UAS Safety & Risk Assessment

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1 Bison Farm flight

Step 1: Proposed Concept of Operations (ConOps)

What is the operation about? The operation is a BVLOS flight to monitor the bisons of Ditlevsdal Bison Farm.

Where are you operating? At Ditlevsdal Bison Farm on Tokkerodvej 24, 5462 Morud, Denmark.

Which UAS do you intend to fly? An eBee X fixed-wing mapping drone.

Sora Semantic model

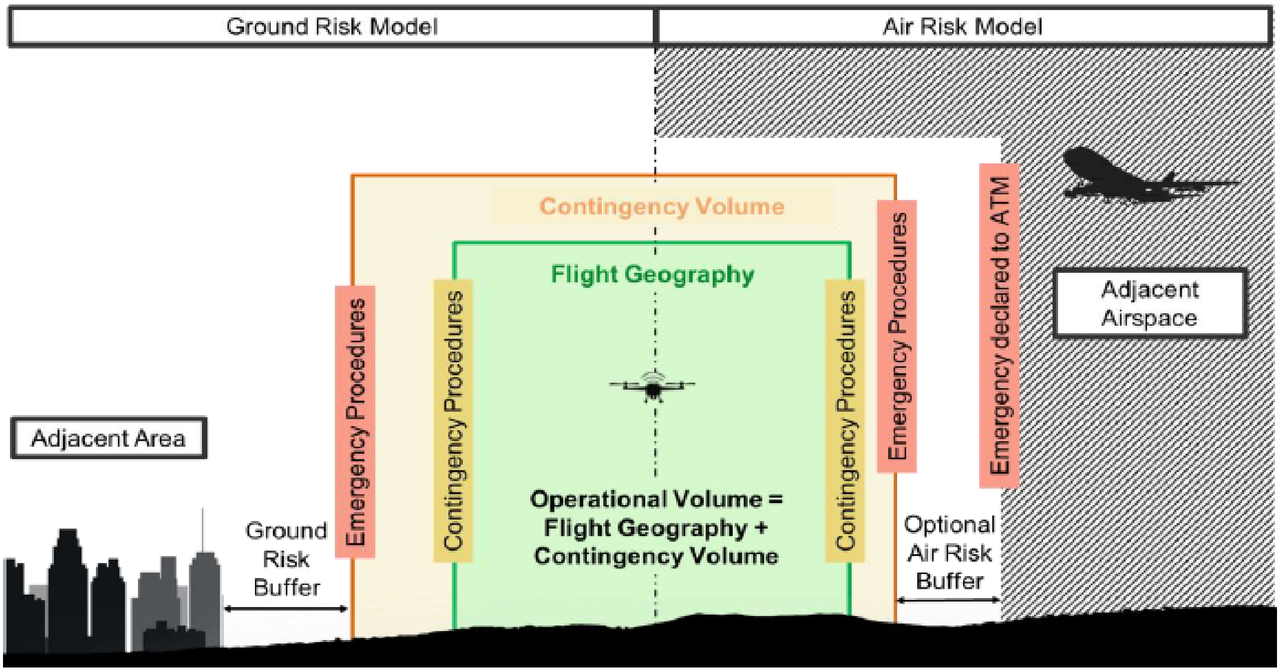

Figure 1: Sora semantic model

Step 2: Intrinsic Ground Risk Class (iGRC)

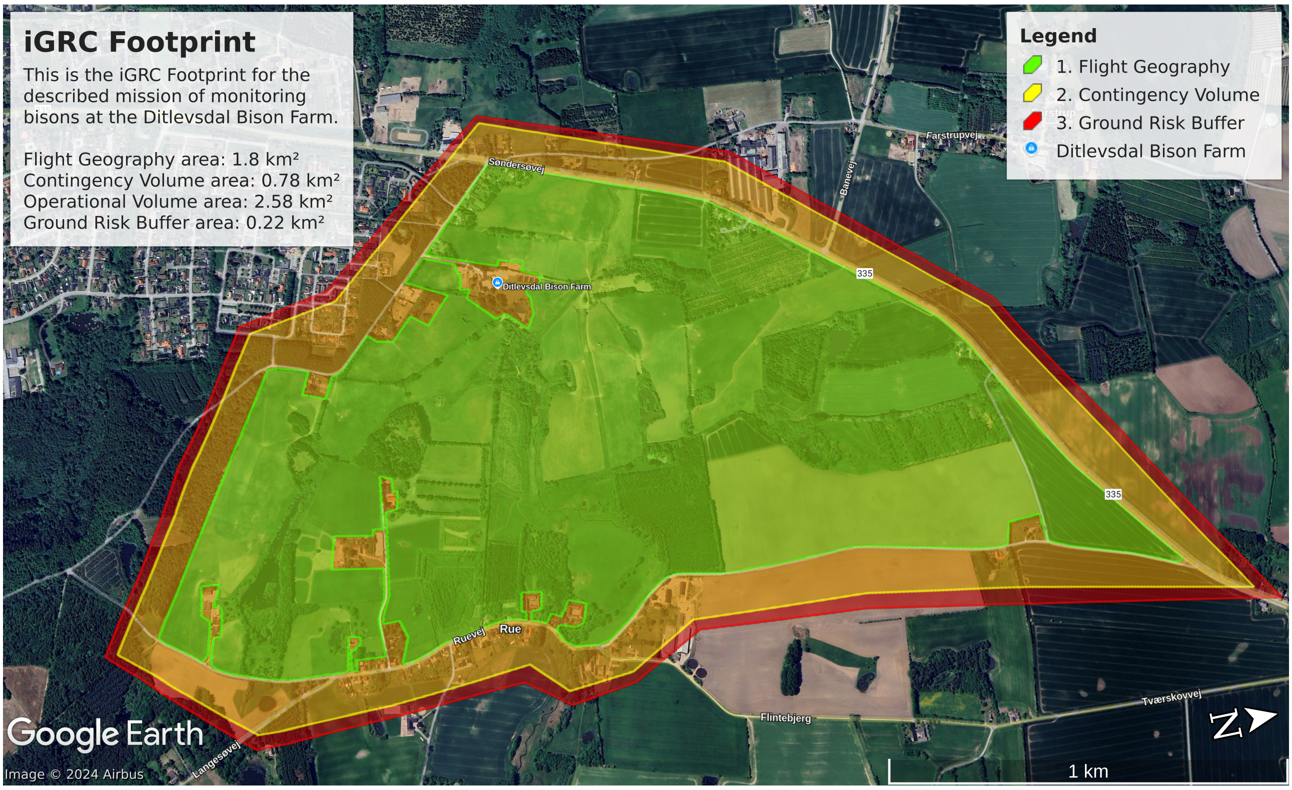

Figure 2: iGRC Footprint

What is the maximum iGRC population density? Since our iGRC footprint includes a bit of Morud, this city will be used as the maximum population density.

The area of Morud is 1.46km^2 with an urban population of 1937. This results in a maximum iGRC population density $d = 1973/1.46\text{km}^2 \approx 1351\text{ppl/km}^2$.

This could theoretically be significantly reduced by picking a smart operational volume e.g. only the fields with bisons are included and not the edge of the town or the areas where the guests and staff of Ditlevsdal would traverse. This would result in a population density of less than 500. However, we did not manage to do this, because we kept a contingency volume with a width of 110 meters to allow for 10 seconds of reaction time at a speed of 11m/s or 3.5 seconds reaction time for the maximum speed of 30m/s.

What is the maximum speed of the UAS? The maximum speed of the eBee X is 30m/s.[1]

What is the maximum width of the UAS? The maximum width, which is the wingspan of the drone, is 1.16m.[1]

What is the iGRC? The final Intrinsic UAS Ground Risk Class for this mission is 6.

[1] https://ageagle.com/drones/ebee-x/

Intrinsic UAS Ground Risk Class						
Maximum UA characteristic dimension		1m / approx. 3 ft	3 m / approx. 10 ft	8 m / approx. 25 ft	20 m / approx. 65 ft	40 m / approx. 130 ft
Maximum speed		*25 m/s*	*35 m/s*	*75 m/s*	*120 m/s*	*200 m/s*
Maximum iGRC population density (people/km^2)	Controlled Ground Area	1	1	2	3	3
	< 5	2	3	4	5	6
	< 50	3	4	5	6	7
	< 500	4	5	6	7	8
	< 5,000	5	6	7	8	9
	< 50,000	6	7	8	9	10
	> 50,000	7	8	Not part of SORA		

Figure 3: Intrinsic UAS Ground Risk Class

Step 3: Final Ground Risk Class (GRC)

Which mitigations are applicable to your case? All guests in the flight geography will be in vehicles since this is a requirement when accessing the parts of the farm with free-roaming bison. They will thus be sheltered from any falling drones. This is not the case for the entire operational volume, since this spans 110m outside of this area. We argue for a Low Level of Robustness concerning sheltering. This will decrease the GRC score by 1.

Our iGRC is highly determined by the maximum population density, which in this case, is the population density of Morud at 1.351ppl/km^2. Since this area is a tiny part of the Intrinsic GRC Footprint, we argue that we won't be close to this area for the majority of the time and thus want to classify our operational restrictions as a medium level of robustness. This will further decrease the GRC score by 1.

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

Figure 4: Mitigation for ground risk

What is the final GRC? The final GRC is $6 - 1 - 1 = 4$

Step 4: Initial Air Risk Class (iARC)

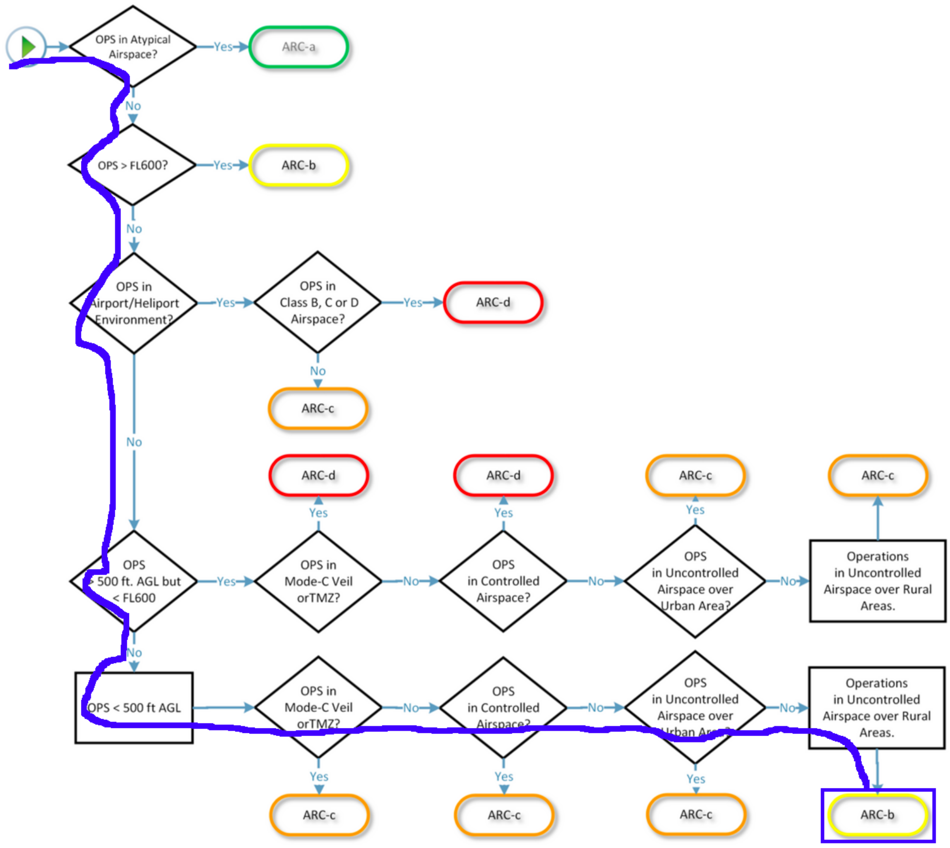

Figure 5: Initial Air Risk Class

Which ARC does the operation fall under? The area in drone zones is not green, and thus, the OPS is not in Atypical Airspace. The OPS isn't larger than FL600 which is equal to a height of 60.000ft which is around 18 km up. We plan to fly at an altitude of 30m. We don't fly with Mode-C veil or TMZ since there is no need to broadcast our position to nearby planes, because of our flight height and geographical position. The OPS is in uncontrolled airspace over Rural Areas and thus the iARC class becomes ARC-b.

Are there NOTAMs or temporary no-fly zones? There is a temporary no-fly zone on the 10th of October 2024.

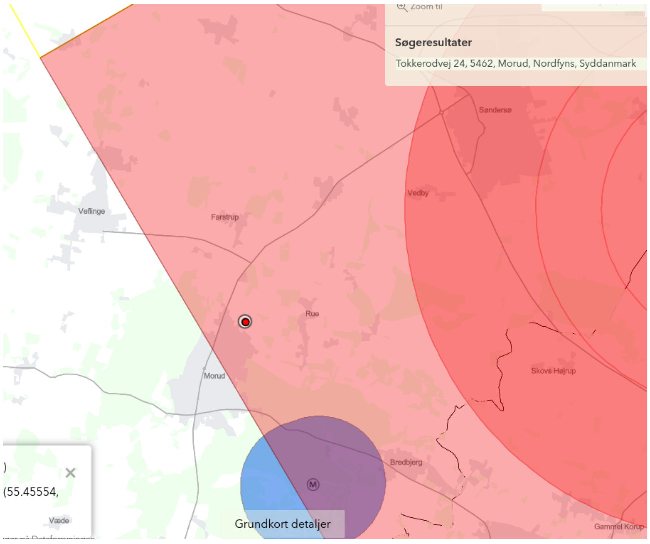

Figure 6: No-Fly Zone

Step 5: Strategic Mitigations

We need to fly during the daytime to get proper monitorization, so we can't utilize a nighttime flight which would be a boundary in chronology. We have chosen to fly with a low altitude of 30m, which is a strategic choice to reduce the ground risk buffer zone but also reduce the general consequences of emergencies. However, this is not enough to change the iARC from class b to class a.

Step 6: Tactical Mitigations Performance Requirements

What is the TMPR level that applies to this application? Since the ARC is class level b, we would have the low-level TMPR level.

Step 7: Specific Assurance and Integrity Levels

What is the SAIL level of this operation? Since the Residual ARC ended at class b, and the final GRC we ended up at sail level 3.

SAIL Determination				
	Residual ARC			
Final GRC	a	b	c	d
≤2	I	II	IV	VI
3	II	II	IV	VI
4	III	III	IV	VI
5	IV	IV	IV	VI
6	V	V	V	VI
7	VI	VI	VI	VI
>7	Category C (Certified) operation[10]			

Figure 7: Enter Caption

Step 8: Containment Requirement

What is the size of your adjacent area? The adjacent area is found as the range that the drone can travel at its maximum speed for a duration of 3 minutes.

$$\text{Adjacent area} = 3\text{min} \cdot 60\text{s} \cdot 21\text{m/s} = 5400\text{m} \tag{1}$$

This places us in case B.

What is the containment requirement of your operation? By finding the intersection of the population density in the adjacent area with the SAIL score on figure 8, we find ourselves to have a low containment requirement.

3 m UA (< 35 m/s) Shelter not applicable for the UA in the adjacent area				
Average Population density allowed	No Upper Limit	< 50,000 ppl/km^2	< 5,000 ppl/km^2	< 500 ppl/km^2
Outdoor Assemblies allowed within 1km of the OPS volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k people	
SAIL				
I & II	Out of scope	High	Medium	Low
III	Out of scope	Medium	Low	Low
IV	Medium	Low	Low	Low
V & VI	Low	Low	Low	Low

Figure 8: Containment requirement 3min UA without shelter assumption

Step 9: Operational Safety Objectives

What is the level of assurance and integrity needed for every OSO? The level of assurance and integrity for each OSO is stated in the table.

OSO	1	2	3	4	5	6	7	8	9	13	16	17	18	19	20	23	24
Level	M	L	M	NR	L	L	M	H	M	M	M	M	L	L	L	M	M

Step 10: Comprehensive Safety Portfolio (CSP)

What should you include in the CSP?

- Detailed operational description
- Safety claims
- Derived requirements
- Compliance evidence
- Justified safety case Compliance matrix

2 Procedures and checklist exercise

Flight planning

- Check weather forecast
- Check the website `https://www.droneregler.dk/dronezoner` for restrictions
- Check for nearby events
- Charge the batteries
- Preliminary check that the drone is operational

Pre-flight

Required immediately before the first flight of the day or after a longer break such as lunch.

- Check that batteries are equipped and that they have charge
- Check drone condition such as rotors and antenna
- Check radio communication
- Make sure that the weather conditions are still adequate for flight
- Check all equipment is working

Normal flight

- Keep checking for nearby planes
- Make sure to be inside flight geography
- If inside contingency area, return to flight geography
- Keep a line of sight and be weary of Fresnel zones

Post flight

- Make sure that the drone hasn't been damaged and is in fine condition
- Conclude on the success of the operation
- Clean up after yourself

Contingency

- Warn fellow operators about the state of the flight
- Attempt to bring back the UAS to a normal state
- Prepare to "kill" the drone if it enters the ground risk buffers
- Check for collision

Emergency

- Understand how to access all areas within the entire adjacent area and iGRC footprint.
- Predetermine the seats in your vehicle
- Know who to call if things go wrong (Airport, Local & National Police, Military & National Guard, Fire & Rescue, Hospital, etc.)