HOW MUCH SAFETY DO SMALL DRONES EMBED?

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69th annual International Air Safety Summit (IASS)
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SOME FIGURES (PROXIMALLY)

- Commercial Aviation
  - 21.000 aircraft
  - 34 million departures annually
  - 3.5 billion miles flown annually
  - 92 accidents / 474 fatalities (2015)
- General Aviation
  - About 365.000 aircraft
  - ? departures
  - 42 million flight hours annually
  - x 50 more accidents than commercial aviation (EASA, FAA)
- Drone market
  - 700.000 - 1.200.000 drones sold worldwide only in 2015
  - ? departures, miles, hours
  - 37 accidents, 584 occurrences only in EU in 2015.

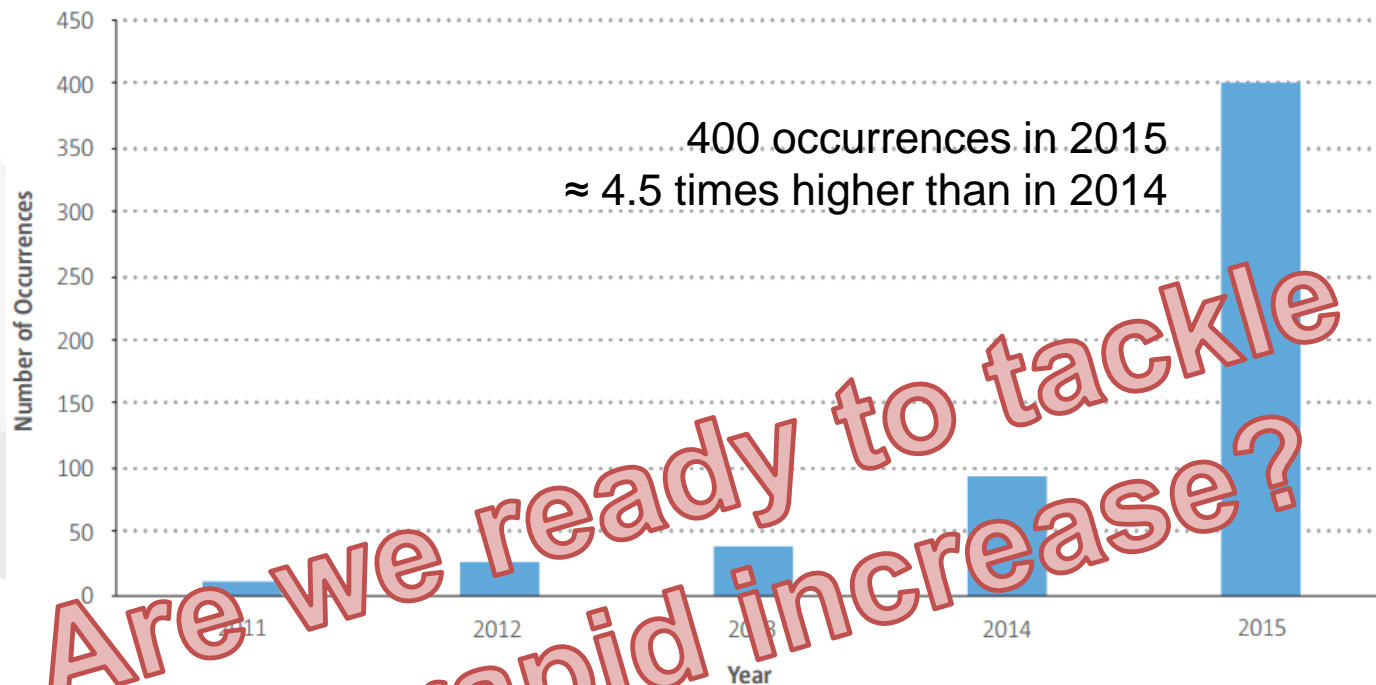# HOW MUCH IS AVIATION REGULATED?

- Commercial aviation:
  - Fully standardized for airworthiness, air operations, staff qualifications, air navigation, aerodromes, airspace control, control & management across all levels (e.g., from pilots to authorities) etc.
- General aviation:
  - Mostly standardized for crew qualifications
  - Less strictly regulated for airworthiness, air navigation, aerodromes, control & management
- Drone flights regulations:
  - Focus mainly on the end-user, who is frequently the only responsible for a safe flight
  - Lack of reference to the role and responsibilities of the manufacturers and authorities
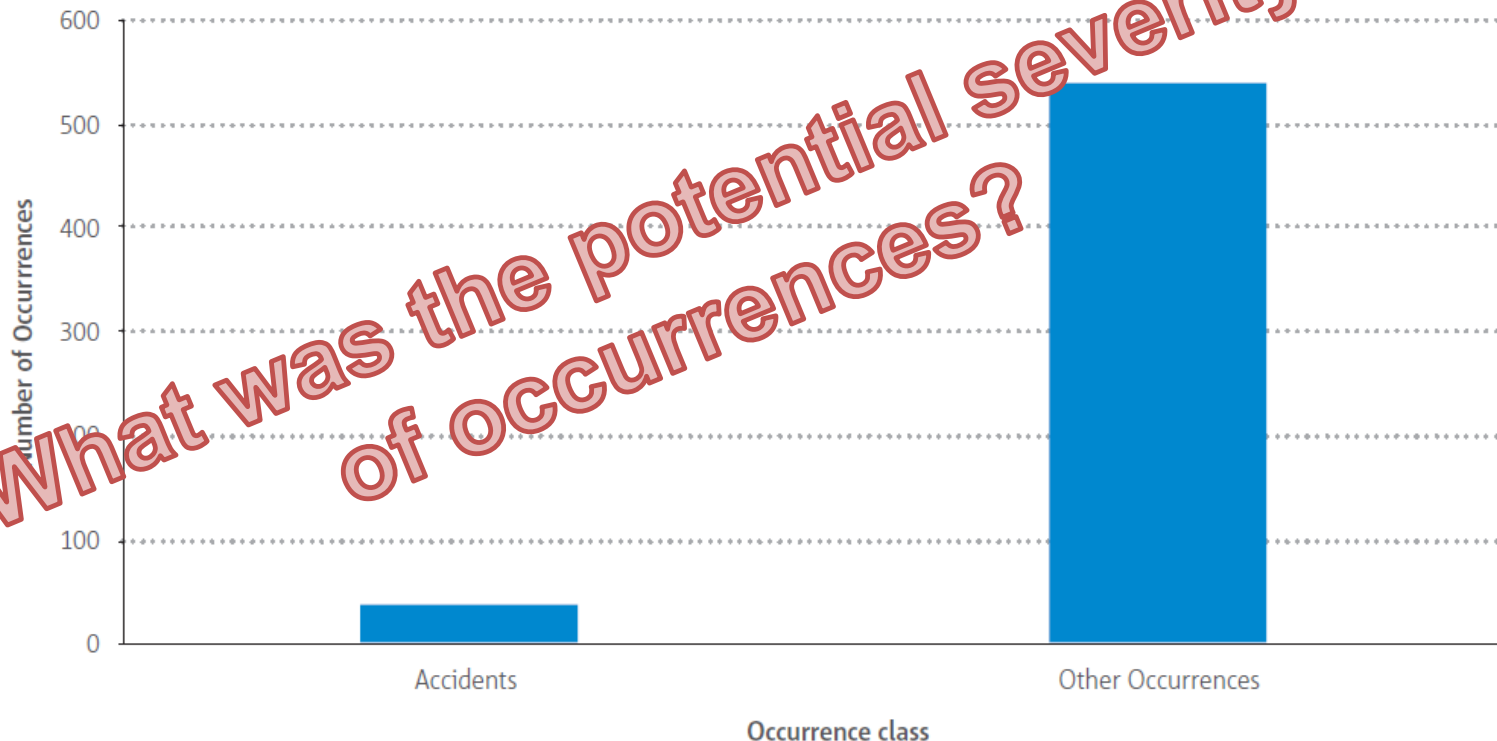 - No universally accepted risk assessment framework

2.8 / million dep

140 / million dep

??? / million dep

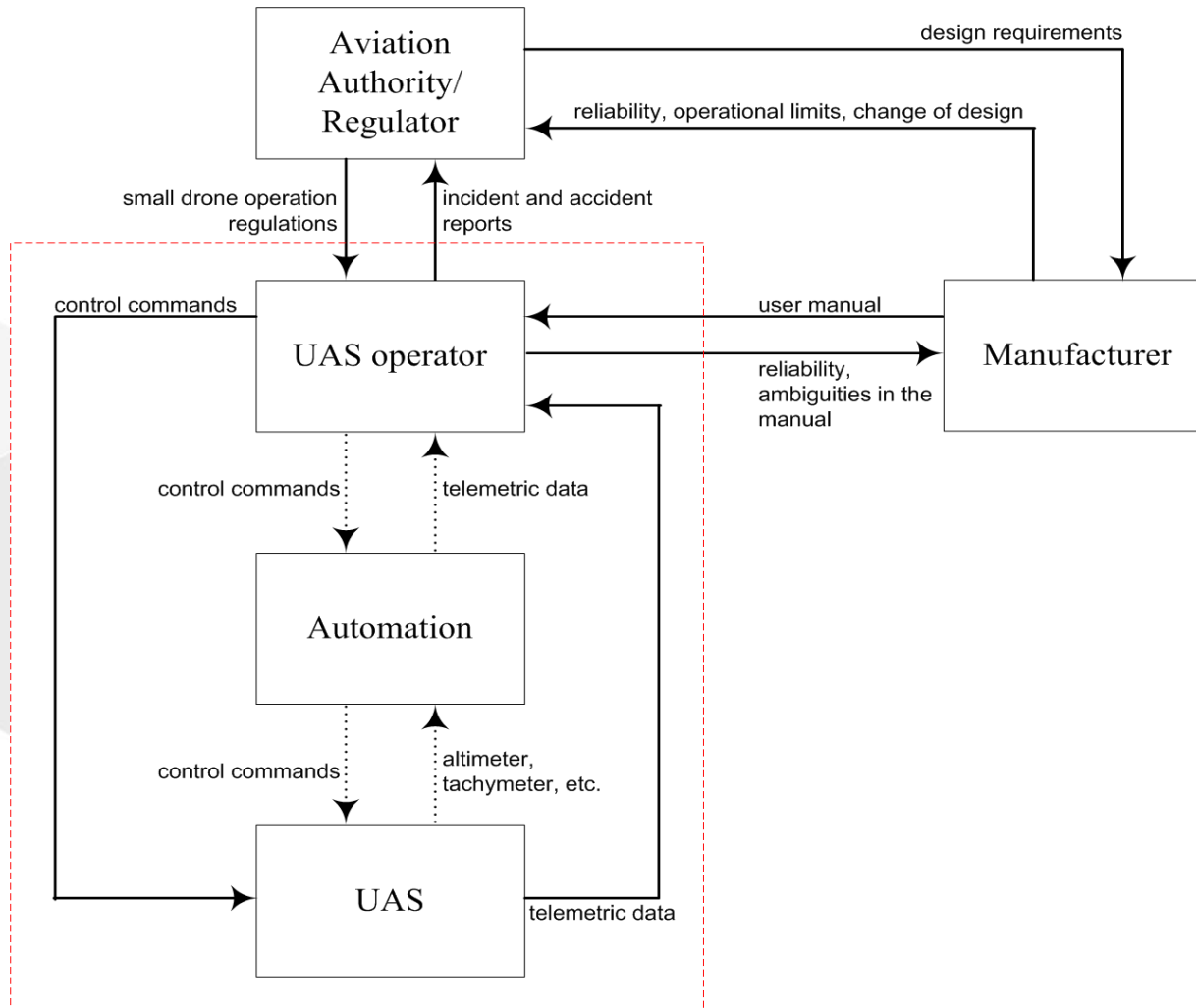# EASA, 2016: OCCURRENCES 2011-2015

400 occurrences in 2015
≈ 4.5 times higher than in 2014

Are we ready to tackle this rapid increase?

EASA, 2016: CLASSIFICATION OF DRONE OCCURRENCES 2011-2015

What was the potential severity of occurrences?

THE CHALLENGES AT THE TECHNICAL LEVEL

- Published hazard analysis and risk assessment methods about drones are based on probabilistic and deterministic approaches.

- However:

  - We do not have data for failures, and such data is too diffult to collect.

  - Our assumptions of "pilot" reliability are mostly invalid:

    - Drone users is a heterogeneous and unmonitored population with the role of both maintaining and flying a drone.

    - The main scope of drone flight is entertainment; no connection of the end-user with social responsibility, job security etc.

    - Drone users without aviation background lack knowledge, experience and training in human performance limitations.

    - Drone users lack detailed technical knowledge of how drones function, so to react successfully to unforeseen events.
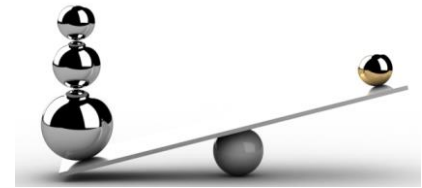
AN (IDEAL) SYSTEMIC VIEW

RESEARCH METHOD

- Application of the System Theoretic Process Analysis (STPA) method (Leveson, 2011) on a typical small drone system.
- Generation of:
  - 28 hazardous states
  - 24 causal factors
  - 67 safety requirements distributed across stakeholders (authority, manufacturer, end-user) and drone automation.
- Gap analysis / statistical comparison of:
  - Specifications of 19 highly marketed drones with available manuals online.
  - Content of regulatory frameworks from 56 countries.

RESULTS: DRONES' ANALYSIS

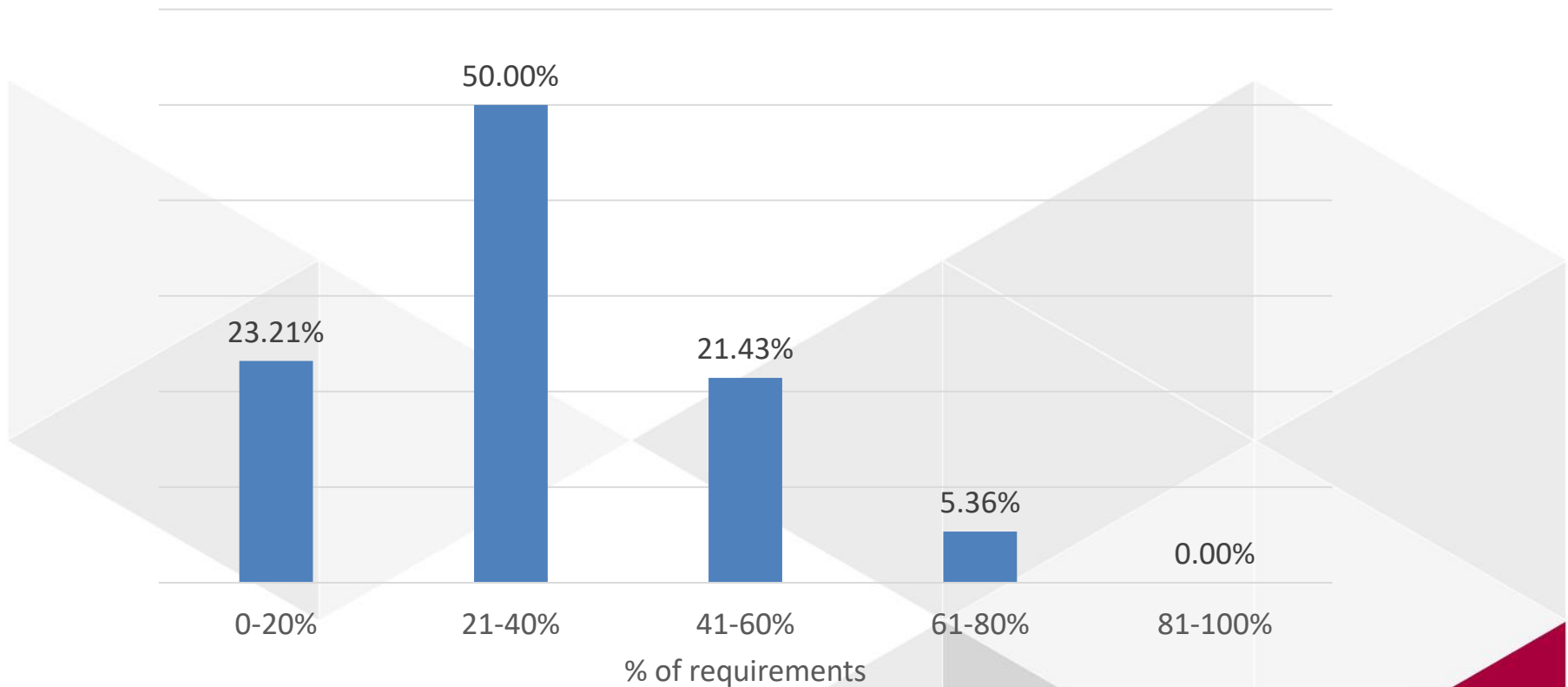| DRONE MODEL	RATE OF REQUIREMENTS MET PER CONTROLLER		
	MANUFACTURER	END-USER	AUTOMATION
1	0.545	0.383	0.362
2	0.727	0.553	0.638
3	0.727	0.596	0.638
4	0.652	0.563	0.489
5	0.455	0.383	0.362
6	0.606	0.511	0.511
7	0.455	0.383	0.319
8	0.636	0.489	0.426
9	0.515	0.404	0.277
10	0.318	0.191	0.404
11	0.303	0.234	0.128
12	0.606	0.617	0.255
13	0.364	0.319	0.277
14	0.773	0.660	0.681
15	0.561	0.447	0.426
16	0.576	0.511	0.319
17	0.515	0.447	0.383
18	0.712	0.660	0.447
19	0.652	0.574	0.426

RESULTS: DRONE'S COMPARISON

- The drones are similar amongst them as follows*:
  - Manufacturer requirements: 0.440
  - End-user requirements: 0.433
  - Automation requirements: 0.433
- The higher the drone price the more the requirements met.

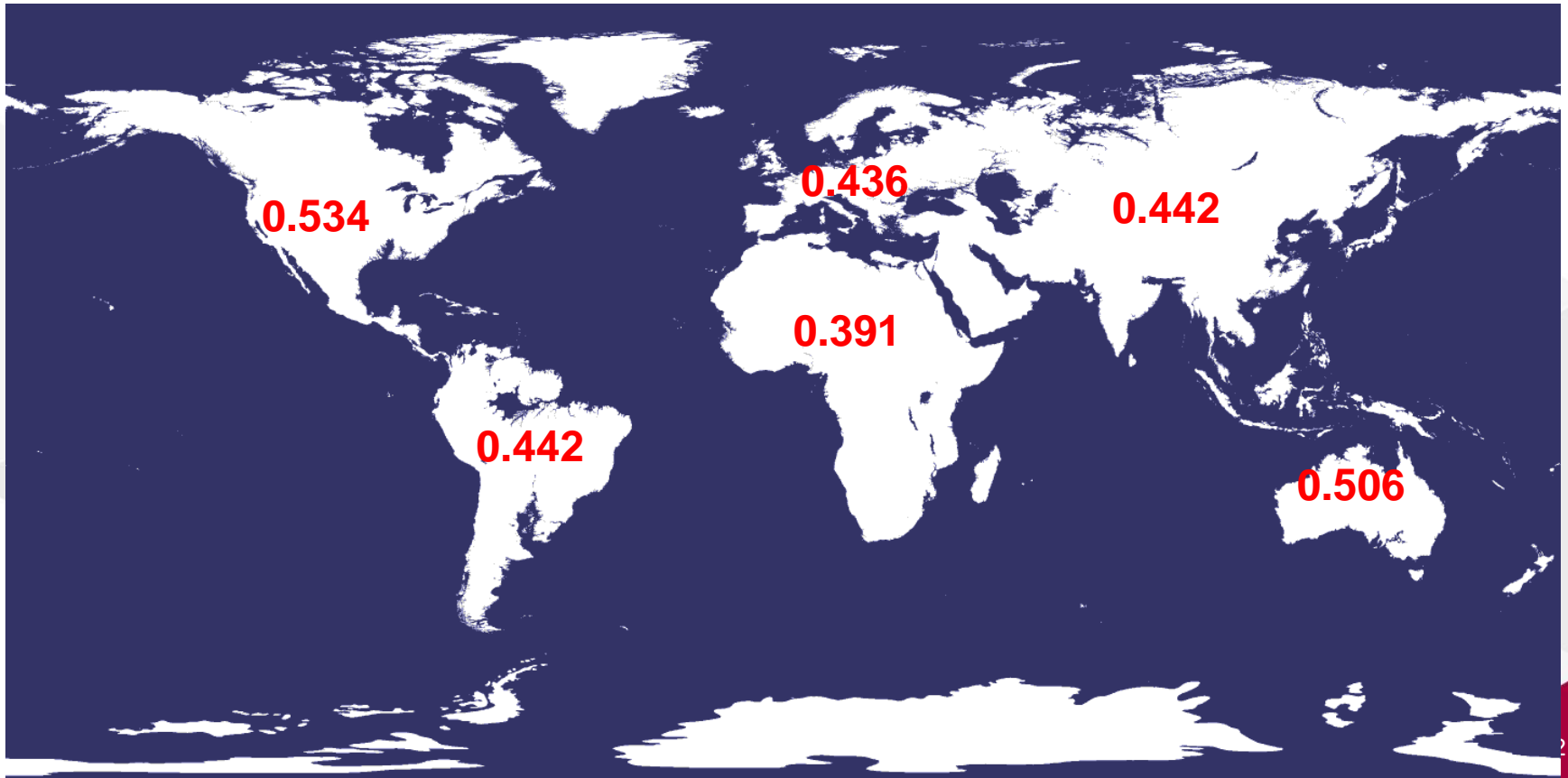* 0.000: totally dissimilar, 1.000: totally similar

RESULTS: REGULATIONS' ANALYSIS

Regulations meeting % of requirements

Minimum value: 5.3%, Maximum value 66.7%

RESULTS: SIMILARITY AMONGST REGULATIONS

0.534

0.436

0.442

0.391

0.442

0.506

SIMILARITY AT INTERNATIONAL LEVEL: 0.432

RESULTS: SIMILARITY OF REGULATIONS

- Similarly is even lower when considering diversity of ways requirements are realised across countries.
  - Example: Operator shall maintain continuous visual contact with drone during flight.
    - All 56 authorities dictate so.
    - 33 States have no value for the distance between end-user and drone. Some require extra attention to weather conditions, obstacles, drone capabilities etc.
    - 11 States allow a maximum distance between 100m to 5.5Km. One of those States express the distance in Ft and another in Miles.
  - Highly different requirements about:
    - Skills and competencies of the user
    - Flight area boundaries
    - Separation from other flying objects

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CONCLUSIONS (1/2)

- Safe predictions for the impact of drones on public safety cannot be made. From a deterministic view, safety events with drones are expected to increase exponentially along time.

- Research on drone safety is mainly based on statistical analysis and specific accident scenarios of large drones. Adequate and reliable data from small drones are not yet available.

- Small drones meet at low-moderate levels the safety requirements generated from the STPA hazard analysis.

- There is high dissimilarity amongst small drones regarding the extent to which they meet the safety requirements derived with STPA.

CONCLUSIONS (2/2)

- A common regulatory framework based on a systemic and systematic risk analysis is missing.

- Current regulations assign the end-user almost as the only responsible for observing rules and limits.

- Existing regulations meet the requirements of the authority level at low to moderate levels.

- Regulations across States are highly different amongst them, even when they address the same requirement.

- The high differentiation of rules across countries might confuse users and negatively affect the market.

RECOMMENDATIONS (1/2)

- Stakeholders need to consider new hazard analysis methods based on systemic approaches.

- Human factors must be embedded early in the design of drones and basic concepts of human performance must be taught in the early years of education.

- Automation needs to support the end-user in meeting the objectives of the flight by maintaining limits (e.g., wireless links of drones with national or regional platforms might allow downloading and uploading such limits).

RECOMMENDATIONS (2/2)

- We need a common regulatory framework based on systemic and systematic risk analysis in order to minimize adverse safety events and avoid impeding drone market growth.

- The framework must clearly state the roles, responsibilities and interdependencies of the main system controllers, namely authorities, manufacturers and end-users.

- Under a performance-based approach, States might adopt a customizable regulatory framework which will:
  - Classify small drones depending on how risk control is distributed between the pilot and the automated functions of drones.
  - Based on the classification above, define the set and boundary values of certification, training, maintenance etc. requirements

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CREATING TOMORROW

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Questions?

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