

Risk Assessment Based on Operations Considerations

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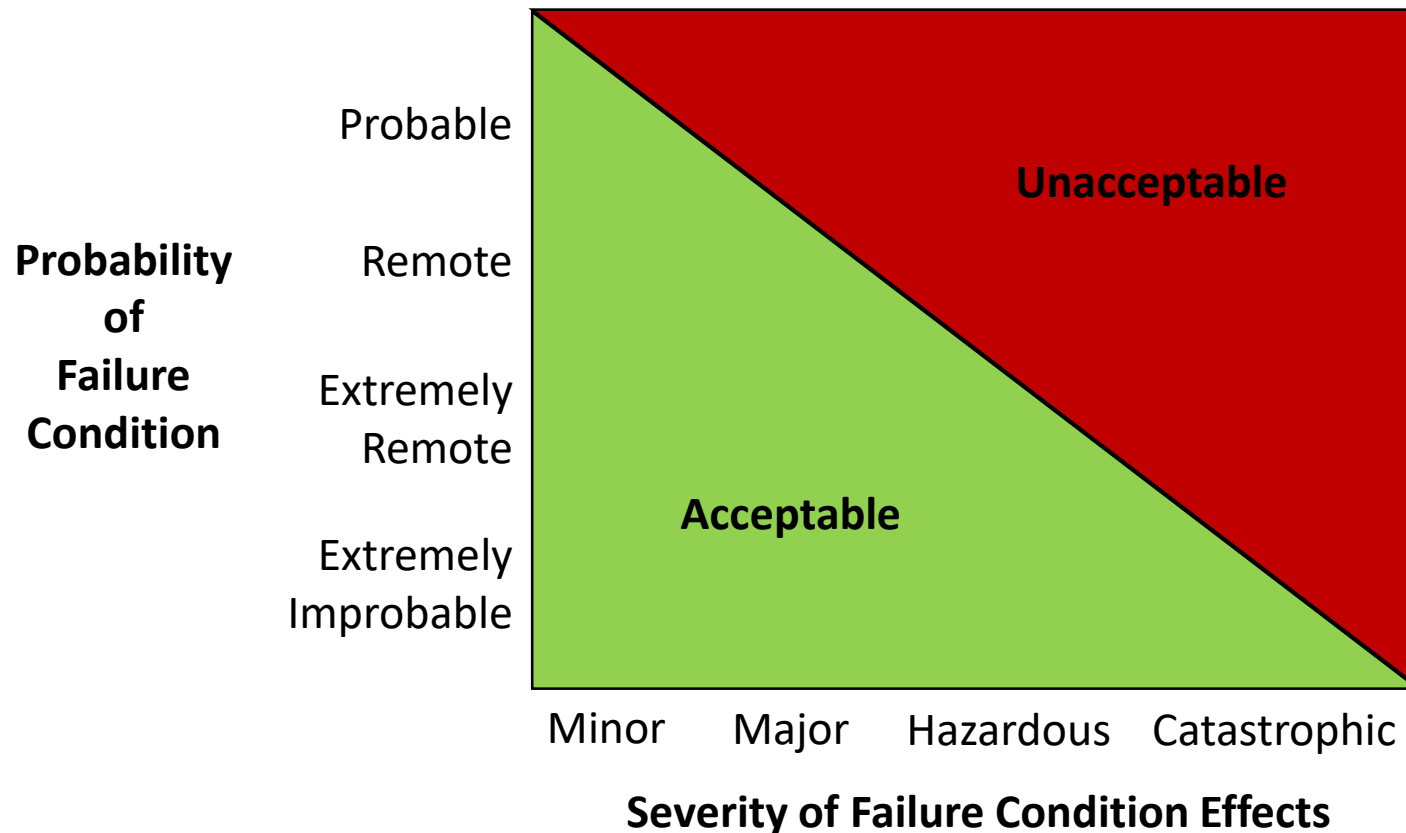
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Objectives

- 1) Estimate flight crew incapacitation probability as function of crew age.
- 2) Compare with established risk acceptability thresholds.

Safety objectives - multi pilot operations

Analogy with CS 25.1309 'System design and analysis'



Major failure conditions must be remote (between 10^{-5} and 10^{-7} per flight hour)

1% rule

ICAO Doc 8994 :

“ a pilot flying a two-pilot aircraft can have an incapacitation risk of no more than one in 10^6 hours, and the operation will achieve the target medical cause fatal accident rate of no more than one in 10^9 hours, since the presence of a second pilot reduces the risk by a factor of 1000.”

“This is widely regarded as an acceptable risk level and was adopted by the European Joint Aviation Authorities as the basis of aeromedical risk assessment.”

Safety objectives – single pilot operations

Analogy with CS 23.2510 ‘Equipment, systems, and installations’

“each catastrophic failure condition is extremely improbable”

Extremely improbable:

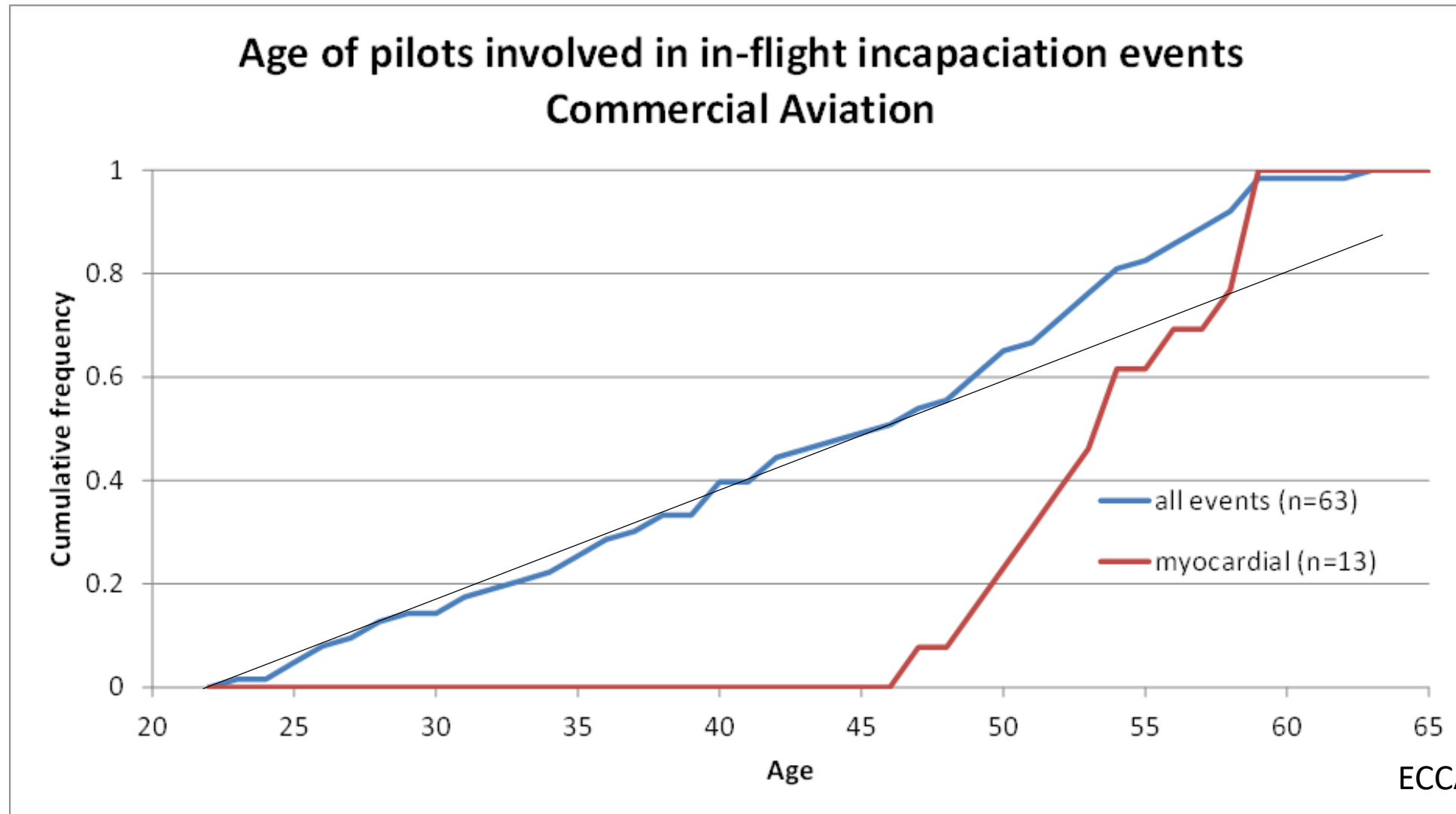
Seating for 10-19 passengers	10^{-9} per flight hr
Seating for 7-9 passengers	10^{-8} per flight hr
Seating for 0-6 passengers, turbine/multi	10^{-7} per flight hr
Seating for 0-6 passengers, single piston	10^{-6} per flight hr

Incapacitation data from reported inflight incapacitation events

Type of incapacitation	Number of occurrences
Gastro-intestinal	35
Myocardial	27
Syncope	5
Cerebrovascular	4
Cancer	2
Diabetes	2
Epileptic	1
Psychiatric	1
Other illnesses	16
Unknown	164

ECCAIRS data 1970-2017
Commercial air transport

Incapacitation data from reported inflight incapacitation events



Estimating incapacitation rates from reported in-flight incapacitation events

ECCAIRS data	$1.4 \times 10^{-7} / \text{hr}$
IATA data	$4.2 \times 10^{-7} / \text{hr}$
DeJohn et al (2004)	$4.5 \times 10^{-7} / \text{hr}$
Evans & Radcliffe (2012)	$2.9 \times 10^{-7} / \text{hr}$

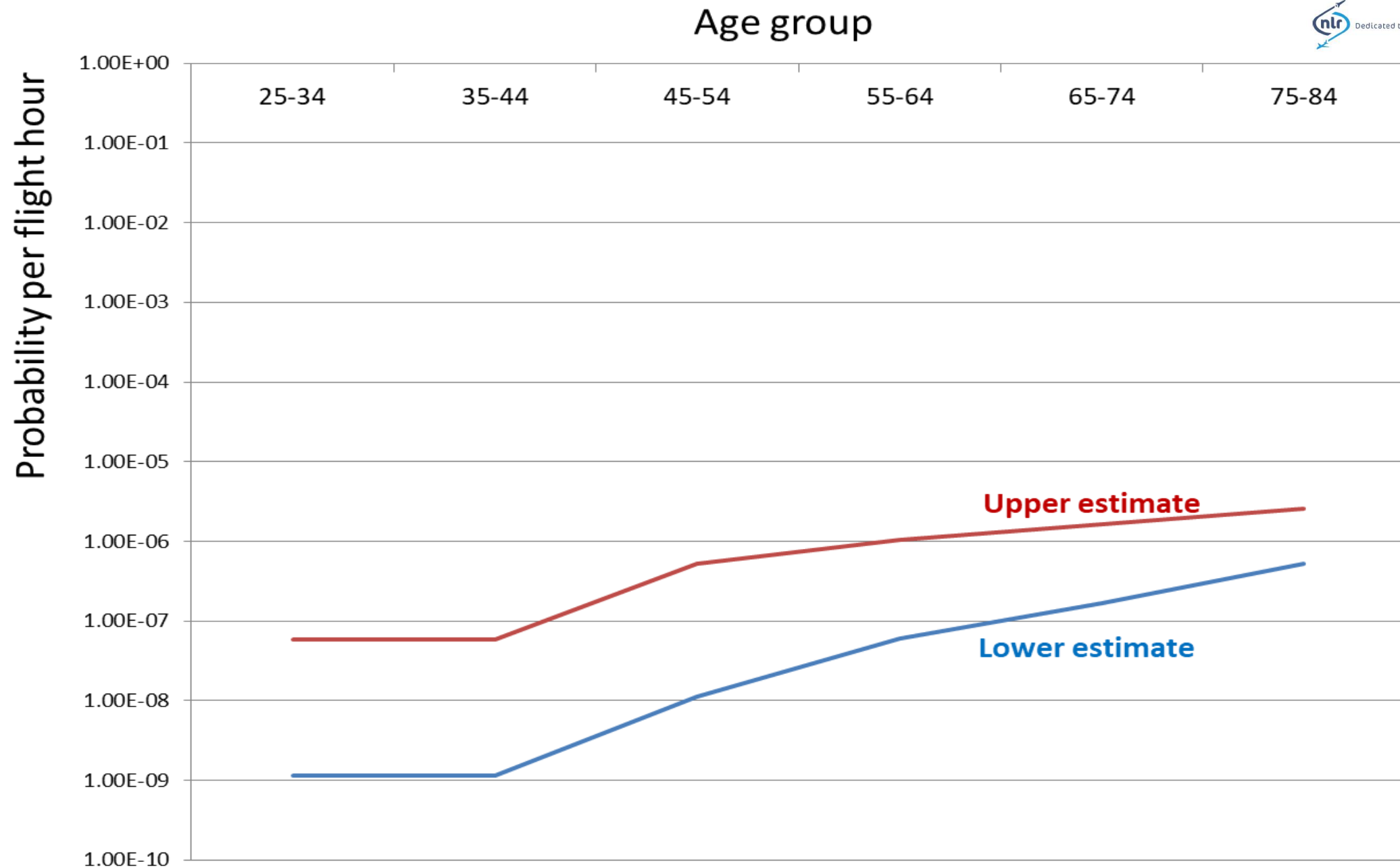
Limitation: Effect of crew age is not known.

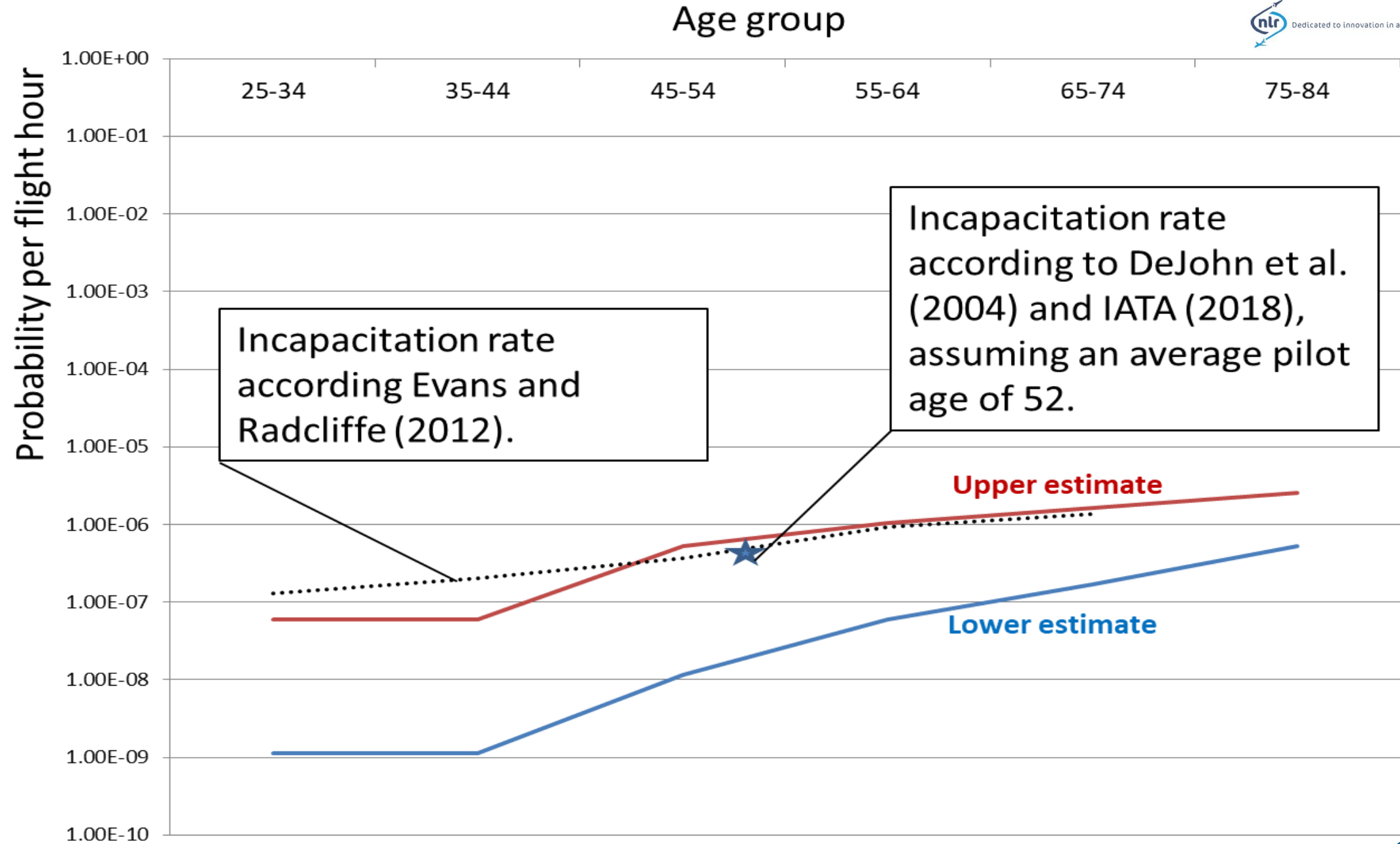
Estimating incapacitation probabilities from population mortality rates and hospital admission rates

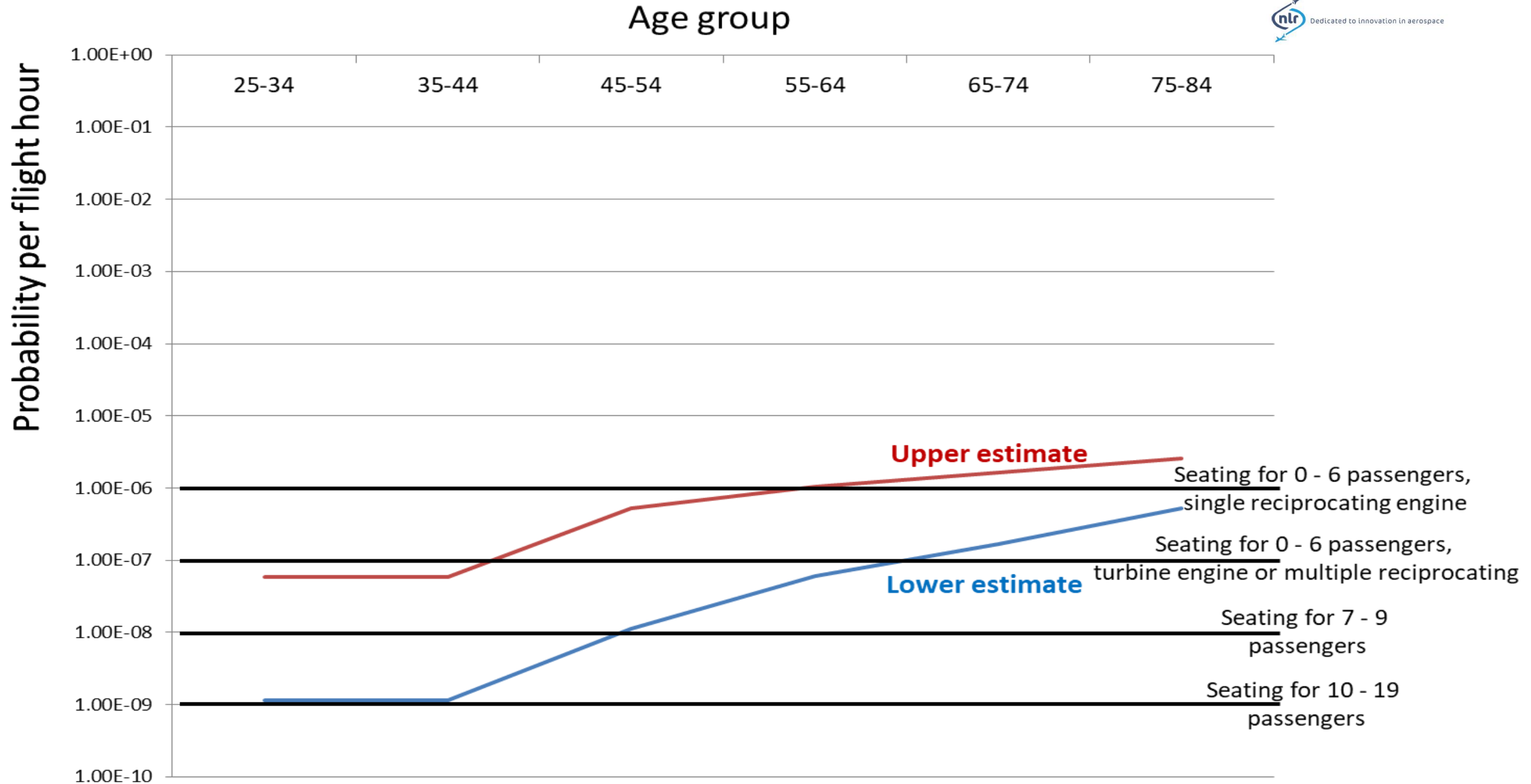
Lower estimate = cardiovascular mortality rate, SMR = 0.5

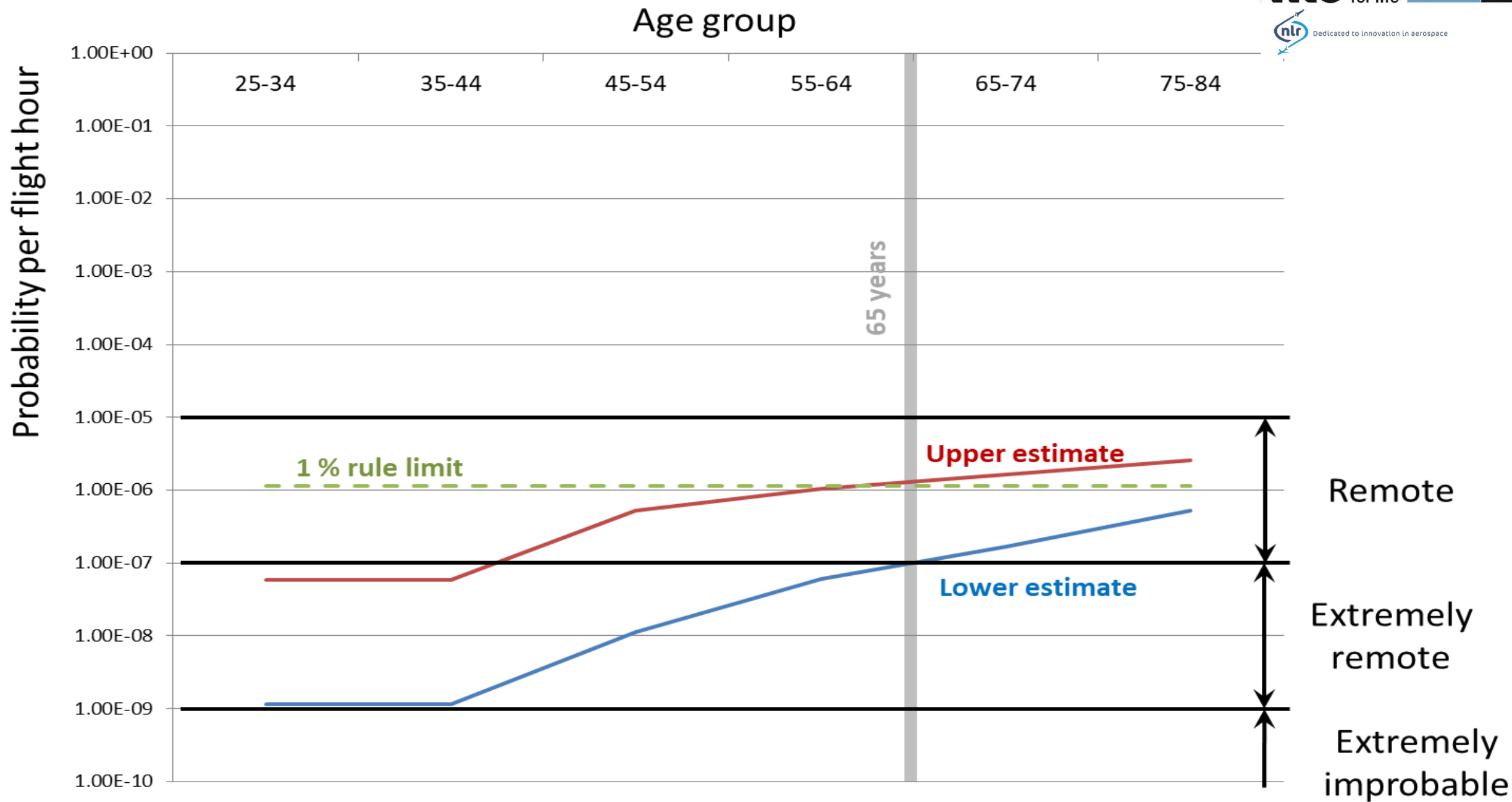
Higher estimate = cardiovascular hospital admission rate, SIR = 1.0

Standardised Mortality/Incidence ratio (SMR/SIR) is assumed to be independent of age.









Conclusion

- Estimated probabilities of sudden complete incapacitation fall within the EASA CS 25 'remote' range of likelihoods.
- The upper estimate of sudden complete incapacitation crosses the 1% rule limit at the 55-65 age group.
- Estimated probabilities of sudden complete incapacitation for pilots older than 60 do not meet CS.23 probability requirements for system failures.

Recommendations

- Allowing pilots older than 65 in multi pilot CAT operations requires additional risk-mitigation measures such as specific tests to support aero-medical decision on the applicant's fitness on an individual basis.
- Any increase of the age limitation for single pilot operations should be accompanied by additional measures to reduce the likelihood of pilot incapacitation to meet current accident acceptability values.

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