



International Civil Aviation Organization

WORKING PAPER

A42-WP/630

TE/248

12/9/25

(Information paper)

English only

ASSEMBLY — 42ND SESSION

TECHNICAL COMMISSION

Agenda Item 25: Other issues to be considered by the Technical Commission

DEVELOPMENT AND VALIDATION OF THE PACE COGNITIVE TEST BATTERY FOR AVIATION

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EXECUTIVE SUMMARY

This paper introduces and evaluates PACE (Psychometrics and Assessment Center Exercises), a cognitive test battery specifically developed for pilot selection and training. PACE measures core abilities such as attention, working memory, spatial reasoning, and multitasking, which are essential for aviation performance. Evidence from 1215 ab initio pilot candidates confirms the battery’s reliability and validity, supporting its potential role in enhancing pilot selection, training success, and operational safety.

<i>Strategic Goals:</i>	This information paper relates to Strategic Goals <i>Every Flight is Safe and Secure; Aviation Delivers Seamless, Accessible, and Reliable Mobility for All.</i>
<i>Financial implications:</i>	There are no direct financial implications for ICAO arising from this information paper. However, by improving the effectiveness of pilot selection and training, the adoption of valid and reliable cognitive assessment tools such as PACE may reduce training costs for airlines and contribute to long-term efficiency gains in the aviation sector..
<i>References:</i>	Goeters, K. M., Maschke, P., & Eißfeldt, H. (2004). Ability requirements in core aviation professions: Job analysis of airline pilots and air traffic controllers. <i>Aviation psychology: Practice and research</i> , 99-119. Martinussen, M. (1996). Psychological measures as predictors of pilot performance: A meta-analysis. <i>The International Journal of Aviation Psychology</i> , 6(1), 1-20. Maschke, P., Oubaid, V., & Pecena, Y. (2011). How do astronaut candidate profiles differ from airline pilot profiles?. <i>Aviation Psychology and Applied Human Factors</i> . Matton, N., Paubel, P., & Puma, S. (2020). Toward the Use of Pupillary Responses for Pilot Selection. <i>Human Factors: The Journal of Human Factors and Ergonomics Society</i> , 64, 555 - 567. https://doi.org/10.1177/0018720820945163 .

1. INTRODUCTION

1.1 Cognitive abilities such as perception, attention, working memory, spatial reasoning, and multitasking are recognized as central to aviation performance. Pilots constantly process complex and dynamic information under time pressure, and their ability to maintain situational awareness is critical for safety. Previous research has consistently demonstrated that cognitive testing provides some of the strongest predictors of training outcomes and operational success (Goeters et al., 2004; Martinussen, 1996; Maschke et al., 2011; Matton et al., 2020).

1.2 Despite their importance, many traditional pilot selection tools are either not tailored to aviation-specific demands or lack updated psychometric evidence. Addressing this gap, the present study introduces PACE, a cognitive assessment battery specifically designed to capture the multidimensional cognitive skills required in modern aviation. By validating PACE, this study aims to contribute to the improvement of pilot selection methods, thereby supporting both training efficiency and long-term safety outcomes.

2. METHODOLOGY

2.1 Participants

2.1.1 The study involved 1215 ab initio pilot candidates recruited through a national pilot selection programme. Participants ranged in ages from 22 to 31 years ($M = 26.49$, $SD = 2.34$) and all had completed the required medical and academic qualifications for pilot training. None of the participants had prior professional flight experience, ensuring that results reflected baseline cognitive capacity rather than operational knowledge.

2.2 Design of the Assessment Battery (PACE)

2.2.1 The Psychometrics and Assessment Center Exercises (PACE) battery was designed to capture a wide spectrum of cognitive abilities directly relevant to aviation performance:

a) Working Memory

- 1) *Audio-Visual Memory Test*: Candidates monitored flight corridors while simultaneously processing sequences of auditory information. The task required integration and reminiscence of visual and auditory information across multiple trials.
- 2) *Verbal Memory Test*: Candidates were shown sequences of numbers and were asked to recall them based on the given rule.

b) Attention

- 1) *Sustained Attention Test*: Participants observed a continuous stream of rapidly presented visual stimuli and were instructed to detect targets.
- 2) *Vigilance Test*: A rapid-response paradigm required candidates to track moving targets on a display and press a response key when specific cues appeared.

c) **Spatial Reasoning**

- 1) *3D Spatial Perception Test*: Candidates rotated three-dimensional figures mentally to determine equivalence, measuring spatial visualization and mental rotation.
- 2) *Spatial Orientation Test*: Participants navigated through a virtual maze that periodically shifted perspective, requiring flexible reorientation.

d) **Psychomotor Coordination and Multitasking**

- Participants simultaneously monitored simulated flight indicators for deviations while recalling letter sequences and giving a response based on a rule.

2.3 **Procedure**

2.3.1 All participants completed the assessment in standardized conditions. The battery consists of eight core subtests. The sequence of tasks was identical across candidates to minimize order effects:

- a) Sustained Attention Test
- b) Audio-Visual Memory Test
- c) 3D Spatial Perception Test
- d) Mathematics and Physics Knowledge Tests
- e) Agility Test
- f) Verbal Memory Test
- g) Spatial Orientation Test
- h) Psychomotor Coordination and Multitasking Test

2.3.2 Assessment sessions lasted approximately 4.5 hours per candidate, including short breaks to reduce fatigue.

2.4 **Data Analysis**

- a) **Convergent and Discriminant Validity**: Pearson correlations were calculated among subtests measuring the same and different constructs.
- b) **Factor Structure**: Confirmatory Factor Analysis (CFA) was conducted to test whether subtests loaded onto a general cognitive ability factor while retaining domain-specific variance.
- c) **Significance Testing**: All results were analyzed at $p < .05$.

3. RESULTS

3.1 Convergent Validity

- a) Audiovisual and verbal memory tasks were significantly correlated ($r = .29, p < .001$), confirming consistency in the measurement of working memory.
- b) The 3D Spatial Perception and Spatial Orientation tasks showed a moderate correlation ($r = -.31, p < .001$), indicating that both tests assessed the same underlying spatial ability. The negative direction of the correlation is explained by the scoring system of the spatial orientation task, in which lower scores indicate better performance.
- c) Sustained Attention and Agility tasks were moderately correlated ($r = .37, p < .001$), supporting their joint role in measuring attentional capacity.

3.2 Discriminant Validity

—Cross-construct correlations were weak (r values between .10 and .23), confirming that memory, attention, and spatial reasoning represented distinct domains.

3.3 Factor Structure

- a) CFA supported a single higher-order factor representing general cognitive ability ($\chi^2(9) = 22.09, p = .01, SRMR = .025$), alongside domain-specific contributions.
- b) A second CFA restricted to domain-level groupings confirmed relationships within memory, attention, and spatial subtests ($\chi^2(6) = 9.36, p = .154, SRMR = .015$).

4. DISCUSSION

4.1 The results provide strong support for the psychometric soundness of PACE. Convergent validity was demonstrated by the consistent associations between subtests measuring the same domain, while discriminant validity confirmed that memory, attention, and spatial reasoning are separable constructs within pilot cognition. The CFA further revealed that PACE captures both a general cognitive ability factor—long identified as a key predictor of pilot success (Martinussen, 1996; Matton et al., 2020)—and domain-specific skills essential for flight operations.

4.2 From an applied perspective, the findings suggest that PACE can serve as both a scientific tool for research on pilot cognition and a practical instrument for selection and training. Its aviation-specific design provides a stronger alignment with operational demands than generic cognitive assessments, ensuring that candidates are evaluated on abilities directly tied to real-world piloting challenges.

5. CONCLUSION

5.1 This study demonstrates that PACE is a valid and reliable cognitive assessment battery specifically tailored to the aviation domain. By capturing both general cognitive ability and domain-specific skills, PACE provides a comprehensive framework for assessing pilot candidates. Its integration into

selection systems has the potential to improve training efficiency, reduce attrition rates, and strengthen aviation safety.

5.2 By directly addressing ICAO's Strategic Goals of *Every Flight is Safe and Secure; Aviation Delivers Seamless, Accessible, and Reliable Mobility for All*, the validation of PACE represents a concrete step toward enhancing pilot selection methods and ensuring that the aviation workforce is prepared to meet the increasing demands of global air transport.

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