European Union Aviation Safety Agency

RESEARCH REPORT

Literature review regarding Extending age limits of HEMS pilots to 65 years: mental health and cognitive screening

Considerations and recommendations

An Agency of the European Union

REPORT CLASSIFICATION: UNCLASSIFIED
DATE: 12 June 2023
KNOWLEDGE AREA(S): Medical/mental health
DESCRIPTOR(S): Literature review
CUSTOMER: EASA/ RMT.0287 (2)(b) rulemaking group
CONTRACT NUMBER: EASA.2019.CEI.14.ECO18
OWNER: European Union Aviation Safety Agency
DISTRIBUTION: Public
CLASSIFICATION OF TITLE: UNCLASSIFIED

Author(s): Ries Simons, MD

REVIEWED BY:	AUTHOR	REVIEWER	MANAGING DEPARTMENT
EASA	**Ries Simons, MD**	Dr. C. Panait	Flight Standards

EXECUTIVE SUMMARY

When the age limit of Helicopter Emergency Medical Services (HEMS) pilots would be extended to 65 years, it is considered necessary to include additional risk mitigating measures beyond the implementation of specific requirements of the medical certification, such as an extended cardiovascular risk assessment, pulmonary assessment, screening for obstructive sleep apnoea (OSA) syndrome, screening for cognitive decline, a comprehensive eye examination, and a comprehensive ear, nose and throat examination. The present paper is aimed at discussing methods to screen for mental health problems and cognitive decline of older pilots and to provide recommendations for screening of neurocognitive decline of pilots above the age of 60.

The risk of mild cognitive impairment (MCI) is known to increase with age, although there is evidence that declines in cognitive abilities between the age of 50 and 65 are small. The results of the only study in HEMS operations indicate that extending the age limit to 65 may have limited operational consequences.

Mental Health including use of alcohol and drugs

There is convincing evidence that the frequency of mental health problems is not increased in the 60-65 age group compared to younger age groups. Furthermore, there is no evidence that hazardous/harmful drinking and alcohol use disorders occur more frequently in the age group 60-65. There is, however, growing evidence of a shift in the demographic profile of people who use illegal drugs, with an increasing substantial number of drug users aged over 40 years. Nevertheless, drug use disorders are still significantly more frequent in young people (15-49 yrs.) than in people aged 60 to 65 years. Therefore, the current EASA requirements mentioned in MED.B.055, AMC1 and GM1 MED.B.055 concerning mental health assessment that apply for pilots under 60 years of age can equally be applied for pilots between 60 and 65 yrs.

Early dementia, brain and metabolic diseases

Data indicate that the prevalence of all cause dementia in the age range 60 to 64 years is 8 per 1000 persons. Although the prevalence in active pilots aged 60-65 is likely to be low, the AME should be vigilant for any clue to early dementia. Particular attention should be paid to the occurrence of a progressive dysexecutive syndrome, which is a subtype of Alzheimer's disease characterized by impaired executive functions such as multi-tasking, completing tasks with multiple steps, learning new computer software, and mental calculations. This syndrome can affect people as early as their 40s and has a much different clinical profile than the memory impairment that is generally associated with Alzheimer's disease.

The AME should consider that all space-occupying processes in the cranium can impair cognitive and/or sensory functioning. Impaired cognitive functioning may also be a first symptom of Parkinson, Alzheimer, Pick's disease and Huntington's chorea, vascular diseases, infectious diseases, and diseases involving a metabolic disorder.

Screening for Mild Cognitive Impairment (MCI), dementia, or cognitive impairment caused by brain or metabolic diseases

Without an indication, neurocognitive testing or using amyloid β and tau (τ) biomarkers to identify MCI or early dementia are not recommended in the context of aeromedical risk assessment of pilots up to the age of 65 years. It is more appropriate that the AME should try and identify signs and symptoms which could indicate neurocognitive decline or brain diseases irrespective of the cause. In case of any suspicion or doubt the pilot should be referred for neuropsychological diagnostic evaluation (neurologist, clinical psychologist, neuropsychological testing). AMEs should preferably have information of examiners of proficiency and line checks, who might –with explicit informed consent of the applicant – inform the AME about any suspicion for

MCI that may emerge from the results of proficiency and line checks. In such cases the AME should consider requesting a specialized diagnostic evaluation.

How to test cognitive abilities of pilots aged 60-65?

In aviation, in the multi-pilot environment it is considered that the presence of the second pilot is mitigating potential signs of mild cognitive decline due to the fact that tasks are divided between the two flight crew members.

For single pilot HEMS operations, the principal concern about a decline of cognitive abilities by increasing age is related to the question whether or not a pilot aged 60-65 operating in single pilot environment is able to safely execute all flying tasks. Operationally Significant Cognitive Impairment is clearly an operational concern, and the solution would be to challenge the applicant in proficiency checks or line checks to give proof that his/her functioning has a sufficiently acceptable safety risk. In this context, the AME/AeMC can contribute only a part of the solution - apart from excluding MCI, dementia, or brain diseases.

There are currently no useful neuropsychological or cognitive tests available to predict a pilot's flight performance and there is no neuropsychological test that enables a decision to be taken on whether the cognitive capacities of an asymptomatic individual have diminished to such an extent that he/she should no longer be allowed to fly. It is not possible to decide solely on the basis of the score achieved in a psychological test. Neuropsychological or cognitive testing of pilots is needed and useful when it is indicated by a known condition affecting cognition, such as brain disease, or when questions regarding cognitive integrity arise. It is emphasized that neurocognitive or neuropsychological tests performed as a routine measure without indication will not provide useful results in the context of determining pilot's cognitive abilities to safely execute all flying tasks.

When safe job performance is to be predicted on an individual basis, it is useful to consider the basic order of the predictors of flight performance: a) domain-independent cognitive and motor skills, such as those assessable with cognitive tests; b) domain-dependent (aviation) knowledge; c) pilot characteristics such as age, cardiovascular status, drug dependency, agreeableness; and d) stressors, such as difficult work conditions, fatigue, and interpersonal conflicts.

When the cognitive functioning of an individual is evaluated, it is of great importance to have information about the occupational history of that person. Data that are relevant in this connection are the functioning of the pilot in the event of incidents and accidents and during simulator sessions, proficiency checks and training courses. This can alert the AME to a deterioration of functioning. After discussion with the pilot concerned, the AME may then order detailed additional screening.

To detect possible neurocognitive shortcomings, essential cognitive factors of flight performance should be incorporated in the regular mandatory License Proficiency Checks (LPC) or Operator Proficiency Checks (OPC). Attention should be focused on abilities to function under highly stressful demands, such as emergency procedures under time pressure. Annex III Part ORO (EASA, 2019-a) offers room to include scenarios enabling to assess pilot's performance during such highly stressful demands.

Conclusions

Mental Health including use of alcohol and drugs

The current EASA requirements mentioned in MED.B.055 concerning mental health assessment including misuse of psychoactive substances that apply for pilots under 60 years of age can equally be applied for pilots between 60 and 65 years. Signs and symptoms of mental health problems including misuse of alcohol and drugs should be identified by the AME and are indications to refer the pilot for specialized further diagnosis. In AMC1 MED.B.055 Mental health, EASA provides the important points of attention for the interview of the AME.

Brain diseases or degeneration including Mild Cognitive Impairment and Early Dementia
The risk of mild cognitive impairment (MCI) increases with age, although there is good evidence suggesting that declines in cognitive abilities between 50 and 65 years of age are small.

It is not recommended to use neurocognitive tests to identify MCI for the aeromedical screening of 60-65 years old pilots if there is no indication found by the AME (reasonable cause, suspicion). It is recommended that the AME should try and identify signs and symptoms which could indicate neurocognitive decline or brain diseases irrespective of the cause. Alarm signs for MCI may emerge from the occupational history and results of proficiency and line checks. In case of any suspicion or doubt the pilot should be referred for specialized diagnostic evaluation (neurologist, clinical psychologist, neuropsychological testing).

Recommendation
To detect possible neurocognitive shortcomings the recommended aeromedical examination should be based on the two most important pillars:
1) The AME interview (thorough history taking and examination); and
2) Operational information: occupational history and functioning of the pilot in the event of incidents and accidents and during simulator sessions, proficiency checks and training courses.

CONTENTS

1. Background

At the request of a number of member states, EASA is presently considering an extension of the age limit for single-pilot HEMS operations to 65 years of age. An EASA study concluded that the incapacitation risk due to cardiovascular and cerebrovascular events of the 55-64 age group is just within the margin of the acceptability limit for catastrophic system failures for single piloted CS23 aircraft with a single reciprocating engine and a seating capacity for 0-6 passengers (EASA, 2019). When the age limit of HEMS pilots is extended to 65 years, it is considered necessary to include additional risk mitigating measures beyond the implementation of specific requirements of the medical certification, such as an extended cardiovascular risk assessment, pulmonary assessment, screening for obstructive sleep apnoea (OSA) syndrome, screening for cognitive decline, a comprehensive eye examination, and a comprehensive ear, nose and throat examination.

In this context, the present paper is aimed at discussing methods to screen for mental health problems and cognitive decline of older pilots. The following sections will be presented:

1. Mental Health including use of alcohol and drugs

2. Brain diseases or degeneration including Mild Cognitive Impairment and Early Dementia

3. How to test pilot’s cognitive ability to safely execute all flying tasks?

4. Conclusions and Recommendations

5. References

Annex: The AME Interview

2. Mental Health including use of alcohol and drugs

2.1 Mental Health

Some of the more common psychological problems amongst pilots include adjustment disorder, mood disorder, anxiety and occupational stress, relationship problems, sexual dysfunction, and alcohol misuse (Bor et al., 2017).

Any mental illness (AMI) is defined as a mental, behavioural, or emotional disorder. AMI can vary in impact, ranging from no impairment to mild, moderate, or severe impairment. Serious Mental Illness (SMI) is defined as a mental, behavioural, or emotional disorder resulting in serious functional impairment, which substantially interferes with or limits one or more major life activities. There is evidence that the significant prevalence of AMI or SMI is not increased in the age group 60-65 compared with other younger age groups (National Institute of Mental Health, 2020; https://www.nimh.nih.gov/health/statistics/mental-illness).

Depression as a result of a life altering event cannot be excluded (Hammen, 2005). With age the risk of losing loved ones (family or friends) to illness is higher, however, there is no evidence for increasing risk of depressive disorder or suicide risk with increasing age (WHO Suicide worldwide in 2019 https://www.who.int/publications/i/item/9789240026643; Scowcroft E. Suicide statistics report 2017). In 2021 males aged 50-54 were found to have the highest suicide rate (22.5 per 100,000) in the United Kingdom (https://www.samaritans.org/about-samaritans/research-policy/suicide-facts-and-figures/latest-suicide-data/).

It can be concluded that there is convincing evidence that the frequency of mental health problems is lower in the 60-65 age group compared to younger age groups. It is considered that this is even more true for pilots due to the healthy worker effect, meaning that it is expected that many of those that have developed mental health disorders during their career are no longer active pilots by the time they reach the age of 60.Therefore, the current EASA requirements mentioned in MED.B.055, AMC1 and GM1 MED.B.055 concerning mental health assessment that apply for pilots under 60 years of age can equally be applied for those pilots between 60 and 65 yrs.

Signs and symptoms of mental health problems including misuse of alcohol and drugs should be identified by the AME and should be triggers to refer the pilot for specialized further diagnosis. In this context, the latest update to Part-MED requirements the provisions of MED.D.020 and MED.D.030 and their corresponding AMC/GM should be considered. This update includes additional training for AMEs on mental health issues including communication and interviewing techniques. In AMC1 MED.B.055 Mental health, EASA provides the important points of attention for the interview of the AME. These points are often translated into a questionnaire that has to be completed by the applicant. Most questionnaires, such as originally developed by Rios Tejada (2018), comprise of 20 questions with scoring on a 5-point Likert scale. This questionnaire can be used by the AME for a structured interview. The advantage of such questionnaire is that it provides structured information on the different aspects that should be checked in order to find red flags. However, pilots will be very aware of the consequences of an unfavourable evaluation and for most aware pilots it may be easy to recognise and tick the most favourable answer. To prevent "box-ticking" exercises, it is recommended that AMEs use the questionnaire as a structured checklist and wave the questions into a complete holistic AME interview, or at least discuss each of the questions and answers with the pilot. This allows the AME to extend questions and get more detailed information, which will facilitate the interpretation of the pilot's answers (e.g., how to interpret a "neither agree, nor disagree" on the Likert scale?).

2.2 Alcohol and drugs screening

Alcohol

Alcohol use is assumed to decline in older age, but older people may be at risk of developing problem drinking – alcohol abuse or dependency often triggered by significant life events such as loss of a loved one, loneliness, retirement, insomnia, illness or pain. On the other hand, there is no evidence that hazardous/harmful drinking and alcohol use disorders (AUD) are increased in the age group 60-65. Global frequencies of AUD found between the ages of 20 to 49 years (2.1% -2.5%) are higher than between the ages of 50 to 69 (1.7%) (https://ourworldindata.org/alcohol-consumption).

Therefore, the current EASA requirements mentioned in MED.B.055, AMC1 and GM2 MED.B.055 Mental health concerning misuse of alcohol that apply for pilots under 60 years of age can equally be applied for pilots between 60 and 65 years of age.

It would be an asset that at first examination after reaching the age of 60 and every two years thereafter laboratory screening would include at least measurement of Gamma-GT (this would also be recommendable for younger age groups). Although the specificity of Gamma-GT for alcohol use is rather low, it is known to have good sensitivity for excessive alcohol use. An increased Gamma-GT level can be considered as a Red Flag for alcohol misuse which can then be further examined by the AME by enhanced laboratory testing, such as determination of Carbohydrate Deficient Transferrin (CDT) which has a low sensitivity but high specificity and is suited for individual screening on excessive alcohol use in the preceding 2-3 weeks. The combination of serum levels of GGT and CDT - using the formula [0.8×ln(GGT)]+[1.3×ln(%CDT)]- is considered as the most sensitive and specific method to be used in these examinations. Hair analysis can be used if alcohol or drug use in the preceding 30 to 90 days should be assessed. Positive cases should be referred to specialized care.

Illicit Drugs

Although information about illegal drug use by people beyond 60 years of age is very scarce, there is growing evidence of a shift in the demographic profile of people who use illegal drugs, with an increasing substantial number of drug users aged over 40 years (Beynon et al., 2010). However, drug use disorders are presently still significantly more frequent in young people (15-49 yrs.) than in people aged 60 to 65 years (https://ourworldindata.org/illicit-drug-use). Therefore, the rules concerning use of illicit drugs that apply for pilots under the age of 60 can equally be applied for pilots between 60 and 65 years.

3. Brain diseases or degeneration including Mild Cognitive Impairment and Early Dementia

3.1 Mild Cognitive Impairment (MCI)

As HEMS operations pose high cognitive demands, age-related mild cognitive decline of helicopter pilots might become a safety risk.

Mild cognitive impairment (MCI) refers to the transitional state between the cognitive changes of normal aging and very early dementia (Petersen & Negash, 2008). MCI is a heterogenous clinical syndrome reflecting a change in cognitive function and deficits on neuropsychological testing but relatively intact activities of daily living. MCI is considered as a risk state for further cognitive and functional decline with 5–15% of people developing dementia per year. However, around 50% of those with MCI remain stable at 5 years and in a minority, symptoms resolve over time (Dunne et al., 2021).

The presence or absence of MCI is dependent on the sensitivity and specificity of the tests used, population norms and estimates of premorbid cognitive functioning. The clinical application of neuropsychological tests for MCI is to predict a future dementia risk in patients with some signs or suspicion of cognitive deterioration. However, the rationale of an aeromedical examination is not to predict future dementia but to predict whether the applicant's cognitive abilities are sufficient to perform safety-sensitive aviation tasks. In that context, MCI might be operationally defined by an impairment of cognitive functioning that leads to an unacceptable aviation safety risk. For aeromedical purposes it might be recommendable to rename the term MCI into Operationally Significant Cognitive Impairment (OSCI).

Prevalence data for the 60-65 age groups are very scarce, because most studies of the prevalence per age group only include retired individuals over 65 years of age. The few studies among active professionals concern physicians beyond the age of 70 (Garrett et al. 2021).

Many epidemiological studies of the prevalence of MCI define MCI as a neuro-cognitive performance that is 1.5 standard deviations (SD) lower than the population mean. Using a 1.5 SD cut-off is more sensitive to decline than a 2 SD cut-off, but inevitably less specific. Any such cut-off is arbitrary, and according to Dunne et al. (2021) 7% of the population will always score lower than the 1.5 SD cut-off used in population studies. Fifty percent of these individuals showed to have stable normal cognitive function in the five years follow up period (Dunne et al., 2021).

The COSMIC collaboration (Sachdev et al., 2015) applied uniform criteria to harmonized data from 11 studies from USA, Europe, Asia, and Australia, and determined MCI prevalence estimates defining cognitive impairment as performance in the bottom 6.681% (equivalent of impairment more than 1.5 SDs below the mean of the total sample of 24,888 persons; mean age 73.6 yrs.). With this criterion, the crude prevalence was 5.9 (5.5–6.3)% overall, and increased significantly with age: from 4.5% among 60–69 year-olds to 5.8% among 70–79 year-olds, and to 7.1% among 80–89 year-olds.). As this study concerned only individuals older than 60 years, the applicability of the results is limited for pilots.

When (self-) perceived cognitive impairment (CI), defined as "confusion or memory loss that is happening more often or is getting worse during the past 12 months" was assessed in a civilian, non-institutionalized population, Centers for Disease Control and Prevention (BRFSS, 2009 www.cdc.gov/brfss) found that the percentage of adults aged 18-49 years with perceived cognitive impairment ranged from approximately 4% to 8% whereas the percentage of adults aged 50 or older with perceived cognitive impairment ranged from 9% to 15% .

A study by Cornelis et al. (2019) about cognitive decline in the UK Biobank population (100,352 to 468,534 participants aged 38–73 years) showed that Fluid Intelligence scores were significantly higher between ages 55 and 64 and significantly lower at 65+ compared to age <45. The number of errors made on the Pairs Matching Test and Symbol Digit Substitution tests was increasingly higher with older age groups. Reaction Time and time taken to complete the Trail Making tests were also increasingly higher with older age. The odds of completing the Prospective Memory (PM) Test correctly on the first attempt were significantly lower with older age.

The only published scientific study that indirectly addressed this problem in HEMS pilots was performed by Müller et al. (2014) who performed a 5-year observational study including 257 regularly operating German and Austrian HEMS pilots aimed at estimating the association between pilot’s age and incidents in HEMS operations. Scoring the number of liability damages (LD) they found that there was no statistically significant main effect of pilot’s age on the number of LD when comparing 35 year old pilots (mean #LD:0.95) with 60 years old pilots (mean#LD:0.25). Only 8.6% of the pilots was aged over 60 years, therefore the results may have limited value for HEMS pilots between 60 and 65 years of age. Furthermore, results might be influenced by a “healthy worker” effect. Despite these possible limitations of the study, the authors conclude that there is no evidence that older pilots have a higher risk than younger pilots of being involved in an incident during HEMS operations.

Conclusion
Above data support the generally accepted opinion that the risk of mild cognitive impairment increases with age, although findings of the study by Cornelis et al. (2019) about cognitive decline in the UK Biobank population suggest that declines in cognitive abilities between the end of the fourth decade and age 65 are small. The results of the study of Müller et al. (2014) indicate that age related cognitive decline may have no direct operational consequences in the sense of liability damages related to HEMS operations, although the proportion of pilots beyond the age of 60 was limited in this study.

3.2 Young onset Dementia

Global prevalence of young-onset dementia
Counting persons with dementia in a community who are younger than 65 years is more challenging than in older persons because the rarity of prevalent dementia in younger patients.

Findings In the recent systematic review of Hendriks et al. (2021) in which 74 studies with 2 760 379 unique patients were included in the meta-analysis showed that estimates increased from 1.1 per 100 000 population aged 30 to 34 years to 77.4 per 100 000 population aged 60 to 64 years. For the age range 60 to 64 years, Hendriks et al. estimated the prevalence of all-cause dementia to be 0.84 per 100 persons, which is similar to estimates made by other studies. In that age range, examining 1000 persons would be necessary to find approximately 8 cases. For the age range 55 to 59 years, Hendriks et al. estimated the prevalence of dementia to be approximately 5 times lower, meaning that screening of 5000 persons would be needed for the same yield of cases. Although the prevalence in pilots aged 60-65 is likely to be low, the AME has to be vigilant for any clue to early dementia and even when in doubt refer the pilot to expert neuropsychological evaluation to exclude early dementia.

Progressive dysexecutive syndrome
A study by Townley et al. (2020) defined a subtype of Alzheimer's disease (AD) characterized by impaired executive function —problems with tasks such as organizing and planning. This subtype called progressive

dysexecutive syndrome, can affect people as early as their 40s and has a much different clinical profile than the memory impairment that is generally associated with Alzheimer's disease. They described 55 patients in which the mean age of reported symptom onset was 53.8 years. Many patients used 'memory trouble' to describe their cognitive difficulties but with further questioning often described difficulties with multi-tasking, completing tasks with multiple steps, playing board games with family, following directions/recipes, learning new computer software, mental calculations, organizing personal calendars, or planning and executing projects at home or work, suggesting more executive dysfunction with prominent deficits in working memory function. Multi-domain cognitive impairment was evident in neuropsychological testing with executive dysfunction most consistently affected. The prevalence of progressive dysexecutive syndrome is unknown, as it is assumed that the diagnosis is often missed in these patients. This subtype of AD is important to be identified in pilots as it may have a considerable negative impact on the planning and execution of a flight.

3.3 Other conditions causing cognitive impairment

- Brain: All space-occupying processes in the cranium can impair cognitive and/or sensory functioning. These include benign and malignant brain tumours, metastatic growths, and haemorrhages (in particular, chronic subdural hematomas). Impaired functioning may also be a first symptom of Parkinson, Alzheimer, Pick's disease and Huntington's chorea, vascular diseases, and infectious diseases (Auto-immune Encephalitis, Creutzfeld-Jacob's disease and HIV(AIDS).
- Metabolic: Impairment of cognitive functioning can be a first symptom of diseases involving a metabolic disorder, such as thyroid diseases (hyperthyroidism and hypothyroidism), kidney diseases, diabetes, liver diseases, and chronic alcohol abuse.
- Chronic fatigue can result in subtle incapacitation as a result of cognitive impairment.

3.4 Screening for Mild Cognitive Impairment (MCI), Dementia, or cognitive impairment caused by other brain diseases

The majority of studies of the sensitivity and specificity of screening tests for MCI have been performed among highly aged study populations with considerable prevalence of dementia and MCI, such as for instance the Drivers Aged 80 and Over study (Traffic Injury Research Foundation, 2013) and studies comparing patients with established dementia, proven MCI, and those who had no cognitive impairment (Dong et al.2012).In the high prevalence groups the predictive value of tests will be high and the false positive rate will be low. However, in the under-65 pilot screening population, prevalence of MCI and early dementia is assumed to be low, resulting in a low specificity of the tests and higher false-positive rates, in particular when the cut-off values are set towards high sensitivity. A high false-positivity rate and a low predictive value are important disadvantages for a screening tool that is intended to be used to determine that someone may be unfit for a highly sensitive job.

The most frequently used clinical instrument, the Mini-Mental State Examination (MMSE), has good sensitivity and specificity to detect dementia. It performs less well in detecting MCI because the instrument is not sufficiently sensitive to detect subtle impairment due to MCI (Sabe et al., 1993). The MMSE is a brief cognitive test that assesses several cognitive domains, such as orientation, attention, concentration, memory, language, and constructional abilities. In a meta-analysis of 34 dementia studies and 5 MCI studies it was found that the MMSE offered modest accuracy with best value for ruling-out a diagnosis of dementia in community settings and primary care. For all other uses (i.e., MCI) it was recommended to combine it with or replace it by other methods (Mitchell, 2009).

The MoCA (Montreal Cognitive Assessment) is considered more efficient in screening for MCI with 90% sensitivity and 97% specificity for MCI according to a validation study by Nasreddine et al. (2005). However, this study used 94 patients meeting MCI clinical criteria supported by psychometric measures, 93 patients with established mild Alzheimer's disease (AD), and 90 healthy elderly controls and it should be considered that the sensitivity of this test might be significantly lower when screening a pilot population with only a small risk of MCI.

The MoCA is a paper and pencil test evaluating different types of cognitive abilities including orientation; short-term memory/delayed recall; executive function/visuospatial ability; language abilities; abstraction; fluency; attention; and Clock-drawing test. The test takes 10 minutes and should be done in the patient's first language to be accurate.

The CAA Australia (CASA) uses no age limits for pilots and uses extra examinations that commence at age 65, and are repeated at age 67, 69, and 71 (annually thereafter). Cognition is assessed by a MoCA paper and pencil test <u>AND</u> a flight test, and the two assessed together {https://www.casa.gov.au/file/80416/download?token=wPaTjI1M).

CASA uses the MoCA after the age of 65 and it is not recommendable to apply the MoCA test in regular aeromedical examinations of pilots under 65 years of age, because of the low prevalence of MCI and dementia in individuals who are younger than 65 years. It may, however, be suited in the context of a neuropsychological examination of a younger applicant of whom the AME has identified signs or symptoms of dementia, e.g., caused by a brain disorder.

It should be considered that this test, as well as most other neurocognitive tests, is freely available on internet and can thus easily be trained prior to an aeromedical examination.

Biomarkers for Alzheimer: what is the predictive value?

According to the criteria of National Institute on Aging–Alzheimer’s Association (NIA-AA) amyloid β and tau (τ) are needed for the diagnosis of Alzheimer’s disease (AD), while neurodegeneration is used to stage disease severity. Individuals who have abnormal levels of amyloid β plus abnormal τ can be considered to have biological AD, even if they do not have cognitive symptoms. However, the clinical significance of biologically defined AD in individuals without cognitive impairment is debated, because 20% of older adults without cognitive impairment are known to have abnormal levels of amyloid β and tau. Although a study by Strikwerda-Brown et al. (2022) of subjects aged 67-76 years showed that hazard ratios for progression to MCI in the group with abnormal levels of amyloid β plus tau compared with normal biomarker groups were 5 or greater, assessment of these biomarkers is currently not recommendable to predict 1-5 years MCI risks in the context of an aeromedical examination. In their discussion about the possible value of AD biomarkers as tool for the FAA pilot screening, Lawrence and Arias (2019) concluded that “when AD biomarker status is known, it should trigger heightened scrutiny of first-class airline pilots but that requiring testing for biomarkers is not justified at this time.” Currently amyloid β and tau assessments are only used in clinical settings to confirm clinical diagnoses of AD.

Conclusion

Routine neurocognitive testing or using amyloid β and tau biomarkers to identify MCI are not recommended in the context of aeromedical risk assessment of pilots up to the age of 65 years. It seems more appropriate that the AME should try and identify signs and/or symptoms which could indicate neurocognitive decline or brain diseases irrespective of the cause. The AME interview should therefore be aimed at building up of a picture of the pilot’s job and work environment, including results of proficiency and line checks and family life. Answers that give clues to potential problems should be followed by an in-depth interview (Hudson & Herbert, 2017).

In case of any suspicious sign or symptom the pilot should be referred for specialized diagnostic evaluation (neurologist, clinical psychologist, neuropsychological testing). AMEs should preferably have information of examiners of proficiency and line checks, who might –with explicit informed consent of the applicant – inform the AME or the medical assessor of the Competent Authority of the pilot about any suspicion for MCI that may emerge from the results of proficiency and line checks. In such cases the AME should consider requesting a specialized diagnostic evaluation. In case consent of the pilot cannot be obtained, methods to report the examiner's findings should be explored in the interest of flight safety. When the condition of the pilot would be a clear threat to flight safety, breaching of confidentiality should be considered when the pilot keeps refusing consent or self-reporting.

4. How to test pilot's cognitive ability to safely execute all flying tasks?

Cognitive decline begins from 40 years of age and its course varies greatly across individuals. The most important changes in cognition with normal aging are declines in performance on cognitive tasks that require one to quickly process or transform information to make a decision, including measures of speed of processing, working memory, and executive cognitive function. Cumulative knowledge and experiential skills are well maintained into advanced age (Murman, 2015). Current literature on executive functions suggests that brain compensatory mechanisms may counter cognitive deterioration due to aging, at least up to certain task load levels. It is generally accepted that in pilots experience can counter cognitive decline up to a certain level. This is supported by the findings of Kay et al. (1994) that showed that recent flight time determined the risk of an accident: the greater the recent flying experience, the fewer the number of accidents. Kay et al. (1994) found that air transport pilots with over 700 hour flight time in the year before the study had the lowest number of accidents. The proportion of critical flight time (landings/take-offs) per flight hour is much higher for HEMS operations than for air transport operations. The findings of Kay et al. (1994) may, therefore, also apply for HEMS pilots because they are engaged in flight phases demanding optimal cognitive and skilled performance for a similar number of flight hours as transport pilots for whom it is estimated that critical flight phases represent around 30% of their total flight time. Further results of the analyses of Kay et al. indicated that the accident risk of private pilots aged 60-65 did not differ significantly from that of most other age groups. These findings in private pilots may, however, not be applicable to HEMS pilots who will most likely fly in much different operational conditions than the average US private pilot.

Cognitive abilities that are generally considered to be important for pilots are:

- perception (e.g., instrument monitoring);
- memory (e.g., recalling ATC information);
- problem solving and decision making (e.g., in case of in-flight events, malfunctions);
- psychomotor coordination (e.g., flight control).

Data on the effects of ageing on cognitive functions are obtained for the most part from studies in which the research population consisted of non-pilots. Only a limited quantity of literature is available on pilots. There are indications that the results of non-pilot studies cannot be extrapolated to pilots because pilots are a select population and are selected for the above-mentioned cognitive faculties. They are better educated, healthier and more intelligent than the average member of the public.

Moreover, pilots frequently practice the tasks they are required to perform, and older pilots have great experience of their flying tasks (Simons et al., 1996). In non-pilot populations it was found that higher age was associated with a lower level of performance on problem solving and decision-making tasks (Salthouse, 1985). However, this association with age has never been demonstrated in surveys of groups of pilots (Mohler, 1981). If age does have an effect on these faculties, any diminution is probably adequately compensated by the greater experience and better judgement of the older pilots (Mohler, 1981).

In studies with pilots, Braune & Wickens (1984) found a significant correlation between tracking accuracy and experience, but not with age. The speed of information processing declines from the age of 25 onwards (Braune et al., 1985). This process occurs at every level of information processing. Many studies showed that in tasks where both speed and accuracy are important, older subjects tended to give more attention to accuracy at the expense of response time (Tsang, 1989).

4.1 Which available tests would be useful to test cognitive abilities of pilots aged 60-65?

If the AME identifies clear symptoms of MCI or dementia, it is clear that the pilot concerned should be grounded pending an expert evaluation by a psychiatrist, clinical psychologist, or neurophysiologist. In most cases, however, it will be difficult for the AME to find evidence for operational significant cognitive decline. Therefore, cognitive or neuropsychological testing as part of the aeromedical examination might be considered. In that context the following considerations should however be taken into account:

The relationship between basic domain-independent cognitive abilities and flight performance is very complex. Functions assessed in cognitive aging studies represent basic, domain-independent, cognitive abilities that are only one factor in determining flight performance. Higher order cognitive factors, including metacognitive skills and domain-specific knowledge, may play an equal or greater role in determining flight performance (Hardy & Parasuraman, 1997). Static measures of cognitive functioning typically obtained in laboratory tests may not be representative of the more complex and dynamic cognitive processes required in real-world tasks.

Age-related differences in measures of pilot cognition are minimally predictive of primary measures of flight performance and there is generally a low predictive validity of laboratory cognitive measures to flight performance (e.g., Damos, 1996). Cognitive ability (including perceptual-motor skills) is moderately associated with job proficiency (Hunter & Hunter, 1984).

Pilot flight performance is the product of domain-independent skills (basic cognitive abilities) and, to a greater extent, domain-dependent knowledge and it is concluded that the weak correlations between these two are not caused by the fact that cognition is unrelated to flight performance, but because the standard cognitive tests are insufficient to capture the complexity and dynamism of the cognitive skills involved in flying an aircraft (Hardy & Parasuraman, 1997).
When examining age and expertise level effects in flight simulator performance, it is expected that expertise will be more likely to aid older expert pilots' performance on perceptual-motor tasks and tasks that are relatively unconstrained by time (Kennedy et al., 2010). In a flight simulator study, Taylor et al. (2007) found that more expert pilots had better flight summary scores at baseline and showed less decline over time. Regarding age, even though older pilots initially performed worse than younger pilots, over time older pilots showed less decline in flight summary scores than younger pilots. Secondary analyses revealed that the oldest pilots did well over time because their traffic avoidance performance improved more as compared to the younger pilots. Taylor et al. (2007) concluded that their findings support previous cross-sectional studies in aviation as well as non-aviation domains, which demonstrated the advantageous effect of prior experience and specialized expertise on older adults' skilled cognitive performances.

Several member states that thus far have applied for an exemption of the age limit of HEMS pilots have a requirement of an "extended psychological or neuropsychological test incl. cognitive skills and performance performed by a certified aviation psychologist" or by a psychiatrist at the "first examination after reaching the age of 60." The concrete type or content of the required "psychological test" is often not mentioned, while it is very important to define which test is required to answer AME's questions about "cognitive fitness".

4.2 Cognitive performance tests

When requiring cognitive testing for pilots who have no signs or symptoms of MCI, one should consider the following:

- Most studies of the predictive value of Cognitive Tests used subjects with MCI or dementia, which resulted in higher predictive values.
- For screening tests for asymptomatic individuals, the cut-off is set towards high sensitivity. Therefore, in a population of pilots aged 60-65, where the prevalence of significant cognitive deficiencies is considered to be low, a considerable number of the positive results are expected to be false positives.
- Cognitive decline begins from 40 years of age and its course varies greatly across individuals. Cut-off values for prediction of safe flying performance are not known and will be difficult to determine. Normative reference data are based on samples of "normal" individuals. For large-scale population research 1.5 standard deviations (SD) lower than the population mean is often used as cut-off value. However, this is not applicable for testing of individual cases: should we disqualify a pilot because his/her score is 1.5 SD lower than the mean of the general population? What about a pilot that passed the proficiency check but has a cognitive test score ≤1.5 SD of a standard population? There have been no normative values published in peer reviewed scientific literature since the retirement age for airline transport pilots was raised to 65 (Hastings, 2019).
- Results of cognitive tests may provide an indication for further evaluation but should not be relied upon for diagnosing brain disease or when making major decisions about a pilot's competency and ability to fly (Mackenzie Ross, 2017).
- Cognitive Function Tests for Pilots are tests designed to ensure pilots have the necessary cognitive skills to function as a pilot: aim is selection of the right people (select-in instead of select-out).
- Standard cognitive tests are insufficient to capture the complexity and dynamism of the cognitive skills involved in flying an aircraft (Hardy & Parasuraman, 1997).
- Age-related differences in measures of pilot cognition are minimally predictive of primary measures of flight performance and there is generally a low predictive validity of laboratory cognitive measures to flight performance (e.g., Damos, 1996).
- Cognitive function tests are useful for large-scale research of populations and for evaluating cognitive side-effects of medication.
- Many computerized tests are freely available on internet and can thus easily be trained prior to an aeromedical examination.

One of the popular computerized tests is CogScreen™ which tests memory, visual perceptual functions, sequencing and problem solving, attention, and information processing speed. The dedicated aviation version of this test (CogScreen-AE™) was recommended by an AsMA-FAA consulting panel in the mid 1980's for cognitive screening of pilots on indication. CogScreen was incorporated into an FAA "core battery" of tests along with a selection of traditional tests. Specifications for neuropsychological evaluations for potential neurocognitive impairment can be found on the FAA website (https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/dec_cons/disease_prot/neurocog/) CogScreen-AE™ is considered to be useful for selection of "the right stuff"(select-in), and can be helpful in a cognitive assessment when there is an indication of MCI. It can also be used for assessing effects of interventions, such as use of potentially sedative medication. It should, however, not be used in the standard examination of pilots who have no appropriate indication that the cognitive integrity might be affected because it is not designed for predicting an individual pilot's performance of flying tasks. It is noteworthy that the CogScreen™ Sample Report (https://cogscreen.com/sampleaeromedicalreport.pdf) mentions: 1) No decisions should be based solely on CogScreen results; material from other sources should be sought before making decisions about an individual. 2) Not all brain disorders produce cognitive deficits that will be detected by CogScreen.

Taylor et al. (2000) studied aviators performing aviation tasks in a Frasca model 141 flight simulator and the CogScreen-AE battery. The majority of the 97 participants (age range 50-69 yr.) were FAA medically certified as Airman Class III (52%), 40% were Class II, and 8% were certified as Class I. Pilots who had ever flown for major air carriers were excluded from participating. A multiple regression analysis indicated that four CogScreen variables could explain 45% of the variance in flight summary scores. Predictors were: Speed/ Working Memory scores, Visual Associative Memory, Motor Coordination, and Tracking. Pilot age was found to significantly improve prediction beyond that which could be predicted by the four cognitive variables. Cockpit monitoring performance was not found to be associated with any of the CogScreen predictors tested in the study.

When job performance is to be predicted on an individual basis, it is useful to consider the basic order of the predictors of flight performance as has been postulated by Hyland et al. (1994) and Hardy and Parasuraman (1997) who classified the predictors as: a) domain-independent cognitive and motor skills, such as those assessable with CogScreen; b) domain-dependent (aviation) knowledge; c) pilot characteristics such as age, cardiovascular status, drug dependency, agreeableness; and d) stressors, such as difficult work conditions, fatigue, and interpersonal conflicts. The predictive value of these different variables depends on the criterion of interest. In this context, a study involving airline pilots by Hoffmann et al. (1998) showed that domain-dependent knowledge predicted training success but not line-check ratings of aircraft control, while conversely CogScreen Manikin and Symbol Digit scores predicted aircraft control, but not training success. CogScreen Dual Task and Divided Attention scores predicted training and compliance with procedures but not aircraft control (Hoffmann et al. (1998). The above-mentioned prediction study of Taylor et al. (2000) found that age still accounted for a significant amount of variance beyond that predicted by CogScreen performance. This could well indicate the possibility that other age-associated pilot characteristics might predict flight performance or bear a risk for in-flight incapacitation.

4.3 Neuropsychological assessment

In contrast to a single cognitive test battery, such as CogScreen-AE™ , a state-of-the-art neuropsychological assessment includes a clinical interview, an Interview of relatives/informants (when indicated), a review of medical, school, and occupational records, an evaluation of mental health, and psychometric testing (Mackenzie Ross, 2017).

Neuropsychological assessment is a performance-based method to assess cognitive functioning. This method is used to examine the cognitive consequences of brain damage, brain disease, mild cognitive impairment, dementia, and mental illness. There are several specific uses of neuropsychological assessment, including collection of diagnostic information, differential diagnostic information, assessment of treatment response, and prediction of functional potential and functional recovery. Neuropsychological testing is also an important tool for examining the effects of toxic substances and medical conditions on brain functioning.

In summary:

- A neuropsychological assessment may be indicated by the AME who has identified possible signs and/or symptoms of mild cognitive impairment or brain dysfunction. The neuropsychological assessment is indicated to find evidence for brain dysfunction, mild cognitive decline, or dementia and covers a wide range of cognitive domains: enabling a differential diagnosis. A neuropsychological assessment has generally accepted diagnostic value in patients with symptoms or suspected history (e.g., found by AMEs).

- A study by Klekociuket al. (2014) showed that the rate of false positive MCI diagnoses, found with brief cognitive tests, can be significantly reduced through the use of sensitive and specific neuropsychological measures of memory and non-memory functions.
- Neuropsychological assessment has never been developed as a 'pass' / 'fail' instrument to screen individuals for highly skilled jobs. Meaningful interpretation of results in asymptomatic individuals is difficult due to lack of validated cut-off points that predict safe flying performance.
- Neuropsychological assessment is designed to assess brain function or dysfunction and is not designed to predict performance in the cockpit.

Validity concerns, methodology issues, sensitivity to age, inadequate input from behavioural observations, insufficient collateral information and deficient normative data are among the weaknesses that can lead to erroneous inferences and denial of medical certification that apply to cognitive testing as well as to neuropsychological testing. In addition, fatigue, test anxiety, inadequate test preparation, distraction by situational stressors and other psychological factors can contribute to unfavourable test scores and an erroneous determination of cognitive impairment (Hastings, 2019).

There is no psychological test or battery of tests that enables a decision to be taken on whether the cognitive capacities of an asymptomatic individual have diminished to such an extent that he/she should no longer be allowed to fly. It is not possible to decide solely on the basis of the score achieved in a psychological test, but the results of such a test or battery of tests can provide useful background information in the process of deciding on the medical certification of an individual who has been referred by the AME/AeMC for a specialist evaluation.

When the cognitive functioning of an individual is evaluated, it is of great importance to have information about the occupational history of that person. Data that are relevant in this connection are the functioning of the pilot in the event of incidents and accidents and during simulator sessions, proficiency checks and training courses. This can alert the AME to a deterioration of functioning. After discussion with the pilot concerned, the AME may then order detailed additional screening, which may also be in the interests of the pilot.

4.4 Testing cognitive abilities of pilots aged 60-65 to guarantee safe performance of flying tasks

Principal Concern related to Flight Safety

The principal concern about a decline of cognitive abilities by increasing age is related to the question whether or not a pilot aged 60-65 years is able to safely execute all flying tasks. The obvious solution would be to challenge the applicant to give proof that his/her functioning has a sufficiently acceptable safety risk. This is clearly an operational concern for which the AME/AeMC can only partly contribute to the solution by identifying MCI, dementia, or brain diseases. However, when the AME observes no signs or symptoms of cognitive decline, occupational history or operational checks may reveal an Operationally Significant Cognitive Impairment. When results of training, proficiency checks, line checks, or occupational and operational information give rise to suspicion or reasonable doubt about the pilot's cognitive integrity, the AME/AeMC should refer the pilot in question for a neuropsychological evaluation by a specialist.

There are currently no tests available that are suited to predict flight performance or to identify subtle impairments of cognitive functioning of ageing pilots. Cognitive testing of pilots is needed when appropriately indicated. It is indicated when a known condition affecting cognition exists (e.g., brain disease) or when questions regarding cognitive integrity arise (Hastings, 2019). It is emphasized that neurocognitive or neuropsychological tests performed as a routine measure without indication or clinical question will not provide useful results in the context of determining pilot's cognitive abilities to safely execute all flying tasks: without a question, there will be no meaningful answer! The AME/AeMC in collaboration with operational examiners should provide the indication for neuropsychological assessment by a neuropsychologist, neurologist, or psychiatrist to whom they refer a pilot with suspected neurocognitive decline.

Currently, it is considered that simulator checks, line checks, and peer review provide the best opportunities to detect below standard performance that may be caused by mental problems or neuro-cognitive impairment. This consideration, initially stated by Evans (2011), is supported by a study group including representatives of ICAO, NASA-Ames, and FAA (Potocko, 2019). It is important that the AME is informed about the results of the simulator and line checks. This information can be provided by the applicant pilot or by the operational examiner. Instructors and operational examiners should be trained to identify impaired cognitive performance and to discuss their concerns with the pilot in question in order to stimulate the pilot to self-report the problems to the AME/AeMC, or to a Peer Support Programme, or get the pilot's approval to share the concerns with the AME/AeMC, while guaranteeing strict confidentiality. To detect possible neurocognitive shortcomings, essential cognitive factors of flight performance should be incorporated in the regular mandatory License Proficiency Checks (LPC) or Operator Proficiency Checks (OPC). With accumulating experience, the cognitive effort required to perform common flight task is less and less, some of these tasks becoming almost automatic. However, for tasks that are not used in the day-to-day operations, such as emergency procedures, the cognitive effort remains high in most cases. Furthermore, by adding other stressors such as time constrains the cognitive effort is expected to be very high, in some cases close to the limit, allowing signs of mild cognitive decline that in other situation are compensated by experience and automated actions to become manifest. These characteristics of the cognitive system explain why for the pilots 60 to 65 years old involved in single pilot operations the operational environment to observe any potential signs of MCI and their relevance for flight safety. Attention should therefore be focused on abilities to function under highly stressful demands, such as high time pressure. In this context, a part of the Observable behaviours proposed for the 'pilot instructor and evaluator competency framework' detailed in ICAO Doc9868 (ICAO, 2020) are useful. The use of existing criteria for observable behaviours makes sense because these are already known for many instructors and examiners and more and more will become familiar with them.

5. Conclusions and recommendations

Mental Health including use of alcohol and drugs

There is convincing evidence that the frequency of mental health problems is lower in the 60-65 age group compared to younger age groups. Therefore, the current EASA requirements mentioned in MED.B.055, AMC1 and GM1 MED.B.055 concerning mental health assessment that apply for pilots under 60 years of age can equally be applied for those pilots between 60 and 65 years involved in single pilot HEMS operations.

There is evidence that the risks of hazardous/harmful drinking and alcohol use disorders (AUD) are not increased in the age group 60-65. Therefore, the current EASA requirements mentioned in MED.B.055, AMC1 and GM2 MED.B.055 Mental health concerning misuse of alcohol that apply for pilots under 60 years of age can equally be applied for pilots between 60 and 65 yrs. As would be applicable to all pilots, Gamma-GT assessment may provide an extra tool to identify an alarm sign for alcohol misuse.

Illicit Drug use disorders are significantly more frequent in young people (15-49 yrs.) than in people aged 60 to 65 years. Therefore, the rules concerning use of illicit drugs that apply for pilots under 60 years of age can equally be applied for pilots between 60 and 65 years.

Signs and symptoms of mental health problems including misuse of alcohol and drugs should be identified by the AME and are indications to refer the pilot for specialized further diagnosis. In AMC1 MED.B.055 Mental health, EASA provides the important points of attention for the interview of the AME.

Brain diseases or degeneration including Mild Cognitive Impairment and Early Dementia

Scientific data support the generally accepted opinion that the risk of mild cognitive impairment increases with age, although there is good evidence suggesting that declines in cognitive abilities between the end of the fourth decade and age 65 are small.

It is not recommended to use neurocognitive tests to identify MCI for the aeromedical screening of 60-65 years old pilots if there is no indication found by the AME (reasonable cause, suspicion). It is recommended that the AME should try and identify signs and symptoms which could indicate neurocognitive decline or brain diseases irrespective of the cause. In case of any suspicion or doubt the pilot should be referred for specialized diagnostic evaluation (neurologist, clinical psychologist, neuropsychological testing). Alarm signs for MCI may also emerge from occupational information and results of proficiency and line checks and should lead to specialized diagnostic evaluation.

How to test cognitive abilities of pilots aged 60-65?

There are currently no useful tests available to identify subtle impairments in cognitive functioning of asymptomatic pilots that are suited to predict flight performance. Cognitive testing of pilots is needed when it is indicated by a known condition affecting cognition, such as brain disease, or when questions regarding cognitive integrity arise. It is emphasized that neurocognitive or neuropsychological tests performed as a routine measure without indication or clinical question will not provide useful results in the context of determining pilot's cognitive abilities to safely execute all flying tasks. The AME/AeMC in collaboration with operational trainers and examiners should provide the indication for neuropsychological assessment by a neuropsychologist, neurologist, or psychiatrist.

To detect possible neurocognitive shortcomings, essential cognitive factors of flight performance should be incorporated in the regular mandatory License Proficiency Checks (LPC) or Operator Proficiency Checks (OPC). Attention should be focused on abilities to function under highly stressful demands, such as emergency procedures under time pressure. Annex III Part ORO (EASA, 2019-a) offers room to include scenarios enabling to assess pilot's performance during such highly stressful demands. For instructors and examiners, a part of the Observable behaviours proposed for the 'pilot instructor and evaluator competency framework' detailed in ICAO Doc9868 are useful.

Recommendation

To detect possible neurocognitive shortcomings, the recommended aeromedical examination should be based on the two most important pillars: 1) the AME interview (history taking) and examination, and 2) operational information: occupational history and functioning of the pilot in the event of incidents and accidents and during simulator sessions, proficiency checks and training courses.

1) AME history taking and examination (Hudson & Herbert, 2017; EASA, 2022)

The AME should try to build an trustful alliance with the applicant and take sufficient time to discuss the applicant's job: type of flying; employer details; length of service in current employment; full-time/part-time; type of contract; total flying hours; hours flown since last medical; roster pattern; number of sectors flown in a duty period; details and fairness of rosters; fatigue; job satisfaction; attitude towards job; aspirations for future career development; difficulties with operational crew resource management (CRM); any difficulties with employer and/or other colleagues and managers; is there company peer support?

Further questions should involve the applicant's role and attitude in accidents or incidents, problems in training or proficiency checks, behaviour or knowledge relevant to the safe exercise of aviation tasks relevant for their class of licence; coping strategies under periods of psychological stress or pressure in the past, including seeking advice from others; family arrangements: married, single; relationship; ages of children; child care; family life; health issues family; partner employment; holidays; hobbies; financial concerns (debts; overtime work, second job) and interpersonal and relationship issues, including difficulties with relatives, friends, and work colleagues.

This should be followed by a structured medical history taking concerning health, illness, symptoms, organ systems (functioning, complaints); sleep: quality and amount (at home and on stopovers; snoring; obstructive sleep apnoea (OSA); use of hypnotics); shift work; rest arrangements prior to duty; medication (prescribed; over-the- counter; via internet); exercise/diet: activities; diet (food during work); and drugs/alcohol/smoking habits (alcohol type/amount/binge drinking, suggested bottle to throttle time, social / party drugs, legal highs, driving license offences).

As mentioned by EASA in AMC1 MED.B.055 Mental health (EASA, 2020), the following aspects should also be taken into consideration when conducting the mental health examination: Appearance; Attitude; Behaviour; Mood; Speech; Thoughts process and content; Perception; Cognition; Insight; and Judgement.

Answers to above questions and observations can provide the AME with a complete picture of the applicant's life and functioning and may give clues to potential problems. When suspicion of cognitive dysfunction emerges, the applicant should be referred to a neuropsychological or neurological expert.

2) Operational information

Occupational history and functioning of the pilot in the event of incidents and accidents can be provided by the applicant or – with explicit consent of the pilot- by occupational physicians, peers, or head of flight department. Information of functioning during simulator sessions, proficiency checks and training courses can be provided – with explicit consent of the pilot- by instructors and examiners. Essential cognitive factors of flight performance should be incorporated in the regular mandatory checks or operator checks. Attention should be focused on abilities to function under highly stressful demands, such as high time pressure. In that context, Annex III Part ORO (EASA, 2019-a) offers room to include scenarios enabling to assess pilot's performance during such highly stressful demands.

Using a part of the Observable behaviours proposed for the 'pilot instructor and evaluator competency framework' detailed in ICAO Doc9868 (ICAO, 2020) to detect possible neurocognitive shortcomings could provide a framework that could be used by the instructor/evaluator to raise a suspicion and refer the case to the AME for more detailed neurocognitive assessment would close the loop of the two layers of measures presented above.

The information obtained using the above two pillars of examination can alert the AME to a deterioration of functioning. After discussion with the applicant in question, the AME should then refer the applicant for detailed additional neuropsychological or neurological screening.

All information gathered in the above-described procedure, will enable taking a reasonable decision in which the consequences for the applicant are weighted against the safety consequences.

Annex: The AME Interview (Hudson & Herbert, 2017)

Aim: Building up of a picture of the pilot's work and family life. Answers that give clues to potential problems should be followed by an in-depth interview. When mental problems emerge, pilots should be referred to aviation psychologist, psychiatrist, or neurologist.

The Job: type of flying; employer details; length of service in current employment; full-time/part-time; total flying hours; hours flown since last medical; roster pattern: long-, medium-, short-haul (when relevant for type of flying); number of sectors flown in a duty period; is this fair or reasonable?; results of proficiency and line checks; fatigue; job satisfaction/; attitude towards flying; aspirations for future career development; is employer sympathetic to individual's personal or work problems; company peer support?

Finance: concerns about money; debts; overtime; second job?

Commuting: distance to work; commuting time; ease of commuting; mode of travel; return journey home

Sleep: quality and amount (at home and on stopovers); jet lag (when relevant for type of flying); rest arrangements prior to duty; sleep medication? Snoring?

Medication: prescribed; over-the- counter; via internet

Drugs/alcohol/smoking habits: alcohol type/amount; suggested bottle to throttle time; social drugs; legal highs; driving license offences?

Exercise/diet: activities; diet; airline food

Hobbies: other interests, hobbies; what do you do in your spare time?

Holidays: how many times/year; where do you go?; does the family join?

Security: airport security checks; fear of terrorism, unruly pax?

Family arrangements: married, co-habiting, or single; relationship; ages of children; child care; family life; bereavement; health issues family; partner employment?

6. References

Beynon C, Stimson G, Lawson E. Illegal drug use in the age of ageing. Br J Gen Pract. 2010; 60(576):481-482.

Bor R, Eriksen C, Oakes M, Scragg P. Pilot mental health in the modern era (Chapter 1). In: R. Bor, C. Eriksen, M. Oakes, P. Scragg (Eds) Pilot Mental Health Screening and Assessment: A Practitioners Guide. Routledge - Taylor & Francis Group, Abingdon, UK. 2017.

Braune R, Wickens CD (1984). Final Technical Report EPL-83-4/NAMRL-83-1. University of Illinois, Engineering-Psychology Laboratory, Urbana-Champaign, IL.

Braune R, Wickens CD, Strayer D, Stokes AF (1985). Age-dependent changes in information processing abilities between 20 and 60 years. In: Proceedings of the Human Factors Society 29th Annual Meeting, Sept.29-Oct.3, 1985. Santa Monica, CA: Human Factors Society. p.226-30.

Cornelis MC, Wang Y, Holland T, Agarwal P, Weintraub S, Morris MC (2019) Age and cognitive decline in the UK Biobank. PLoS ONE 14 (3): e0213948. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0213948

Damos, D. L. (1996). Pilot selection batteries: Shortcomings and perspectives. The International Journal of Aviation Psychology, 6, 199-209.

Dunne RA, Aarsland D, O'Brien JT, et al. Mild Cognitive Impairment: the Manchester consensus, Age and Ageing 2021:50(1):72–80. https://doi.org/10.1093/ageing/afaa228

EASA (2019). Age Limitations Commercial Air Transport Pilots. Final Report EASA_REP_RESEA_2017_1 https://www.easa.europa.eu/sites/default/files/dfu/EASA_REP_RESEA_2017_1.pdf

EASA (2019-a). Easy Access Rules for Air Operations. Section Annex III Part ORO. https://www.srvsop.aero/site/wp-content/uploads/2020/06/7-EasyAccessRules_for_AirOperations-Oct2019-EASA.pdf (accessed 15 October 2022).

EASA (2020). Easy Access Rules for Medical Requirements. https://www.easa.europa.eu/sites/default/files/dfu/Easy_Access_Rules_for_Medical_Requirements.pdf (accessed 15 October 2022)

Evans, A. (2011). Upper age limit for pilots. Presentation held on behalf of the Aviation Medicine Section International Civil Aviation Organization, Montreal. Mexico City, April 2011. https://www.icao.int/NACC/Documents/Meetings/2011/AVMED2011/Day01-06-ICAO-Evans.pdf (accessed 30 October, 2022)

Garrett KD, Perry W, Williams B, Korinek L, Bazzo DEJ. (2021). Cognitive Screening Tools for Late Career Physicians: A Critical Review. Journal of Geriatric Psychiatry and Neurology. 2021;34(3):171-180. doi:10.1177/0891988720924712

Hammen C. (2005). Stress and Depression (Review). Annu. Rev. Clin. Psychol. 2005. 1:293–319

Hardy, D.J., & Parasuraman, R. (1997). Cognition and flight performance in older pilots. Journal of Experimental Psychology: Applied, 3, 313-48.

Hastings J. (2019). Flying, Thinking and Innocence Neurocognitive Fitness to Fly. https://www.lpba.org/Uploads/ConventionsEvents/wINTER2019/190309%20-%20945am%20-%20John%20Hastings%20Handout.pdf (accessed 31 October, 2022)

Hendriks S, Peetoom K, Bakker C, et al. Global Prevalence of Young-Onset Dementia: A Systematic Review and Meta-analysis. JAMA Neurol. 2021;78(9):1080–1090. doi:10.1001/jamaneurol.2021.2161

Hoffmann CC, Hoffmann KP, Kay GG. The role that cognitive ability plays in CRM. Paper presented at NATO Symposium, Human Factors & Medicine panel on Collaborative Crew Performance in Complex Operational Systems, Edinburgh, Scotland. April 1998.

Hyland DT, Kay EJ, Deimler JD. Age 60 study, Part IV: Experimental evaluation of pilot performance. Washington, DC: Office of Aviation Medicine 1994; DOT/FAA/AM-94/23.

Hudson M, Herbert K. The practicalities of fitting mental health screening into the time-limited annual medical check and the problems of confidentiality (Chapter 12). In: R. Bor, C. Eriksen, M. Oakes, P. Scragg (Eds) Pilot Mental Health Screening and Assessment: A Practitioners Guide. Routledge - Taylor & Francis Group, Abingdon, UK. 2017.

Hunter, J. E., & Hunter, R. F. (1984). Validity and utility of alternate predictors of job performance. Psychological Bulletin, 96, 72-98.

ICAO (2020). Doc 9868 Procedures for Air Navigation Services – Training. Third Edition, 2020. International Civil Aviation Organization, Montréal, Canada H3C 5H7 (p. 74 cont).

Jones, D.R. (1992). Mental health aspects of the aging flyer. Paper presented at the Annual Scientific Meeting of the Aerospace Medical Association, Miami Beach, FL. Abstract in Aviation, Space, and Environmental Medicine, Vol. 63, p. 427, 1992.

Kay, E.J., Hillman, D.J., Hyland, D.T., Voros, R.S., Harris, R.M., & Deimler, J.D. (1994). Age 60 rule research, Part III: Consolidated data base experiments final report. (Tech. Rep. No. DOT/FAA/AM-92-22). Washington, DC: Federal Aviation Administration, Office of Aviation Medicine.

Kennedy Q, Taylor J. L, Reade G, Yesavage J. A. (2010). Age and expertise effects in aviation decision making and flight control in a flight simulator. Aviation, Space, and Environmental Medicine 81: 489–497.

Klekociuk S, Summers J, Vickers J, Summers M. (2014). Reducing false positive diagnoses in mild cognitive impairment: The importance of comprehensive neuropsychological assessment. European Journal of Neurology. 21. 1330-1336. 10.1111/ene.12488.

Lawrence MW, Arias JJ. (2019). Alzheimer's disease biomarkers: another tool for FAA pilot screening? Journal of Law and the Biosciences, 2019, 85–110. doi:10.1093/jlb/lsz011

Mackenzie Ross S.(2017). Assessing cognitive function in airline pilots (Chapter 7). In: R. Bor, C. Eriksen, M. Oakes, P. Scragg (Eds) Pilot Mental Health Screening and Assessment: A Practitioners Guide. Routledge - Taylor & Francis Group, Abingdon, UK. 2017.

Mitchell AJ. (2009). A meta-analysis of the accuracy of the mini-mental state examination in the detection of dementia and mild cognitive impairment. J Psychiatr Res. 2009; 43(4):411-31. doi: 10.1016/j.jpsychires.2008.04.014.

Mohler SR (1981). Reasons for eliminating the 'Age 60' regulation for airline pilots. Aviat Space Environ Med, 52:445-54.

Müller A, Prohn MJ, Huster KM, Nowak D, Angerer P, Herbig B. (2014). Pilots ’ age and incidents in helicopter emergency medical services: a 5-year observational study. Aviat Space Environ Med 2014; 85:522 – 8 .

Murman DL. The Impact of Age on Cognition. Semin Hear. 2015 Aug; 36(3): 111–121.

Nasreddine ZS, Phillips NA, Bédirian V, et al.(2005). "The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment". J Am Geriatr Soc. 53 (4): 695–9.

Petersen RC, Negash S. (2008). Mild cognitive impairment: an overview. CNS Spectr. 2008 Jan;13(1):45-53. doi: 10.1017/s1092852900016151

Potocko J. (2019). Comparing Methods to Evaluate Cognitive Deficits in Commercial Airline Pilots. Presentation held in the ICAO panel session at the AsMA Annual Scientific Meeting 2019. https://www.icao.int/safety/aviation-medicine/Documents/Potocko%20ICAO%20AsMA%202019%20Public.pdf (accessed 30 October, 2022).

Rios Tejada F. (2018). Mental Health: AESA Approach. Presentation held at the ECAM Conference 21-09-2018, Prague. https://www.esam.aero/images/docs/3-FRT.pdf (accessed 2 September, 2022)

Sabe L, Jason L, Juejati M, Leiguarda R, Starkstein S. (1993). Sensitivity and specificity of the Mini-Mental State Exam in the diagnosis of dementia. Behav Neurol. 1993;6(4):207-10. doi: 10.3233/BEN-1993-6405.

Sachdev PS, Lipnicki DM, Kochan NA, Crawford JD, Thalamuthu A, Andrews G, et al. (2015). The Prevalence of Mild Cognitive Impairment in Diverse Geographical and Ethnocultural Regions: The COSMIC Collaboration. PLoS ONE 10(11): e0142388. doi:10.1371/journal.pone.0142388

Salthouse TA (1985). A theory of cognitive aging. Amsterdam: North-Holland/Elsevier Science Pub.

Scowcroft E . Suicide statistics report 2017: Including data for 2013-2015. 2017. https://www.samaritans.org/sites/default/files/kcfinder/files/Suicide_statistics_report_2017_Final.pdf (Accessed 2 September 2022).

Simons M, Valk PJL, Krol JR, Holewijn M (1996). Consequences of raising the maximum age limit for airline pilots. Proceedings of the Third ICAO Global Flight Safety and Human Factors Symposium (Human Factors Digest No. 13). No. CIRC 266-AN/158, p. 248-55.

Strikwerda-Brown C, Hobbs DA, Gonneaud J, St-Onge F, Binette AP, et al. (2022). Association of Elevated Amyloid and Tau Positron Emission Tomography Signal With Near-Term Development of Alzheimer Disease Symptoms in Older Adults Without Cognitive Impairment. JAMA Neurol. 2022 Jul 30. doi: 10.1001/jamaneurol.2022.2379. Epub ahead of print.

Taylor, J. L., O'Hara, R., Mumenthaler, M. S., & Yesavage, J. A. (2000). Relationship of CogScreen-AE to flight simulator performance and pilot age. Aviation, Space, and Environmental Medicine, 71(4),373-380.

Taylor JL, Kennedy Q, Noda A, Yesavage JA. (2007). Pilot age and expertise predict flight simulator performance: a 3-year longitudinal study. Neurology. 2007;68(9):648-654. doi:10.1212/01.wnl.0000255943.10045.c0

Townley RA, Graff-Radford J, Mantyh WG, Botha H, Polsinelli AJ, et al. (2020). Progressive dysexecutive syndrome due to Alzheimer's disease: a description of 55 cases and comparison to other phenotypes. Brain Commun. 2020;2(1):fcaa068. doi: 10.1093/braincomms/fcaa068. Epub 2020 May 27.

Tsang PS (1989). A reappraisal of aging and pilot performance. In R.S. Jensen (Ed): Proceedings of the 5th International Symposium on Aviation Psychology. Columbus: University of Ohio Press. p. 521-6.

European Union Aviation Safety Agency

European Union Aviation Safety Agency

Konrad-Adenauer-Ufer 3
50668 Cologne
Germany

Tel.	+49 221 89990- 000
Mail	research@easa.europa.eu
Web	www.easa.europa.eu

An Agency of the European Union