COMMERCIAL PILOT EDUCATION: ALIGNING EASA 100 KSA WITH CDIO STANDARDS

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ABSTRACT

This paper examines the alignment of the European Aviation Safety Agency (EASA) 100 Knowledge, Skills, and Attitude (KSA) framework with the Conceive-Design-Implement-Operate (CDIO) standards and syllabus. The EASA 100 KSA introduces a competency-based approach to pilot training that emphasises both technical skills and those traditionally classified as “non-technical", such as critical thinking, decision making, situational awareness and crew resource management. However, in line with the CDIO standards, these competences should not be considered as separate components, but as interconnected skills that emerge from the technical context and operational practice. In pilot education, it is essential to combine technical expertise with the ability to communicate effectively and make informed decisions, and to promote synergies between the different competency areas to ensure holistic development of future aviation professionals. Building on this integrated approach, the EASA 100 KSA framework represents a significant shift from traditional flight hour-centered training to a holistic methodology that meets the modern needs of the aviation industry. The study finds substantial alignment between the EASA framework and CDIO principles, particularly in fostering skills such as teamwork, problem-solving, and hands-on learning. The innovative aspect of this work lies in bridging aviation and engineering education frameworks, showing the adaptability of CDIO principles in enhancing pilot training standards. This research contributes to the evolution of aviation education, emphasizing a balanced approach to competency development that equips professionals for the complexities of modern aviation.

KEYWORDS

Commercial pilot education, Aviation education, EASA 100 KSA Framework, CDIO Syllabus, Standards 2, 3, 7.

INTRODUCTION

The aviation industry faces the challenge of adequately preparing pilots for the increasingly complex demands of modern flight operations. Traditional pilot training, which relies heavily on flight hours and memorization, often fails to develop comprehensive skills that are essential for safety and efficiency. This paper examines the European Aviation Safety Agency's (EASA) 100 Knowledge, Skills and Attitudes (KSA) framework and compares it to the Conceive-Design-Implement-Operate (CDIO) standards used in engineering education. The aim is to address the gap in aviation training by exploring methods that incorporate both technical and non-technical skills into pilot education.

The EASA 100 KSA (Annex II to ED Decision 2018-001-R.pdf) is a framework as an innovative model for competency-based aviation training. In contrast to traditional methods, it emphasises a holistic approach covering four areas: Aeronautical Knowledge, Practical Skills, Airmanship, and Human Factors. The validity of the framework is supported by its rigorous, evidence-based structure and its implementation of both formative and summative assessments. The results show an improvement in the holistic preparation of commercial pilots that is consistent with global safety standards and technological advances. Compared to previous methods, this model enhances both technical proficiency and non-technical competences. However, limitations include challenges in implementation due to resource constraints and the risk of overemphasizing broad competencies at the expense of technical expertise. Addressing these issues may require adjustments in curriculum design and resource allocation. Comparison with the CDIO standards shows the similarities in emphasizing the integration of theoretical knowledge with practical application, teamwork and critical thinking. The research highlights potential areas where aviation education can be aligned with engineering education methods to improve pilot readiness.

This research underscores the need for an interdisciplinary, competency-based approach to pilot education. The alignment between EASA 100 KSA and CDIO framework provides opportunities for mutual reinforcement to improve both aviation and engineering education. Future research could focus on refining competency profiles, evaluating the long-term impact of such training on operational safety and exploring cross-industry applications. The findings argue in favor of continuously adapting curricula to meet evolving technological and operational demands in aviation. By aligning with CDIO standards, this approach promises to improve both safety and efficiency in aviation and pave the way for future innovation in professional training methods.

EASA 100 KSA FRAMEWORK

Valdés et al (2017) emphasize that the European aeronautics industry, a major economic driver, is projected to double in economic output and employment by 2030, necessitating a significant investment in high-quality vocational education and training to address the growing demand for skilled professionals. In this context, education, certification, and experience are crucial in developing the knowledge, skills, and abilities required to meet the evolving needs of the industry. They are interconnected, build on each other and contribute to an individual's overall competence and expertise. Education provides the basic knowledge and theoretical understanding necessary for the development of KSAs. It serves as a foundation for future learning and skills development. Formal education programmes provide structured learning experiences that introduce key concepts, principles and frameworks relevant to a specific field. Watkins et al (2016) mention that education forms the foundation on which experience is built. Experience, especially practical experience, plays a crucial role in enabling individuals to apply their knowledge and develop specific skills. It provides opportunities to learn by doing, to solve real-world problems and develop abilities, emphasizing the importance of experience in building the foundation laid by education. Ford and Schmidt (2000) also emphasize the significance of experience in developing expertise, particularly in critical areas such as emergency response. Certification validates an individual's KSAs and provides external verification of their competence. It signifies that an individual has met specific standards and has the necessary knowledge and skills for a particular role or profession. Baird & Brooks, (1988) explain that certification implies competence and is often based on a combination of formal training and experience. Watkins et al (2016) state that certificate holders in their study rated their KSAs higher than non-certificate holders. In some professions, certification may be a requirement for employment or career advancement. The development of comprehensive competences that go beyond technical knowledge and skills plays a decisive role. These include emotional, social and cognitive intelligence competencies that are essential for success in the modern, dynamic workplace. (Bonesso et al., 2020) (Sari et al., 2021)

According to Glassman et al (2015), the three most important factors aviation managers consider when hiring new team members are education, certification and experience. They found that education is considered essential for new hires and upward mobility, especially in management roles. Certification is critical for specific career fields in aviation, such as aircraft operations, maintenance or servicing aircraft. Finally, experience, particularly with a military background, is highly valued, especially when dealing with in-flight emergencies. Employee certification and training are key factors that influence an employee's knowledge, skills and abilities. Recruiters tend to look for candidates with a mix of these characteristics when making hiring decisions. It is important to recognize that these KSAs are not only important for individual productivity, but also for effective teamwork.

Building on this, the EASA 100 KSAs framework used for the training and assessment of commercial pilots is closely aligned with these hiring priorities. It is divided into four main categories - Aeronautical Knowledge, Practical Skill, Airmanship, and Human Factors — and provides a structured approach to developing a wide range of competences including technical proficiency, decision-making, situational awareness and crew resource management.

To gain a better insight into these competences in the context of the 100 KSAs, it is important to examine the development of training principles in aviation over the generations. In the field of aviation training, Kearns (2016) examines how training methods have evolved over three different generations. These generations illustrate the transition from traditional, manual training approaches to more sophisticated, technology-driven methods, with each phase requiring a unique set of KSAs:

- First Generation: Apprenticeship - This era focused on basic flight training through direct supervision by experienced pilots. Training consisted of classroom instruction and in-flight training, with an emphasis on mastering specific maneuvers and performance standards. The training model allowed for hands-on learning and the transfer of knowledge and skills from experienced pilots to aspiring aviators. This corresponds to the Aeronautical Knowledge and Practical Skill components of the EASA 100 KSA concept.
- Second generation: Simulation - The invention of the Link Trainer in 1929 marked the beginning of flight simulation. This enabled weather-independent training and expanded the scope of training to include instrument and system operations. While simulation became a key component, the training model of classroom instruction and in-flight training remained. The focus remained on achieving performance standards, with the added benefit of improving technical proficiency through simulation-based

exercises. The Practical Skill aspect of 100 KSA is further developed through the use of simulations.

- Third generation: Safety - This generation arose from concerns about human error in aviation accidents. Crew Resource Management (CRM) training emerged, emphasizing the effective use of all available resources for safe and efficient flight operations. This shift brought a new focus on non-technical skills such as communication, teamwork and decision-making alongside traditional flight training. The emphasis on CRM aimed to enhance the overall safety and efficiency of flight operations by utilizing the collective expertise and collaboration of the flight crew. This is in line with the *Airmanship and Human Factors* components of the 100 KSA concept.

This holistic approach goes beyond technical proficiency and emphasises the importance of critical thinking, decision-making, situational awareness and crew resource management. By defining these specific KSAs, EASA has provided a robust and evidence-based foundation for ensuring that commercial pilots possess the necessary capabilities to handle the complex and dynamic challenges of modern aviation.

In this sense, the implementation of the 100 KSA framework marks a shift in the industry's approach to pilot training and assessment, moving away from a narrow, quantitative focus towards a more qualitative assessment of pilot competence. This has the potential to increase flight safety and overall operational efficiency. As such, it is a valuable contribution to ongoing efforts to improve the quality and effectiveness of commercial pilot education.

EASA's technical review of the theoretical knowledge syllabi, learning objectives, and examination procedures for air transport pilot licence, multi-crew pilot licence, commercial pilot licence and instrument ratings (RPRO, 2016) propose several important requirements for pilot training and knowledge. The learning objectives are updated to reflect modern cockpit practises and industry needs, and to enhance pilots' core competences and decision-making abilities. New learning objectives are introduced under 100 KSA, to be assessed by Approved Training Organisations (ATO) rather than through formal examinations. The document also recommends a process to regularly review and update these learning objectives to keep pace with evolving safety threats, technological advances and operational practices. The changes proposed will impact on pilot training in several ways, with a focus on updating the learning objectives to better align with the current needs of the aviation industry.

CDIO STANDARDS AND ALIGNMENT WITH EASA 100 KSA

The CDIO initiative is a global framework for engineering education that provides a comprehensive framework for the development of students' professional competences. While the CDIO standards are primarily focused on the broader field of engineering, they also provide valuable insights and principles that can be applied to the context of commercial pilot education. The CDIO standards emphasize a holistic approach to education that encompasses the entire lifecycle of a product or system - Conceiving, Designing, Implementing, and Operating. This aligns closely with the EASA 100 KSA concept, which focuses on developing a comprehensive set of knowledge, skills and attitudes required for safe and effective pilot operations.

A key area of alignment is the CDIO standard for personal and professional skills, which includes competencies such as critical thinking, problem solving and teamwork. These skills are also emphasised within the EASA 100 KSA, particularly in the Airmanship and Human Factors categories. (Du & Zhu, 2022)

The CDIO's emphasis on hands-on, active learning and the integration of theoretical and practical knowledge aligns with EASA's focus on the development of practical skills and the application of aeronautical knowledge.

This synergy between the two approaches provides valuable insights for improving the effectiveness of commercial pilot education. The alignment between the CDIO and EASA frameworks suggests that the adoption of a similar holistic, competency-based approach could significantly enhance the effectiveness of commercial pilot training programmes. By incorporating the development of both technical and non-technical skills, such as communication, decision making and resource management, aspiring pilots would be better equipped to meet the complex and dynamic challenges of the modern aviation industry.

As valuable as the opportunities for greater integration and mutual reinforcement of these two frameworks are, there are also potential drawbacks to consider. The holistic approach emphasized by the CDIO framework aligns well with EASA's focus on comprehensive pilot competencies. However, there is a risk that overly broad training could weaken the essential technical skills required for safe flight operations, even though the CDIO's emphasis on personal and professional skills such as communication and teamwork remains critical for pilots navigating the complex aviation environment. It is crucial to maintain a balance between developing these non-technical competencies and ensuring that pilots possess a deep understanding of aircraft systems, aerodynamics and other core technical knowledge. Finding the right balance between theoretical instruction and practical application will be an important consideration. Ultimately, while the CDIO framework provides a valuable reference point, the specific design and implementation of commercial pilot education programmes must be carefully tailored to the unique needs and constraints of the aviation industry. A nuanced approach that preserves essential technical expertise while meaningfully incorporating non-technical competencies may be the most effective path forward.

However, it is crucial to strike a balance between the holistic competency development advocated by the CDIO framework and the need to maintain the technical expertise required for safe flight operations. The integration of theoretical and practical learning advocated by the CDIO standards may also present challenges in the time and resource constrained environment of commercial pilot training. (Brink et al., 2020)

The US Naval Academy's approach to the CDIO curriculum, described in (Crawley et al., 2014), focuses on providing a framework for practical, hands-on engineering education. The Department of Aerospace Engineering took this approach to go beyond theoretical "paper designs" and train graduates capable of operating complex systems, which is the operational focus of the Navy and Marine Corps. They wanted to create a programme where midshipmen could conceive, design, implement and operate complex aerospace systems in a team-based environment. This approach was also driven by a desire to meet ABET accreditation standards and benefit from the experience of other universities that were implementing CDIO.

Table 1 illustrates the alignment between the EASA 100 KSA framework, which defines the essential Knowledge, Skills, and Attitudes for commercial pilot training, and the CDIO standards and syllabus. Both frameworks emphasize holistic, competency-based learning that integrates technical and non-technical skills.

Table 1. Alignment of EASA 100 KSA Framework with CDIO Standards

EASA 100 KSA Category	Description	Aligned CDIO Standards	Explanation of Alignment	Aligned CDIO Syllabus	Explanation of Alignment
Aeronautical Knowledge	Foundational knowledge such as flight theory, regulations, and systems.	**2 (Learning Outcomes)**, **3 (Integrated Curriculum)**	CDIO ensures detailed learning outcomes and integrated courses that build foundational knowledge crucial for aeronautical expertise.	**1.2 (Core Engineering Fundamental Knowledge); 1.3 (Advanced Engineering Fundamental Knowledge, Methods and Tools)**	The CDIO Syllabus emphasizes disciplinary knowledge, forming the theoretical foundation of pilot education.
Practical Skill	Technical mastery, simulator exercises, and real-world flight performance.	**6 (Engineering Workspaces)**	Simulator-based training and in-flight exercises correspond to CDIO's emphasis on hands-on, iterative design and implement phases.	**2.2 (Experimentation, Investigation and Knowledge Discovery); 2.3 (System Thinking)**	Hands-on training and iterative flight exercises align with CDIO's focus on practical application and systems thinking.
Airmanship	Leadership, teamwork, and operational responsibility in aviation.	**7 (Integrated Learning Experiences)**, **8 (Active Learning)**	Integrated learning enhances decision-making and teamwork through CRM principles; active learning fosters real-world scenario engagement.	**3.1 (Working in teams), 3.2 (Communication)**	CDIO highlights the role of teamwork and communication in professional practice, essential in crew resource management (CRM).
Human Factors	Skills such as communication, decision-making, and situational awareness.	**1 (Context)**, **9 (Enhancement of Faculty Competence)**, **10 (Teaching Competence)**	Human factors align with CDIO's focus on real-world system operations and faculty development in teaching interpersonal and situational awareness skills.	**2.4.4 (Creative Thinking), 2.4.5 (Critical Thinking)**	Critical thinking and situational awareness are integral to safe flight operations, as emphasized in CDIO.
Continuous Improvement	Regular updates to pilot training to reflect industry advancements.	**11 (Learning Assessment)**, **12 (Program Evaluation)**	Both frameworks emphasize iterative assessment and evolution of training programs to adapt to new challenges and improve effectiveness.	**2.4.7 (Learning Agility, Lifelong Learning and Educating)**	Both frameworks stress iterative learning and adaptation to technological and operational changes.
Holistic Competency Development	Emphasis on integrating technical and other skills for comprehensive pilot training.	**2 (Learning Outcomes)**, **3 (Integrated Curriculum)**, **7 (Integrated Learning Experiences)**	The holistic integration of theoretical, practical, and interpersonal skills aligns with CDIO's multidimensional learning outcomes and structured interdisciplinary approach.	**3.1 (Working in teams); 3.2 (Communication), 4.1 (External, Societal and Environmental Context)**	CDIO emphasizes the integration of technical and other skills, essential for comprehensive pilot training.

Each row highlights how specific EASA KSA categories relate to one or more CDIO standards. This alignment shows synergies in areas such as foundational knowledge, practical skills development, teamwork and continuous improvement. By integrating CDIO principles into aviation training, pilot education programs can benefit from structured, practical and interdisciplinary approaches that improve both technical proficiency and operational safety. In the education of commercial pilots, which clearly requires an engineering foundation, the CDIO Syllabus emphasises the importance of preparing students for professional practice rather than serving as a rigorous process model. While there are structured phases in pilot training, the CDIO framework emphasises the need for an integrated approach that develops both technical and professional competencies in real-world contexts. Understanding flight principles and regulations, planning flights and procedures, executing flight maneuvers and managing aircraft systems are not just sequential steps, but interconnected aspects of a pilot's professional role. Commercial pilot training often emphasises scenario-based training and simulator work to allow students to develop their operational skills in a controlled environment. Also, the emphasis on teamwork in the CDIO curriculum aligns with the principles of Crew Resource Management (CRM) in commercial aviation, as highlighted in (Du & Zhu, 2022). CRM training, which improves communication, coordination and decision-making within a cockpit crew, is an example of how professional skills are deeply embedded in the technical and operational aspects of aviation.

ADVANCING PILOT EDUCATION AND ALIGNING WITH CDIO STANDARDS AT THE UNIVERSITY OF ZAGREB

The Department of Aeronautics at the University of Zagreb (Faculty of Transport and Traffic Sciences), Croatia, has incorporated the EASA 100 KSA framework into its curriculum, aligning its teaching approaches with evolving competency standards in the aviation industry. Key competencies that are developed include communication, leadership and teamwork, problem solving and decision making, situational awareness, workload management, application of knowledge, threats and error management, and mental math skills that are critical for flight safety. To achieve these goals, the Department applies a structured, evidence-based approach to education and evaluation. This includes continuous assessment of both technical and non-technical skills using a 5-point grading system and multiple assessments. Student pilots undergo at least three mandatory assessments during their flight training, which are integrated into the study programme. The first, a formative assessment, identifies learning gaps and encourages improvement through targeted feedback and reflection. Summative assessments, conducted in the middle of the flight training and at the end of the theoretical lessons, evaluate competence levels against predefined indicators and ensure that they are prepared for professional requirements. The use of structured debriefing and feedback loops supports the continuous improvement and self-awareness in student pilots. To further improve practical skills, mental maths tests and assessments are conducted, focusing on flight-critical calculations where students must achieve a minimum accuracy of 75 per cent. The study programme spans three years (six semesters), with three mandatory assessments conducted two months to ensure continuous progress and competence development. This comprehensive integration of the EASA 100 KSA framework is in line with the CDIO concept and ensures that graduates of the University of Zagreb's Department of Aeronautics are equipped with the necessary competences to be competitive in the dynamic and demanding aviation industry. The self-assessment of the study programme shows a high level of alignment with CDIO standards but also indicates areas for improvement. In particular, the programme is highly aligned with the standards in learning outcomes, integrated curriculum and integrated learning experiences. The programme is designed in accordance with the regulations and standards of the European Aviation Safety Agency, which are listed in CDIO Standard 2, among others. The implementation of the learning outcomes is prescribed in detail and is regularly reviewed to fulfil the legal requirements. All national standards are applied in accordance with the Croatian and European qualification frameworks. Within the disciplinary courses there is an explicit link between the content and the learning outcomes. Students are expected to achieve a comprehensive set of learning outcomes that are consistent with the objectives of the programme. Compliance with the European Aviation Safety Agency regulations and the Croatian and European Qualifications Framework can be cited as evidence of well-defined learning outcomes. Furthermore, the programme emphasises the link between disciplinary courses and learning outcomes, as well as the use of certified laboratories where students work individually with instructors. However, the self-assessment also shows lower scores for other standards. For Standard 6, the programme uses certified labs but admits that there is a lack of formal assessment of these spaces. Similarly, for Standard 7, although the programme claims a high level of integration in learning experiences, it notes a lack of regular evaluation and revision of courses in this aspect. The self-assessment of Standard 4 reflects a lack of learning flexibility as the focus is on the design and implementation of processes within basic design and implementation projects as part of the planned activities of the relevant aviation authorities. Explicit planning for professional skills development could also be improved according to Standard 3. Finally, for Standard 1, the programme refers to an early stage of application, suggesting that full implementation of CDIO principles is still a work in progress.

CONCLUSION

This paper examines the European Aviation Safety Agency (EASA) 100 Knowledge, Skills, and Attitude (KSA) framework and its alignment with the Conceive-Design-Implement-Operate (CDIO) standards. The EASA 100 KSA introduces a competency-based approach to commercial pilot education, emphasizing technical and non-technical competencies, including critical thinking, decision-making, situational awareness, and crew resource management. This framework represents a significant shift from traditional flight-hour-centric training to a holistic methodology addressing the modern demands of the aviation industry. The study finds substantial alignment between the EASA framework and CDIO principles, particularly in fostering skills such as teamwork, problem-solving, and hands-on learning. The innovative aspect of this work lies in bridging aviation and engineering education frameworks, showing the adaptability of CDIO principles in enhancing pilot training standards. This cross-disciplinary perspective underscores the broader applicability of competency-based approaches across industries. The validity of the EASA 100 KSA framework is supported by its rigorous, evidence-based structure and its implementation of both formative and summative assessments. Analyses conducted at the University of Zagreb's Department of Aeronautics over the past five years demonstrate an improvement in the holistic preparedness of pilots, aligning with global safety standards and technological advancements. Compared to prior methods, this model enhances both technical proficiency and non-technical competencies (BAA Training, 2021). However, limitations include challenges in implementation due to resource constraints and the risk of overemphasizing broad competencies at the expense of technical expertise. Addressing these issues may require adjustments in curriculum design and resource allocation. Future work should focus on fine-tuning the integration of technical and non-technical skills in training programs, investigating long-term impacts on safety and operational efficiency, and exploring adaptations for other high-stakes professions. This research contributes to the evolution of aviation education, emphasizing a balanced approach to competency development that equips professionals for the complexities of modern aviation.

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