JOINT AUTHORITIES FOR RULEMAKING OF UNMANNED SYSTEMS

WG-6 – Lorenzo Murzilli (Swiss FOCA) – Bruxelles – 03.12.2014
INTRODUCTION OF THE WORKING GROUP 6

1. JARUS WG-6 deals with UAS System Safety Analysis and, in particular, with proposing an Acceptable Means of Compliance with the 1309 requirement.

2. JARUS WG-6 deliverable is the AMC RPAS.1309 with the accompanying Scoping Paper.

3. JARUS WG-6 is not responsible for the 1309 requirement itself.

AMC RPAS.1309 should only be taken into consideration if Type Certification is required.
STATUS OF AMC RPAS.1309

- Fully reviewed within JARUS (internal consultation completed)
- Published **28.01.2014** for public consultation
- 300 comments received and currently under review
- Expected publication date Q2-2015
WHAT IS SAFETY?

SAFETY is the state in which RISK is ACCEPTABLE

EUROCAE ED-79A
AMC RPAS.1309 - FAILURE CONDITIONS CLASSIFICATION

CATASTROPHIC
Failure conditions that could result in one or more fatalities

HAZARDOUS
Failure conditions that would reduce the capability of the RPAS or the ability of the remote crew to cope with adverse operating conditions to the extent that there would be the following:

– Loss of the RPA where it can be reasonably expected that a fatality will not occur, or
– A large reduction in safety margins or functional capabilities, or
– High workload such that the remote crew cannot be relied upon to perform their tasks accurately or completely
AMC RPAS.1309

GROUND IMPACT
VISUALIZE BIG NUMBERS

1,000,000 grains

10,000 grains
BUT... GROUND IMPACT OF AN RPA DOES NOT POSE ANY RISK TO OCCUPANTS AS THERE ARE NONE!
ICAO Circular 328 (2010):  
(UAS) must not present a hazard to persons or property on the ground or in the air that is any greater than that attributable to the operation of manned aircraft of equivalent class or category.

EASA Policy (E.Y013-01 - 2009):  
A civil UAS must not increase the risk to people or property on the ground compared with manned aircraft of equivalent category.

Airworthiness standards should be set to be no less demanding than those currently applied to comparable manned aircraft nor should they penalise UAS by requiring compliance with higher standards simply because technology permits.
Population density has not been considered as an airworthiness risk factor *for type certification (!)* where the *assumption* is for unrestricted operation:

\[
\text{RISK}_{a/w} = f(\text{Accident Rate, Impact dynamics})
\]

As the impact dynamics will be related to the aircraft category:

\[
\text{RISK}_{a/w} = f(\text{Accident Rate, Category})
\]
• As Accident rates/Category is already a measure of safety for manned aircraft, it is not necessary to define different criteria for RPAS

• Equivalence with manned aircraft can be achieved by maintaining the same surface impact accident rate/category (all causes)

• The risk for someone on the ground is independent of whether the aircraft is manned or unmanned.
In the context of the AMC RPAS.1309 it is not allowed to “trade” fatalities of manned aircraft passengers with RPA fatalities of third parties on the ground.
For those smaller RPAS that have no equivalence with manned a/c, a lower limit of airworthiness is proposed to be set at $10^{-4}$.
DERIVATION OF SYSTEM SAFETY OBJECTIVES (GROUND IMPACT)

\[ P_{FC} = \text{(Accident rate} \times \%\text{ budget for systems})/\text{n. of systems} \]
COMPLEXITY LEVELS

I
- Conventional technology
- Manual control
- Very limited use of CEH and S/W

II
- Pilot workload relief
- Limited automatic capabilities
- Manual reversion

III
- Automatic full authority on flight management
- Manual reversion in case of failure
- Extensive use of CEH and S/W

IV
- Fully autonomous
- Outside of scope of AMC RPAS.1309
## PUTTING IT ALL TOGETHER

<table>
<thead>
<tr>
<th>Aircraft type</th>
<th>UAS Complexity Level (CL)</th>
<th>Accident rate (must be maintained for equivalence)</th>
<th>10% due to systems</th>
<th>Potential Catastrophic Failure Conditions</th>
<th>Probability of a systems failure condition leading to accident.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAS-23 class I</td>
<td>CL I &amp; II</td>
<td>$1 \times 10^{-4}$</td>
<td>$1 \times 10^{-1}$</td>
<td>$10 ,(10^{-1})$</td>
<td>$&lt;1 \times 10^{-6}$</td>
</tr>
<tr>
<td></td>
<td>CL III</td>
<td>$1 \times 10^{-4}$</td>
<td>$1 \times 10^{-1}$</td>
<td>$100 ,(10^{-2})$</td>
<td>$&lt;1 \times 10^{-7}$</td>
</tr>
<tr>
<td>CS-LURS Light Unmanned Rotorcraft Systems</td>
<td>CL I &amp; II</td>
<td>$1 \times 10^{-4}$</td>
<td>$1 \times 10^{-1}$</td>
<td>$10 ,(10^{-1})$</td>
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</tbody>
</table>
SYSTEM SAFETY OBJECTIVES (GROUND IMPACT) – IMPROVEMENTS?

\[ P_{FC} = \text{Accident rate} \times \frac{\% \text{ budget for systems}}{\text{n. of systems}} \]

- Equivalent to manned (if exist)
- Flat lined to $10^{-4}$ for smaller than manned

- Increased granularity for smaller than manned?
- Lower accident rate due to fleet size effect?
- Consideration to RPAS specific ops?

- Budgeted to 10% contribution to total accident rate

- Different budget:
  - 1%
  - 100%?

- Function of Complexity Levels/Class (10 or 100)

- Refined Complexity Levels?
- Function of other parameters?
- Specific to each RPA?

Joint Authorities for Rulemaking of Unmanned Systems
SAFE SEPARATION
SAFE SEPARATION: BASIC CONCEPT

• Loss of the Detect & Avoid (D&A) alone can not result in a Mid-Air Collision.

• For a MAC to occur an external event must also happen (i.e. there is another aircraft on a conflicting trajectory)

• JARUS WG-6 considers the D&A function as a protection function against this external event.
SAFE SEPARATION: BASIC CONCEPT

• Development of protection functions is fully described in EUROCAE ED-79A/SAE ARP4754A §5.2.4

• The development of safety objectives for the loss of a protection function is dependant on:
  – Severity of loss of protection function alone (expressed as a function of reduction in safety margins)
  – Severity of loss of protection function combined with the external event (i.e. MAC→CAT)
  – Probability of external event
SAFE SEPARATION: CONCLUSIONS

• The AMC RPAS.1309 does not prescribe safety objectives for D&A.
  – It offers a model to be used to derive safety objectives given the required inputs
  – It recommends using a given set of input values until more mature data is available

• More studies are required to define the probability of being in conflict with another aircraft (airspace, IMC/VMC, etc.)
DERIVATION OF SYSTEM SAFETY OBJECTIVES (GROUND IMPACT)

DEVELOPMENT ASSURANCE LEVEL (DAL)
DERIVATION OF SYSTEM SAFETY OBJECTIVES (GROUND IMPACT)

WARNING: DAL ≠ Probability!
The AMC RPAS.1309 recognises EUROCAE ED-79A as an acceptable method for establishing a development assurance process for all classes of RPAS.
JARUS WG-6 – NEXT STEPS

- Reinforce WG-6 membership
- Complete comments resolution phase and publish Issue 1
- Re-establish contact with industry representatives to create a common platform to reconcile, when possible, decisions taken by WG-6 with industry recommendations.
Questions

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