

Risk assessment for drones operations

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MINISTÈRE
DE LA TRANSITION
ÉCOLOGIQUE
ET SOLIDAIRE



D S N A



Direction Générale de l'Aviation Civile

Ministère de la Transition écologique et solidaire

DGAC /DSNA /DTI

- French Air Navigation Service Provider
 - is responsible for delivering Air Traffic control services within the French metropolitan airspace (800.000 km²) and overseas dependencies
 - handles roughly 2.8 million flights a year more than 80 control towers, 7 ACC (2 overseas, 5 in ECAC airspace).
- DTI (DSNA Technical and Innovation center)
 - contributes to the definition and upgrade of CONOPS, associated systems and services
 - has participated as a leader or contributor in more than 70 projects during SESAR steps 1&2 (2009/ 2013)



Outline

Introduction

• Drone European regulation

Operational risk assessment

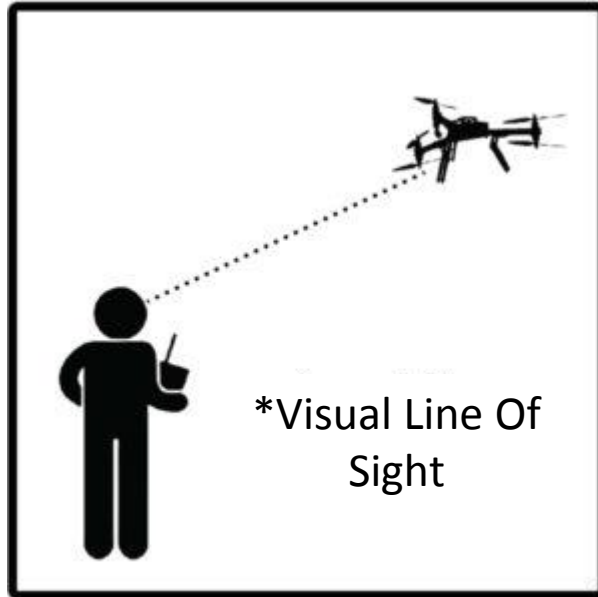
Navigation, GNSS ... requirements

Conclusion

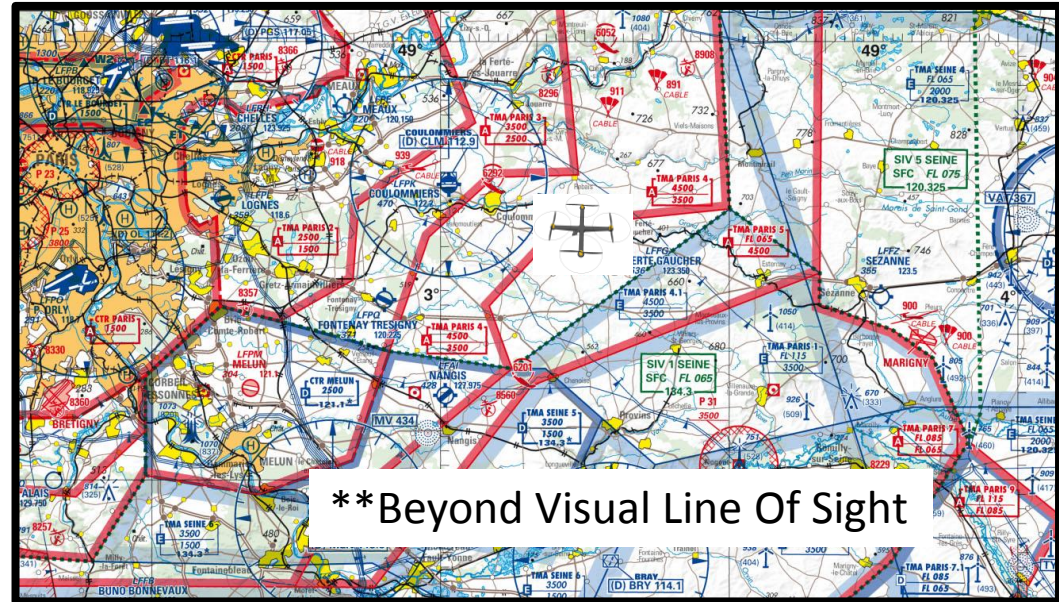
	High Altitude UASs	Drones sharing the airspace	Low Altitude drones
Operations	Above conventional manned aviation activities	RPAS applying IFR rules or accommodation	In parts of the airspace not (usually) open to manned aviation
C2Link	Reliable C2link + VHF relay?	Reliable C2Link + VHF relay	C2Link requirements TBD Low cost
Navigation	GNSS + IMU (Inertial Measurement Unit)	RNP (Required Navigation Performance)	GNSS + IMU + SLAM (Simultaneous Localisation And Mapping) + ?
Surveillance	TBD	Mode S / ADS-B (1090ES / UAT)	Identification, surveillance (situational awareness for the remote pilot) and tracking
Management	ATM** + accommodation	ATM + UTM*** (U-Space)	UTM (U-Space) but interface with ATM

* Unmanned Aircraft System, ** Air Traffic Management, ***UAS Traffic Management

VLOS *



BVLOS**



The remote pilot is responsible for exercise of vigilance at any time:

- In VLOS, with his eyes;
- In BVLOS, using situational awareness provided by systems (sensors on-board or from UTM/ ATM)



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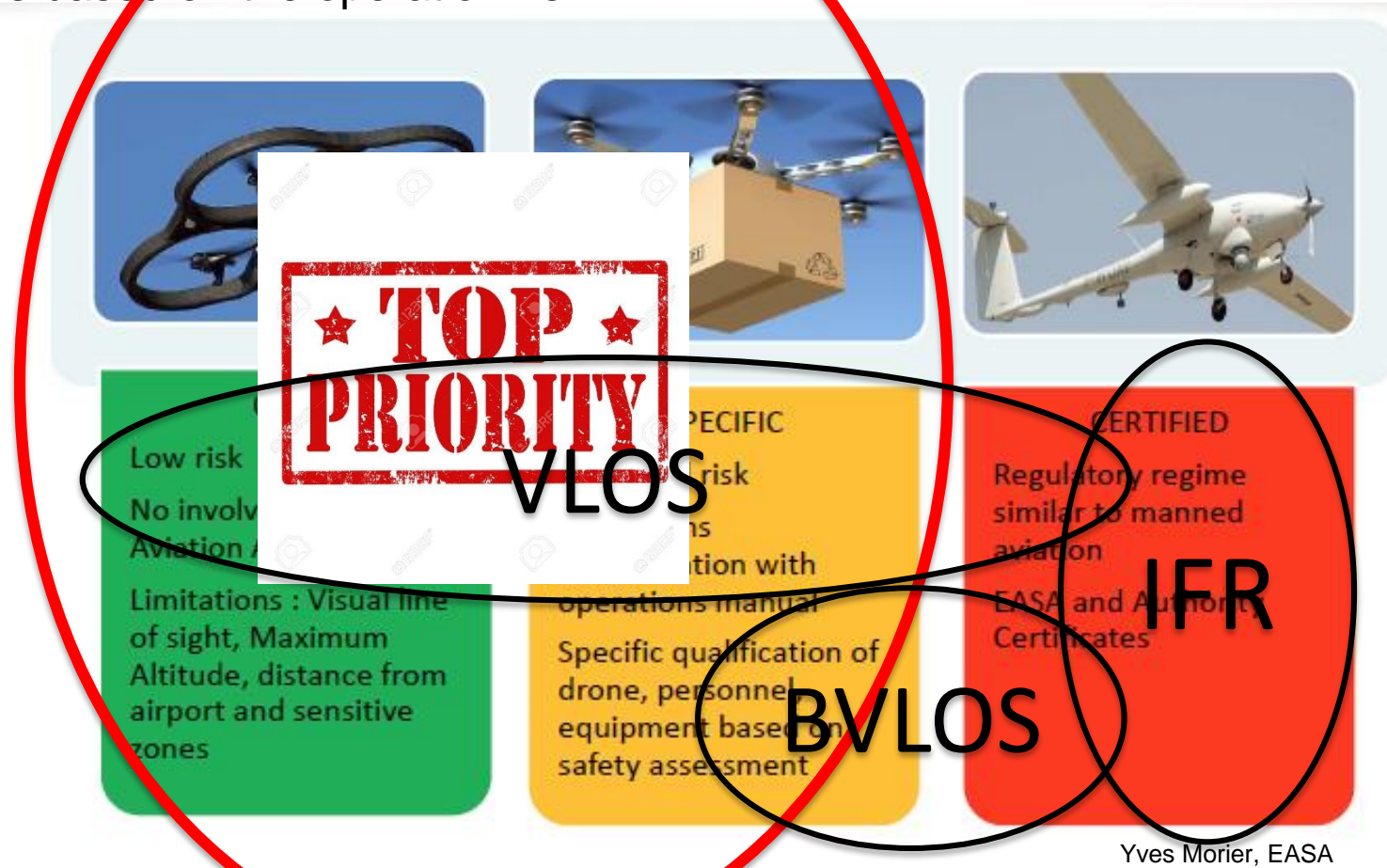
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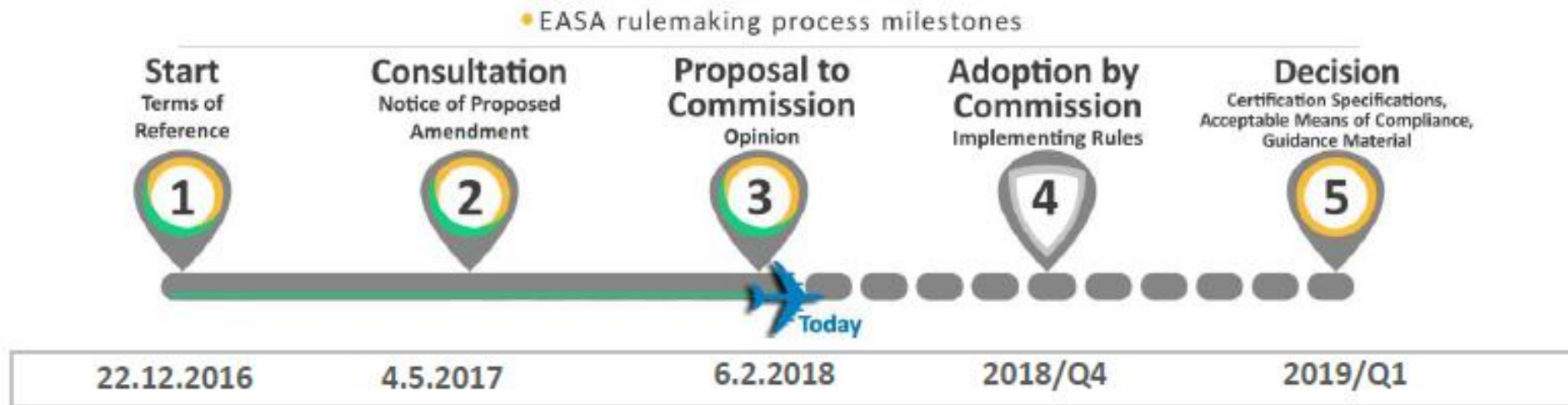
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A-NPA : Advanced Notice of Proposed Amendment, published in July 2015, is based on the operation risk.





European regulation for Open and Specific categories should be applicable end of 2019.

Categories of operations

	Open	Specific	Certified
Operational approval	No	Yes	No
Type Design (TC/STC)	No	Maybe*	Yes
Certificate of Airworthiness	No	Maybe*	Yes
Conformity to Design Standard	Maybe	Maybe*	Yes
Pilot License	No	Maybe*	Yes
Operator Approval	No	Maybe*	Yes
Maintenance Approval	No	Maybe*	Yes
Production Approval	No	Maybe*	Yes

*- implies that some approvals may not be mandatory depending on the outcome of the risks assessment

Source : JARUS



CERTIFIED
Regulatory regime
similar to manned
aviation
EASA and Authority
Certificates

IFR

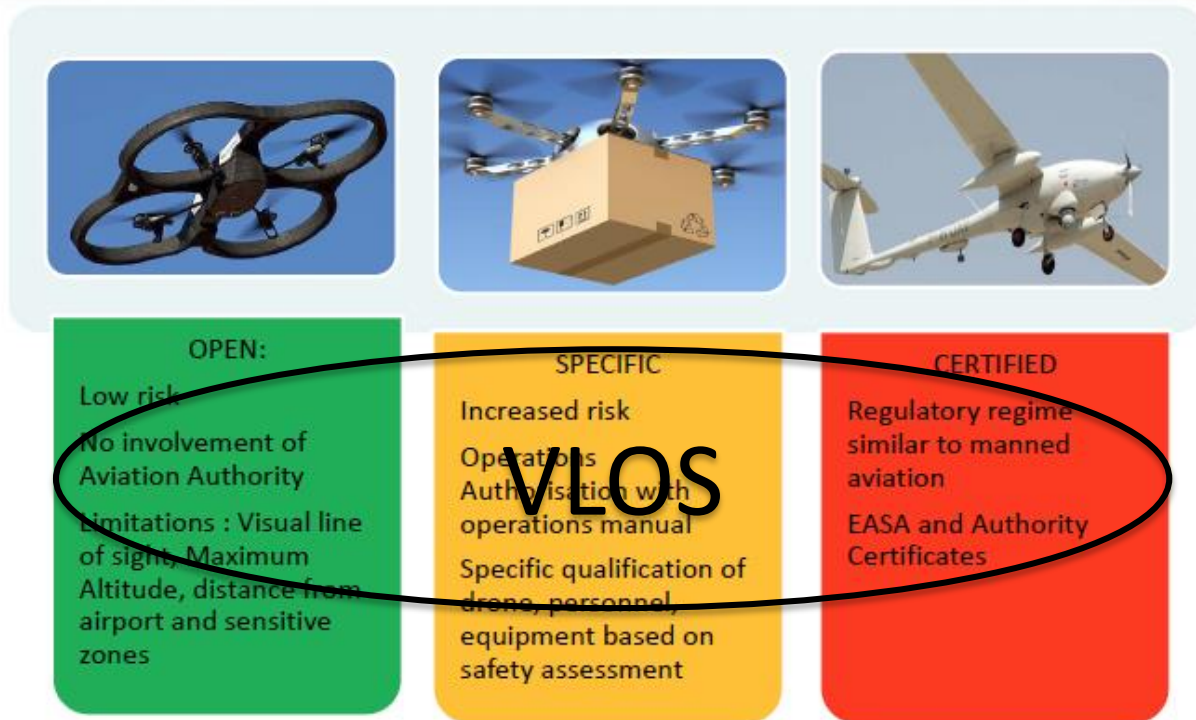
- Requirements similar to manned aviation
- Access to Airspace Classes Performance based
- Remote pilot situational awareness, ATC surveillance



Certified equipments: Required Navigation Performances (RNP)

Drone European regulation

Navigation high level requirements (2)



- The remote pilot is responsible for the drone navigation with his eyes.
- But:
 - Geo-awareness based on GNSS
 - Geo-fencing based on GNSS
 - Geo-caging based on GNSS



Margins
Containment areas



- Risk assessment for the operation
- Navigation requirements
- Access to volumes of airspace Performance based



Margins
Containment areas
UTM/ U-Space services

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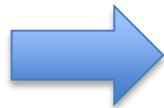
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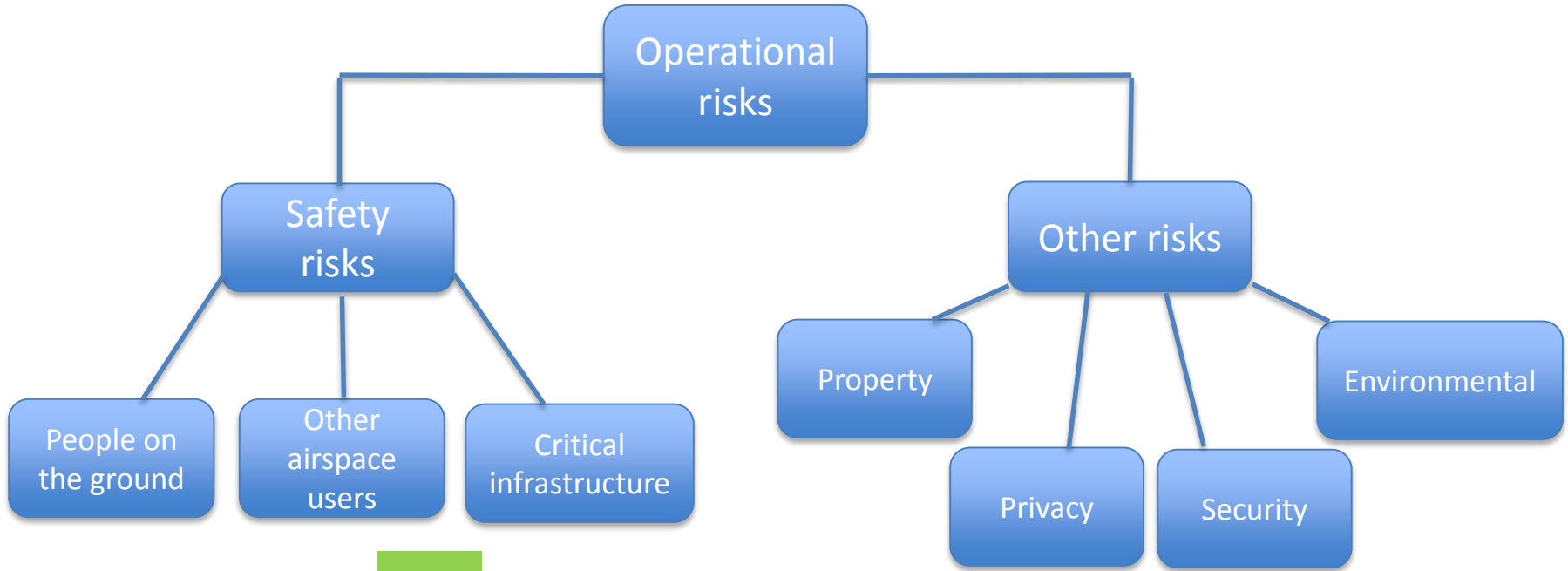
Specific Operational Risk Assessment (SORA)

- For all UAS operations, but mainly Category Specific
- Carriage of people on board UAS is explicitly excluded
- Security aspects are excluded
- Privacy aspects are excluded



Methodology for the risk assessment in order to support the application for an approval to operate UAS

* Joint Authorities for Rulemaking on Unmanned systems



Low



Medium

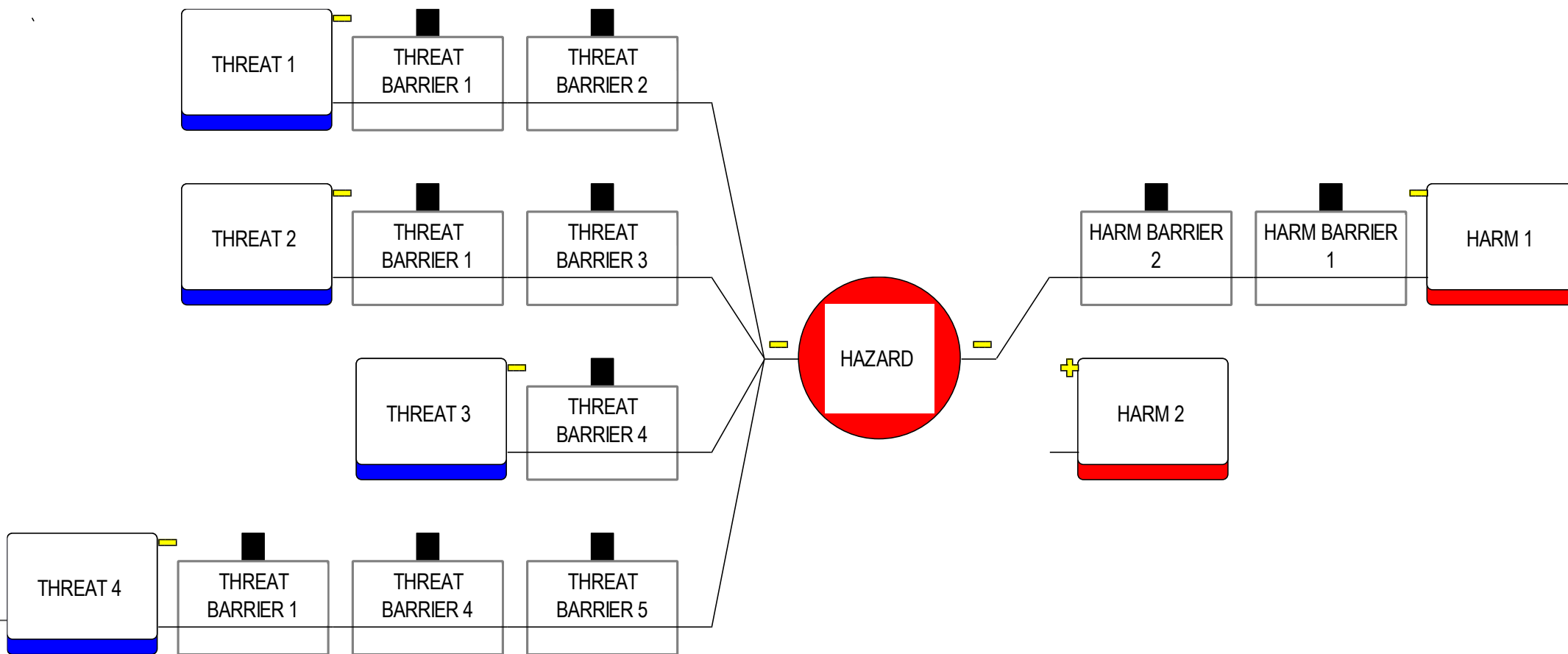
High

Mitigations with 3 levels of robustness

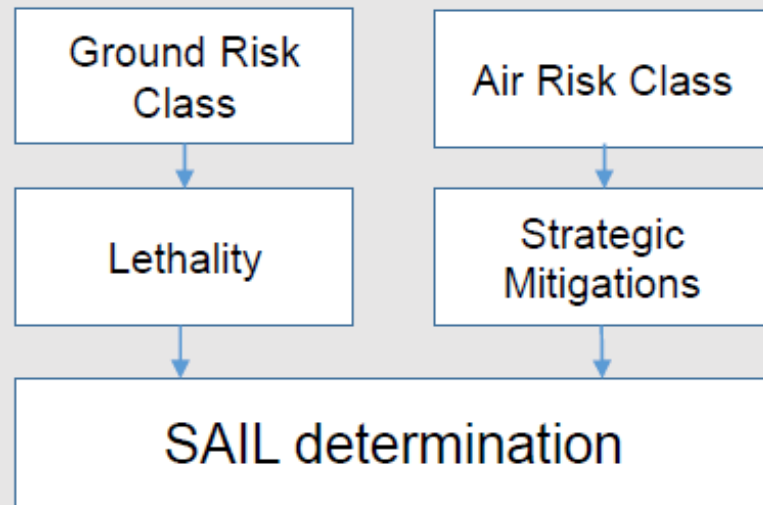
given by the SAIL (Specific Assurance and Integrity Level)

Note: SORA has been proposed by JARUS and is still under development

- Hazards considered
 - UAS operation is out of control
- Harms
 - Fatal injuries to third parties on the ground
 - Fatal injuries to third parties in the air (Mid-air collision with manned aircraft)
 - Damage to critical infrastructure
- Generic threats
 - Technical issue with the UAS 
 - Human error
 - Loss of safe separation
 - Adverse operating conditions
 - Datalink deterioration
 - Deterioration of external systems supporting the UAS operation 
 - Fire



Specific Assurance and Integrity Level (SAIL) determination



SAIL							
UAS Lethality	Operation Ground/Air Risk Class						
	7	6	5	4	3	2	1
HIGH	VI	VI	V	IV	III	II	I
AVERAGE	VI	V	IV	III	II	I	0
LOW	V	IV	III	II	I	0	0

Source: JARUS WG-6

1. Technical issues with UAS
2. Operational procedures
3. Remote crew training
4. Safe design
5. Deterioration of external systems supporting UAS operation
6. Human Error
7. Adverse Operating Conditions

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OPERATIONAL PROCEDURES		LEVEL of INTEGRITY		
		Low	Medium	High
Comments	N/A	N/A	N/A	N/A
Criterion #2 (Procedure complexity which could jeopardize adherence to)	Operational procedures are complex and/or lead to a significant increase of workload of the remote flight crew and/or interactions with several entities (ATM...)	Operational procedures involve the remote pilot to take manual control ¹ when the UAS is usually automatically controlled.		Operational procedures are simple
Comments	N/A	¹ This is still under discussion since not all UAS have a mode where the pilot could directly control the surfaces.		
Criterion #3 (Consideration of Potential Human Error)	Operational procedures at minimum: <ul style="list-style-type: none"> a clear distribution assignment of tasks an internal check staff are performing assigned tasks. 			
Comments	N/A			

The “operational procedures” covers:

- the deterioration of the UAS itself,
- the deterioration of any external system supporting the operation, such as systems used to:
 - launch / take-off the UAS,
 - make pre-flight checks,
 - keep the UA within its operation volume (e.g. GNSS, Satellite Systems, Air Traffic Management, UTM).

avoiding stress and increasing efficiency.

DETERIORATION OF EXTERNAL SYSTEMS SUPPORTING UAS OPERATION BEYOND THE CONTROL OF THE UAS		LEVEL of ASSURANCE		
		Low	Medium	High
OSO #13 External services supporting UAS operations are adequate to the operation	Criteria	The applicant declares that the requested level of performance for any externally provided service necessary for the safety of the flight is achieved (without evidence being necessary if available).	<p>The applicant has supporting evidence that the required level of performance can be achieved for the full duration of the mission.</p> <p>This may take the form of a Service-Level Agreement (SLA) or any official commitment that prevails between a service provider and the applicant on relevant aspects of the service (including quality, availability, and appropriate actions if real-time performance could lead to the loss of control of the operation).</p>	<p>Same as Medium. In addition:</p> <ul style="list-style-type: none"> The evidence of the externally provided service performance is achieved through demonstrations
	Comments	N/A	N/A	N/A

It is the responsibility of the operator to ensure that the level of performance of any externally provided service necessary for the safety of the flight is adequate for the intended operation.

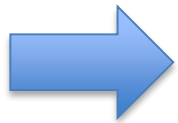
Access to volumes of airspace will be Performance Based

- Navigation requirements
- Surveillance means, Detect And Avoid
- ATM, UTM (geo-fencing, tactical deconfliction), services provided by Military.

GNSS req in terms of precision, availability, integrity and security

The SORA process should not be used to support operations in a given airspace **without the UAS being equipped with the required equipment for operations in that airspace** (e.g. equipment required for navigation or to ensure interoperability with other airspace users).

Up to now, RNP is well defined for IFR operations, but still need to be specified for other drones' flights. To be consistent with SORA, could be 3 levels of robustness?



Use of GNSS/ Galileo (resilience) + EGNOS/ SBAS (integrity)

- How to guaranty requirements with non-certified equipments?
- How to guaranty interoperability without standards?
- What about competency of operators, remote pilots?
- (...)

UTM/ U-Space could be part of the answer.

Cooperation between Research, Industry, Regulators is needed !

GAUSS project: Galileo-EGNOS as an Asset for UTM Safety and Security

<https://www.gsa.europa.eu/galileo-egnos-asset-utm-safety-and-security>

Questions?



DSNA



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OPERATIONAL PROCEDURES		LEVEL of INTEGRITY		
		Low	Medium	High
OSO #08, OSO #11, OSO #14 and OSO #21	Criterion #1 (Procedure definition)	<ul style="list-style-type: none"> Operational procedures appropriate for the specificities of the operation to be approved are defined and cover at least the following elements: <ul style="list-style-type: none"> Flight planning, Pre and post-flight inspections, Procedures to evaluate environmental conditions before and during the mission (i.e. real-time evaluation), Procedures to cope with adverse operating conditions (e.g. what to do in case icing is encountered during the operation, when the operation is not approved for icing conditions) Normal procedures, Contingency procedures (to cope with abnormal situations), Emergency procedures (to cope with emergency situations), and Occurrence reporting procedures. Normal, Abnormal and Emergency procedures are compiled in an Operation Manual. The limitations of the external systems supporting UAS for safe operations are defined in an Operation Manual. 		

OPERATIONAL PROCEDURES		LEVEL of ASSURANCE		
		Low	Medium	High
OSO #08, OSO #11, OSO #14 and OSO #21	Criteria	<ul style="list-style-type: none"> Operational procedures are not validated against a recognized standard. The adequacy of the operational procedures and checklists is declarative, except for the Emergency Procedures, which are tested. 	<ul style="list-style-type: none"> Operational procedures are validated against recognized standards. The adequacy of the Contingency and Emergency procedures is proved through: <ul style="list-style-type: none"> Dedicated flight tests, or Simulation, provided that the representativeness of the simulation means is proven for the intended purpose with positive results. 	<p>Same as Medium. In addition:</p> <ul style="list-style-type: none"> A competent third party validates operational procedures/checklists, flight tests and simulations. Any flight test performed to validate the operational procedures cover the complete flight envelope or be proven to be conservative.
	Comments	N/A	N/A	N/A



ATM

- Existing Concept of operations (CONOPS) and systems
- Services provided by Air Navigation Service Provider
- High level of safety
- High costs

UTM (U-Space)

- Need to define CONOPS and systems
- Safety and security issues
- Relationship between ATM* and UTM*
- Business model (low costs)

UTM (U-Space) = A new idea all over the world, many initiatives!!!

*Air Traffic Management **UAS Traffic Management