further than 1 km (unless a different distance is defined by the competent authority) from the AO who is nearest to the UA.	Operation manual at para xx provides AO procedures	I declare that the procedures have been developed according to standards xx.... evidence can be found in appendix y to this document

Apply for authorisation



SORA - Ansökan

Ansökan ska innehålla:

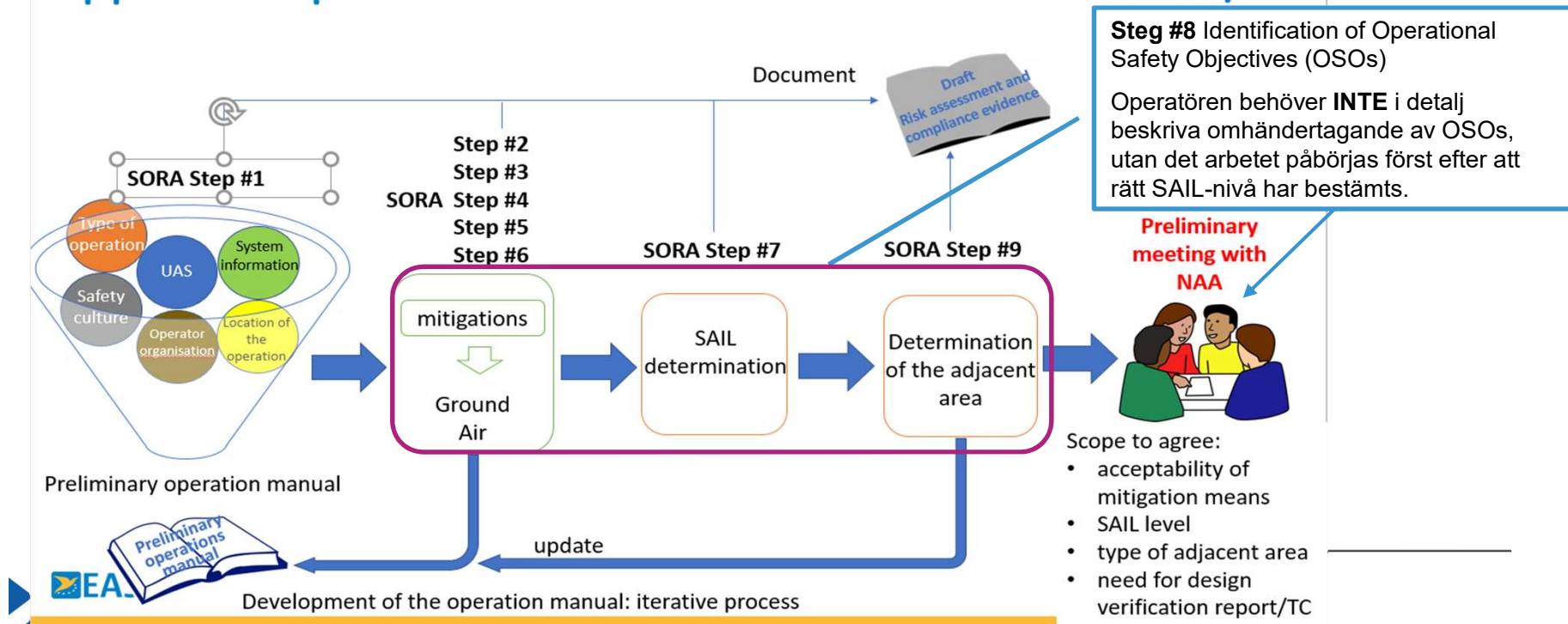
- Ansökningsblankett
- Kravuppfyllnadsblankett
- Operativ Manual
- **Riskanalys**
- Dokumentation som styrker eventuella mitigeringar och OSOs till rätt nivå



[operational risk analysis overview for operations in the specific category \(transportstyrelsen.se\)](https://transportstyrelsen.se)

SORA – Riskanalysen

Application process in case of SORA risk assessment 1/3

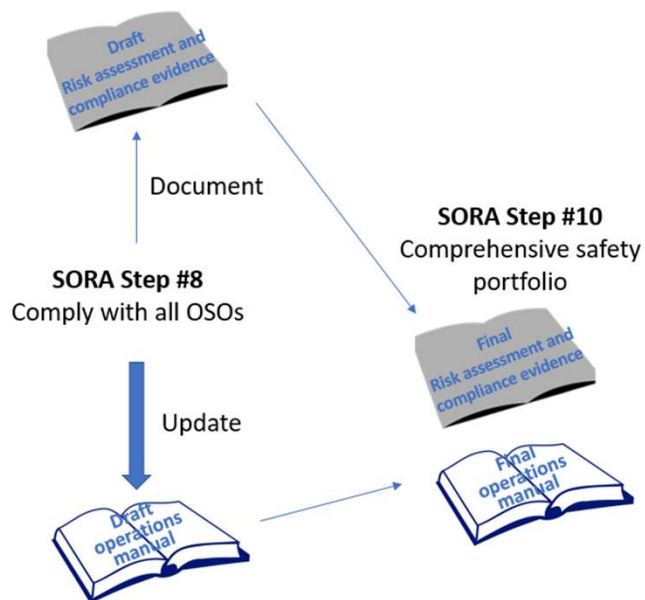


SORA – Riskanalysen

Application process in case of SORA risk assessment 2/3

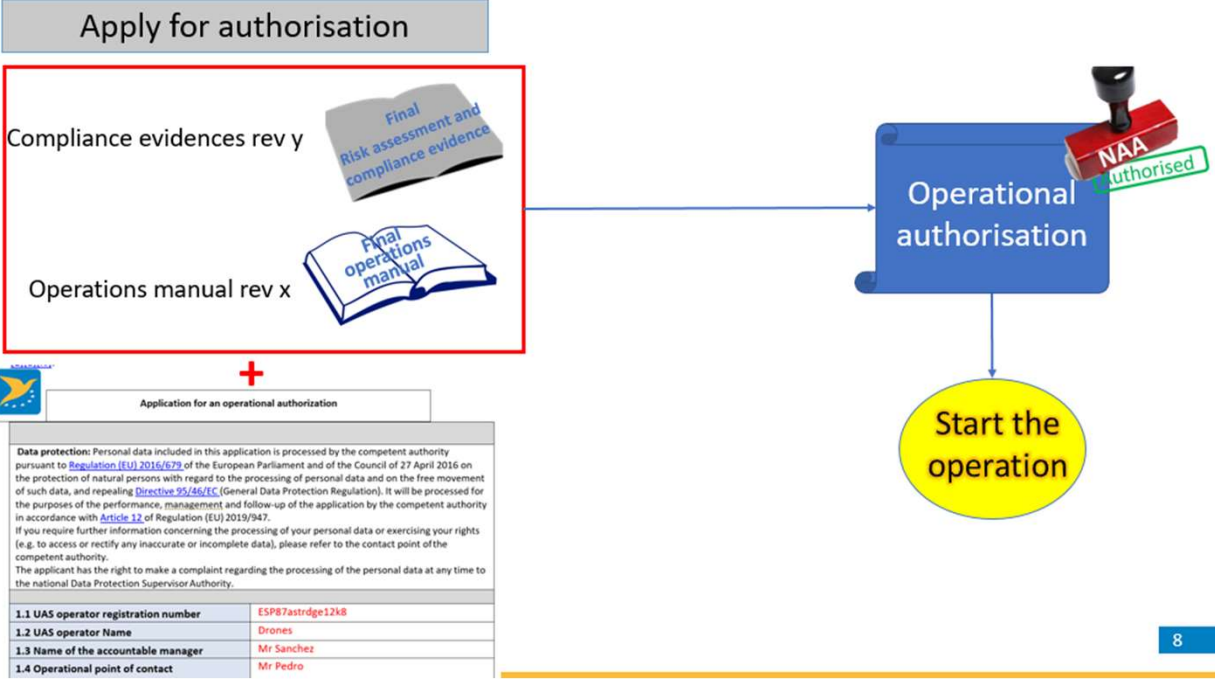
SAIL agreed with NAA

OSO number (in line with Annex E)	Technical issue with the UAS	SAIL					
		I	II	III	IV	V	VI
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	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 CoCops	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
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



SORA – Riskanalysen

Application process in case of SORA risk assessment 3/3



Steg #5 Strategic Mitigations

En strategisk mitigering skulle kunna vara:

Avtal med ATS om att upprätta en sektor

