Developing a safety methodology for drones

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Developing a safety methodology for drones

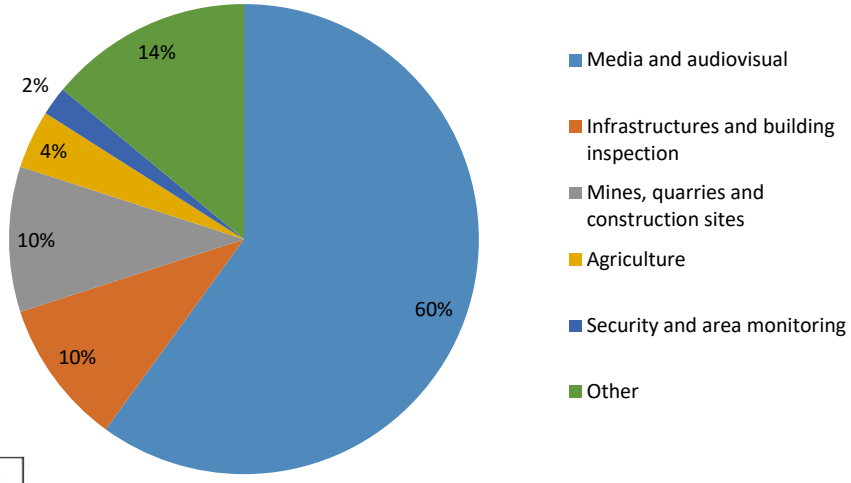
1. Professional civil drones in France
2. A needed change of paradigm in regulations
3. A Safety methodology for drones
    1. Third party presence likelihood
    2. Fatal failure likelihood
4. Way forward

Professional civil drones in France

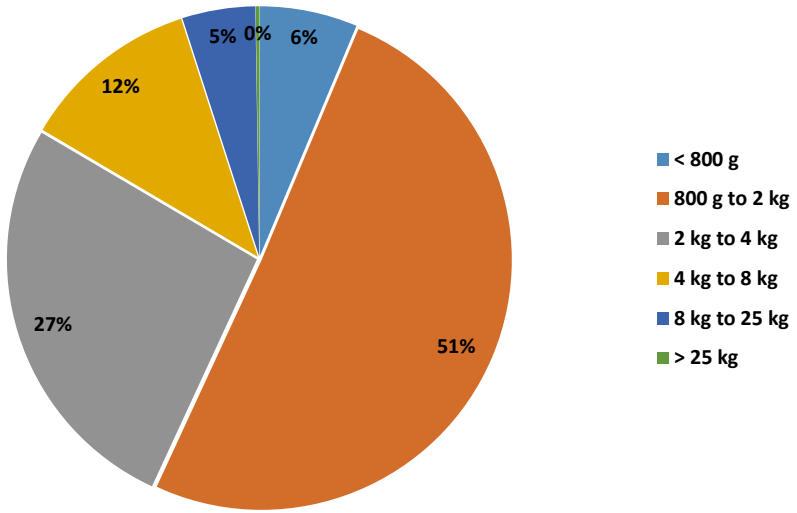
- **A fast-growing business**

~7 100 operators, ~12 500 professional drones, ~11 000 jobs and an estimated turnaround of 250M€ in 2017

Professional drones activity in France (2017)



Mass repartition of professional drones in France (end 2017)



(source : DGAC/DSAC)

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Professional Civil drones in France

Professional Civil drones in France

- **Overview of the French civil drones regulation (2012, updated 2015 and 2018)**

Leisure and competition
(incl. aeromodelism)

Aerial Work

Experimentation

VLOS

SCENARIO 1
Non-populated area
Mass < 25 kg
Height < 150 m
Dist < 200m

115 000 Fl.Hr

SCENARIO 3
Populated area
Mass < 8 kg
Dist<100m
Height<50m
Safety perimeter

56 700 Fl.Hr

BVLOS

SCENARIO 2
Non-populated area
D < 1 km
Mass < 25 kg and
Height < 50 m
Or Mass< 2kg and height < 150m

15 300 Fl.Hr

SCENARIO 4
Non-populated area
Mass < 2 kg
Height<150m
Above third

1 100 Fl.Hr

2017
(declared)

A needed change of paradigm in regulations

- **French experience shows that the « operational restriction » approach has already reached its limits**
  - No ability to develop new « scenarios »
  - Experimentations possible, but no way forward for mass uses

- **New approach in the Civil Drones Council**
  - Clear allocation of responsibilities to the operator and to the manufacturer (and to the authority…)
  - Development of a trustworthy safety methodology based on aeronautical standards
    - **To Guarantee a safety level at least equivalent to today's civil aviation system…**
    - **…. and compatible with estimated drone traffic increase at low levels**
    - Exportable at European level

A safety methodology for drones

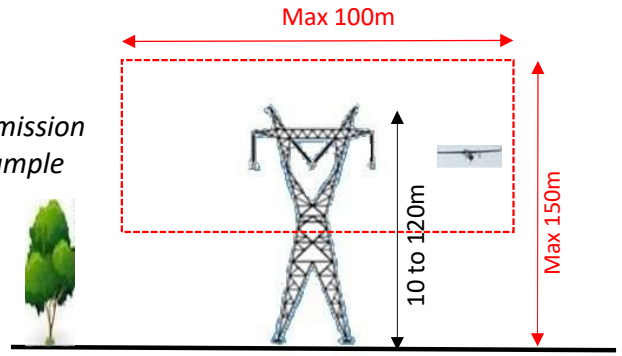
- **The use case : Long Range Operations**

- A challenging mission envelope:
  - Daily long range surveillance of linear infrastructures
    - Long range: 200 to 500 km
    - Low level: 50 to 150 m
    - Capabilities of flying over people
    - Non-segregated airspace

Very specific profile

- Corresponding to a proven end user need:
  - Productivity and efficiency gains compared to existing means, new types of operations enabled
  - Applicable to > 1 Million km of infrastructures in France only
  - Major and proactive potential clients, unified specification request
  - Many challenges of interest for the industry as a whole
- Many technical and safety-related barriers:
  - Trajectory assurance, communications, airspace integration…
- An airworthiness methodology exportable to other use cases:
  - ➔ **From operational restrictions to an appropriate airworthiness**

RTE mission example



End user	Type of infrastructure	Length
SNCF	Railways	33 000 km
RTE	Powerlines (high voltage overhead lines)	105 000 km
ENEDIS	Powerlines (low & medium voltage overhead lines)	760 000 km
GRTgaz	Gas lines	32 000 km
EDF	Powerlines (high voltage overhead lines)	32 900 km
	Dams & water inlet channels	200 000 km
VINCI	Highways	4 000 km

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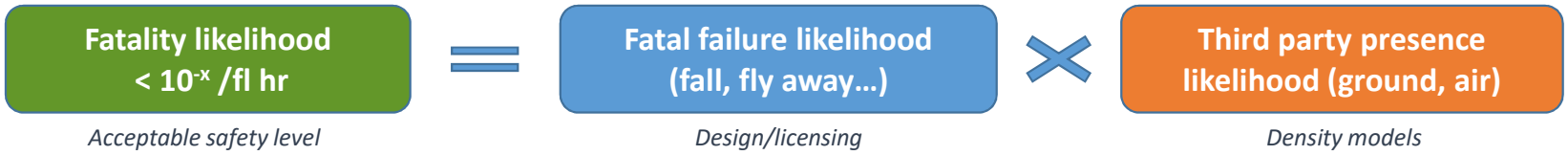
- **At the core : the safety equation**



- **Two applications**
  - Interim long range operations : restricted activity volume (in fl hr) in predefined zones

10^{-7} /fl hr, adaptable depending on volume	Partial proof of design	Limited area of operation and activity volumes

→ Controlled exposure to third party ⇔ Adapted requirements on design
→ Regulatory framework: French derogations and Specific cat. Standard scenario
→ Timeframe ~ 2018/19

  - "Ultimate" long range operations : daily operations « almost everywhere » without prior notice

10^{-7} /fl hr	Approved airworthiness, proof of design	No restriction other than local exception

→ Few restrictions on third party presence⇔ high requirements on design (close to certified)
→ Regulatory framework: presumably EASA Certified category
→ Timeframe ~ 2022

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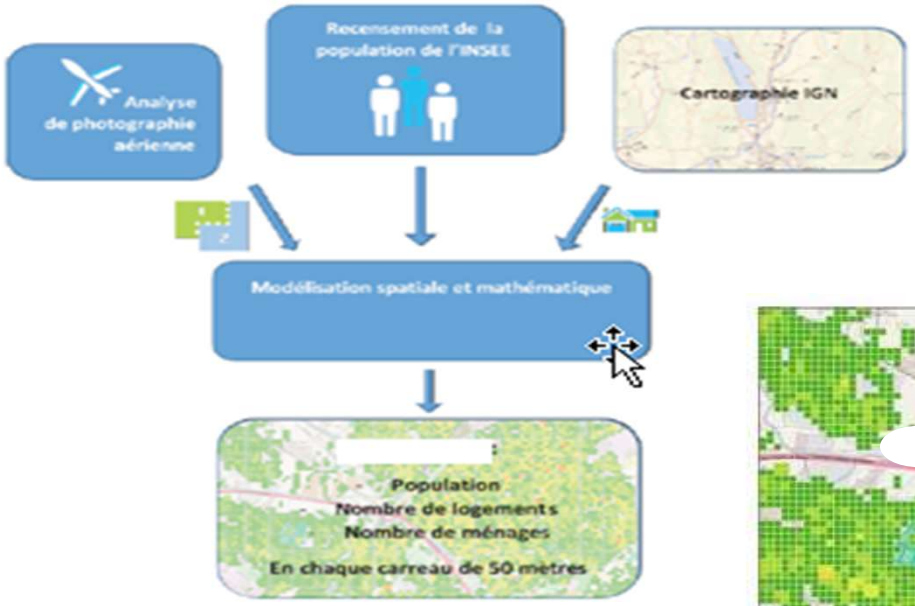
Third party presence likelihood (ground, air)

- **Third-party presence likelihood (ground)**

Development of a **quantification methodology** of ground presence based **on various and consolidated data**

Example (cartographic information and population census)



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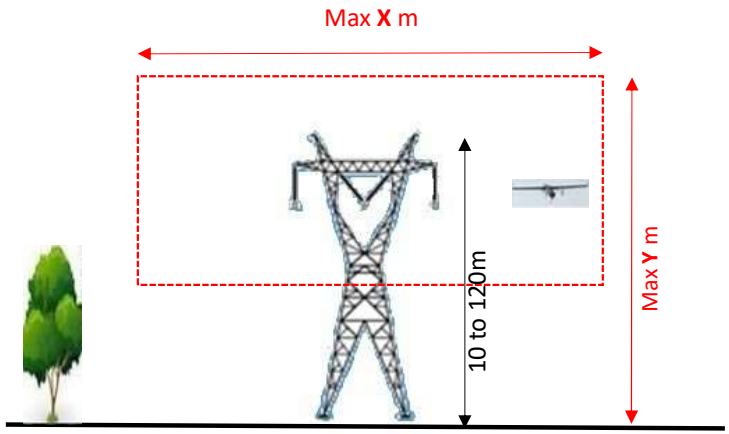
Third party presence likelihood (ground, air)

- **Third-party presence likelihood (air)**

On a short-term basis : in the absence of a reliable collision avoidance system, the air risk is mitigated by operating in a ***de facto*** **segregated airspace**

→ No regulated areas but a mission volume close enough to the infrastructure to be considered empty of any other a/c

→ Maximum « *fly away* » probability capped @ 10^{-7}/fl hr.



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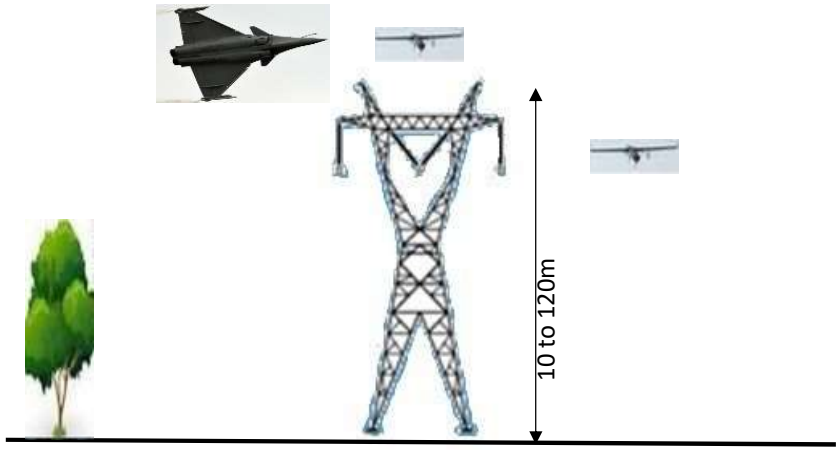
Third party presence likelihood (ground, air)

- **Third-party presence likelihood (air)**

Longer term : airspace shared with other a/c

Implies traffic separation solutions: onboard collision avoidance system (collaborative or not), UTM, etc.



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Fatal failure likelihood (fall, fly away…)

- **Identifying undesirable events levels: from societal damages to classes of failures**

	Level 0 : Societal impact	Level 1: Operations		Level 2 : LR RPAS functional failures
Ground risks	Probability or likelihood of lethal injuries to third parties on the ground	**Catastrophic**	**• Excursion out of the predefined volume of flight • Fall without guarantee of falling in a predefined area (included in fly away)**	For each function : - Undetected faulty performance - Detected faulty performance - Undetected loss - Detected loss - Untimely triggering
Flight risks	Probability or likelihood of lethal injuries to third parties in flight	Hazardous	• Fall into a predefined area where population density is very low • Controlled fall into an area where population density is known (id est, controlled risk)	
Infrastructure risks	Probability or likelihood of damage to a critical infrastructure	Major	Loss of capability : • To modify the ongoing mission • To be detected by other aircraft (loss of navigation lights, etc…)	

References:

EASA
- CS 23
- SC-RPAS.1309-01
- NPA 2017-05

EUROCAE/RTCA/SAE
- ARP-4754 & 4761
- DO-178, 254, 326 & 356

JARUS
- UAS Operational Categorization
- CS-LUAS
- AMC RPAS.1309
- SORA
- Design Objectives for RPAS DAA

Defense
- DGA Instruction technique CEV 202001 version 1.0 [26/102002]
- NATO UAV Systems Airworthiness Requirements [Version 2 Juillet 2004]

A safety methodology for drones

Fatal failure likelihood (fall, fly away…)

- Collective development of a generic **safety analysis methodology** of a drone system

1 Undesirable event	2 Severity level	3 Target probability of failure pfh		4 No single failure results in the UE	5 Target global FDAL
		Ground risk	Air risk		
• Crash not guaranteed to be within planned crash area • Fly away without separation capabilities	CATASTROPHIC	Cumulated probability < 10^{-7}		yes	B
• Crash within planned crash area • Controlled crash • Fly away with separation capabilities	HAZARDOUS	$\frac{10^{-7}}{\text{Probability of impact w/ person on ground}}$	10^{-5}	no	B to C
• Loss of control on current mission • Loss of capability to be detected by other a/c	MAJOR	10^{-3}		no	D

6 Allocation to high-level safety functions through FHA

Way forward

- **Unfortunately, the future European regulation has a similar approach than the current French regulation**
  - No clear allocation of responsibilities between operator and manufacturer
  - No decision on the acceptable safety level for drones operations
  - No quantification of risk
  - No genuine generic approach :
    - SORA is mission-based and entirely the responsibility of the operator

- **We believe in our approach and will keep lobbying European institutions**

- **Many thanks to P. Hadou, DGA, and the organisation team of MAC 2018, for allowing us the opportunity to present our work today**
  - We think there are commonalities between civil drones for high-added value missions and some military ones and welcome your comments

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