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 aircrew 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
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 difficult 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

- **Aviation Authority/Regulator**:
  - Small drone operation regulations
  - Incident and accident reports

- **UAS operator**
  - Control commands
  - Telemetric data

- **Automation**
  - Control commands
  - Altimeter, tachymeter, etc.

- **UAS**
  - Telemetric data

- **Manufacturer**
  - User manual
  - Reliability, ambiguities in the manual

Design requirements:
- Reliability, operational limits, change of design

Flow of information and interactions between the entities in the 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

<table>
<thead>
<tr>
<th>DRONE MODEL</th>
<th>RATE OF REQUIREMENTS MET PER CONTROLLER</th>
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<tr>
<td></td>
<td>MANUFACTURER</td>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
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</table>
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

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 \text{Ft} and another in \text{Miles}.
  • Highly different requirements about:
    • Skills and competencies of the user
    • Flight area boundaries
    • Separation from other flying objects
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
AVIATION ACADEMY: UPCOMING EVENTS IN AMSTERDAM

• MASTER CLASS RISK ASSESSMENT
  6 – 10 FEBRUARY 2017

• MASTER CLASS INCIDENT INVESTIGATION
  20 – 24 MARCH 2017

• MASTER CLASS HUMAN FACTORS AND SAFETY
  19 – 23 JUNE 2017

Information:
www.amsterdamuas.com/aviation
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Questions?

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