EASA Research project
‘Vulnerability of manned aircraft to drone strikes’
Background

Recommendation from the EASA drone – aircraft collision Task Force 2016:

The Task Force recommends that further research should be conducted to establish hazard severity thresholds for collisions between drones and manned aircraft.

• Impact analyses should be performed to determine the effects of a drone threat impacting aircraft critical components (...).

• To gain confidence in the model, the method should be validated against tests on representative aircraft components such as airframe parts, windshields and rotating elements (i.e. rotors, propellers and fan blades).

The Drones Strikes research project fully captures the recommendation
<table>
<thead>
<tr>
<th>#</th>
<th>Objective</th>
<th>Deliverable</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Educate the public to prevent and reduce misuse of drones around aerodromes</strong></td>
<td>1. Safety promotion material to create public awareness and understanding of the existence and purpose of geographical zones. &lt;br&gt; 2. AMC/GM defining a common unique digital format for UAS geographical zones.</td>
<td>Completed 2020 &amp; <strong>Ongoing</strong> Completed Feb-22</td>
</tr>
<tr>
<td>2</td>
<td>Prepare aerodromes to mitigate risks from unauthorized drone use</td>
<td>EASA guidance material (in the form of a manual) describing the roles and responsibilities of the actors, and best practices on how to respond to unauthorized drones in the surroundings of an aerodrome.</td>
<td>Completed Mar-21</td>
</tr>
<tr>
<td>3</td>
<td><strong>Support the assessment of the safety risk of drones to manned aircraft</strong></td>
<td>Preliminary paper (Input to Objective 2) addressing the consequences of drone collision with manned aircraft in aerodrome zone</td>
<td>Completed Mar-21 &amp; Oct-23</td>
</tr>
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<td>4</td>
<td>Ensure that C-UAS measures are swiftly considered and implemented from a global safety perspective</td>
<td>Contribution to the development of International Standards to support the safe and harmonised implementation of Counter-UAS Systems into airport environment and ATM/ANS systems.</td>
<td><strong>Ongoing</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>Support adequate occurrence reporting</strong></td>
<td>1. Define high-level criteria to classify airprox events. &lt;br&gt; 2. Evaluate compatibility of existing occurrence reporting procedures for inclusion of occurrences involving UA. &lt;br&gt; 3. Develop suitable action plan to integrate UA in common occurrence reporting procedures.</td>
<td>Partially completed Feb-23 <strong>Ongoing</strong></td>
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</table>

**Research results will now replace the paper providing complete and verified information agreed with stakeholders**
Research project overview

Key objectives:

→ to deepen understanding - through experimental testing and simulation techniques — of the effects of collisions between mass market drones and manned aircraft;

→ to identify drone design strategies aimed at containing the risk that drone-aircraft collision may induce on the aircraft and its occupants; and

→ pending the research results, to define a draft design requirement and test standards for future drones to be put on the market within the EU open category (CE marking).
Observed near missed between drones and manned aircraft

The vast majority of sightings of drones from aircraft occur:
- Below 6,000ft altitude
- During the Approach phase of flight

Phases of manned aircraft flight and drone detection (from EUROCONTROL voluntary ATM incident reporting by airlines [rotorcraft and GA not included])

Any type of occurrence involving manned aircraft AND UAS (source ECR database, UK excluded)
Bird strike comparison

- Drone impacts are more severe than collisions with birds of the same mass
  - Drone impact forces are concentrated at component locations
  - Greater peak forces in drone collisions
  - Bird can flow around a structure
Drone ‘threats’ modelled within the programme

<table>
<thead>
<tr>
<th>Name</th>
<th>Mass</th>
<th>Dimensions* (width x length x height)</th>
<th>Maximum speed (Sport mode)</th>
<th>Image of Threat Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>DJI Mavic Mini</td>
<td>0.249kg</td>
<td>202x159x55mm</td>
<td>13.0 ms(^1)</td>
<td></td>
</tr>
<tr>
<td>Eachine Wizard X220s</td>
<td>0.540kg</td>
<td>210x175x80mm</td>
<td>27.0 ms(^1)</td>
<td></td>
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<tr>
<td>DJI Mavic 2</td>
<td>0.905kg</td>
<td>322x242x84mm</td>
<td>20.0 ms(^1)</td>
<td></td>
</tr>
<tr>
<td>Delair UX11</td>
<td>1.365kg</td>
<td>1100x675x120mm</td>
<td>23.2 ms(^1)</td>
<td></td>
</tr>
<tr>
<td>DJI Inspire 2</td>
<td>3.426kg</td>
<td>520x465mm</td>
<td>26.1 ms(^1)</td>
<td></td>
</tr>
</tbody>
</table>
Vulnerability evaluation

Completion of approximately 1,500 collision simulations, evaluating impacts:

- Of all drones considered
- Against all manned aircraft considered
- On critical impact locations
- On a range of realistic speeds

**Hazardous event:** if estimated effect is HEC 1 or 2 (Hazardous Event Classification). does not mean that fatalities will necessarily occur

Data have been further elaborated for manned aircraft take-off/landing and approach/climb phases to provide a pragmatic result in terms of probability.
Limitations and cautions

- The study has assessed collisions against traditional aluminium alloy airframes, rather than more-modern composite constructions.

- Probabilities are derived from a simplified perfectly frontal collision:
  - In particular for rotorcraft probabilities are referred to fuselage impacts only, addressing rotors separately.

Role of cooperation

- Gaps of study strongly filled with international cooperation (ASSURE and other organizations):
  - Engine ingestion
  - Main rotor and tail rotor blades (specimens not available to cover all classes)
Recommendations for drones design

• **Excessively-heavy constructions and excessive maximum speeds**, that are not required to meet the legitimate operational use-case requirements of the product, should be avoided.

• **Multi-rotor drones**: frangible and/or folding motor arms are preferred to stiff/strong constructions;

• Where **major components**, including forward-mounted cameras, are assembled in close proximity and/or installed along the **body axis**, it is desirable to:
  - include gaps between them avoiding high stiffness which could cause them to act as a single projectile;
  - offset them vertically and/or laterally, rather than aligning them on common axis.

• **Fixed wing drones**: ‘pusher prop’ designs are greatly preferred, rather than ‘puller-prop’ configurations. Where **spinners** are used on horizontally-mounted motors, slender and / or pointed designs should be avoided, and the potential of energy-absorbing mechanisms considered.

• **Batteries**: batteries containing cylindrical steel-case cells should be avoided. Pouch-style batteries (in rolled or layered configurations), with cases that are not excessively strong are preferred.
Usability of research results

→ Complementary data to inform C-UAS risk assessments
→ No hazard for Large Aircraft and Business Jets align with simplified rules for drones under 250 gr (no registration; no DRI) -
→ Recommendations and draft standards for drone design
→ Recommendation and observation for manned aircraft design
→ (By-product): confirmation of JARUS crash area model
→ Inform the identified safety issue Damage tolerance to UAS collisions (SI-4019) and Airborne conflict with an unmanned aircraft system (UAS) (SI-2014) found in volume III of the EPAS
→ Support EASA’s efforts to understand the severity of drones strikes to manned aircraft. Through the Safety Risk Management process, this will then lead to appropriate EPAS actions
For more information on the Drones Strikes project please contact:
- Antonio Marchetto (antonio.marchetto@easa.europa.eu)