RESTORING PRACTICAL IFR CERTIFICATION TO SINGLE ENGINE ROTORCRAFT

John Bouma

In Memory of Erik Oltheten - Bell Tech Fellow

AIM

Reduce weather-related accidents in the largest population of helicopters:

14 CFR 27, Single-Engine

- Provide a safe but cost-effective IFR solution for single-engine rotorcraft
  → No change to regulation required – just adjust interpretation / allowed methods
- Provide Helicopters able to capitalize on FAA investment in WAAS capability
- Provide a population of helicopters able to operate in a WAAS-based IFR airspace
- <u>Change the culture of rotorcraft operations to make the safety of IFR commonplace</u>

Helicopter IFR 2000-2019

4 Pax Piston

4-5 Pax Turbine

6-8 Pax Turbine

4 Pax Piston

Entry Level IFR
for Fixed Wing

By the time a typical Helicopter pilot gets to an IFR-capable rotorcraft, the culture of avoiding weather by flying beneath it is long established and entrenched

Entry Level IFR
for Rotorcraft

6-8 Pax Twin Turbine
e.g., B-429, H-135, A-109

Accidents

2001 to 2013 for 14 CFR 27 single-engine helicopters accidents world-wide*

- 194 accidents related to IIMC or CFIT due to low-level flight to avoid weather
- 133 of these accidents involved fatalities
- 326 people lost their lives in these accidents
- 57 of these accidents occurred in the United States

* 2015 Industry and Associations White Paper

Recognition of the Issue

- **2014 “Helicopter Operations” makes NTSB’s “*10 most wanted list*”**
- **2015 “Public Helicopter Operations” still on NTSB “*10 most wanted list*”**
- **US Congress forces Helicopter Air Ambulance (HAA) rules - adopted in 2014**
  - Class-G VFR weather minimums increased for <u>all helicopters</u>
  - Special Class-G weather minimums for HAA Operations
  - IFR pilot rating required for HAA pilot-in-command
    (but does not have to be current)
  - Yearly IIMC training
  - IFR operations now allowed at locations without Wx reporting
  - Mandatory Rad-Alt equipment for all Part 135 Helicopters
  - Mandatory HTAWS & FDM equipment for HAA operation
  - Mandates Preflight risk analysis /Operations Control Centers

Clear message:
- Encourage more IFR
- Better decision tools
- Better tools when in trouble

What happened to Single Engine IFR?

Single-Engine IFR rotorcraft circa 1980s:

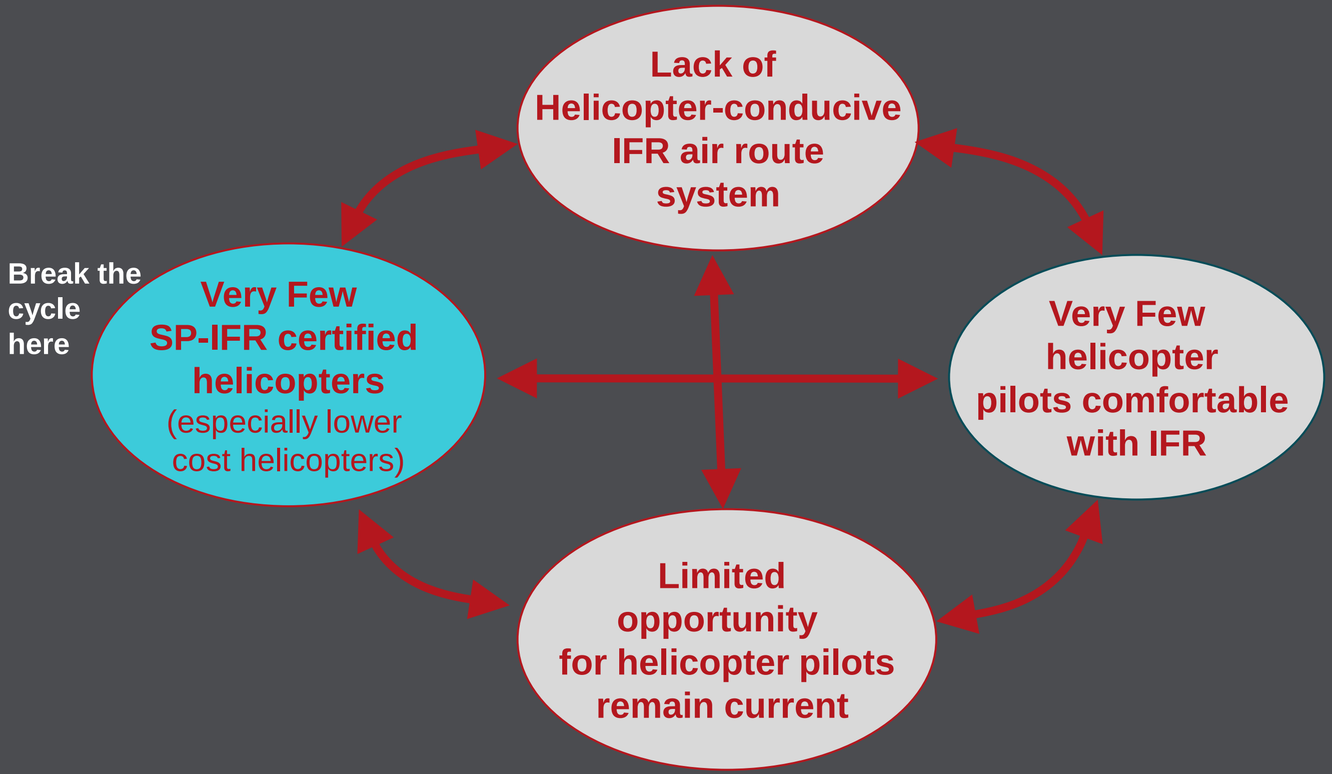
“Airliner” level numerical safety analysis methods adopted by FAA in 1999

Technology improvements:

- WAAS GPS navigation / ADS-B
- GPS LPV Approaches
- Electronic flight sensors
- Synthetic Vision / Moving map
- Autopilot / SAS technology

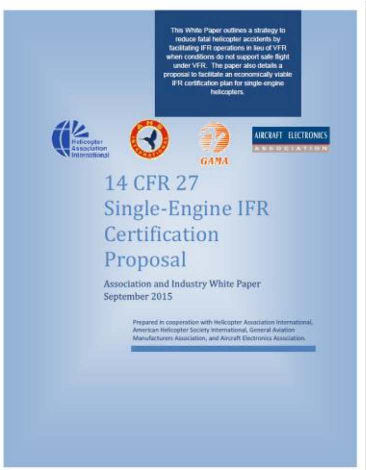
But no single-engine IFR certification since 1999

Changing Helicopter Culture – A Chicken-and-Egg issue



USA Timeline

- March 2014: AEA / GAMA / HAI Rotorcraft Forum
  - Executive Director FAA Certification (Dorenda Baker) challenges Associations and Industry to provide consensus recommendations to enable practical single-engine IFR certification.
- November 2014: HAI headquarters, Washington DC: Industry Meeting to review draft white paper
- March 2015: AHS (Now VFS) joins as 4th industry Association to endorse white paper
- March - April 2015: Industry Press joins in and supports initiative
- April 2015: Major Topic at 2015 International Rotorcraft Safety Forum
- Sept 2015: White Paper published
  - Addressed areas of recommended change
- Jan 2016: Initial meeting with FAA
- Feb/March 2016: FAA begins to brief Safety Continuum policy as response
- July 2016: FAA letter committed for release of policy



This White Paper outlines a strategy to reduce fatal helicopter accidents by facilitating IFR operations in lieu of VFR when conditions do not support safe flight under VFR. The paper also details a proposal to facilitate an economically viable IFR certification plan for single-engine helicopters.

14 CFR 27 Single-Engine IFR Certification Proposal

Association and Industry White Paper
September 2015

Prepared in cooperation with Helicopter Association International, American Helicopter Society International, General Aviation Manufacturers Association, and Aircraft Electronics Association.

USA Timeline

- March 2017: FAA issues Safety Continuum Policy for comment
  - Industry comments that policy does not go far enough to restore practical IFR – only 1 of 6 areas addressed
- June 2017: FAA issues final Safety Continuum Policy PS-ASW-27-15

U.S. Department of Transportation
Federal Aviation Administration

Policy Statement

Subject: Safety Continuum for Part 27 Normal Category Rotorcraft Systems and Equipment	**Date:** June 30, 2017 **Initiated By:** ASW-100	**Policy No:** PS-ASW-27-15

Summary

This policy establishes a safety continuum for certificating systems and equipment installed on normal category (14 Code of Federal Regulations (CFR) Part 27) rotorcraft. The policy sets classes of normal category rotorcraft used for establishing a graduated scale for the certification standards for systems and equipment. These classes are based on aircraft weight, engine type and count, and occupant capacity for rotorcraft weighing up to 7,000 pounds. The purpose of the safety continuum concept established by this policy is to facilitate a more rapid incorporation of advances in technology for systems and equipment by recognizing a balanced approach between the risk and safety benefits for installing such technology.

Current Regulatory and Advisory Material

The regulation applicable to this subject is 14 CFR §27.1309. This section lays out the regulatory basis for the installation and approval of systems and equipment on normal category rotorcraft. Guidance on this subject is discussed in Advisory Circular (AC) 27-1B, *Certification of Normal Category Rotorcraft*.

Background

The airworthiness standards for certificating normal category rotorcraft are prescribed in 14 CFR Part 27. These airworthiness standards apply to rotorcraft with a maximum gross weight of 7,000 lbs. and nine or less passenger seats. Since the promulgation of 14 CFR Part 27, large variations in size, capability, and performance have developed among the normal category rotorcraft models. Part 27 rotorcraft can range from a single reciprocating engine to twin-turbine engine rotorcraft models with up to nine occupants. These rotorcraft perform a wide variety of operations such as flight training, helicopter air ambulance, search and rescue, external loads/utility, firefighting, electronic newsgathering, and air tourism. The composition of the U.S. civil rotorcraft fleet ranges from models certificated over 50 years ago under the Civil Aviation

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- Nov 2017: Associations & FAA meet to find path forward for remaining items
  - Actual applicant certification plan and issue paper process will be used to set precedence
- Jan 2018: Bell submits 407GX retrofit IFR STC certification plan – the test case
  - Uses safety continuum and proposes all 5 remaining white paper areas
- April - May 2018: FAA responds to cert plan / Issue Paper drafts submitted
- Sept 2018 Bell submits a second IFR STC cert plan for new 407GXi
- June 2019: Leonardo receives IFR certification for TH-119
- August 2019: Certification of Bell 407GXi IFR STC - sells 3 in first month
  - Certifies using safety continuum policy and sets precedence for all but 2 white paper recommendations

Prior to Safety Continuum Policy

Compared to Airplanes

Class of Airplane AC 23.13091E	No Safety Effect	Minor Probable	Major Improbable	Hazardous / Severe-Major Extremely Remote	Catastrophic Extremely Improbable
	Allowable Quantitative Probabilities and SW Development Assurance Levels				
Class I (Typically SRE under 6000 lb)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ P=D	$<10^{-4}$ P=C, S=D For CNS: P=D,S=D	$<10^{-5}$ P=C, S=D For Com/Nav: P=D, S=D	$<10^{-6}$ P=C, S=C
Class II (Typically MRE or STE under 6000 lb)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ P=D	$<10^{-5}$ P=C, S=D For CNS: P=D, S=D	$<10^{-6}$ P=C, S=D For Com/Nav: P=D, S=D	$<10^{-7}$ P=C, S=C
Class III (Typically SRE, STE, MRE, & MTE equal or over 6000 lb)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ P=D	$<10^{-5}$ P=C, S=D	$<10^{-6}$ P=C, S=C	$<10^{-8}$ P=B, S=C T=C
Class IV (Commuter Category) 12.5 to 16K lb < 19 Pax	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ P=D	$<10^{-5}$ P=C, S=D	$<10^{-7}$ P=B, S=C	$<10^{-9}$ P=A, S=B, T=B
Part 25 Transport Category Airplanes	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ P=D	$<10^{-5}$ P=C, S=C	$<10^{-7}$ P=B, S=B	$<10^{-9}$ P=A, S=A T=B
All Part 27 Normal Category Rotorcraft < 7000 lbs	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ P=D	$<10^{-5}$ P=C, S=C	$<10^{-7}$ P=B, S=B	$<10^{-9}$ P=A, S=A T=B

Part 23 Airplanes <12.5K lbs < 10 Pax

Special Case

P=Primary, S=Secondary, T=Tertiary

Typically requires dual if hazard is for loss of function

Typically requires triplex if hazard is for loss of function

Equal Per AC 27-1B

For Part 27 Mostly Affected IFR because most electronic systems only become critical when used for IFR

Safety Continuum Policy (PS-ASW-27-15)

Part 27 Normal Category Rotorcraft ≤7K lbs ≤ 10 Occupants

Class of Airplane	No Safety Effect	Minor Probable	Major Improbable	Hazardous / Severe-Major Extremely Remote	Catastrophic Extremely Improbable
	Allowable Quantitative Probabilities and SW Development Assurance Levels				
Class I (SRE, ≤ 5 occupants)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ D Note 1 & 2	$<10^{-4}$ C Note 1, 2 & 4	$<10^{-5}$ C Note 1 & 2	$<10^{-6}$ C Note 1, 2 & 3
Class II (STE, ≤ 5 occupants ≤ 4000 lb)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ D Note 1 & 2	$<10^{-5}$ C Note 1 & 2	$<10^{-6}$ C Note 1 & 2	$<10^{-7}$ C Note 1, 2 & 3
Class III (STE, > 6 occupants 4001-7000lbs)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ D Note 1 & 2	$<10^{-5}$ C Note 1 & 2	$<10^{-7}$ C Note 1 & 2	$<10^{-8}$ B Note 1, 2, 3 & 5
Class IV (Twin Turbine)	No Probability or SW Development Assurance Levels Requirement	$<10^{-3}$ D Note 1 & 2	$<10^{-5}$ C Note 1 & 2	$<10^{-7}$ B Note 1 & 2	$<10^{-9}$ A Note 1, 2 & 3

Typically requires dual if hazard is for loss of function

Typically requires triplex if hazard is for loss of function

Note 1: Letter denotes the typical Development Assurance Level (DAL)
Note 2: Numerical probability indicate an order of probability of failure range, qualitative assessments allowed for Minor and Major
Note 3: At the rotorcraft function level, no single failure will result in a catastrophic failure condition
Note 4: Secondary systems must meet the same criteria if installed to meet probability requirements
Note 5: Intent is that this requirement can be met by a dual systems of sufficient robustness reliability and independence

Reduces Cost and Weight for IFR systems – Similar to Fixed Wing

Summary of White Paper Items:

Certification Precedence Achieved by 407GXi Single Pilot IFR STC

- Alternate HIRF Means of Compliance
- Mitigations for SAS and Boost Redundancy (and methods to show compliance)
- Assessment of unrecoverable Loss of all Nav / Com

Still to be addressed

- Large Battery in Lieu of Second Generator
- Single Pitot / Static System

Alternate HIRF Methods of Compliance

- 14 CFR 23 Airplanes have FAA Policy PS-ACE-23-10
    - Allows general characteristics to determine required equipment qualification
- AC 20-158A was only method available for Helicopters – same as 14 CFR 25
    - Requires proof of airframe HIRF attenuation through test (esp. cockpit/cabin)
    - Applies to electronics with critical functions (IFR displays / Autopilots)
    - Expensive test – may have to be repeated for config. changes (kits & custom)
- Issue Paper proposed airframe / pedestal / wiring construction-based credit for attenuation based on past test experience with similar designs
- FAA plan 14 CFR 27 HIRF Safety Continuum policy based on IPs from applicants

White Paper Item:

<u>Mitigations for SAS and Boost Redundancy</u>

(and methods to show compliance)

- Conventional thinking: Redundancy is always required for IFR
  - Dual SAS is heavy & expensive
  - Adding 2nd boost not practical in many rotorcraft.
  - Tends to be the biggest obstacle preventing IFR STC to existing models.

- Adjusted Thinking: Rotorcraft certified VFR without SAS / Single-boost <u>must</u> have a degree of visual cuing where continued flight in IFR is safe.
  - Large attitude presentation / Synthetic Vision / IFR automation provide mitigation
  - Boost has to have reliable design and history to support, since boost fail→ no SAS

- 3-inch indicator
- 2-inch horizon line
- Parallax

- 8-inch horizon line
- Synthetic Vision
- Integrated Area Nav / HTAWS / Nav Com

SAS / Boost Failure Evaluation program:

- 16 pilots involved in evaluation
- Included FAA, Bell, External pilots with varying degree of experience (Many not current IFR)

Assured IMC experience

- Most flights > 1 hour after boost off
- Included enroute IFR, enroute change flightplan, instrument approach (precision & non-precision), missed approach, and different type approach on second approach
- Scored against Practical Test Standard as if flying with no failures
- Included small stature female pilot (hydraulics off strength)

<u>Unrecoverable loss of NAV / COM</u>

- Conventionally "Catastrophic" by 14 CFR 25 guidance (adopted for 29 <u>and 27 IFR)</u>
- Recognized at "Hazardous" in 14 CFR 23
  - For aircraft still able to dead reckon nav to likely VMC & small emergency landing footprint
  - Why different? Same mitigation would seem to apply to single-engine rotorcraft
- HIRF for "Catastrophic failure" is primary issue → Qualification for ENV-I survival
  - Lower cost/weight Nav/Coms designed/qualified for 23 market
  - Must either specially qualify 23 radios or include a radio designed for 25
  - Impact of not recognizing mitigation to "Hazardous" for Class-1/2/3 rotorcraft IFR is burdensome
- Accepted by FAA in cert plan methodology

Items still needed to make IFR practical for Single-Engine Rotorcraft

407GXi Flying IFR in actual IMC

Large Battery in Lieu of Second Generator

- Key to practical IFR especially for retrofit to existing fleet
  - Often difficult or heavy to install 2nd generator
  - Regs allow IFR with single generator & large battery in single-engine aircraft (including turbine airplanes & helicopters)
- Helicopter guidance (AC 27-1B) places onerous requirement on Battery in this config.
  - Requires battery power to run required load for ½ the max fuel duration (e.g. ~2hrs)
  - Forces reduction of fuel capacity when Battery size becomes impractical → reduces safety
  - Compared to Fixed-wing requirements 30-60 minutes – no relation to fuel capacity
- Part 135 requires 1-hour assured power to carry paying passengers
- Proposed Method: Placard battery duration (target >1hr) and limit IFR to 1 hour from suitable emergency landing site. No relation to fuel capacity.

Single / Pitot Static System

- Often difficult to retrofit and certify second pitot/static installation
  - Dual heated pitot/static can significantly increases battery load

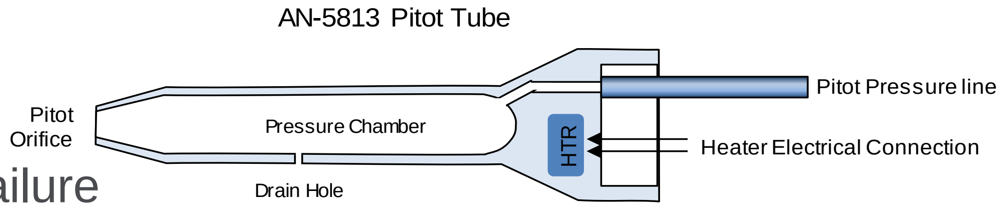
- Regs allow single pitot/static system with alternate static when single-pilot IFR
  - Allowed on aircraft where dedicated copilot instruments are not installed

- Common in IFR airplanes
- Used to be common in IFR helicopters
- Better mitigations today than in the 90s

Single Pitot Tube

MD Explorer – Certified Single-Pilot IFR in mid 1990s

Single / Pitot Static System



- Loss of airspeed indication – if recognized – is a manageable failure
- Misleading airspeed due to a pitot problem is the concern
  - Considered "Catastrophic" if not identified
  - Icing is the most common source of inflight misleading data
  - Blockage by foreign object while in-flight is rare.
    - Drain hole design in heated pitot makes probable result "loss"
    - Both pitot orifice and drain hole would have to block for "misleading" – not likely
  - Foreign matter blockage at exit from pitot pressure chamber – e.g., insect activity
    - Should be apparent before entry into IMC due to no airspeed reading.
- Method: Redundant pitot heat power source, and robust monitoring design
  - Address the most realistic threat to prevent the remaining "misleading" state

Summary of Progress – USA

Growth of IFR infrastructure (WAAS/ADS-B)

DONE!

Significant technological advances since 1999

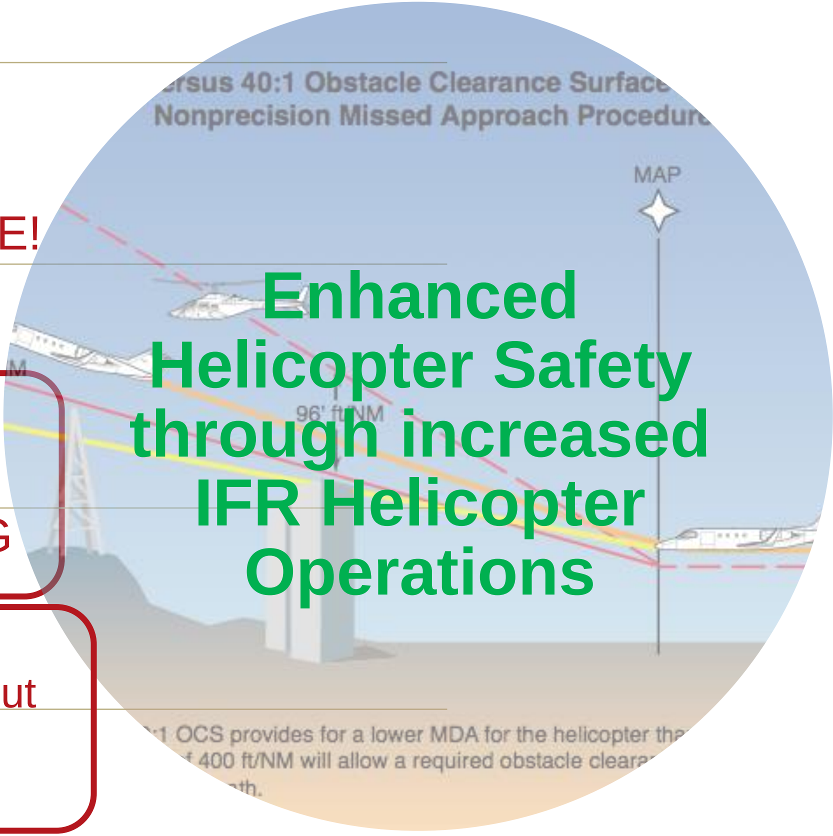
DONE!

FAA and industry cooperation to improve 14 CFR 27 IFR certification

IN PROG

Operator and pilot cultural change

NEEDS attention, but <u>will</u> follow availability



Enhanced Helicopter Safety through increased IFR Helicopter Operations

EASA Activity – NPA 2021-11

- Intent: To provide proportionate and cost-efficient rules in the field of the safety assessment provisions for equipment, systems and installations for rotorcraft while maintaining high level of safety

- Additional Intent: Increase harmonization of the safety assessment provisions for rotorcraft with their (FAA) equivalents

European Union Aviation Safety Agency

Notice of Proposed Amendment 2021-11

in accordance with

Articles 6(3), 7 and 8 (Standard procedure: public consultation) of MB Decision No 18-2015

Enhancement of the safety assessment processes for rotorcraft designs

RMT.0712

- The NPA introduces proportionality in the safety assessment objectives for the design of rotorcraft systems and equipment and the methodology that is used to identify the presence of hazards in the design

NPA 2021-11 Proposal

- "Enhancement of the safety assessment processes for rotorcraft designs"
  - Proposing to change the Acceptable Means of Compliance (AMC) for CS27.1309 to introduce a Safety Continuum similar to FAA policy statement PS-ASW-27-15
  - AMC introduces four classes of rotorcraft, allowing for proportional safety objectives based on the size and complexity of the aircraft, thus facilitating the installation of equipment and technology that could improve safety

Summary

- Bell looks forward to using the AMC to facilitate validation of single engine IFR capability
- We look forward to continued EASA activity in this area to provide opportunity to improve safety for single engine operations in the EU

THANK YOU