EASA Task Force
Drone Collision with manned Aircraft

Workshop

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October 24, 2016

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An agency of the European Union

TE.GEN.00409-001

Objectives

- Present the work of the EASA TF
- Review & Discuss the Conclusions and the Recommendations

Outline

- Background
- Overall Approach
- Drone Threat
- Impact Effect Assessment (IEA)
- Hazard Effect Classification (HEC)
- Consultation
- Main Conclusions
- Recommendations
- Way Forward

Background

PRESS RELEASE

04 MAY **2016**

EASA creates task force to assess the risk of collision between drones and aircraft

- *Review all relevant occurrences*
- *Analyse the existing studies*
- *Study the vulnerabilities of aircraft*

Report has been published on October 6

(http://www.easa.europa.eu/document-library/general-publications/drone-collision-task-force)

Background

- Assessment to focus on the **current situation in terms of threat and existing mitigation means**
- Determine if any conclusions can be already drawn
- Provide meaningful recommendations for further research needed to address the issue.

No or limited time to do additional research or detailed technical assessment

Background

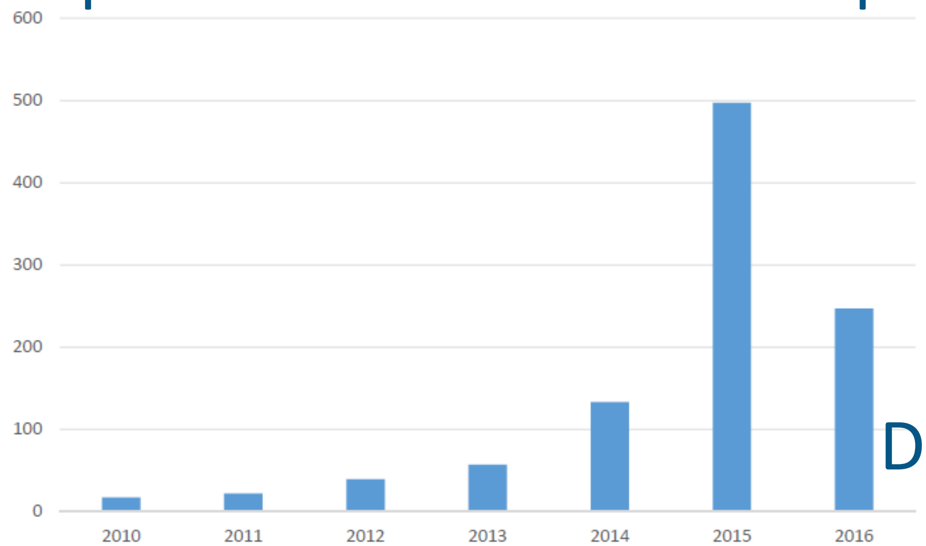
Task Force Composition:

- Manageable and Efficient working group,
  - the number of participants in the TF has been kept to a small number
- The TF includes EASA experts & EU A/C Industry representatives to cover:
  - Aeroplanes & Rotorcraft
  - Engines & Propellers

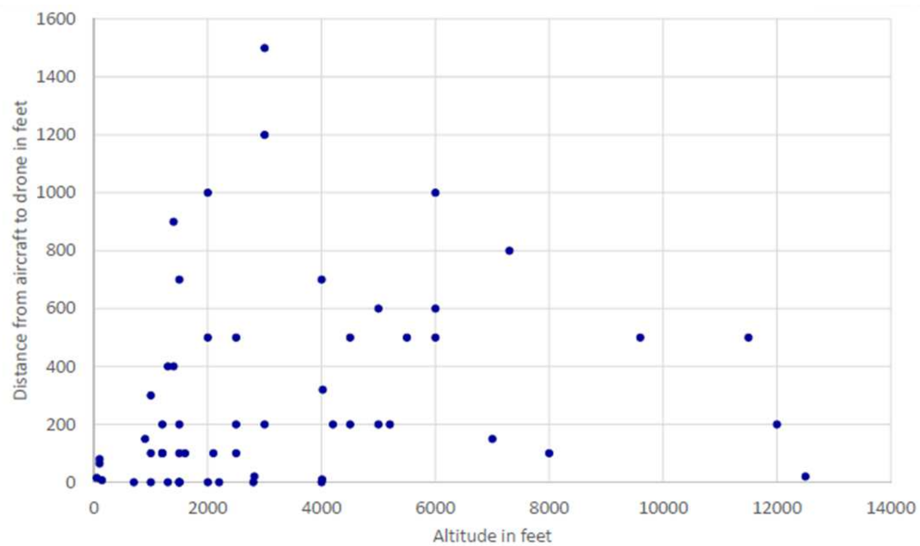
But the TF consulted!

Background

Reported RPAS occurrences per Year



Distribution of RPAS occurrences



Background

- **Airborne Conflict** (potential collision between a drone and an aircraft in the air)

Date	Airspace type	Altitude in ft	A/C type	Aircraft Registration	Drone type	Aircraft Damage	Comments
30/08/2015	Unknown	2500	Grumman AA-1	N3LY	Unknown	None	RPAS struck undercarriage
30/04/2015	Controlled airspace	700	Robin DR 400-180	F-GSBM	SAS Wildthing	Scraping on wing	Type of airspace unknown - final approach - exact altitude not available
05/04/2015	G	630	Pioneer 300	G-OPFA	Valenta Ray X, S037996	Scuffing and scraping (GBP 1 400)	Uncontrolled airspace
14/08/2010	Controlled airspace	50	Shpakow SA 750	N28KT	AJ Slick model airplane	Lower left wing crushed aft to the main spar	Video

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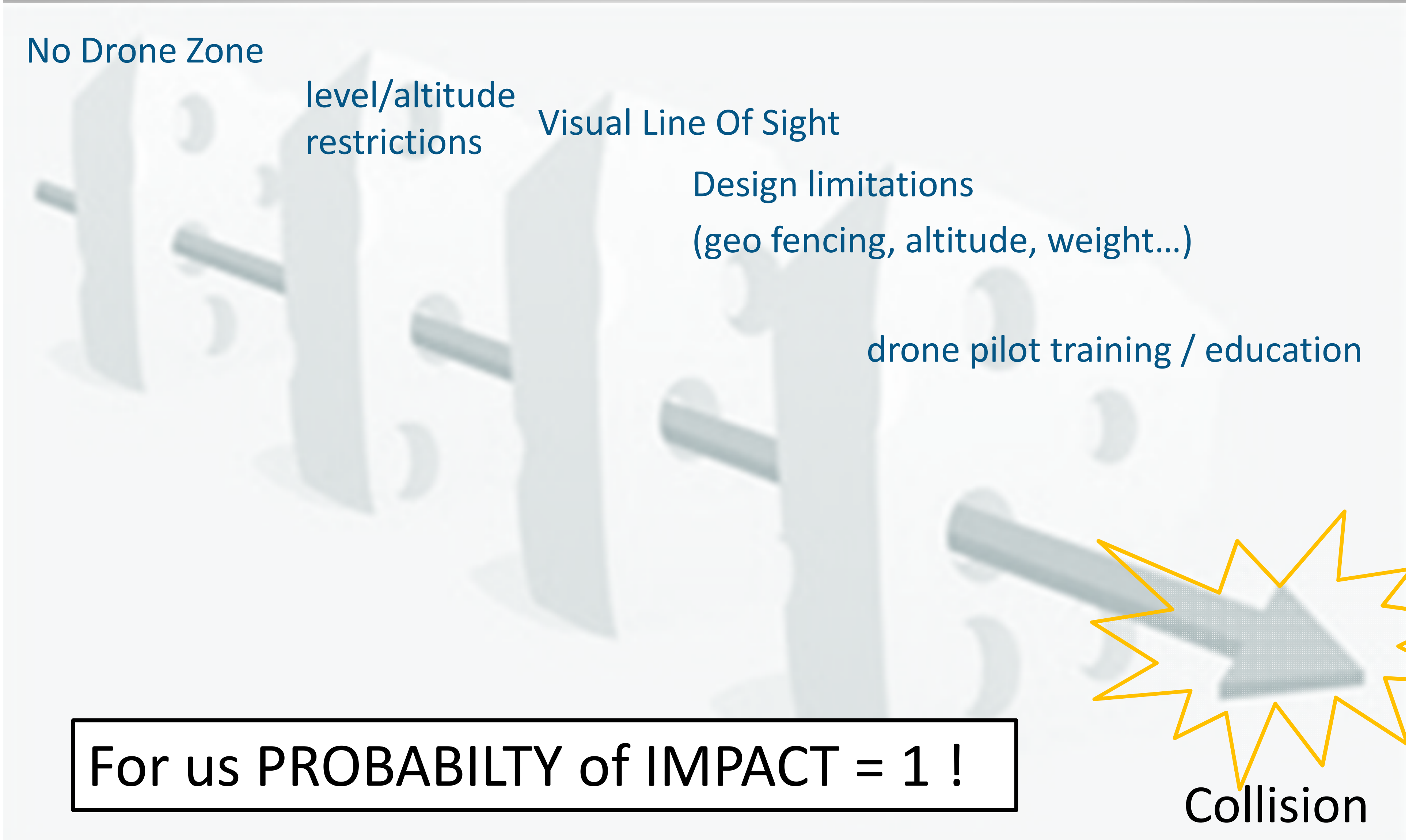
Overall Approach

- Part of a global Safety Risks Management process:
  - Hazards identification
    - Severity
  - Risks assessment
    - Severity vs likelihood
  - Decision-making
    - Actions to mitigate the risks

Task Force Work

Overall Approach



For us PROBABILTY of IMPACT = 1 !

Overall Approach

1) DRONE Threat Specification (DTS)

2) IMPACT Effect Assessment (IEA)

Component Level assessment
- Windshield, Engine, Airframe, Propeller, Rotor, ...

3) Hazard Effect Classification (HEC)

Aircraft Level assessment
- operation, occupants...

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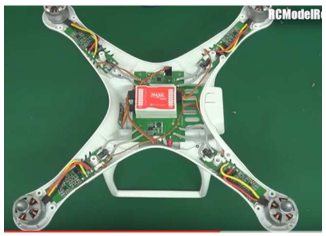
Drone Threat

- OPEN CATEGORY only (<25 kg)

- Drone Threat Modelization : Simplified
  - **Mass-market** study and
  - **Key Critical Component (KCC)** concept

- Validation of the assumptions: Limited
  - **In-service events data**
  - **Published Research & Studies**

Drone Threat



Frangible,

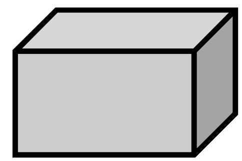
Low density Body

Weight & Volume of the

Complete Drone

Less frangible, ductile,
Medium Density Elements

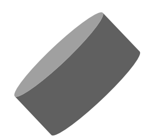
Battery, Camera,



Stiff & Sharp, not frangible

High Density Elements

Motor



Generic Drone Threat Specifications

4 Drone Class.

- 3.5 Kg
- 1.5 Kg
- 0.5 Kg
- 0.25 Kg

2 KCC

- Battery
- Motor

Drone Class	Threat Type	Element	Weight (g)	Density (kg/m3)	Dimensions (mm)/Typical Shape	Quantity	Max speed (m/s)	Zd-max (m)	Zd-lim (m)
Large	Tl	Drone	3500	-	450x450x301	-	20	5000	500
	Tm	Battery	670	2000	Parallel piped	1			
	Th	Motor	106	4000	Cylinder	4			
Medium	Tl	Drone	1500	-	290x196x290	-	20	5000	500
	Tm	Battery	462	2000	Parallel piped	1			
	Th	Motor	56	4000	Cylinder	4			
Small	Tl	Drone	500	-	328x382x89	-	18	1000	150
	Tm	Battery	130	2000	Parallel piped	1			
	Th	Motor	15	4000	Cylinder	4			
Harmless	Tl	Drone	250	-	200x200x140	-	18	1000	150
	Tm	Battery	65	2000	Parallel piped	1			
	Th	Motor	7.5	4000	Cylinder	4			

Threat Type:

- Tl: Threat: **low** density
- Tm: Threat- **medium** density
- Th: Threat- **high** density

Altitude:

- Zd-max: Maximum flyable altitude capability above sea level.
- Zd-lim: Max altitude limited by hard-coded software limitation

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Impact Effect Assessment (Component)

- Limited Zones of impact
  - Single and Front Impact (except side impact for Tail Rotor)
  - No secondary Impact
  - Most Critical Areas

Retained	Not Retained
Windshields Nose Areas leading edges (including slats) trailing edges (flaps) Engines (excluding reciprocating engines) Main and Tail Rotors Propellers Landing gears & landing gear doors ….	Fuselage and windows (side impact only considered for Tail rotor) Reciprocating engines Transmission (main and tail rotor) APU and ECS Air Intakes Ailerons, rudders, elevators and spoilers External probes, small antennas, wipers Hoist …..

Impact Effect Assessment (Component)

Estimation of Effects @ Component Level

Drone Threat

- ✓ Specific Threats assessed in Certification (Bird, Ice, Hail)
- ✓ Other Certification & Industry Design Standards
- ✓ Existing Research conclusions
- ✓ In-service collision data

Components	Requirement	Title	Threat Category	Threat Specification	A/C Conditions	Pass/Fail Criteria
CS23 Commuter						
Windshield	CS 23.775(h)	Windshields and Windows	Bird	Bird 0.91 kg (2 lbs)	VFE	continued safe flight and landing,
CS23 High Performance and Jets						
Windshield	By Special Condition CRI typically	Windshields and Windows	Bird	Bird 0.91 kg (2 lbs) Tested on W Screen.	VFE	continued safe flight and landing,
Airframe	By Special Condition CRI typically	Bird Strike	Bird	0.91 kg by analysis on A/F critical areas only	Worst Case	continued safe flight and landing,
CS25 Large Aeroplane						
Complete Aeroplane	CS 25.631	Bird strike damage	Bird	4 lbs	VC at sea-level or 0·85 VC at 2438 m (8000 ft),Vc	continued safe flight and landing
Empennage	FAR 25.631	Bird strike damage	Bird	8 lbs	Vc	continued safe flight and landing
Windshield	CS25.773b4	absence of openable windows	Sever Hail	multiple 2 inch ice balls impact (ANSI/ASTM F 320-10)	approach & landing	it is shown that an area of the transparent surface will remain clear sufficient for at least one pilot to land the aeroplane safely in the event

Impact Effect Assessment (Component)

- Specific Criteria for each impacted component have been proposed for the assessment

Impact Effect Assessment (IEA) at Component Level

Component/Effects	High	Medium	Low
Nose/Radome/Large antennas	Penetration, major deformation, part detachment	No penetration but limited deformation.	Only dents or scratches
fuselage area below windshields	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Canopy (fuselage area above windshields,)	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Chin Window (fuselage area below Radome on rotorcraft)	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Wings (leading edges (including slats), trailing edges (flaps))	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Winglets	Significant damage, part detachment.	Limited damage, no part detachment	Only dents or scratches
Fairings (e.g. wing to fuselage)	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Horizontal Stabiliser Leading edge	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Vertical Stabiliser leading edges	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Engine pylons, nacelles, air intake cowling	Penetration, major deformation, part detachment	No penetration but limited deformation	Only dents or scratches
Engine (gas turbine)	Significant mechanical damage or detachment of parts. Immediate or ultimate reduction of Engine performance. Significant deterioration of Engine handling characteristics. (see note (*) below)	Non-significant mechanical damage. Reduction of Engine performance, deterioration of Engine handling characteristics and possible Increase of Engine operating temperatures,	No or acceptable damage (as per AMM)

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Hazard Effect Classification (A/C)

- 5 levels of severity (1 to 5)
- Effects on: A/C, Occupants and Operation

Hazard Effect Classification at Aircraft level

Hazard Classification	1 (most severe)	2	3	4	5 (least severe)
Effect on A/C	Normally with hull loss	Large reduction in Functional capabilities or safety margins	Significant reduction in Functional capabilities or safety margins	Slight reduction in Functional capabilities or safety margins	No effect on operational capabilities or safety
Effect on Occupants (excluding. Flight Crew)	Multiple fatalities	Serious or fatal injury to a small number of passengers or cabin crew	Physical distress, possibly including injuries	Physical discomfort	Inconvenience
Effect on Flight Crew	Fatalities or incapacitation	Physical distress or excessive workload impairs ability to perform tasks	Physical discomfort or a significant increase in workload	Slight increase in workload	No effect on flight crew
Effect on Operations	Total loss of separation. Total loss of control, mid-air collision, flight into terrain or high speed surface movement collision.	Large reduction in separation or a total loss of air traffic control for a significant period of time	Significant reduction in separation or significant reduction in air traffic control capability.	Slight reduction in separation or slight reduction in air traffic control capability. Significant increase in air traffic controller workload.	Slight increase in air traffic controller workload.

High | Low | "Harmless"

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Consultation

- Detailed and self explanatory Questionnaire sent to:
  - Aircraft Industry: For ACTION
    - EU, US, Canada and Brazil
  - NAA, FAA, TCCA: For INFO
  - OTHERS (Operators, Drone Industry, Associations): For INFO "on request"

EASA "Drone Collision" Task Force - Stakeholders Questionnaire

Certification Directorate

"Drone Collision" Task Force

Stakeholders Questionnaire

Ref. EASA-DC-TF_Questionnaire Issue 1

Appendix V : Questions

(MS word format)

Please send the Appendix V with your responses **not later than 3rd July 2016** to:
TO: antonio.marchetto@easa.europa.eu
CC: eric.duvivier@easa.europa.eu

1 Interviewee Information

Please fill in the following contact details:

Interviewee Contact Details		
Name		
Current Position		
Organisation		
Postal Address		
Email address		
Telephone number		
Do you agree to be contacted for follow-on questions / clarification in case of need?	☐ Yes	☐ No

NOTE: The contact details and the data provided will be treated with confidentiality. They will only be used for the purposes of the work conducted by this task force and will not be made public.

65 questions

- 56 on IEA & HEC (product specific)

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Main Conclusions

- LARGE Aeroplane & Rotorcraft are by the nature of their scale and design requirements more resilient to collisions with drones than SMALL Aeroplane and LIGHT Rotorcraft

- LARGE Aeroplane: LOW Severity level for 0.5 Kg and 1.5 Kg drone @ Altitude below 10 Kft
  - "Harmless" Severity level is confirmed for the 250g drone

- Rotorcraft: LOW Severity level only for the 250g drone
  - More research needed for the Tail rotor!

- General Aviation: Windscreen and Empennage most vulnerable
  - HIGH Severity level for 0.5 kg drone and above
  - HIGH Severity level for 250g drone for the windscreens of the lowest end of the GA spectrum

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Recommendations: Drone Threat

- Simplified DTS has been used based on “mass market” and Key Critical Components concept
  - Lack of validation (no collision or test data)
  - Current situation only, no prediction for future evolutions

Reco. 1

- Development of an Analytical model of the drone threat
  - detailed analysis of the construction of drones
  - assessment of the dynamic behaviour of drones and their components (motors and batteries)
- Model & method should be validated against laboratory tests,
  - to confirm the prediction of the overall frangibility of the drone.

Recommendations: Lithium batteries

- Lithium batteries contain hazardous materials such as lithium metal and flammable solvents, which can lead to exothermic activity and runaway reactions in case of impact with aircraft components following collisions.

Reco. 2

Conduct a specific risk assessment to assess the behaviour of lithium batteries on impact with structures and rotating parts and possible ingestion by jet engines (core)

The assessment should be supported by testing and should address the risks of explosion, fire and air contamination.

Recommendations: Impact effect assessment (IEA) and hazard effect classification (HEC)

- Simplified IEA and HEC processes have been proposed
  - Only frontal impacts , no “Secondary” impacts ....
  - Strong Assumption on Large Aeroplane Speed scenario

Reco.3

- Impact analyses should be performed to determine the effects of a drone threat (as established per Recommendation 1) impacting critical aircraft components,
- Possibly capitalising on existing computing and software capabilities and other particular risk assessments (bird, tyre and engine debris impacts)
- Model & 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).

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Way Forward

- A **coordinated** and **collaborative** research programme should be established to further assess the consequences of a drone collision on an airborne manned aircraft.
- The results should be shared to inform the responsible parties and facilitate the development of future safety measures that may be necessary to ensure the safe operations of drones & manned A/C

- EASA plan to initiate a "**Research programme on collisions with UASs"**
  - Aims to analyse and prepare the inclusion of the recommended Task Force actions in a Research Work Programme

Questions?

EASA
European Aviation Safety Agency

Thank you
and
Great Thanks to the Team !

Organisation	Name	Role
EASA	Mr. Eric Duvivier	Task Force Leader
EASA	Mr. Antonio Marchetto	Drone Technologies Expert Task Force Secretary
EASA	Mr. Richard Minter	Structure specialist
EASA	Mr. Alexandre Peytouraux	Large Aeroplane EASA focal point
EASA	Mr. Paul Hatton	General Aviation EASA focal point
EASA	Mr Raffaele Di Caprio and Mr. Clement Audard	Rotorcraft EASA focal point
EASA	Mr. Karl Hoier,	Engines and Propellers EASA focal point
EASA	Mr. Yngvi Rafn Yngvason	Safety Analysis
EASA	Mr. Selcuk Akdogan	Trainee
Airbus	Mr. Thierry Salmon	Large Aeroplane Industry focal point
Airbus Helicopters	Mr. Marc Greiller	Rotorcraft Industry focal point
Dowty	Mr. Gabor Zipszer	Propellers Industry focal point
SAFRAN	Mr. Charles Douguet	Engine Industry focal point
GAMA	Mr. Brian Davey and Mr. Oliver REINHARDT	General Aviation Industry focal point

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European Aviation Safety Agency

Backup slides

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Impact & Hazard Effect Assessment