EUROPEAN AVIATION SAFETY AGENCY
AGENCE EUROPÉENNE DE LA SÉCURITÉ AÉRIENNE
EUROPÄISCHE AGENTUR FÜR FLUGSICHERHEIT

Safely flying in icing conditions - EASA regulatory actions

EASA Safety Conference 2013

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EASA Rulemaking – Product Safety
15 October 2013

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Content

- **1) In-flight icing issues**
  - Priority items from the regulator point of view – large aeroplanes
- **2) EASA actions**
  - Certification, Rulemaking, Research,
- **3) Perspectives for the future**
  - Needs for Research, Tools, Rulemaking

1) In-flight icing issues

1) In-flight icing issues

Priority items - large aeroplanes

- High altitude convective areas
  - **Ice crystals and mixed phase icing**

- Severe supercooled liquid icing
  - **Supercooled large droplet (SLD) icing**
  - **Freezing fog**

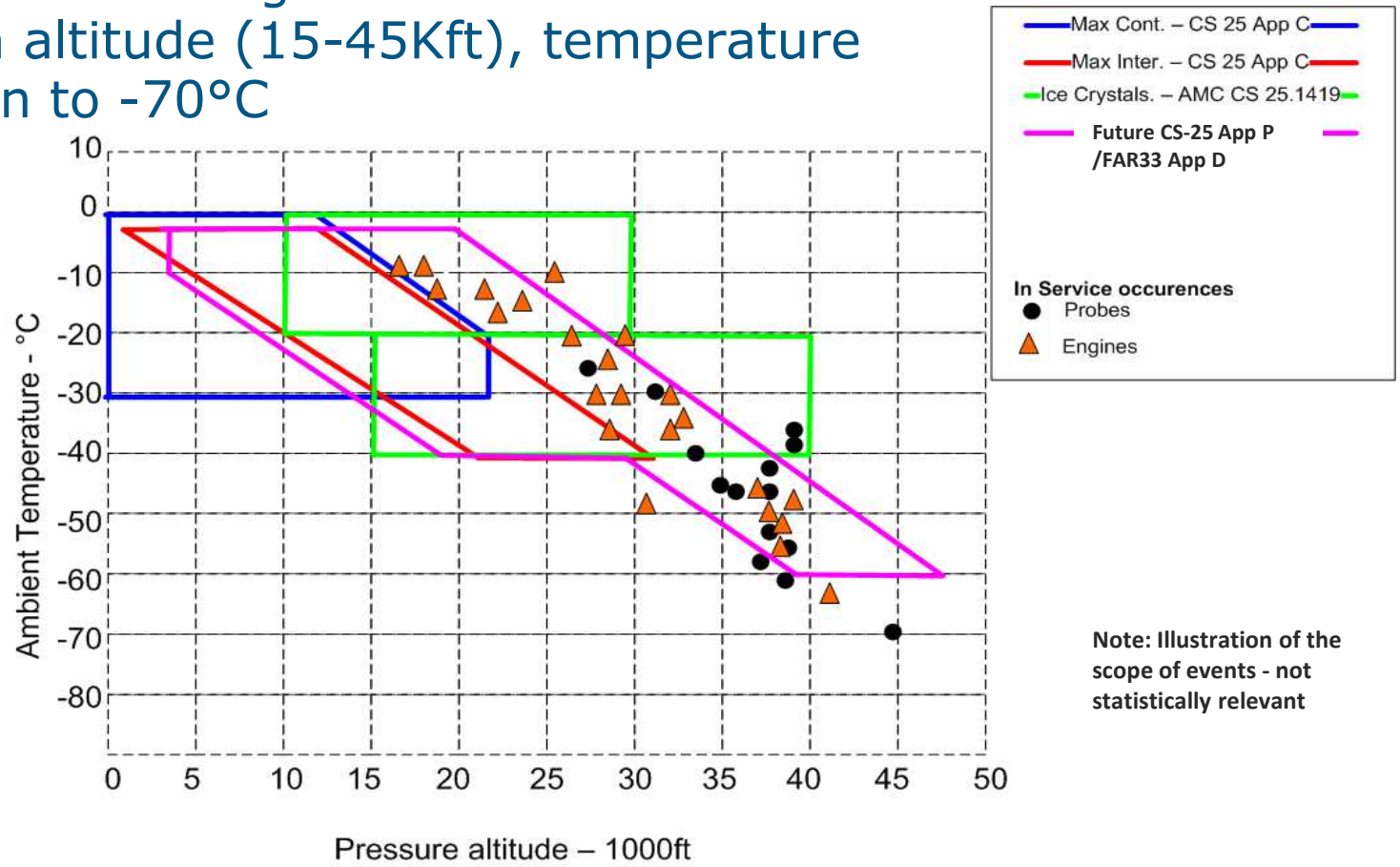
1) In-flight icing issues

- **A) Ice crystals/mixed phase icing**
  - Cells of deep convection developing into storms – high altitude small ice crystal sizes in high concentrations
  - Not visible (or very difficult) with airborne weather radars (small particles with low reflectivity)
  - Threat for surfaces with high collection coeff. and/or warm parts: external flight probes, engines and APUs
  - Not an issue for cold areas (crystals bouncing)

1) In-flight icing issues

A) Ice crystals/mixed phase icing (cont'd)

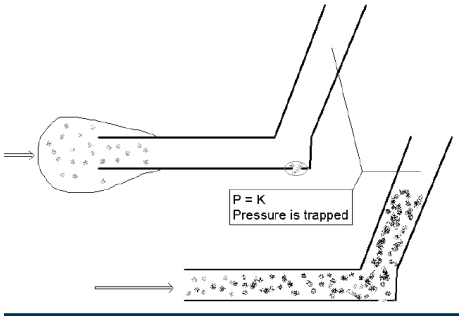
Probes and engines events occurred at high altitude (15-45Kft), temperature down to -70°C



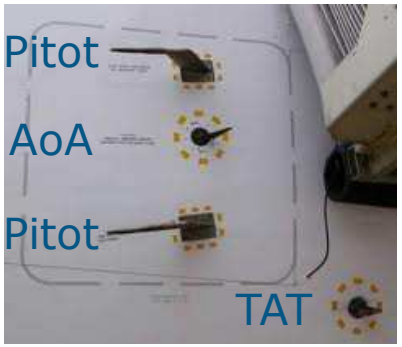
Note: Illustration of the scope of events - not statistically relevant

1) In-flight icing issues

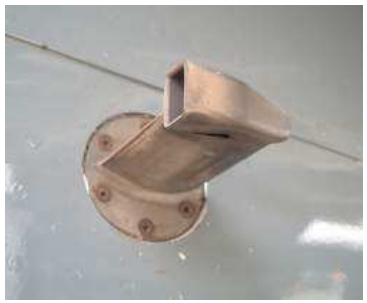
- **A) Ice crystals/mixed phase icing** (cont'd)
  - Probes (e.g. Pitots, AoA, TAT) may provide erroneous indication in presence of high concentration of ice crystals



Pitot tube: clogged



AOA: ice crystals build-up on rotating plate

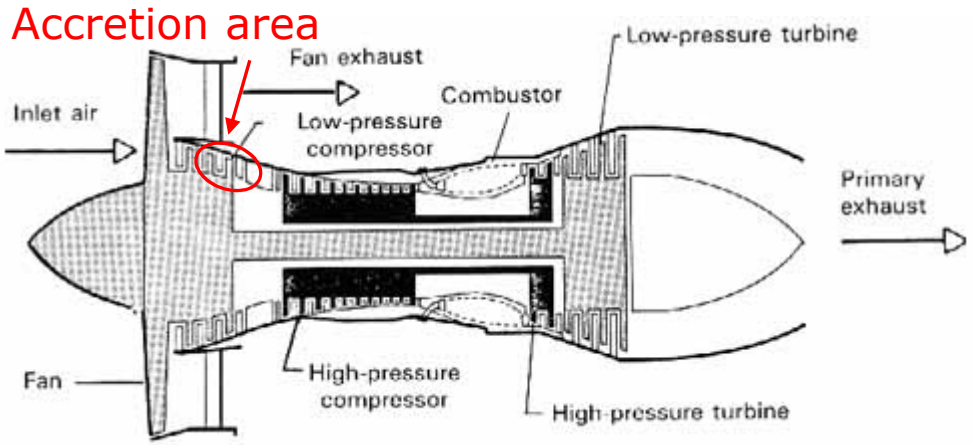


TAT probe: ice crystals build-up in thermocouple area

AoA: Angle of Attack
TAT: Total Air Temperature

1) In-flight icing issues

- **A) Ice crystals/mixed phase icing** (cont'd)
  - Ice crystal icing inside <u>turbine engines</u>
    - Complex mechanism: crystals impinge on compressor (warm) vane surfaces, melt and cool the surface; when vane surfaces are cold and wet enough, ice accretion begins



Loss of/unstable thrust/power, vibrations, flameout, or damages from ice release

1) In-flight icing issues

- **B) Supercooled Large Droplet (SLD) icing**
  - SLD icing (freezing rain, freezing drizzle) beyond CS-25 appendix C – droplet diameter >50µm
  - Encountered in or below stratiform clouds – freezing drizzle 0 to 22kft; freezing rain 0 to 12kft (proposed CS-25 App. O)
  - Impingement & accretions (clear ice) on aerofoils also behind protected areas
  - Potential large accretions of ice on the airframe in a short time

NASA – Twin Otter

1) In-flight icing issues

- **B) Supercooled Large Droplet icing** (cont'd)
  - Threats:
    - Aerofoil aerodynamic : loss of performance, high forces on moving parts (ailerons, elevator)
    - Release of ice accretions
    - Increase mass, change of the CG location (small a/c)

Loss of control events (including hull losses) have occurred – A/C with MTOM<27.000Kg/ 60.000Lbs, reversible flight controls, de-icing protection systems

MTOM: Maximum Take-off Mass

1) In-flight icing issues

- **B) Supercooled Large Droplet icing** (cont'd)
  - Amazing ground freezing rain accretions:

This is a helicopter!

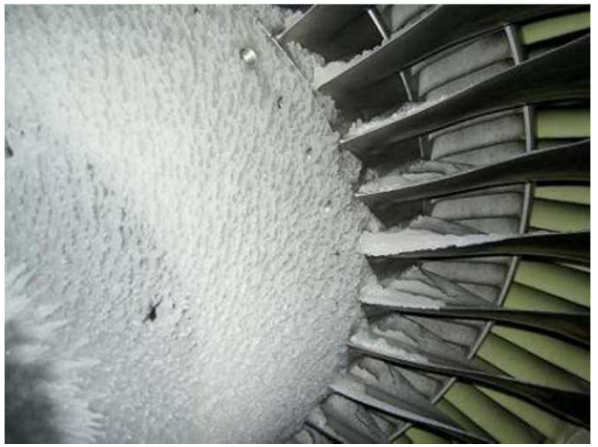
Source: Flight Global, Sept 2013

1) In-flight icing issues

- **C) Freezing fog**
  - Freezing fog occurs when supercooled liquid fog droplets freeze to surfaces (at temperatures just below freezing i.e. 0 to -18°C), forming white soft or hard rime

1) In-flight icing issues

- **C) Freezing fog** (cont'd)
  - Threat identified for turbine engines after prolonged operation at ground idle in freezing fog
  - Ice accretion inside the engine: static parts, fan blades, spinner, engine probes
  - If not shed or removed before Take-off, ice can then be released and create important damages into the engines



1) In-flight icing issues

- **C) Freezing fog** (cont'd)
  - Multiple engine failure at Take-off scenario
  - Events occurred leading to compressor damages on engines
  - Effects may be noticed only during subsequent flights

2) EASA actions

2) EASA actions

A) Certification

2) EASA actions

- **A) Certification /Engine (CS-E)**
  - **Generic CRI "Tests in Ice-Forming Conditions" – for Turbine engines**
    - Advisory Material (clarification of AMC E 780)
    - Supercooled liquid icing: additional guidance on conditions, exposure and ice build/shed cycle demonstration; introduce the CPA to identify critical points
    - Ground freezing fog compliance demonstration: policy clarified for the exposure time and the minimum temperature
    - Ice crystal icing: remove the existing statement that "Pitot" type intakes are not susceptible; comparative analysis to in-service events or good experience; identify susceptible design features
    - Guidance provided for engine Probe certification

CRI: Certification Review Item

2) EASA actions

- **A) Certification /Airframe (CS-25)**
  - **Generic CRI "Flight Instrument External Probes – Qualification in Icing Conditions" – for Large Aeroplanes probes**
    - Special Condition & Advisory Material
    - Probes (including, but not necessarily limited to Pitot probes, alpha vanes, side slip vanes and temperature probes) are requested to be evaluated against specified icing conditions including supercooled liquid water (CS-25 Appendix C), ice crystals, mixed phase, and heavy rain.

CRI: Certification Review Item

2) EASA actions

- **A) Certification /Airframe (CS-25)**(cont'd)
  - **CRI based on JAA interim policy INT/POL/25/11 "Severe Icing Conditions"** (dated 01 October 1998)
    - Special Condition
    - For aeroplanes equipped with unpowered roll controls and pneumatic de-icing boots
    - Requires protection against loss of control by providing means of detection and exiting from freezing drizzle and freezing rain – consistent with AD's raised after accidents (JAA/FAA)
    - Not yet used since EASA creation (no relevant application)

CRI: Certification Review Item

2) EASA actions

- **A) Certification /Airframe (CS-25)**(cont'd)
  - **Generic CRI "Freezing Fog"**
    - Interpretative Material
    - Protection against prolonged exposure to freezing fog beyond the conditions demonstrated for compliance to CS-25
    - Conditions defined in CS 25.1093(b)(2), in terms of time and temperature, considered as limitations (available in the AFM)
    - Possibility for applicants to demonstrate and operate beyond CS 25.1093(b)(2) conditions

CRI: Certification Review Item

2) EASA actions

B) Rulemaking

2) EASA actions

- **B) Rulemaking**
  - 2 rulemaking tasks amending CS-25 and CS-E icing specifications:
    - **Task 25.058 amending CS-25 (large aeroplanes)**
    - **Task E.009 amending CS-E (engines)**
  - Started in 2010
  - Based on the work of the ARAC IPHWG (supported by other sub-groups)(1997-2009)
  - Cooperation with FAA

2) EASA actions

- **B) Rulemaking**
- Task 25.058 (large aeroplanes):
  - NPA 2011-03 (Mar 2011) – CS-25 Book 1
    - Introduces new icing environments:
      - SLD icing: new Appendix O = Part I icing environment + Part II airframe accretions)
      - Ice crystals/mixed phase icing: new Appendix P
    - The A/C must be able to either safely exit following the detection of any, or specifically identified, App. O SLD icing conditions, or safely operate without restrictions (3 options under a new CS 25.1420 paragraph)

2) EASA actions

- **B) Rulemaking**
- Task 25.058:
  - NPA 2011-03 (Mar 2011) – CS-25 Book 1
    - Performance and handling qualities requirements amended to include App.O icing accretions
    - New or revised components requirements to demonstrate safe functioning in the new environments (App.O & P as applicable): windshields, flight instrument external probes, engine and APU air intakes, propellers
    - Operating limitations
      - Powerplant: ground icing operation (run-up proc. param.)
      - Prohibit operation in non-certified App. O conditions

2) EASA actions

- **B) Rulemaking**
- Task 25.058:
  - CRD 2011-03 published Nov 2012
    - Responses to comments
    - Updated regulatory text

2) EASA actions

- **B) Rulemaking**
- Task 25.058:
  - NPA 2012-22 (Nov 2012) – CS-25 Book 2
    - AMC and GM to show compliance to Book 1 CS's
    - For flight probes, AMC 25.1324 addresses some in-service events that occurred beyond the new App.P (Ice crystal/mixed phase)
      - Higher ("peak") concentration of ice crystals
      - Recommend considering temperatures down to -70°C
  - Consultation complete (30 April 2013)
  - Analysis of comments on-going

2) EASA actions

- **B) Rulemaking**
- Task E.009 (turbine engines):
  - NPA 2011-04 (Mar 2011) – CS-E Book 1
    - CS-E 780 amendment to:
      - Introduce new icing environments (CS-25 App. O & P): applicability function of the airframe on which the engine will be fitted (CS 2x.1093(b))
      - New ice ingestion paragraph

2) EASA actions

- **B) Rulemaking**
- Task E.009:
- NPA 2011-04 (Mar 2011) – CS-E Book 1
  - CRD 2011-04 published Dec 2012

2) EASA actions

- **B) Rulemaking**
- Task E.009:
  - NPA 2012-23 (Dec 2012) CS-E Book 2
    - AMC E 780 amendment addressing:
      - Engine testing configuration & facility
      - Determining tests points for supercooled liquid icing conditions (including SLD)
        - Critical Points Analysis
        - Minimum test points for in-flight operation testing
        - Ground freezing fog and snow test points

2) EASA actions

- **B) Rulemaking**
- Task E.009:
  - NPA 2012-23 (Dec 2012) CS-E Book 2
  - Ice crystals/mixed phase
    - Recognize no full scale facility available
    - Compliance by flight test and/or analysis
    - Design precautions required
    - Comparative analysis (service experience of comparable engine design)
  - Ice ingestion test
    - Minimum ice slab dimensions
    - Compliance by validated analysis (equivalent soft body testing)
  - Engine air data probes testing

2) EASA actions

- **B) Rulemaking**
- Task E.009:
  - NPA 2012-23 (Dec 2012) CS-E Book 2
  - Consultation complete (30 April 2013)
  - Analysis of comments on-going

2) EASA actions

- **B) Rulemaking**
  - Task 25.058 and task E.009 completion in 2014 (02Q)
    - Amendment of CS-25 and CS-E (Books 1 and 2)

2) EASA actions

C) Research

2) EASA actions

- **C) Research**
  - EASA HighIWC project (Ice water content of clouds at high altitude):
    - Phase 1 (EASA.2011.C30) completed in 2012 (review avail. Knowledge and prepare flight campaign)
    - Phase 2 planned for 2014 (support flight test campaign)

Content

- **3) Perspectives for the future**

3) Perspectives for the future

- **Research**
  - International flight test campaign on high altitude deep convection areas (Darwin, Australia - 2014) - planned
    - Learn more on ice crystal/mixed phase icing environment
    - Validate or update new CS-25 Appendix P
  - Ice crystal icing phenomenon into turbine engine cores (compressors)
    - Improve the knowledge on how it happens (physics) and how to protect against it

3) Perspectives for the future

- **Tools**
  - SLD icing
    - Develop SLD accretions simulation codes
    - Improve existing or build new SLD icing wind tunnels (for testing of aerofoils/models/ice detectors/probes)
  - Ice crystal icing
    - Improve existing or build new Ice crystal icing wind tunnels (for testing of probes, engines)

3) Perspectives for the future

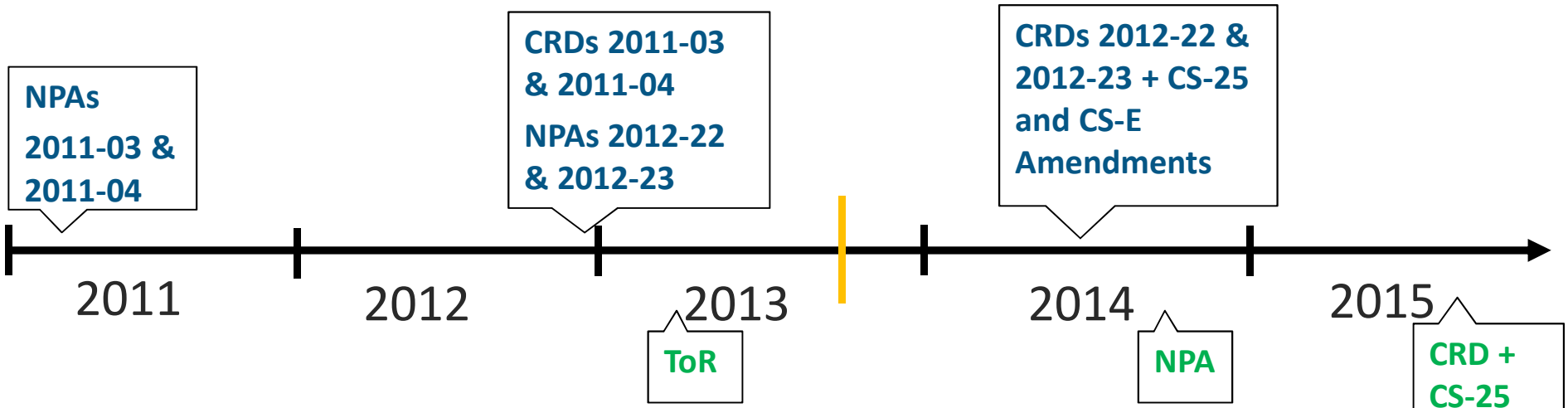
- **Rulemaking**
  - CS-25 AMC&GM amendment for compliance to SLD specifications by comparative analysis (EASA task RMT.0572 on-going)
  - Lessons learnt from the international flight test campaign on high altitude deep convection areas– re-visit the new CS-25 Appendix P (ice crystals/mixed phase environment)

3) Perspectives for the future

- **Rulemaking**
  - ETSO C16a (Pitot tubes) update
    - New standards being prepared by EUROCAE WG-89/SAE – EASA represented in the Group
      - AS5562/ED-225 (Icing test requirements) end 2013
      - AS8006A (Design requirements) end 2013
      - ETSO/TSO update recommendation end 2013
    - ETSO C16b planned in rulemaking task RMT.0206 (ETSO.011) – NPA in 2014
  - ETSO for ice detectors
    - Function of the outcome of EUROCAE WG-95 work to propose a standard(s) - EASA represented in the Group

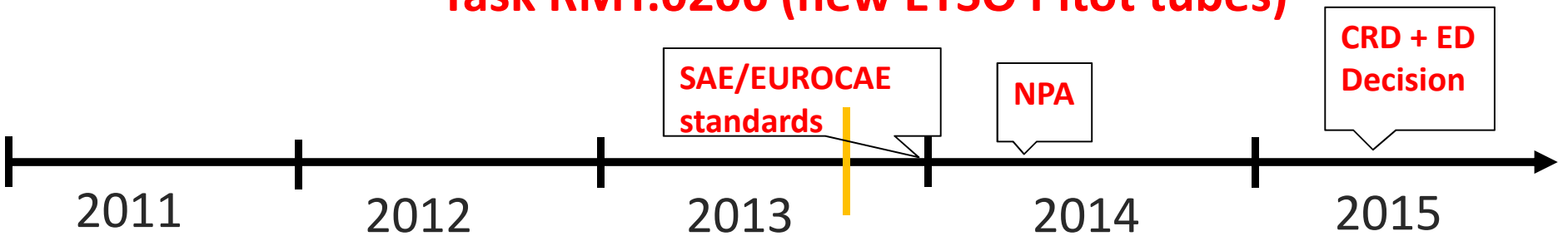
3) Perspectives for the future

Tasks 25.058 and E.009 (new icing environments)



Tasks RMT.0572 (SLD specs compliance by comparative analysis)

Task RMT.0206 (new ETSO Pitot tubes)



The End

Thank you for your attention

Questions?

Back-up slides

Back-up slides

- **Rulemaking – main comments addressed**
- Task 25.058:
  - NPA 2011-03 :
    - Applicability of CS 25.1420
      - Some comments required harmonization with FAA i.e. apply only to A/C with a maximum take-off mass (MTOM) less than 60.000 lbs or with reversible flight controls
      - EASA response:
        - SLD environment exists (confirmed by flight test characterisation) => must be considered for certification
        - All A/C are flying in the same environment although some A/C more sensitive

2) EASA actions

- Task 25.058:
  - Applicability of CS 25.1420 (cont'd)
    - EASA response (cont'd)
      - New A/C designs may not be able to take full credit of previous safe experience (new ice protection systems, new aerodynamic characteristics, new A/C performance or operational procedures…)
      - Some A/C have safe in-service experience although meeting the FAA applicability criteria
  - Availability of SLD means of compliance
    - Comments that simulation tools and test facilities are not sufficiently available – natural SLD flight testing impractical – SLD detectors are missing

2) EASA actions

- Task 25.058:
  - Availability of SLD means of compliance (cont'd)
    - EASA response:
      - Recognize that simulation tools and test facilities need to be further developed to cover full App.O
      - Safety related rule cannot be based on tools availability only – in this case the new rule drafting started in 1997 (IPHWG) leaving some time for tools development – SLD exist !
      - EASA willing to provide similarity analysis option as a MoC for applicants owning a fleet with proven safe operation in icing conditions

2) EASA actions

- Task 25.058:
  - Availability of SLD means of compliance (cont'd)
    - EASA RMT.0572 "Use of similarity analysis when showing compliance to SLD icing specifications" started Feb 2013 – Group –Develop AMC material - NPA 04Q2014
    - Need to prioritize R&D to:
    - - Develop engineering tools (SLD simulation codes)
    - - Develop test facilities (SLD icing wind tunnels)

2) EASA actions

- Task 25.058:
  - Availability of SLD means of compliance (cont'd)
    - EUROCAE WG-95 "In-flight Ice Detection Systems" started April 2013 - Collaboration with SAE AC-9C – include standard for detection of App.O in its objectives – EASA represented in this group

2) EASA actions

- Task 25.058:
  - Availability of ice crystal icing test facilities (e.g. for flight probes qualification)
    - Comment that current test facilities are limited and would not meet full App.P conditions
    - EASA response:
      - Existing simulation tools limitations (e.g. low temperature capability) recognised
      - But conditions exist and events occurred – must be addressed by available means
      - Use engineering extrapolation means when limitation exist (e.g. to reach extreme low temperature)

2) EASA actions

- Task 25.058:
  - Availability of ice crystal icing test facilities (e.g. for flight probes qualification) (cont'd)
    - Need to prioritize funding to:
    - - Develop engineering tools (simulation codes)
    - - Develop test facilities (ice crystal icing wind tunnels)
  - Appendix P validation/update
    - Some events (engines/flight probes) out of the proposed Appendix P envelope (Alt/T°C/TWC)
    - Appendix P is theoretical and need to be confirmed by flight measurements

2) EASA actions

- Task 25.058:
  - Appendix P validation/update (cont'd)
    - EASA response:
      - Research is on-going to prepare an international flight test campaign (see dedicated presentation later in this conference)
      - EASA fully support the EU project HAIC
      - EASA contributes with EASA HighIWC project:
      - - Phase 1 (EASA.2011.C30) completed in 2012 (review avail. Knowledge and prepare flight campaign)
      - - Phase 2 planned for 2014 (support flight campaign)

2) EASA actions

- Task E.009:
  - NPA 2011-04 :
    - AMC/GM is needed
      - EASA response: NPA 2012-23 proposing an amendment of AMC E 780 (published 04/12/2012)
    - Clarify that engine icing certification is required also when the aircraft is not certified for icing
      - EASA response: CS-E 780(a) revised to link the engine required icing conditions to paragraph CS 2X.1093(b) (air intake) – consistency between engine-air intake-nacelle-propeller (if applicable)

2) EASA actions

- Task E.009:
  - NPA 2012-23 :
    - Detailed technical comments mainly on:
      - Definitions,
      - Description of the Critical Points Analysis (SLW icing),
      - Establishment of test points for in-flight operation (SLW icing) (i.e. definition of the test cycles),
      - Establishment of test points for ground operation (ground freezing fog and snow),
      - Ice ingestion (ice slab test and validated analysis based on soft body testing)
      - Air data probes testing

2) EASA actions

- Task E.009:
  - NPA 2012-23:
    - EASA is updating the proposed AMC E 780 considering the positive comments received

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