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Enabling safe drone operations

Proposal for
Air Risk Mitigation framework
to enable safe **BVLOS flights**

presented to

BELGIAN CIVIL DRONE COUNCIL & ID2MOve

October 4th 2022

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SKEYDRONE IN SHORT

Joint venture between **skeyes** and **Brussels Airport Company**

We offer a ***one-stop-shop*** for all your **drone needs**:

1. Protection of your business-critical assets against the risks induced by 3rd party drone flights
2. Improving your business performance through drone-powered solutions

We are **unique** through:

- Our end-to-end **eco-system approach** and our strategic and commercial partnerships with leading technology suppliers, allowing to integrate and front-end the best solutions for your needs.
- Our **customer driven service**-oriented approach.
- Our **aviation-grade and certified solutions**, guaranteeing the highest levels of **reliability**, **safety and security**.

OUR UNIQUE SELLING PROPOSITION

"WE ARE THE ONE-STOP-SHOP SOLUTION FOR INTEGRATING DRONE-POWERED SOLUTIONS IN YOUR BUSINESS" through PARTNERSHIPS

Protection services

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Business services

ROBOVISION

Authorization services

Drone Service Application

UNIFLY

Traffic management services

skeydrone MONITOR

Drone flight services

CITYMESH

S.A.B.C.A.

DRONEMATRIX

SKYEBASE

INFRABEL Right On Track

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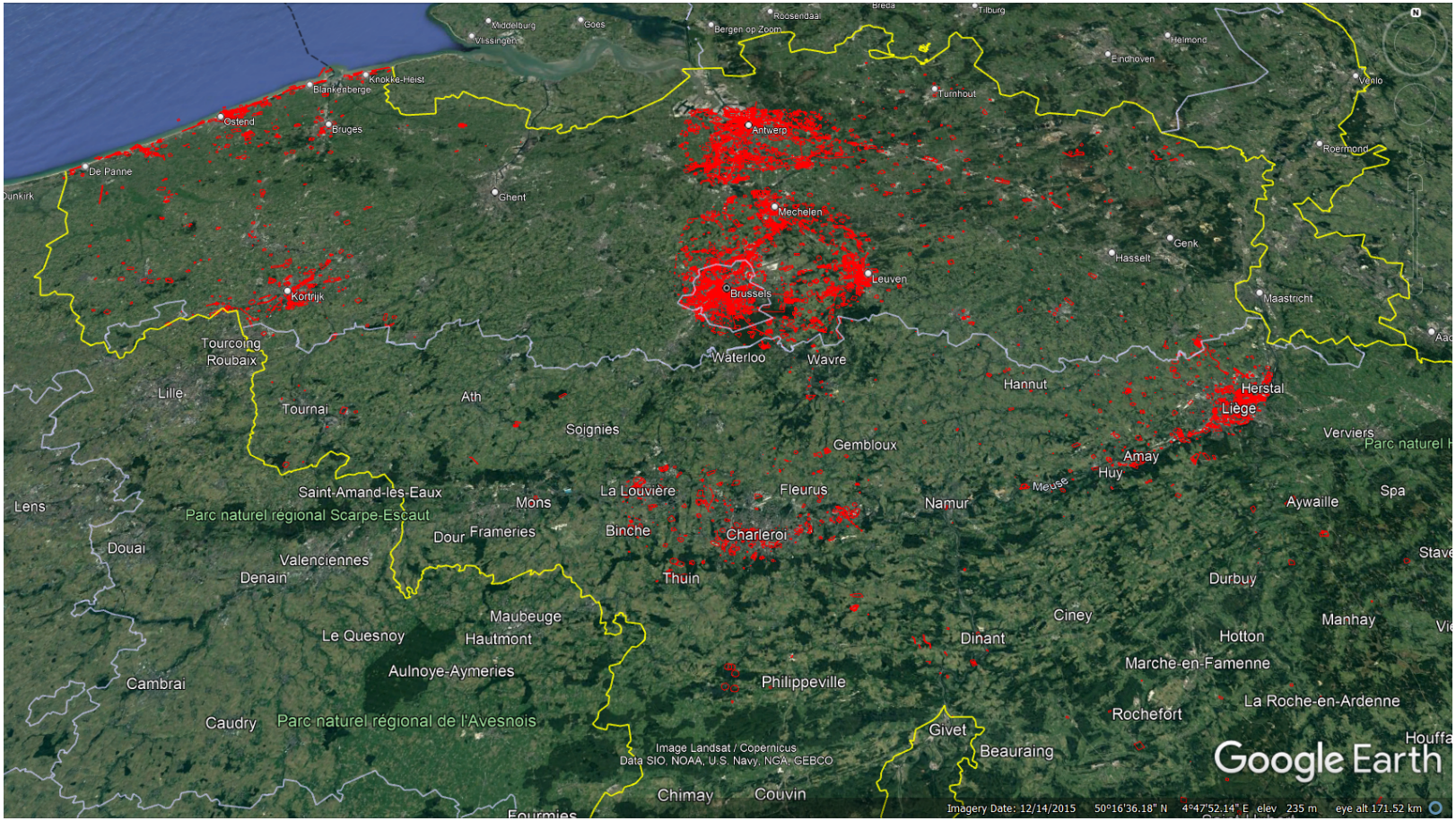
Problem statement & solution

- High demand for BVLOS operations (long distance operations & linear inspections)
- Lack of structural and scalable risk mitigation framework for the approval of Operational Authorisation (BCAA) within SAIL II
- Proposed solution: ***Air Risk mitigation*** approach
  - (strategic) **reduction of air risk category** through **strategic mitigations** by **Operational Restriction** and **Common Structures & Rules**
  - (tactical) **mitigation of residual air risk** through a (pre-U-space) Traffic information service
- Where: in "restricted" **UAS geo-zones of skeyes** and the **Port of Antwerp-Bruges**

skeyes nice to guide you

Port of Antwerp Bruges

Drone Heatmap in skeyes' CTR's



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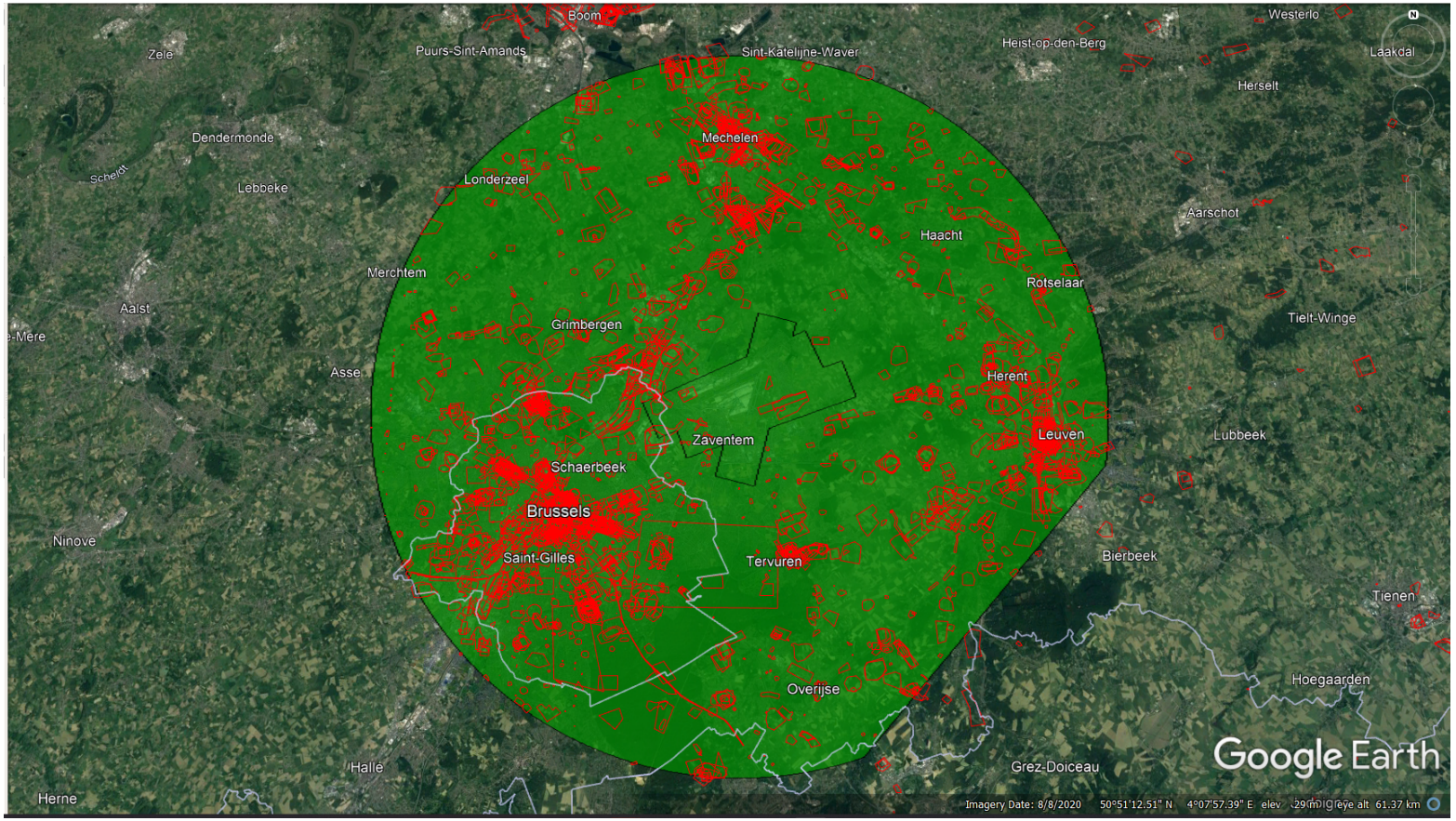
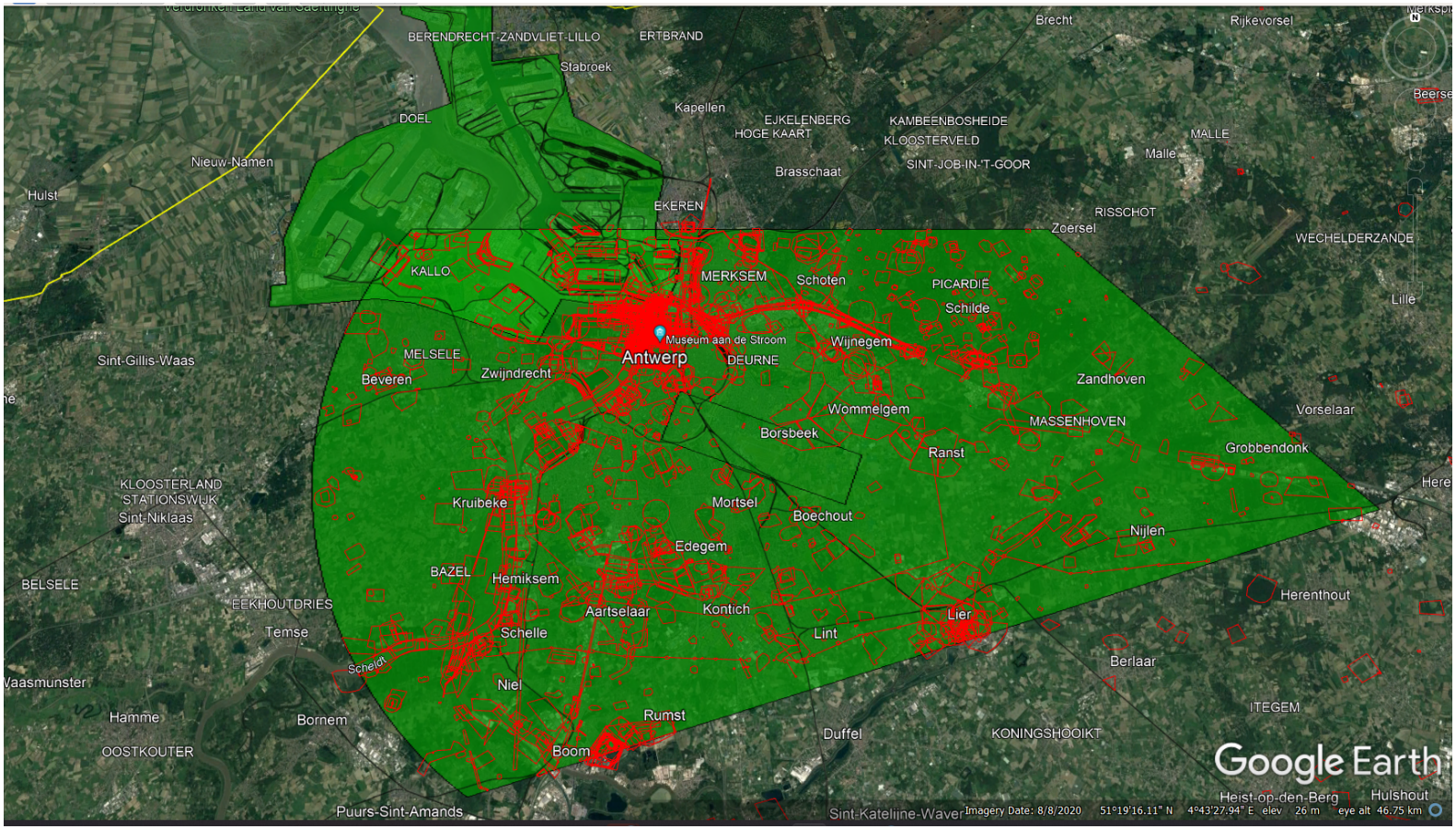
Drone Heatmap – EBBR (CTR)



Drone Heatmap – EBAW (CTR)



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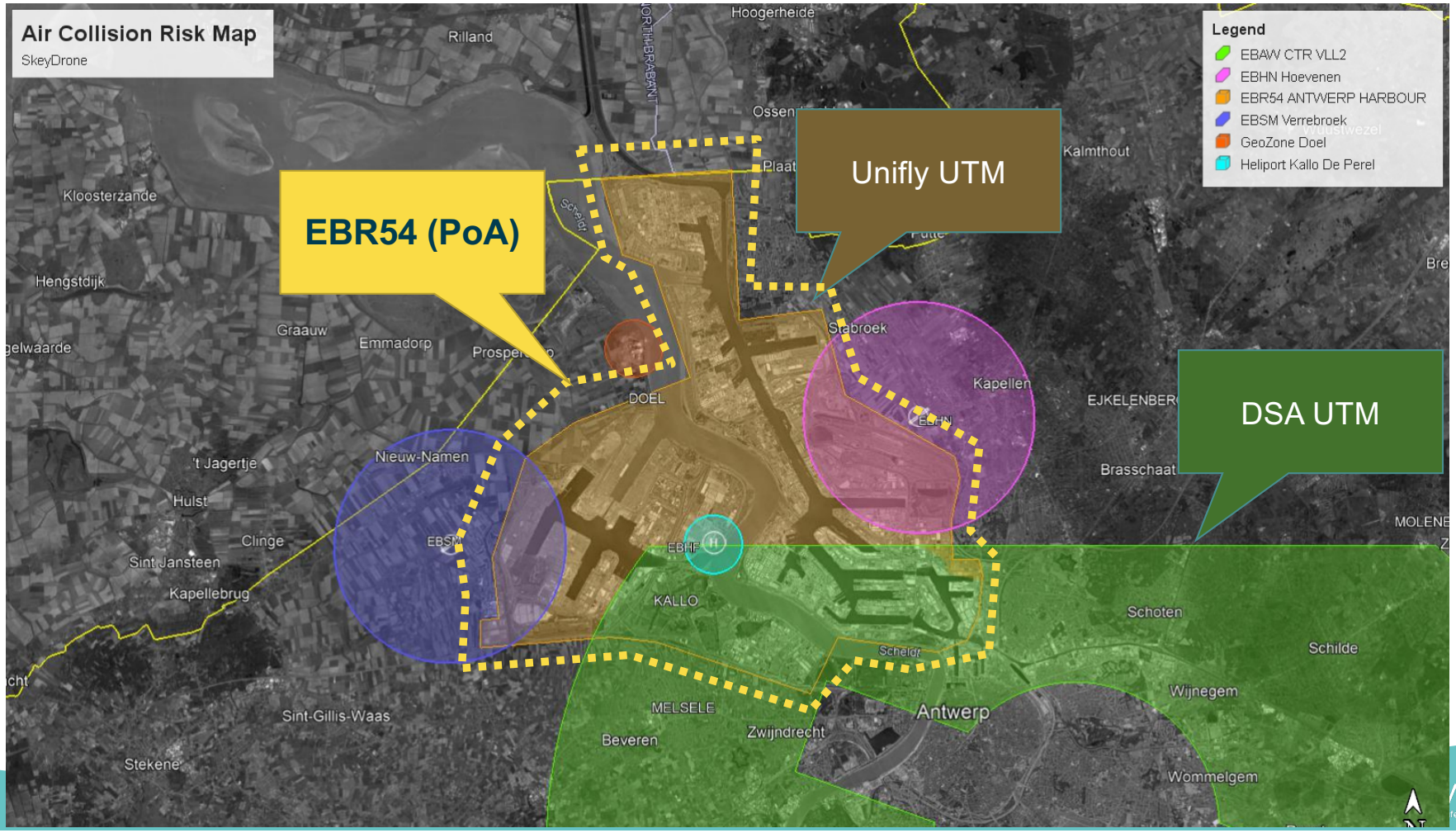
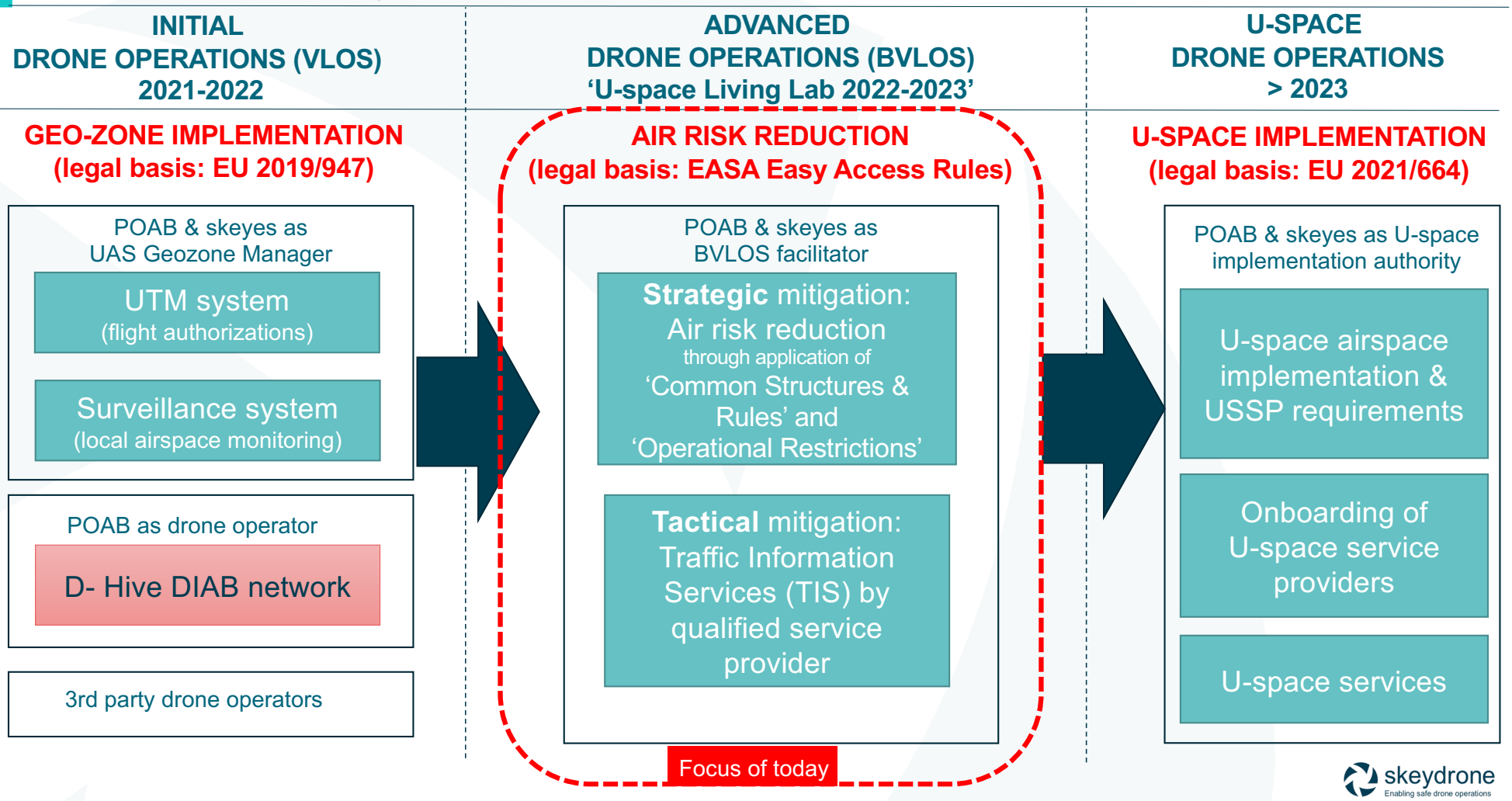
BVLOS Needs Analysis – Port of Antwerp

- Europe's second-largest seaport (volume)
- Europe's largest seaport (surface) 129km²
- 26 Terminals / 160 km Quayside
- 39 sea-going vessels transit PoA per day
- 1200 UAV Flight Authorisation requests per year
- # BVLOS Drone Use Cases:
  - PoAB – (D-Hive Network) 6 DIAB operated by Port Authorities
  - Infrabel, TotalEnergies, BASF, … multiple industries investing in DIAB Capacity
  - …

Airspace (Air Risk) Overview



POAB & skeyes drone operations roadmap



Current BVLOS Roadblocks

- SAIL II Risk level is currently the highest achievable level
- Operators have difficulties to mitigate risks **to achieve SAIL II**

Specific Assurance and Integrity Level

- Achieving SAIL I or II by mitigating the Air and Ground Risks

Intrinsic GRC and Initial ARC mitigations to achieve SAIL I or II				
	Initial ARC			
Intrinsic GRC	a	b	c	d
≤ 2	No mitigations(1)		ARC mitigations(3)	
3				
4	GRC mitigations(2)		GRC and ARC mitigations(2,3)	
5				
6				
7				
> 7	Category C operation			

1: Increase of 1 GRC in case no or Low robust Emergency Rssponsone Plan
2: GRC mitigation insufficient when UAV wingspan is > 8m or typical kinetic energy expected > 1084 kJ
3: Depending on the AEC, mitigations by operational restriction and/or common structures and ruls can be applied

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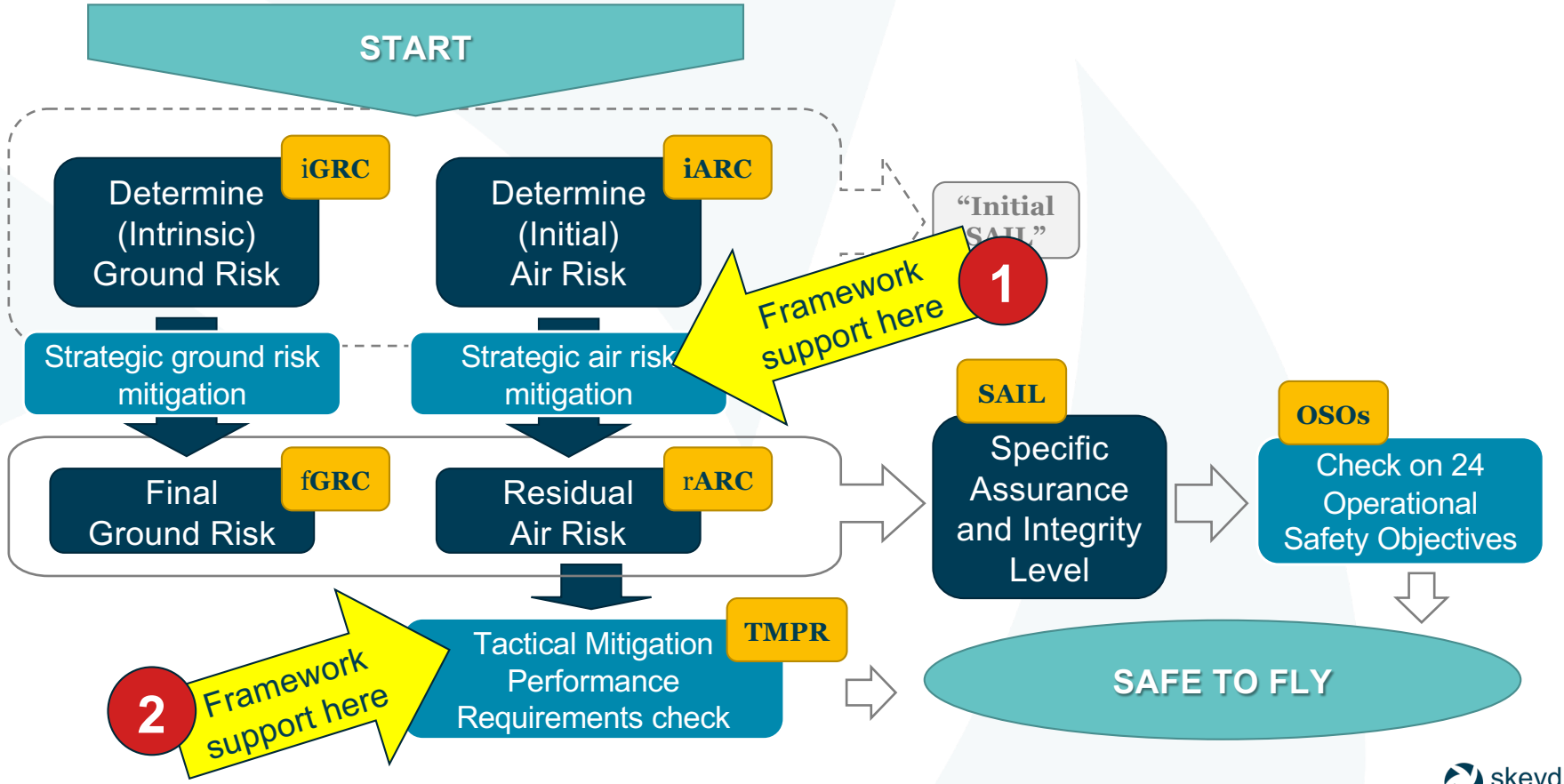
SORA process: start & outcome



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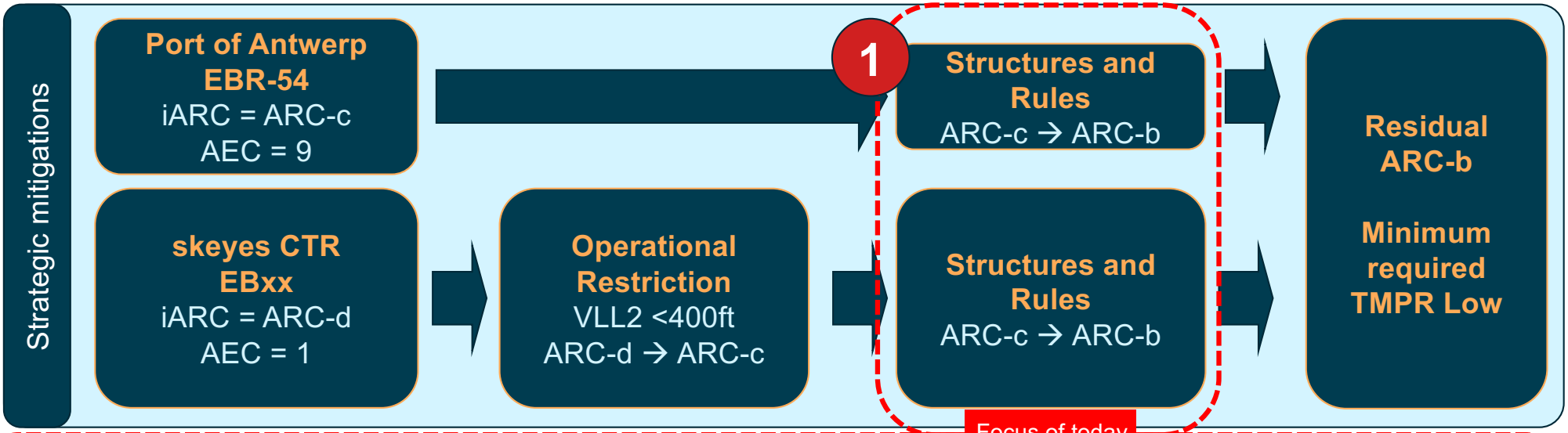
The Framework *summarized* (ARC reduction)

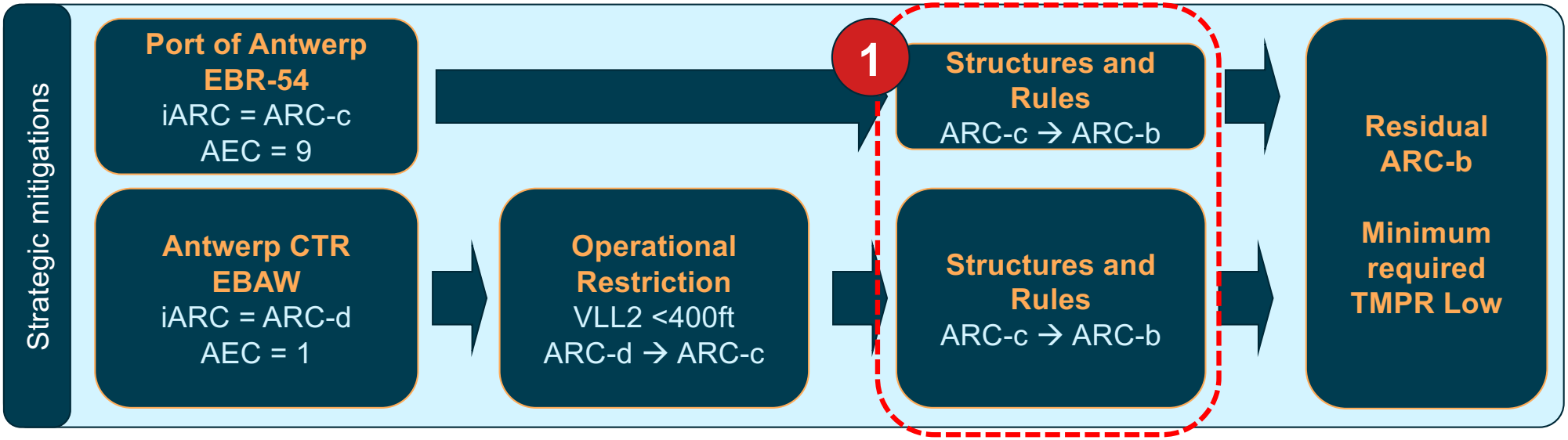


Tactical mitigation

2

Function	TMPR Target	Rationale
Detect	Medium 90%	SkeyDrone Monitor and (pre-) U-space **Traffic Information Service** based on ADS-B/FLARM receiver network + skeyes Mode S radar infra. Own UAS position & other traffic shown in SkeyDrone Monitor increases situational awareness.
Decide	Medium	SkeyDrone **Conformance Monitoring and Alerting** service integrated in the SkeyDrone Monitor alerts the UAS Operator with intrusion alerts. 3D geographical-based alerting.
Command	Low	**C2 link latency** shall be less than 5 seconds.
Execute	Low	**UAS avoidance manoeuvres** in place for navigation to a safe area and/or descending to a safe altitude in less than 1 minute.
Feedback	Medium	SkeyDrone Monitor and associated services are **designed according to U-space standards** under development, including performance targets like data update rates, latency, and service robustness levels.

The Framework *summarized* (ARC reduction)



Tactical mitigations

Function	TMPR Target	Rationale
Detect	Medium 90%	SkeyDrone Monitor and (pre-) U-space **Traffic Information Service** based on ADS-B/FLARM receiver network + skeyes Mode S radar infra. Own UAS position & other traffic shown in SkeyDrone Monitor increases situational awareness.
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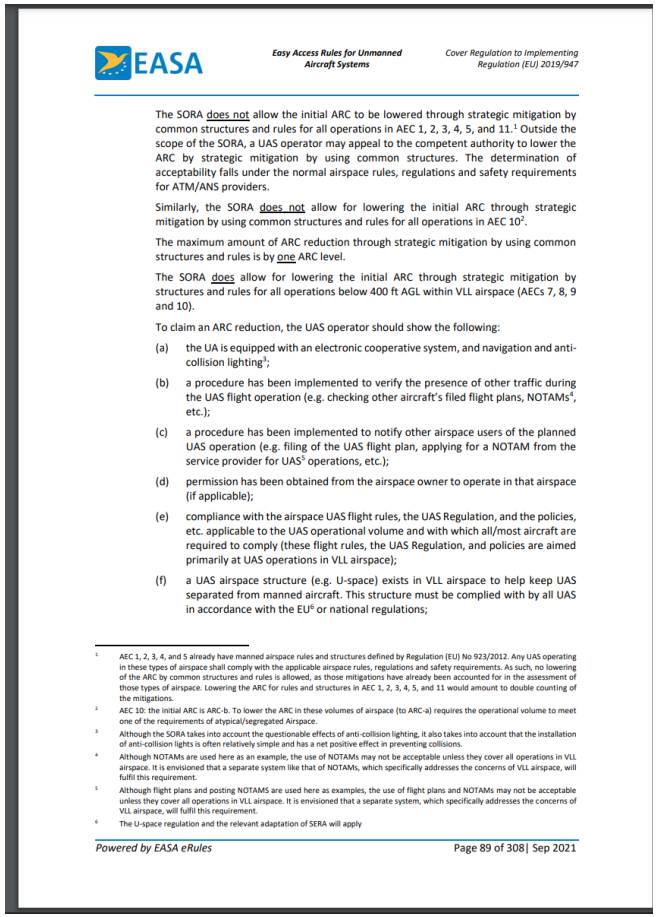
EASA Easy Access Rules: Structures and Rules



The SORA does not allow the initial ARC to be lowered through strategic mitigation by common structures and rules for all operations in AEC 1, 2, 3, 4, 5, and 11.[1] Outside the scope of the SORA, a UAS operator may appeal to the competent authority to lower the ARC by strategic mitigation by using common structures. The determination of acceptability falls under the normal airspace rules, regulations and safety requirements for ATM/ANS providers.

Similarly, the SORA does not allow for lowering the initial ARC through strategic mitigation by using common structures and rules for all operations in AEC 10[2].

The maximum amount of ARC reduction through strategic mitigation by using common structures and rules is by one ARC level.

The SORA does allow for lowering the initial ARC through strategic mitigation by structures and rules for all operations below 400 ft AGL within VLL airspace (AECs 7, 8, 9 and 10).

To claim an ARC reduction, the UAS operator should show the following:

(a) the UA is equipped with an electronic cooperative system, and navigation and anti-collision lighting[3];

(b) a procedure has been implemented to verify the presence of other traffic during the UAS flight operation (e.g. checking other aircraft's filed flight plans, NOTAMs[4], etc.);

(c) a procedure has been implemented to notify other airspace users of the planned UAS operation (e.g. filing of the UAS flight plan, applying for a NOTAM from the service provider for UAS[5] operations, etc.);

(d) permission has been obtained from the airspace owner to operate in that airspace (if applicable);

(e) compliance with the airspace UAS flight rules, the UAS Regulation, and the policies, etc. applicable to the UAS operational volume and with which all/most aircraft are required to comply (these flight rules, the UAS Regulation, and policies are aimed primarily at UAS operations in VLL airspace);

(f) a UAS airspace structure (e.g. U-space) exists in VLL airspace to help keep UAS separated from manned aircraft. This structure must be complied with by all UAS in accordance with the EU[6] or national regulations;

1 AEC 1, 2, 3, 4, and 5 already have manned airspace rules and structures defined by Regulation (EU) No 923/2012. Any UAS operating in these types of airspace shall comply with the applicable airspace rules, regulations and safety requirements. As such, no lowering of the ARC by common structures and rules is allowed, as those mitigations have already been accounted for in the assessment of those types of airspace. Lowering the ARC for rules and structures in AEC 1, 2, 3, 4, 5, and 11 would amount to double counting of the mitigations.

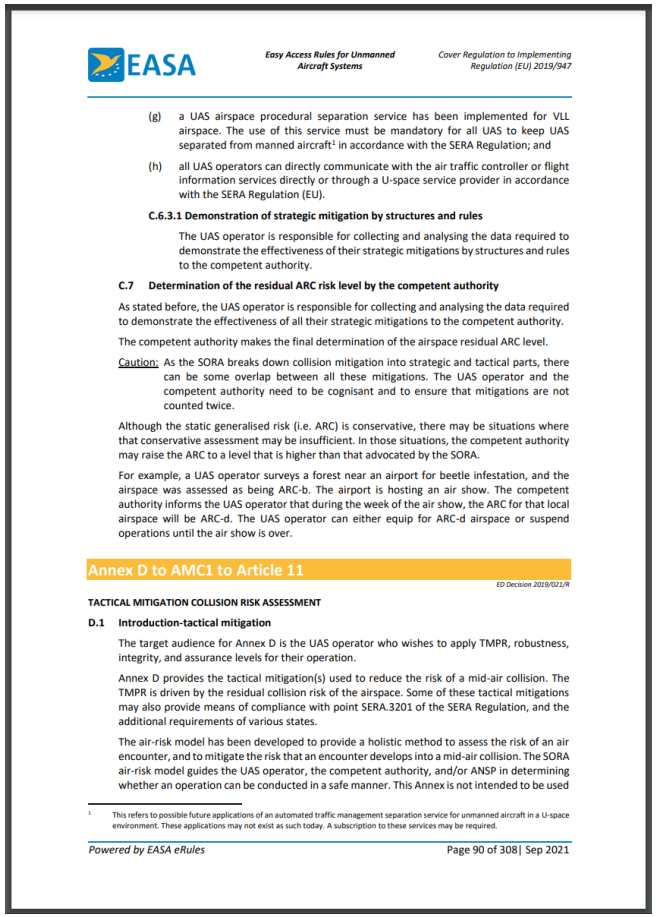
2 AEC 10: the initial ARC is ARC-b. To lower the ARC in these volumes of airspace (to ARC-a) requires the operational volume to meet one of the requirements of atypical/segregated Airspace.

3 Although the SORA takes into account the questionable effects of anti-collision lighting, it also takes into account that the installation of anti-collision lights is often relatively simple and has a net positive effect in preventing collisions.

4 Although NOTAMs are used here as an example, the use of NOTAMs may not be acceptable unless they cover all operations in VLL airspace. It is envisioned that a separate system like that of NOTAMs, which specifically addresses the concerns of VLL airspace, will fulfil this requirement.

5 Although flight plans and posting NOTAMS are used here as examples, the use of flight plans and NOTAMs may not be acceptable unless they cover all operations in VLL airspace. It is envisioned that a separate system, which specifically addresses the concerns of VLL airspace, will fulfil this requirement.

6 The U-space regulation and the relevant adaptation of SERA will apply



(g) a UAS airspace procedural separation service has been implemented for VLL airspace. The use of this service must be mandatory for all UAS to keep UAS separated from manned aircraft[1] in accordance with the SERA Regulation; and

(h) all UAS operators can directly communicate with the air traffic controller or flight information services directly or through a U-space service provider in accordance with the SERA Regulation (EU).

C.6.3.1 Demonstration of strategic mitigation by structures and rules

The UAS operator is responsible for collecting and analysing the data required to demonstrate the effectiveness of their strategic mitigations by structures and rules to the competent authority.

C.7 Determination of the residual ARC risk level by the competent authority

As stated before, the UAS operator is responsible for collecting and analysing the data required to demonstrate the effectiveness of all their strategic mitigations to the competent authority.

The competent authority makes the final determination of the airspace residual ARC level.

Caution: As the SORA breaks down collision mitigation into strategic and tactical parts, there can be some overlap between all these mitigations. The UAS operator and the competent authority need to be cognisant and to ensure that mitigations are not counted twice.

Although the static generalised risk (i.e. ARC) is conservative, there may be situations where that conservative assessment may be insufficient. In those situations, the competent authority may raise the ARC to a level that is higher than that advocated by the SORA.

For example, a UAS operator surveys a forest near an airport for beetle infestation, and the airspace was assessed as being ARC-b. The airport is hosting an air show. The competent authority informs the UAS operator that during the week of the air show, the ARC for that local airspace will be ARC-d. The UAS operator can either equip for ARC-d airspace or suspend operations until the air show is over.

Annex D to AMC1 to Article 11

ED Decision 2019/021/R

TACTICAL MITIGATION COLLISION RISK ASSESSMENT

D.1 Introduction-tactical mitigation

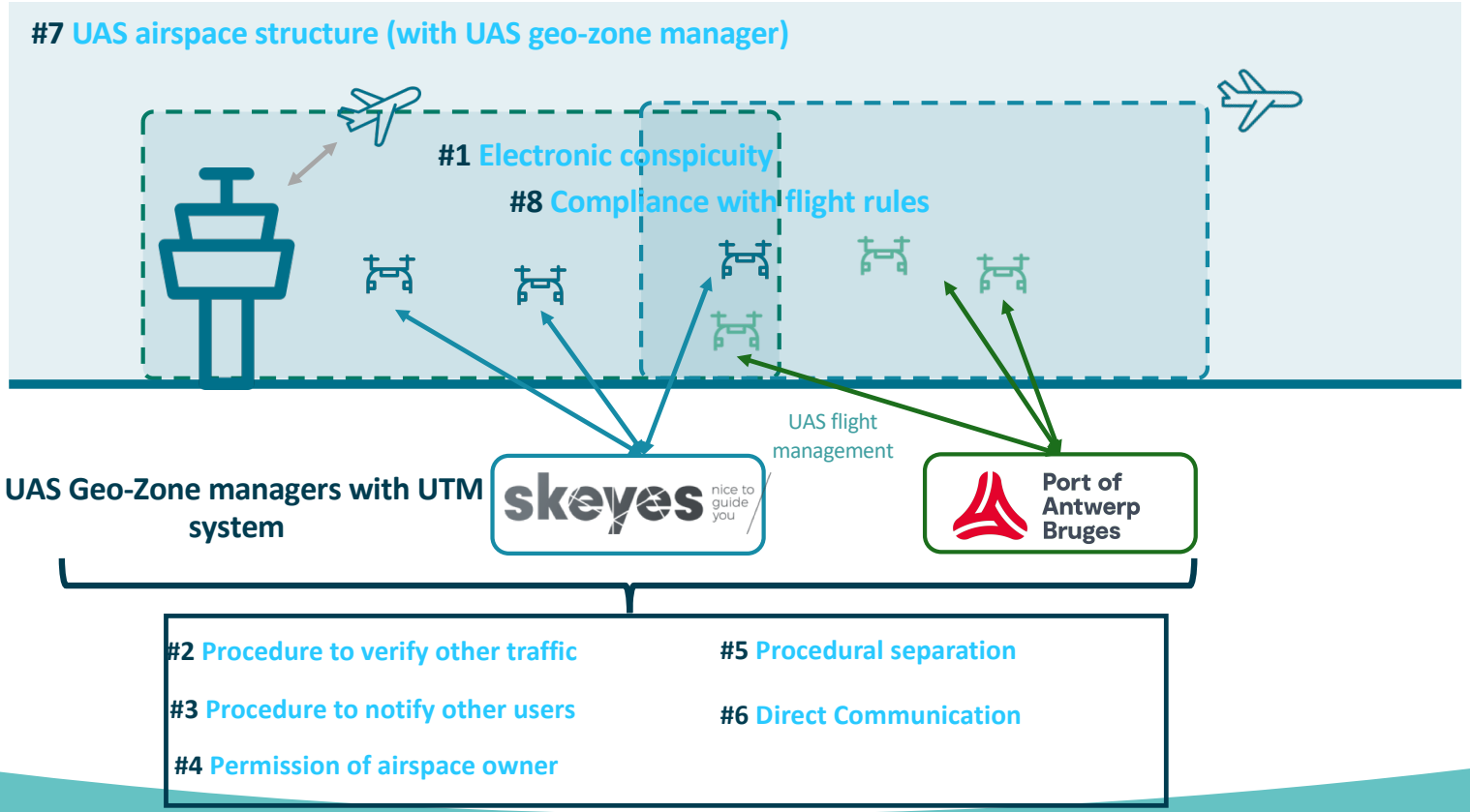
The target audience for Annex D is the UAS operator who wishes to apply TMPR, robustness, integrity, and assurance levels for their operation.

Annex D provides the tactical mitigation(s) used to reduce the risk of a mid-air collision. The TMPR is driven by the residual collision risk of the airspace. Some of these tactical mitigations may also provide means of compliance with point SERA.3201 of the SERA Regulation, and the additional requirements of various states.

The air-risk model has been developed to provide a holistic method to assess the risk of an air encounter, and to mitigate the risk that an encounter develops into a mid-air collision. The SORA air-risk model guides the UAS operator, the competent authority, and/or ANSP in determining whether an operation can be conducted in a safe manner. This Annex is not intended to be used

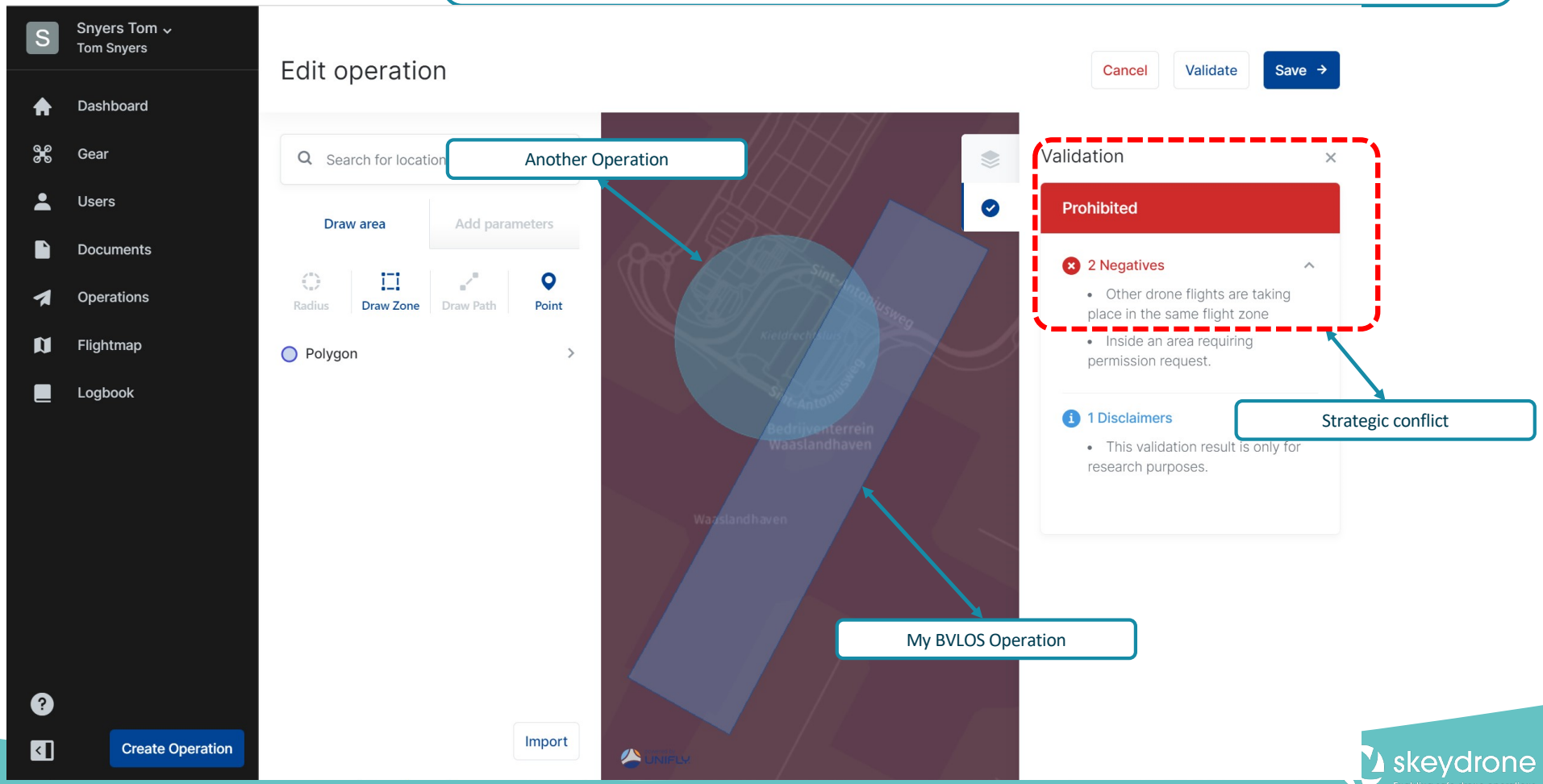
1 This refers to possible future applications of an automated traffic management separation service for unmanned aircraft in a U-space environment. These applications may not exist as such today. A subscription to these services may be required.

Strategic Mitigation by Structures & Rules: Framework of #8 points



UTM POAB

Stractegic deconfliction of BVLOS drone Operations:



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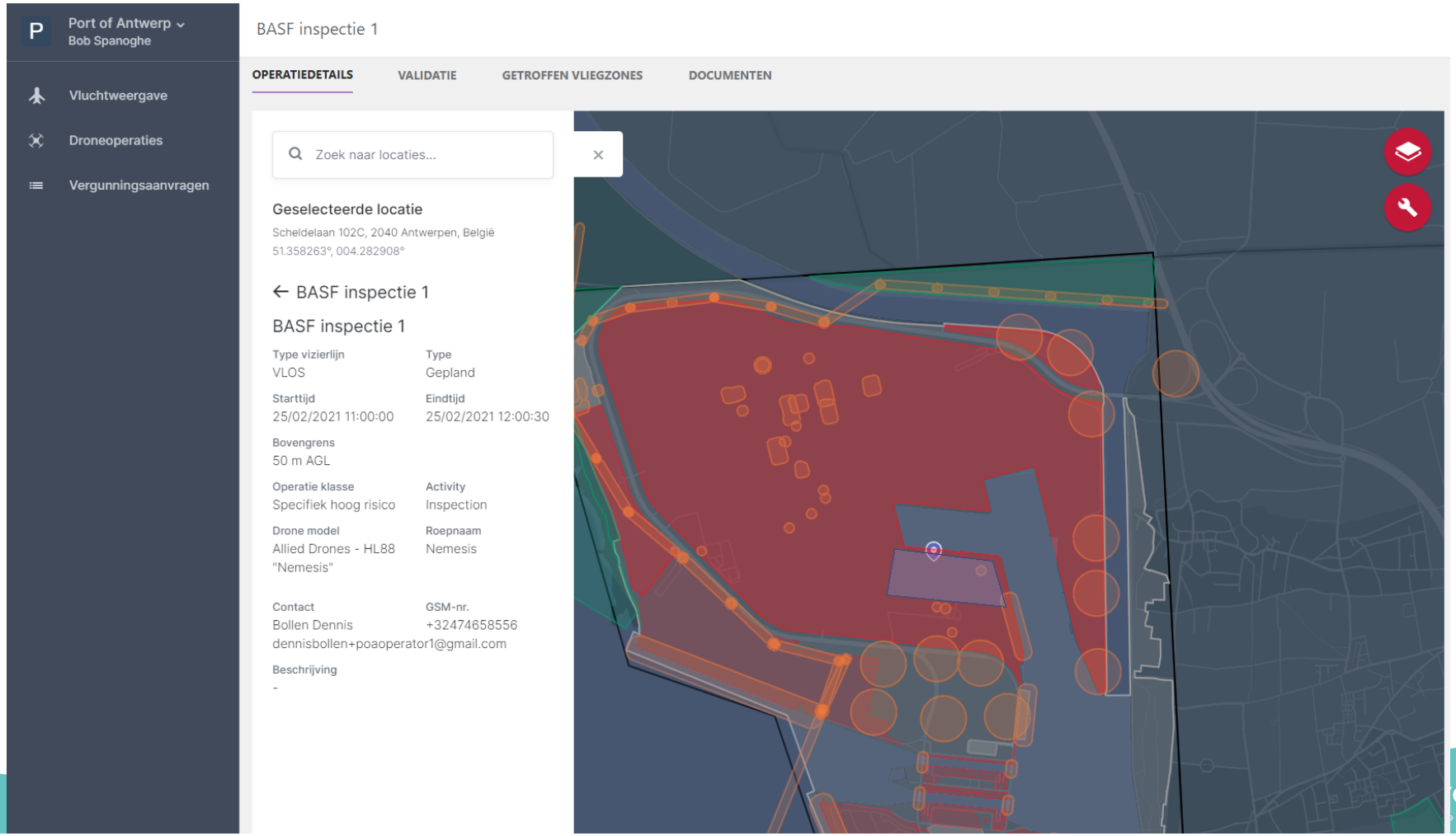
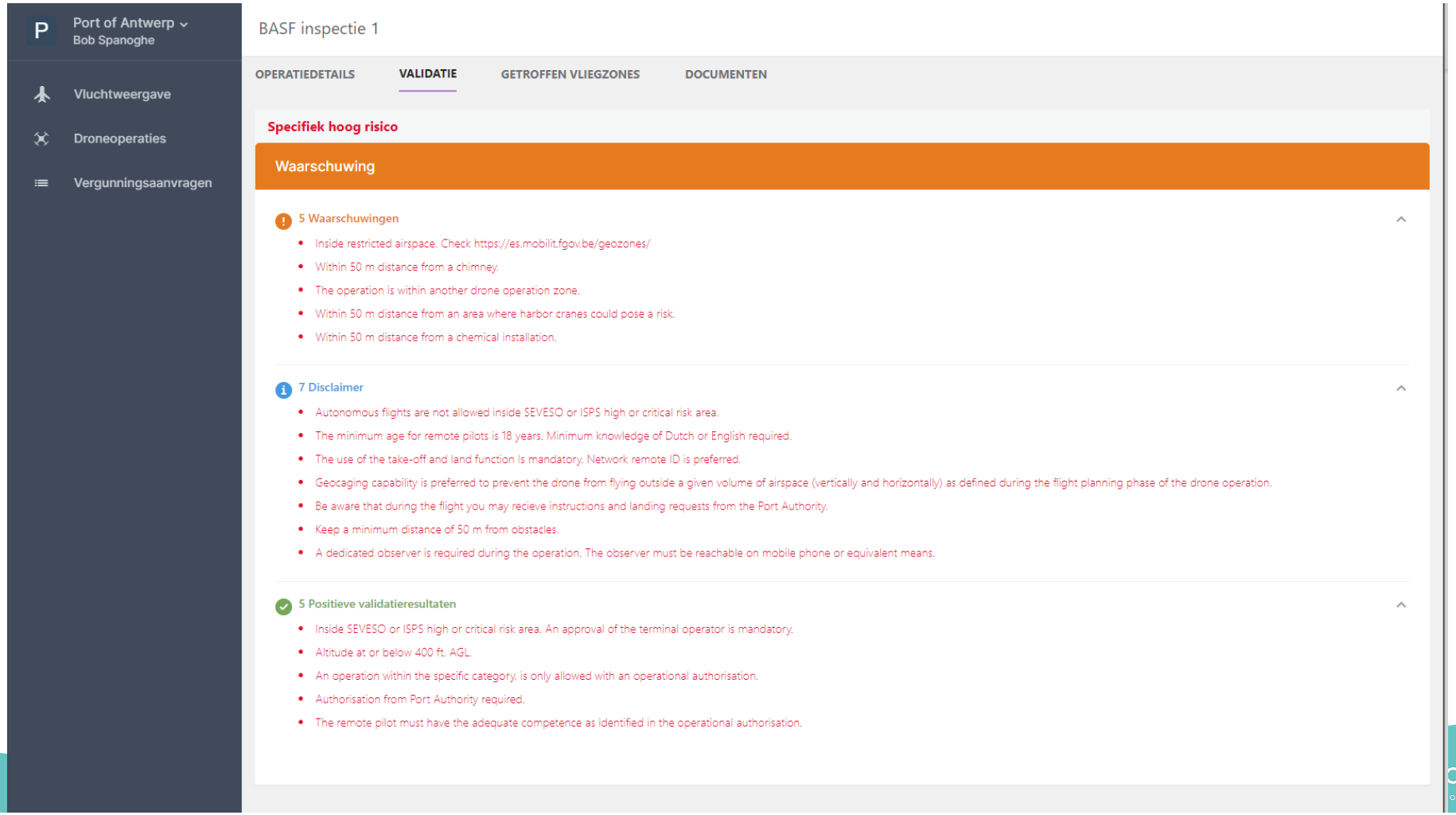
Strategic mitigations

Flight authorisations example

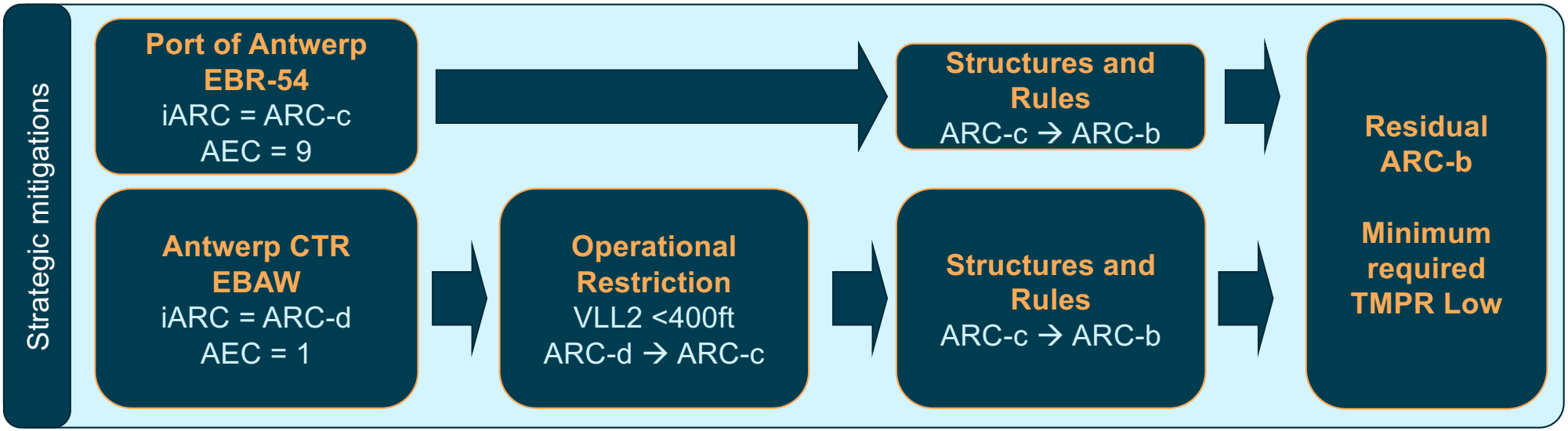


Strategic mitigations

Flight authorisations example: Mitigations & warnings



The Framework *summarized* (ARC reduction)



Tactical mitigation 2

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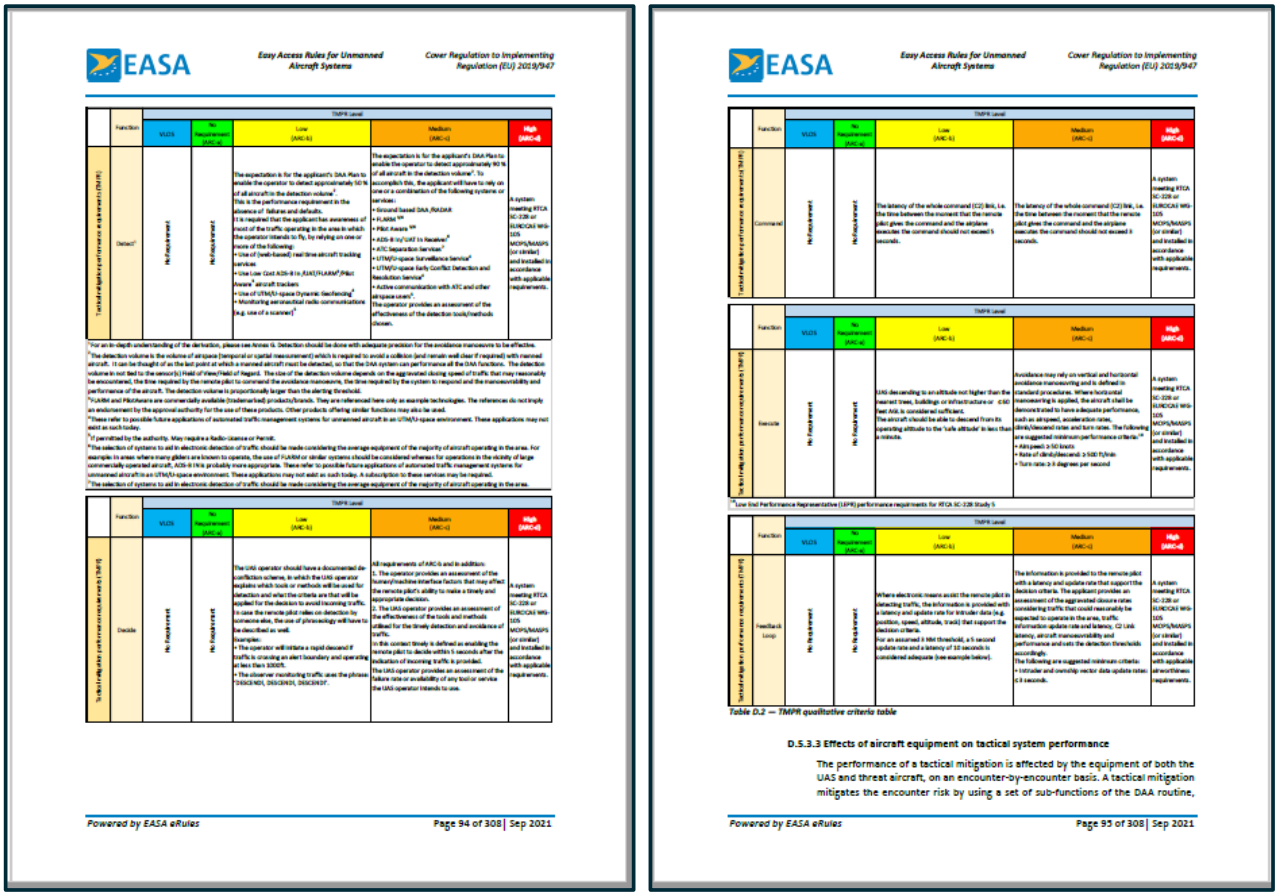
Command	Low	**C2 link latency** shall be less than 5 seconds.
Execute	Low	**UAS avoidance manoeuvres** in place for navigation to a safe area and/or descending to a safe altitude in less than 1 minute.
Feedback	Medium	SkeyDrone Monitor and associated services are **designed according to U-space standards** under development, including performance targets like data update rates, latency, and service robustness levels.

EASA Easy Access Rules: TMPR



EASA

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

	Function	TMPR Level				
		VLOS	No Requirement (ARC-a)	Low (ARC-b)	Medium (ARC-c)	High (ARC-d)
Tactical mitigation performance requirements (TMPR)	Detect[2]	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[3]. This is the performance requirement in the absence of failure 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 (well-based) real time aircraft tracking services • Use Low Cost ADS-B In /UAT/FLARM[4]/Pilot Aware[4] aircraft trackers • Use of UTM/U-space Dynamic Geofencing[5] • Monitoring aeronautical radio communications (e.g. use of a scanner)[6]	The expectation is for the applicant's DAA Plan to enable the operator to detect approximately 90 % of all aircraft in the detection volume[3]. 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 [4] • Pilot Aware [4] • ADS-B in/ UAT In Receiver[4] • ATC Separation Services[7] • UTM/U-space Surveillance Service[8] • UTM/U-space Early Conflict Detection and Resolution Service[8] • Active communication with ATC and other airspace users[9]. 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.
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 human eye, 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.

[2] For an in-depth understanding of the definition, please see Annex G. Detection should be done with adequate precision for the avoidance manoeuvre to be effective.
[3] 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.
[4] 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.
[5] 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.
[6] If permitted by the authority. May require a Radio License or Permit.
[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. 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/a 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.
[8] 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.

EASA

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

	Function	TMPR Level				
		VLOS	No Requirement (ARC-a)	Low (ARC-b)	Medium (ARC-c)	High (ARC-d)
Tactical mitigation performance requirements (TMPR)	Command	No Requirement	No Requirement	The latency of the whole command (C2) link, i.e. the time between the moment that the remote pilot gives the command and the airplane executes the command should not exceed 5 seconds.	The latency of the whole command (C2) link, i.e. the time between the moment that the remote pilot gives the command and the airplane executes the command should not exceed 3 seconds.	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable requirements.
Tactical mitigation performance requirements (TMPR)	Execute	No Requirement	No Requirement	UAS descending to an altitude not higher than the nearest trees, buildings or infrastructure or ≤50 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 degree 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 requirements for RTCA SC-228 Study 5

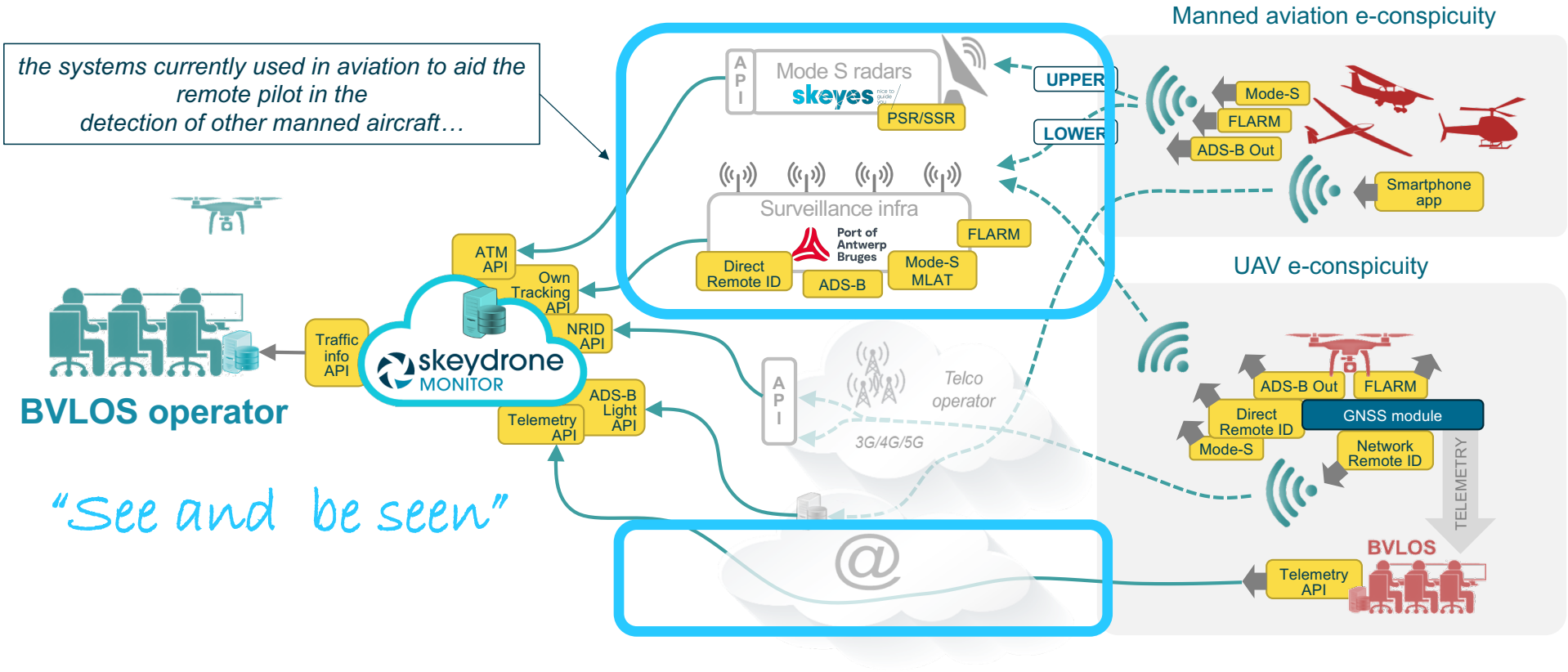
	Function	TMPR Level				
		VLOS	No Requirement (ARC-a)	Low (ARC-b)	Medium (ARC-c)	High (ARC-d)
Tactical mitigation performance requirements (TMPR)	Feedback Loop	No Requirement	No Requirement	Where electronic means assist the remote pilot in detecting traffic, the information is provided with a latency and update rate for intruder data (e.g. position, speed, altitude, track) that support the decision criteria. For an assumed 1 NM threshold, a 5 second update rate and a latency of 10 seconds is considered adequate (see example below).	The information is provided to the remote pilot with a latency and update rate that support the decision criteria. The applicant provides an assessment of the aggravated closure rates considering traffic that could reasonably be expected to operate in the area, traffic information update rate and latency, C2 Link latency, aircraft manoeuvrability and performance and sets the detection thresholds accordingly. The following are suggested minimum criteria: • Intruder and ownship vector data update rates: ≤ 5 seconds.	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable airworthiness requirements.

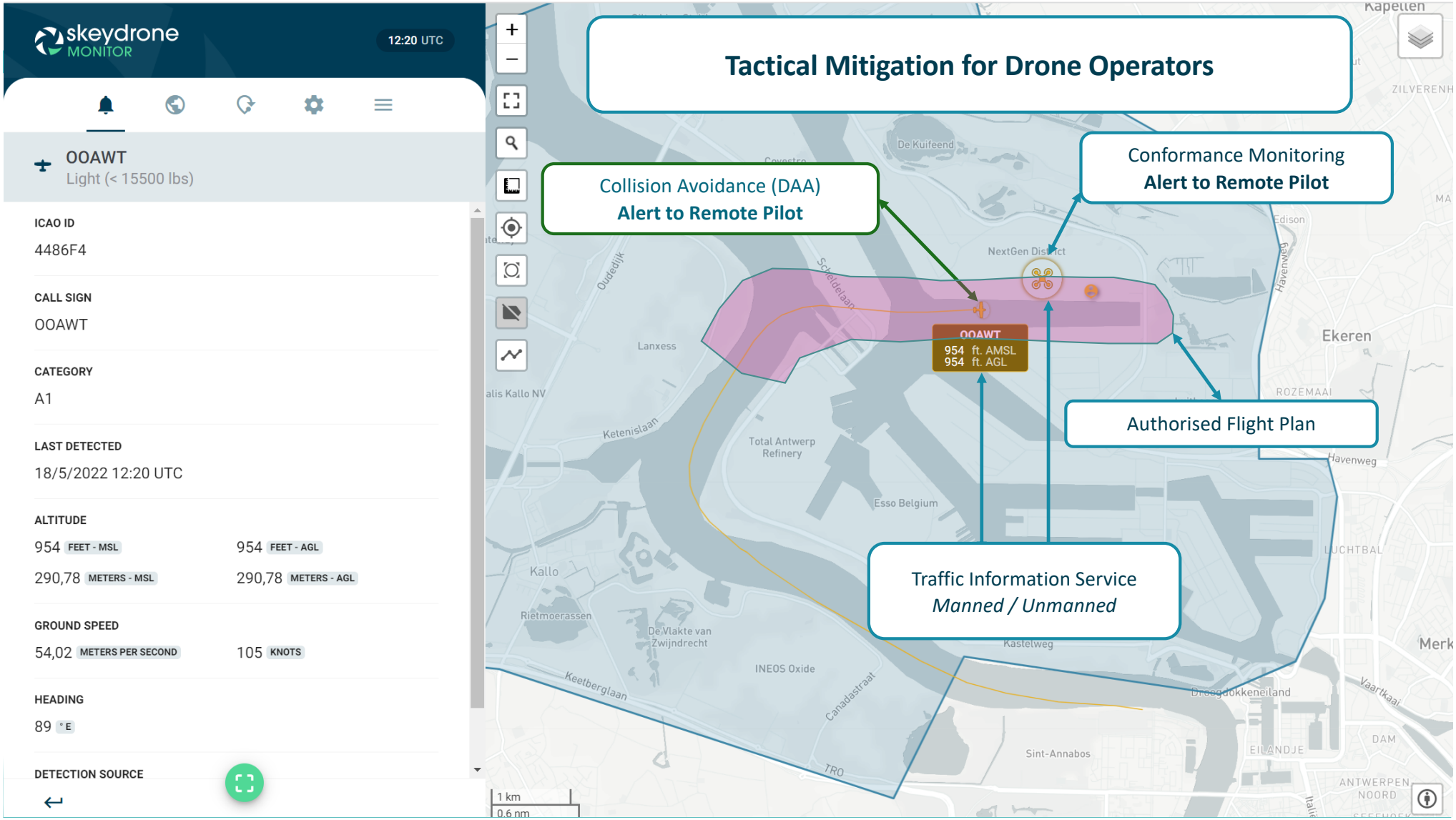
Table D.2 — TMPR qualitative criteria table

D.5.3.3 Effects of aircraft equipment on tactical system performance

The performance of a tactical mitigation is affected by the equipment of both the UAS and threat aircraft, on an encounter-by-encounter basis. A tactical mitigation mitigates the encounter risk by using a set of sub-functions of the DAA routine,

SkeyDrone's (current) Traffic Information Service

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GROUND SPEED
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HEADING
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DETECTION SOURCE
Tactical Mitigation for Drone Operators
Collision Avoidance (DAA)
Alert to Remote Pilot
Conformance Monitoring
Alert to Remote Pilot
Authorised Flight Plan
Traffic Information Service
Manned / Unmanned
OOAWT
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NextGen District
Lanxess
Total Antwerp Refinery
Esso Belgium
INEOS Oxide
Kallo
Rietmoerassen
De Vlakte van Zwijndrecht
Sint-Annabos
Ekeren
Kapellen
1 km
0.6 nm

Our proposal

- Creation of a '**regulatory sandbox'**,
  - Where the structural (air) risk mitigation framework, developed by skeyes/POAB/SkeyDrone/EuroUSC, can be implemented in a gradual manner,
  - With the objective to execute the first (operational and scalable) BVLOS flights in the second half of this year, by operators such as Infrabel and DroneMatrix
- This sandbox would initially be implemented in the **geozones 'Antwerp Port' (= EBR54) and 'Antwerp Airport' (= CTR EBAW).**
- The BCAA is asked - as a partner of Skeyes and POAB - to take an **active and facilitating role in the implementation, evaluation and (where necessary) adjustment of the proposed sandbox and risk mitigation framework**. We and all partners involved are convinced that intensive knowledge sharing and involvement of all expertise domains is crucial in the realisation of a thriving but also safe Belgian drone market.
- This framework can be seen as a first "**Belgian PDRA**."

skeydrone
Enabling safe drone operations