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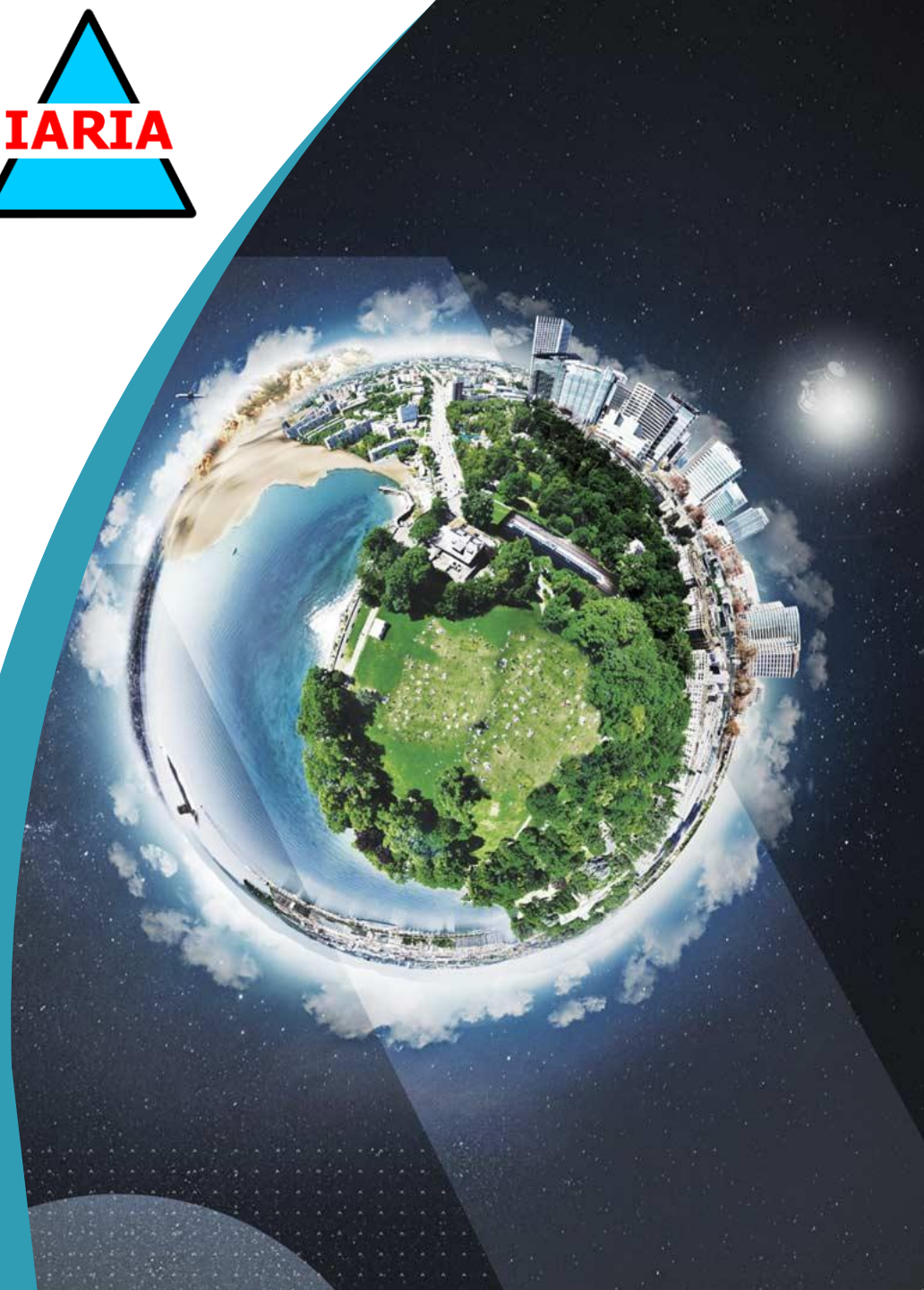

Using SORA Principles to Assess The Safety of Unmanned Traffic Management (UTM) Services

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Short Resume of Eng. Sara Rachid

Professional Experience:

- Sara Rachid has an engineering degree in the quality and dependability of industrial systems.
- She is currently working as a system safety engineer in Thales France, on Air Traffic Management (ATM) and Unmanned Traffic Management (UTM) systems.
- Her research interest lies in the enhancement of safety methodologies for emerging industrial needs.

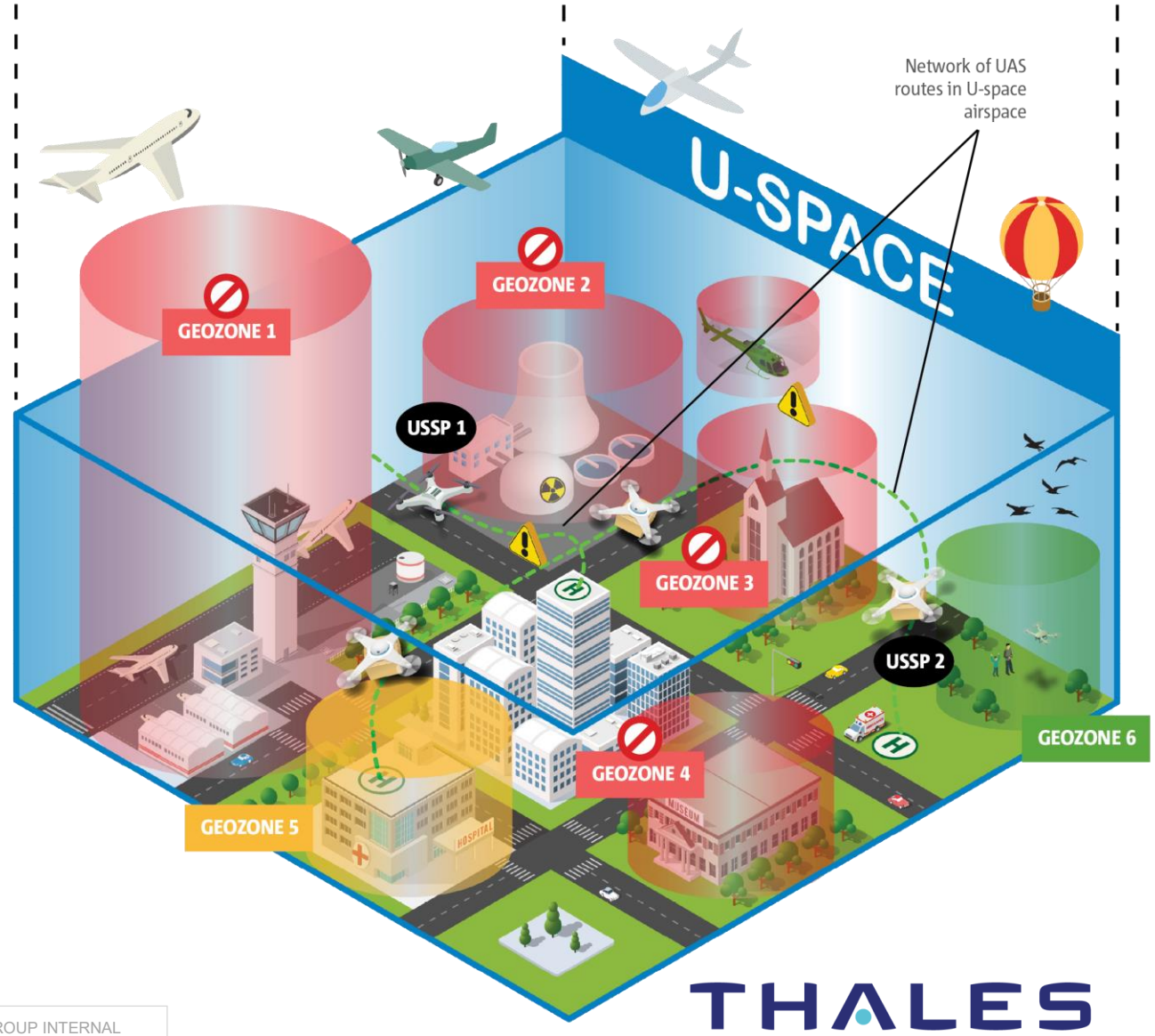
Context Introduction

This paper is related to the management of drones traffic and its potential safety risks on:

- Other aircraft
- And on humans on the ground

Hereafter two key terms on the subject:

- Unmanned Aircraft Systems (UAS)
  - Include drones and their control-and-command systems
- Unmanned Traffic Management (UTM)
  - includes all services used to manage UAS operations



Specificity of UTM Systems

Include different services:

- Services to monitor drone positions
- Services to detect potential conflicts between drones
- Etc.

Manage UAS operations with several variables:

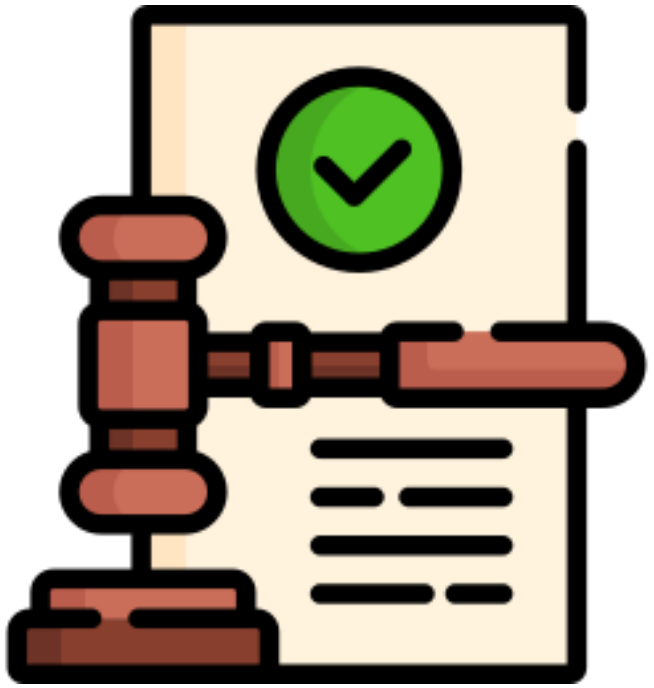
- Dimensions of the drone.
- How the remote pilot monitors their drone.
- Reliability of the drone, command-and-control systems and other services used for the operation.
- Aircraft density in the air.
- Population density on the ground.

Safety Requirements in UAS Regulations

Regulators (e.g., European) require demonstrating the safety of :

- UAS operations (e.g., through the SORA Method)
- The UAS airspace
- Services supporting UAS operations, **like UTM services**.

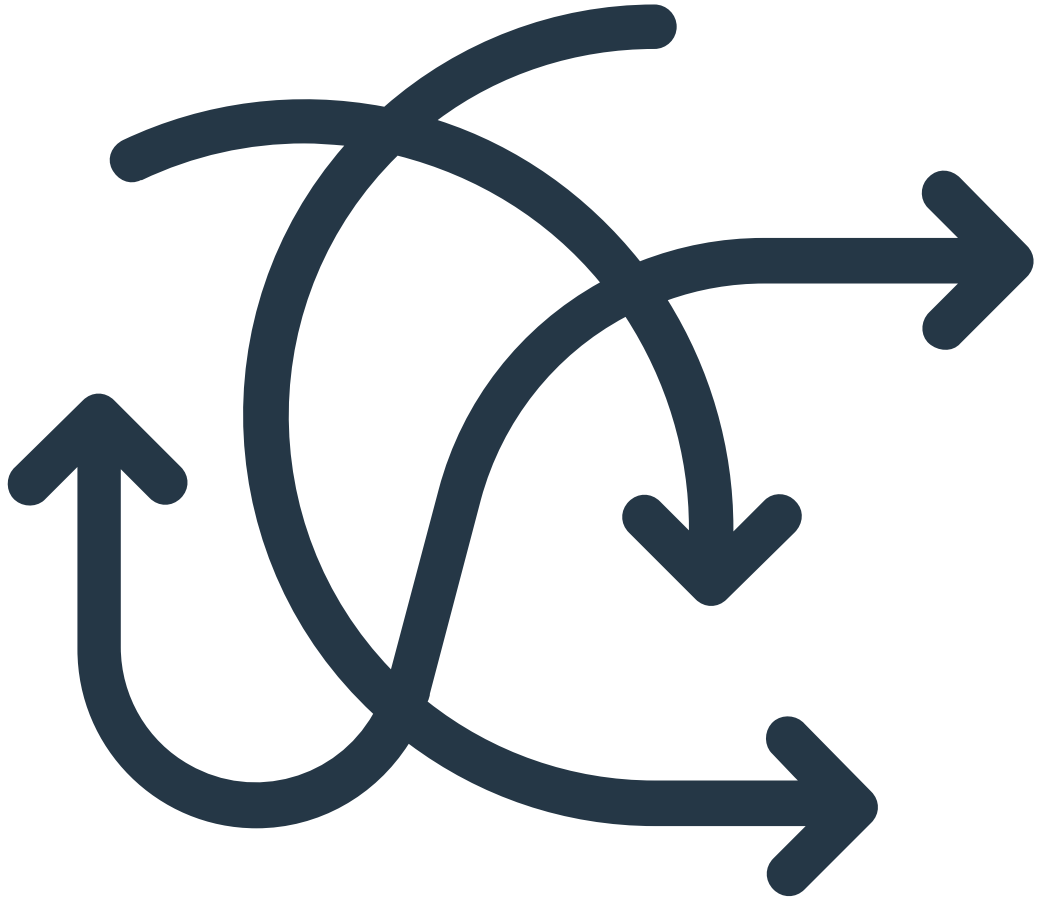
→ UTM system manufacturers shall demonstrate the safety of their systems.



Challenges to Assess The Safety of UTM Systems

Challenges to Assess The Safety of UTM Systems :

- Variable safety risk depending on operational scenarios
- Only traditional safety assessment methods are available for UTM safety assessment
- No specific methods defined by EASA to apply in this context
- No adapted safety tools (e.g., severity matrix) or methods for the UAS/UTM operational context
- Difficulty to allocate the appropriate safety objectives to UTM systems



Purpose of The Paper

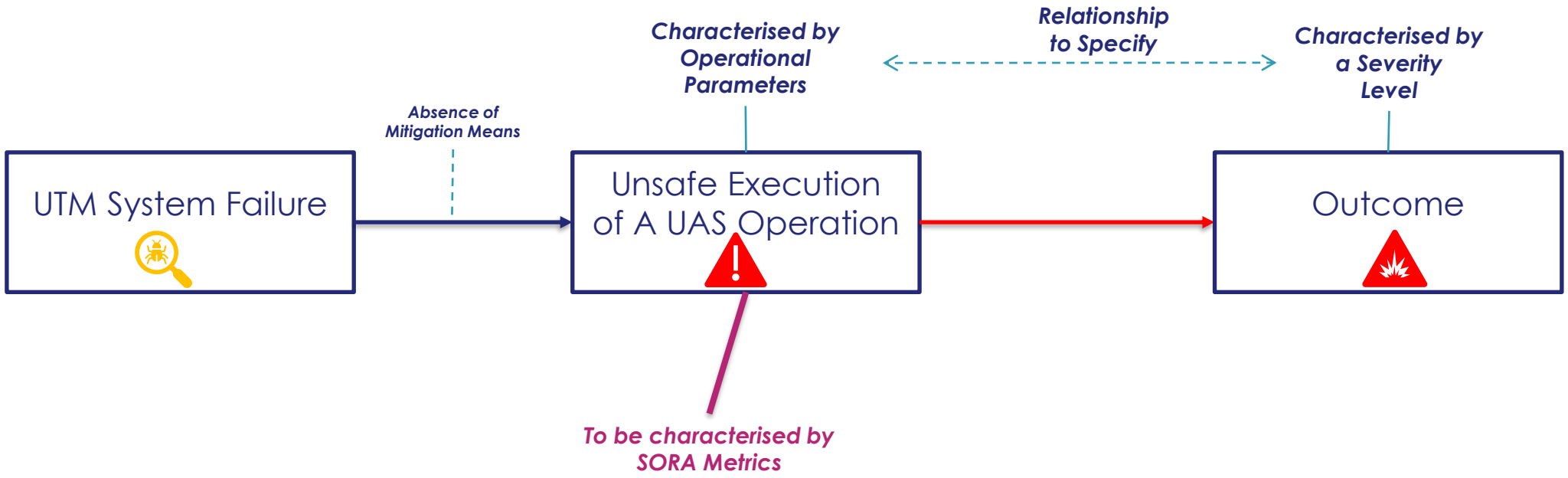
This paper presents a UTM safety assessment method :

- That provides tools to assess the safety impact of UTM systems.
- That considers the variability of UAS operations.
- Adapted to UTM operational specificities
- That can be integrated smoothly in traditional aeronautical safety frameworks (e.g., SAM by EUROCONTROL)

Assumptions of The Method

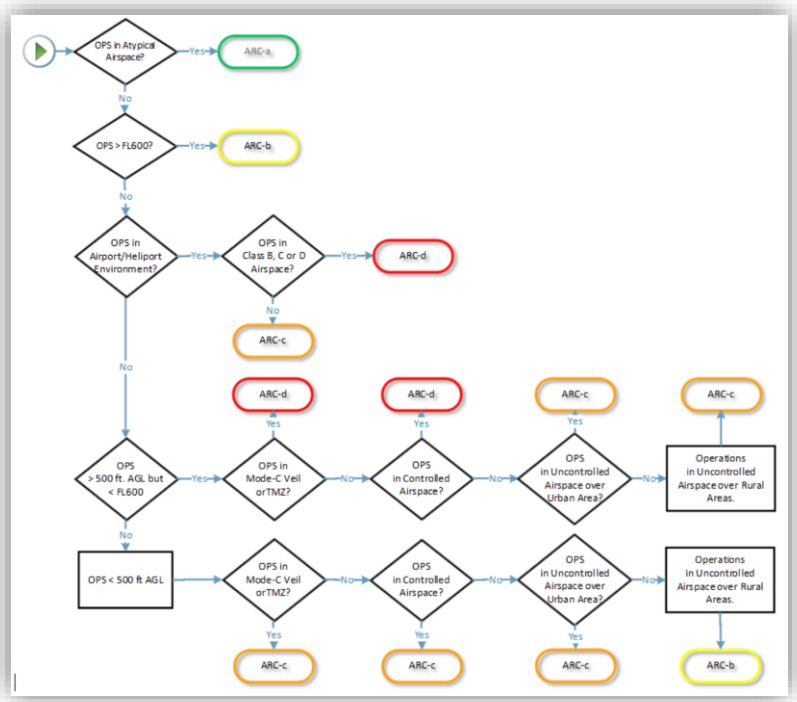
To build this method, the following assumptions are considered:

- The unmitigated failure of a UTM system can ultimately result in an unsafe execution of the UAS operations managed by that system.
- An unsafe execution of a UAS operation is characterised by its operational parameters.



The SORA Methodology

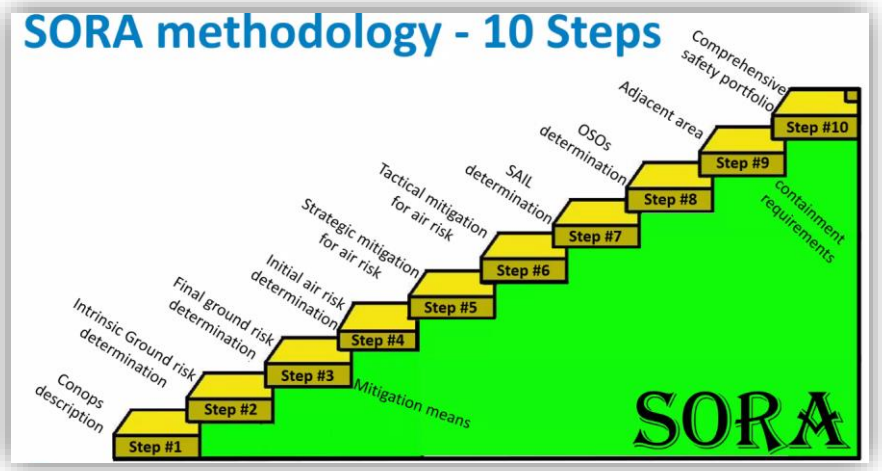
- The SORA is performed by UAS operators, to assess and demonstrate the safety of their UAS operation(s).
- The SORA defines two metrics:
  - ARC (Air Risk Class) to represent the risk of collision between a drone and manned aircraft
  - and GRC (Ground Risk Class) to represent the risk of collision between a drone and a human on the ground.



Max UAS Characteristics Dimension		1 m ≈ 3 ft	3 m ≈ 10 ft	8 m ≈ 25 ft	20 m ≈ 65 ft	40 m ≈ 130 ft
Maximum Speed		25 m/s	35 m/s	75 m/s	120 m/s	200 m/s
Maximum Population Density (people/ km²)	**Controlled Ground Area**	1 (S5)	1 (S5)	2 (S5)	3 (S4)	3 (S4)
	< 5 (Remote)	2 (S5)	3 (S4)	4 (S4)	5 (S3)	6 (S2)
	< 50 (Lightly populated)	3 (S4)	4 (S4)	5 (S3)	6 (S2)	7 (S1)
	< 500 (Sparsely populated/ Residential lightly populated)	4 (S4)	5 (S3)	6 (S2)	7 (S1)	8 (S1)
	< 5,000 (Suburban/ Low density metropolitan)	5 (S3)	6 (S2)	7 (S1)	8 (S1)	9 (S1)
	< 50,000 (High density metropolitan)	6 (S2)	7 (S1)	8 (S1)	9 (S1)	10 (S1)
	> 50,000 (Assemblies of people)	7 (S1)	8 (S1)	*Not part of SORA v2.5*		

Choice of SORA and Applicability

- SORA metrics are chosen to characterise the safety risk of a UAS operation because:
  - They represent a finite number of risk classes
    - A simpler association to severity levels
  - They rely on concrete operational parameters
    - Easier evaluation of the safety impact
  - The SORA is recognised and recommended by the European Aviation Safety Agency*.



- The SORA and the proposal of this paper do not cover the risk of collision between drones.

** The SORA is recommended as an acceptable means of compliance with Article 11 of the UAS Regulation (EU) 2019/947.*

Contribution 1 : Definition of Severity Levels

A severity matrix adapted to the context of UAS was defined to:

- Determine the aspects potentially impacted by a UTM failure
- Determine the potential undesired events on these aspects
- Classify these events based on their severity

Severity Category		Effect on People on The Ground	Effect on Manned Aircraft	Effect on UAS Crew
S5	No Safety Effect	Discomfort to persons	No safety effect	No safety effect
S4	Minor	Physical distress or minimal injuries to persons	Potential contingency manoeuvre to anticipate a reduction in safety separation, with no safety effect on the manned aircraft crew.	Slight increase in UAS crew workload, such as flight plan changes.
S3	Major	Non-serious injuries to persons	Significant reduction in safety separation between unmanned and manned aircraft	Significant increase in UAS crew workload or impaired remote crew efficiency
S2	Hazardous	Serious injuries to one or many persons, with no fatalities	Large reduction in safety separation between unmanned and manned aircraft	High workload such that the UAS crew cannot be relied upon to perform their tasks accurately or completely
S1	Catastrophic	Fatality or fatal injury to one or many persons	A collision with a manned aircraft	

Contribution 2 : Relationship between SORA GRC and Severity Levels

GRC represents the risk of collision between a drone and a human on the ground.

It is assumed that :

- A strike by a drone can be fatal if the kinetic energy released ≥ 150 J.
- Drones with a speed of 25 m/s can release a kinetic energy ≥ 150 J.
- The first column of the GRC table includes the highest severity level (fatalities on the ground).

As a result:

- GRC=1 is associated to 'no safety effect'
- GRC=7 is associated to 'one or more fatalities on the ground'
- Other GRC-Severity associations are determined based on the ground population density.

Max UAS Characteristics Dimension		1 m ≈ 3 ft	3 m ≈ 10 ft	8 m ≈ 25 ft	20 m ≈ 65 ft	40 m ≈ 130 ft
Maximum Speed		25 m/s	35 m/s	75 m/s	120 m/s	200 m/s
Maximum Population Density (people/ km²)	Controlled Ground Area	1 (S5)	1 (S5)	2 (S5)	3 (S4)	3 (S4)
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	> 50,000 (Assemblies of people)	7 (S1)	8 (S1)	*Not part of SORA v2.5*		

Contribution 2 : Relationship between SORA ARC and Severity Levels

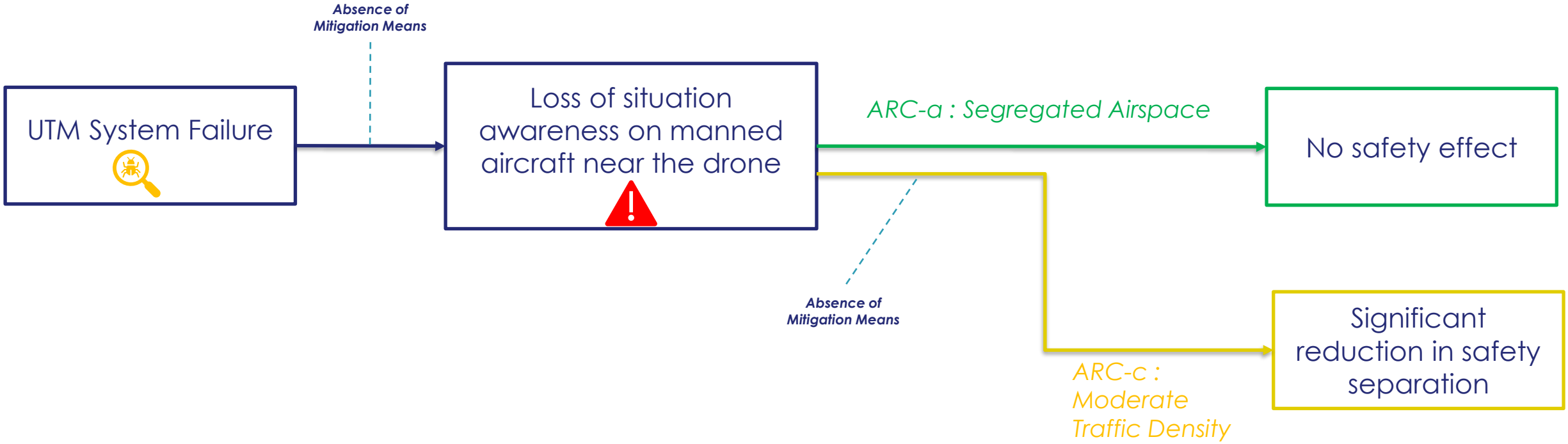
- ARC represents the risk of collision between a drone and a manned aircraft in the air.
- SORA provides textual definitions for ARC classes.
- The table below is proposed to define ARC classes as a matrix:

Manned A/C Encounter Probability (Based on Intrinsic Airspace Characteristics)	Efficiency of Available Strategic Mitigation Means		
	Low	Medium	High
Extremely low	ARC-a (S5)	ARC-a (S5)	ARC-a (S5)
Low	ARC-b (S4)	ARC-b (S4)	ARC-b (S4)
Moderate	ARC-c'(S2)	ARC-c (S3)	ARC-b (S4)
High	ARC-d (S1)	ARC-c'(S2)	ARC-c (S3)

- The matrix representation enables a modulation of ARC-c into two sub-classes:
  - ARC-c & ARC-c'
- This enables a one-to-one mapping between ARC and severity levels.

Application through Use Case

The following scenario is an application of the proposed methodology to determine the safety outcome of a UTM system failure:



Conclusion and Future Work

Methodology proposed by the paper:

- A severity matrix adapted to UTM operational specificities
- Transfer functions between the severity matrix and SORA risk metrics

Benefits:

- It helps UTM system manufacturers assess the safety effect of UTM systems.
- It can be integrated in traditional aviation safety frameworks (e.g., EUROCONTROL SAM).
- The use of SORA principles enables more practice harmonisation between different UAS actors.

Future work:

- Integration of the risk of collision between drones
- Revision of methodology assumptions based on growing return on experience

THANK YOU