

The Skywards series

Elevating Airline Excellence

Published earlier:



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This book is dedicated to Generations Z and A,
the new and upcoming generations of airline pilots.

They are not the same as the earlier generations.

Because we can train them much better than ever before.

Skywards: The Next Airline Pilot Ed.1.00 (2025)



Paperback ISBN 9789083594224

Cover design by Plan A

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“You can never train
for every situation.
But with the right
training, you can
handle any
situation.”

Captain Chesley “Sully” Sullenberger
(paraphrased from post-Hudson interviews)



The best way to
survive the
unexpected is to
have trained for
the unthinkable.

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Foreword

Airline pilot training is at a turning point. Traditional approaches, designed to prepare crews by rehearsing a catalogue of possible scenarios, can no longer keep pace with the demands of modern aviation. Today's environment is defined by highly automated aircraft, increasingly complex airspace, multinational crews, and an unyielding expectation of flawless safety. It is no longer possible to script every response. Pilots must be trained to adapt, to make sound decisions, and to lead effectively when faced with challenges that no one has anticipated.

Competency-Based Training and Assessment (CBTA) has become the foundation of modern pilot development. Supported by ICAO, IATA, EASA, the FAA, and regulatory authorities worldwide, CBTA and its operational counterpart, Evidence-Based Training (EBT), shift the focus from task repetition to the cultivation of core competencies. Other than excellence in flying the aircraft which remains the most basic competency in all circumstances, these also include problem-solving, decision-making, communication, and resilience—qualities that enable flight crews to operate safely under pressure, in both routine and extraordinary circumstances.

This book provides a comprehensive and practical guide to this new training philosophy. It explains how CBTA can be embedded at every stage of pilot development—from ab-initio training to command upgrade, from instructor preparation to examiner standardization. It addresses the importance of resilience, the use of operational data to inform course design, and the alignment of training practices with global regulatory standards. Complex concepts such as Transfer of Training (TOT), Training Efficiency Ratio (TER), and the management of “black swan” events are presented in clear, practical terms, making them accessible to training organizations of any scale.

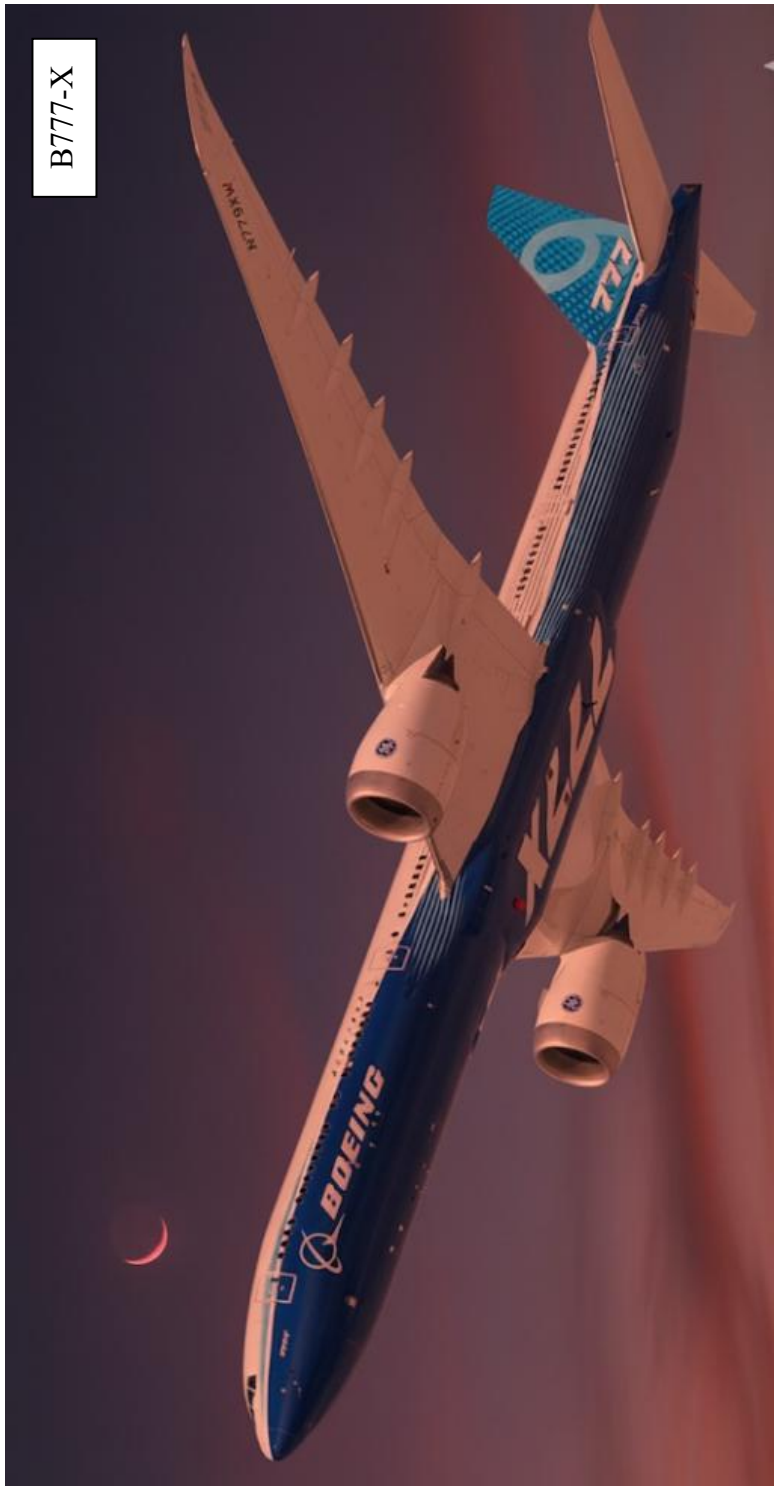
The significance of this approach cannot be overstated. Accident history demonstrates that major events rarely occur because a checklist was forgotten; they occur when situational awareness,

leadership, or decision-making breaks down under stress. By focusing on competence rather than rote compliance, CBTA provides the tools to close this gap. It equips pilots not only to fly the aircraft, but to manage the unexpected, to coordinate their crew, and to make critical decisions when time is short and consequences are severe.

The material contained in these pages is valuable to a wide audience. Trainee pilots will find clarity on why training is structured as it is, and how each exercise contributes to core competencies. Instructors will gain guidance on how to observe, assess, and develop performance beyond simple task execution. Airline managers and regulators will see how CBTA can be integrated into organizational structures, and how operational data can be used to drive evidence-based improvements. Even those outside aviation will gain insight into how one of the world's most complex industries prepares its professionals for the unknown.

Above all, this book is a call to action. Aviation safety cannot rely on tradition or technology alone. It depends on disciplined, forward-looking training that develops competent, resilient, and adaptable pilots. Implementing such training requires leadership, innovation, and the willingness to challenge outdated methods. *The Next Airline Pilot – Competency at the Core* offers a definitive roadmap for meeting this challenge and for shaping the future of airline training worldwide.

B777-X



Introduction

Congratulations on your purchase of *Skywards – The Next Airline Pilot*.

This reference book guides you inside the world of airline pilot training—how to prepare someone to safely fly and command a large commercial jet, even in the most overwhelming, complex, or unthinkable situations. The kind of moments no training can fully recreate, yet every passenger trusts the pilot to handle safely.

For decades, airline training tried to cover “every possible scenario.” When the unimaginable knocked on the door, airlines relied on statistics and hope that these things would never happen. But hope is no strategy.

This book shows what really works. It reveals how modern training develops pilots who can adapt, improvise, and succeed when everything is on the line. You’ll discover the critical factors that drive safety, efficiency, and resilience—not just in aviation, but in any high-stakes profession.

Whether you are a trainee, pilot, instructor, examiner, airline manager, regulator, or simply an aviation enthusiast, the insights here will sharpen your perspective and deepen your understanding. Other industries—from medicine to nuclear energy, from the military to emergency response, can benefit from these principles as well.

The Next Airline Pilot is more than a book about flying—it’s a blueprint for mastering unknown situations.

We start with an example of what happens when things go wrong to connect accidents to pilot training. We review how resilience and competence saved the biggest airliner ever build, an Airbus A380, from falling out of the sky when a disintegrating engine ripped through its wing. We embark on a journey to understand how the airline industry is moving towards a system that trains pilots for resilience and competencies.

Chapter one is dedicated to the vision of airline pilot training, what we are trying to achieve and why. Chapter two delves into the history of pilot training to understand where we are coming from and what lessons we have learned so far.

We provide insights into the pillars of pilot training and what can be improved: the instructors, training methods and training aids. The instructor is the beating heart of the training program, so we start with them. We will explore training methods, define the optimum method, explore new grounds and later dive into more details of Initial Operational Experience (IOE) and Command Upgrade training.

When impressed by all those beautiful training aids, we will discuss current and upcoming legislation, talk a lot about simulators, virtual reality and put those things in a didactic perspective. Taking a well proven and rational approach we use TOT (Transfer of training) and TER (training efficiency ratio) to rate new training aids.

We explore how data is an important part of the training system. We discuss how training procedures are managed and published. You'll also learn the "boring stuff" about training records and training efficiency, and how these factors impact training culture, safety, and excellence.

We will review the instructor and management staff selection and training and explain why this is so important. Ranging from ground instructors to training managers.

We'll discuss airline and trainer aircraft safety. We'll review the latest developments in enhancing airline safety, and the regulator's role. We close with a chapter on sustainability. We review why we need to train pilots on sustainability, what their mission is; how important that is and what the sustainability issues are. We will focus on commercial jet sustainability and on trainer aircraft.

This book is not your standard book that you read from cover to cover. It is to be used as a reference; **you should focus on what is of most interest to you**. It may be smart to read the first chapter about the training vision and grasp the competency-based training and assessment (CBTA) concepts. Reading the whole book from start to

Introduction

finish will give you all the insights but will take a sizeable amount of your time. Skip the things you already know and spend more time on new subjects.

To optimize your time:

- The first chapter explains the dynamics of a training environment and shows why CBTA is different from other concepts. Skip it if you are familiar with CBTA.
- The other chapters can be read without the need to follow a specific order. Pick what you like.
- Knowledgeable professionals can **skip all the boxes and anecdotes** for faster assimilation. If you know the accidents and the conclusions discussed in the book, skip these. I included these for reference only to make my point.

Imagine for instance, a training organization looking to buy a learning management system or a new trainer aircraft. They look up the chapter in this book and refine their requirements. They can focus on the capabilities they are looking for. Because what is described here, **is not marketing yuck speak, but the result of years of experience researching and interacting with these training aids**. An HR person may want to read about pilot selection; they can look at that chapter.

A new instrument instructor on a light aircraft may want to learn about how to teach *attitude flying* and why it is important. He can learn how and why in the chapters about instructors and training methods.

A trainee may want to understand **why it is hard to become an airline pilot** and why (s)he must perform exercises repeatedly. (S)he might also want to understand better how instructors and examiners look at his/her generation. You'll find it in the chapters about ab initio training..

With this knowledge, you'll be equipped to improve, innovate, and implement changes to make training of an airline pilot safer, more

efficient and sustainable—and you will find insights applicable far beyond airline pilot training.

The book is formatted to make it easier and faster to read as follows:

PRIMER

Basic knowledge, well known to aviation professionals, is between these double lines. I included it as a refresher for those in need and for readers that are not familiar with the subject.

Stories, incidents, examples, and anecdotes are indented in the text like here. You might be familiar with the incidents and skip these. The stories are illustrative of the subject but may be of less academic value. All are real stories, but unless it is public knowledge, names, dates and other details are not included or are altered to protect individuals, flight schools and airlines.

Information

Information boxes cover other interesting subjects related to airline training. These boxes provide interesting background information and can be read independent of the rest.

Chapter 1: The Vision

The Bigger Picture

Traditional pilot training, established in response to safety issues operating older-generation aircraft, is recognized as insufficient to prepare the next generation of pilots.

The traditional approach emphasizes maneuver-based practice and adherence to prescriptive regulatory requirements. This method does not develop the competencies required to manage unforeseen events.

The global aviation community is shifting slowly towards competency-based training. This approach emphasizes the development of pilot competencies—combinations of **knowledge, skills, and attitudes**—required for safe operation. These programs use evidence gathered from real-world operations to identify training needs. The goal is to move beyond rote memorization and maneuver executions towards developing pilots' resilience and ability to manage unexpected situations.

Many aviation accidents result from human error. As explained in *Skywards: Managing Flight Operations* (Berger, 2025), this does not mean that pilots are the weak link in the safety system. In fact, a well-trained pilot is the **most reliable safety measure in aviation**, preventing countless incidents every day (NASA, 2023).

Is training an airline pilot still a priority? Some argue that with advancements in programming, artificial intelligence, and specialized electronic agents, the role of the pilot will change dramatically and will disappear. Somewhere in the future, I can imagine that that will be the case.

But the question is when it will be possible to design, certify, and mass-produce commercial aircraft that can safely transport hundreds of passengers across long distances without a human pilot? These designs will need to operate with limited supporting infrastructure, over high terrain, in extreme weather, with disruptions in ground- and

space-based systems, failed communications, cyber threats, and other technical failures.

No one knows the answer, *but it will not happen tomorrow*. Considering the challenges involved and the time needed to solve the problems without unnecessary loss of life, **the timeline is measured in decades and longer**. Just recently, the initiative to fly commercial jets with just one pilot in the cockpit during cruise has been rolled back for years to come. And that concept is still far away from flying commercial aircraft without pilots.

IT companies point to AI as the all-in-one solution, but it is not. Present AI models struggle to have accuracy levels above 70% for tasks that are vital in aviation. To put it in perspective: if you fly **every single day of your life**, it will take you, on average, **over 20,000 years** before being involved in a fatal accident. If you are flying using (the current generation of) AI for critical systems, you will probably die every single day.

Training new airline pilots is still essential, now and during the coming decades. I would take the decision to become an airline pilot again today in the blink of an eye.

Engineering efforts, including artificial intelligence, are directed toward making commercial aviation more sustainable rather than removing **the most effective safety device** from the cockpit. A well-trained crew will remain the most successful safety device in aviation for many years to come.

However, our industry needs to move away from the lip service it pays to using competencies and data. Airlines will tell you they use Evidence Based Training and Competencies (EBT and CBTA). And some do that in an excellent way. However, that is not the norm, but the exception. Many do not see the urge to change.

When you look at what most airline pilot training schools (not all of them) dare to produce as “licensed pilots”, this is not how we should train the next generation of pilots at all. So read on.

This book is about how to train a human being in the flight deck to be the best safety guarantee in commercial aviation, today and tomorrow. With competence, resilience and ready to tackle real world challenges.

Things did go Wrong

On April 4, 1994, KLM Cityhopper Flight 433, a Saab 340B aircraft, took off from Amsterdam's Schiphol Airport on a routine flight to Cardiff, Wales (Netherlands Aviation Safety Board, 1995).

At approximately 2:30 PM, while climbing through 16,500 feet, the pilots of Flight 433 received a master caution warning, indicating a potential mechanical failure. The warning light pointed to a problem with the right engine's oil pressure. While this action is not in the procedure, the pilot in command immediately reacted by reducing the power on the right engine to idle, a precautionary measure to prevent potential engine damage. This action was premature, as the oil pressure gauge indicated a normal reading, suggesting that the warning might be false¹.



Figure 1: Saab SF340B Central Warning Panel indications

¹ An Exercise in Self-Deception: The crash of KLM Cityhopper flight 433 - Admiral Cloudberg, <https://admiralcloudberg.medium.com/an-exercise-in-self-deception-the-crash-of-klm-cityhopper-flight-433-8187cdaab106>

Despite this indication, the pilots continued to be concerned about the warning light. They consulted the emergency checklist, which stated that if the oil pressure gauge showed a normal reading, they could continue normal operation. However, the pilots failed to comprehend that the oil pressure in the right engine was a bit lower due to the reduced power setting, completely normal for this type of engine. The reduced (but normal) oil pressure observation, coupled with the persistent warning light, fueled their apprehension about the engine's abnormal condition.



Figure 2: Saab SF340B engine indications

Instead of restoring the right engine to its normal power setting, as he should have done, the captain became fixated on the perceived engine problem. This misinterpretation, driven by confirmation bias, led him to return to Amsterdam.

The pilots contacted air traffic control and declared a PAN-PAN call, indicating an urgency but not an emergency. They then proceeded to turn the aircraft around and initiate the descent back to Schiphol. During the descent, the pilots discussed how the idle engine would affect the landing. They mistakenly believed that leaving the engine at idle would be less problematic than shutting it down completely. An idle engine however

creates more drag than a shut-down engine, because of the propeller position creating more drag in “idle” than in “feather”, which is the position of the propeller when the engine is shut down. An idling engine makes the aircraft more challenging to control, especially during an aborted landing.

As the aircraft approached the runway, the pilots encountered further difficulties. With the right engine at idle, the plane experienced an asymmetric power condition, causing it to yaw to the right. The autopilot, which had been compensating for this yaw, was disengaged. While the pilots initially managed to stabilize the approach, the situation was aggravated by an 8-knot tailwind. At a height of 45 feet, the captain decided to abort the landing and go-around.

During the go-around, the pilots continued to struggle with the asymmetric thrust. They applied full power to the left engine while leaving the right engine at idle, further exacerbating the yaw. Instead of using the rudder to counteract the yaw, they relied solely on the ailerons, which served to keep the wings level but did not address the imbalance in yaw.

The aircraft rolled violently to the right, pitched up, and stalled. Despite their attempts to recover at this low altitude, the plane crashed into a field just short of the runway. Three of the 24 people on board were killed, including the captain, whose death was attributed to not wearing his shoulder restraints, and nine others were seriously injured.



Figure 3: Cityhopper 433 lifted by a crane after the accident (BAAA 1994)

Probable causes (Netherlands Aviation Safety Board, 1995) were attributed as: inadequate use of the flight controls during an asymmetric go around resulting in loss of control. Insufficient understanding of the flight crew of the SAAB 340B engine oil system. Lack of awareness of the consequences of an aircraft configuration with one engine in flight idle. Poor Crew Resource Management.

The crash of KLM Cityhopper Flight 433 highlights failures in manual flying skills, situational awareness and decision-making. The pilots, while proficient in well-defined tasks, failed to grasp the bigger picture to make sound judgments. Pilots' performance was compromised by:

- **Manual flying skills:** the accident investigators saw this as the primary cause of the accident. Inadequate use of rudder during the go around on one engine caused a severe problem with the stability of the aircraft.
- **Situational Awareness:** The captain's attention was fixated on the initial oil pressure warning, even though other indicators suggested it might be false.

- **Applied knowledge:** The pilots misinterpreted the aircraft's reduced climb performance as an engine malfunction, failing to recognize it as a direct consequence of their own action of reducing engine power.
- **Applied knowledge:** The pilots did not fully comprehend the implications of flying with one engine at idle, leading them to make incorrect assumptions about its effect on the approach and go around.
- **Manual flying skills:** The captain's training records revealed that he had failed twice the engine-out checks. This suggests a potential weakness in his ability to handle such situations and raises questions about the adequacy of his training.² In a task-based training and assessment system, it suffices to do the same exercise again successfully to pass a check ride.
- **Leadership and Teamwork:** The first officer was relatively inexperienced compared to the captain, having fewer flight hours overall and on the Saab 340. This difference in experience may have made him less likely to challenge the captain's decisions.

The series “Air Crash Investigation” dedicated an episode to this accident, Season 19, episode 3 (Air Crash Investigation, 2019).

The crash of KLM Cityhopper Flight 433 underscores the importance of pilot competency and how it is assessed or not. The pilots, despite their individual capabilities, failed to grasp the gravity of the situation and made sound judgments.

² KLM Cityhopper Flight 433 - Wikipedia,
https://en.wikipedia.org/wiki/KLM_Cityhopper_Flight_433

This, and other accidents, should not be blamed on the individuals involved. I have worked with many aviation professionals. These are typically good, integer, highly motivated and professional people doing their utmost to save the day. We need to ask ourselves: what can we do, as an industry, to prevent this from happening?

We know now that we **need to train pilot core competencies**, not only tasks. A competency is a combination of **knowledge, skill, and attitude**. Training and assessing only pre-defined tasks and using this to determine if someone fits all criteria is the wrong way to train an airline pilot.

Because in our world, **the sum of all tasks does not constitute a competence**. Task-based assessments allow shortcomings in competencies to pass. This is what we learned, not only from this accident, but regrettably, from a score of accidents. This has far-reaching consequences that not yet everyone in the industry, including flight schools and regulators, fully grasp.

Saving an Airbus A380

On November 4, 2010, Qantas Flight QF32, an Airbus A380 commanded by Captain Richard Champion de Crespigny, took off from Singapore Changi Airport at 9:56 a.m. local time (ATSB, 2013). Onboard were 440 passengers and 29 crew members, including five pilots: Captain de Crespigny, First Officer Matt Hicks, Second Officer Mark Johnson, Check Captain Harry Wubben, and Senior Check Captain David Evans. This highly experienced flight crew had a combined 140 years in aviation and 71,000 flight hours.

As the Airbus A380 climbed smoothly, passengers settled in for the long journey. However, just four minutes after take-off, at 7,000 feet above Batam Island, two loud bangs shook the aircraft. The number two engine, located on the left side near the fuselage, had suffered a catastrophic uncontained failure. Debris from the

disintegrating engine was ejected with force, some pieces even striking buildings on the island below.

The engine failure triggered a series of critical malfunctions. Shrapnel from the explosion tore through the left wing, puncturing holes and damaging the fuel system. Fuel began leaking, and a fire ignited in one of the fuel tanks, though the resulting depressurization quickly extinguished it.

The damage extended beyond the wing. One of the hydraulic systems failed, along with the anti-lock braking system. The outer left aileron lost control, and the landing flaps were compromised. Inside the cockpit, alarms blared as the ECAM screens flooded with failure messages. Out of 22 major aircraft systems, 21 were affected. The only system that remained fully functional was the oxygen supply—not of much use at this low altitude.

Amid the chaos, Captain de Crespigny and his crew worked to stabilize the aircraft. They soon realized the auto-thrust system was inoperative, requiring manual control of speed and engine thrust. The full extent of the damage was unclear; the cockpit showed a multitude of alarms adding to the complexity of their situation.

Passengers peered out of their windows at the unfolding disaster. They saw large holes in the wing, fuel streaming out, and debris trailing behind. Some even watched as the Qantas kangaroo logo, ripped from the inner engine cowling, tumbled toward the ground.

With the aircraft somewhat stable, the crew faced a crucial choice—land immediately or enter a holding pattern to assess the damage. Knowing they needed time to understand the situation and prepare for landing, Captain de Crespigny chose to hold.

For nearly two hours, QF32 circled near Singapore Changi Airport. The crew methodically worked through

approximately 80 system alerts, identifying and addressing failures while configuring the aircraft for landing.

While the pilots managed the technical crisis, the cabin crew ensured order in the cabin. Michael von Reth, the cabin services manager, had witnessed the engine explosion from his jump seat, describing it as "marbles rattling on corrugated iron." Recognizing the severity, he immediately shifted from routine service mode to emergency response.



Figure 4: Left wing of QF32 A380 during the emergency flight

Initial communication with the cockpit was difficult due to system failures, but once established, the cabin crew played a vital role. They relayed crucial observations, such as the visible fuel leak, and reassured passengers with calm announcements.

Bringing a damaged A380 to the ground was a formidable task. The aircraft was 60 tons over its maximum landing weight. Its compromised systems meant reduced braking ability, non-functional spoilers, and an inoperative left engine thrust reverser. Despite these obstacles, Captain de Crespigny executed a controlled landing.

However, the crisis was not over. After touchdown, the number one engine refused to shut down. Fuel continued leaking near the hot brakes, creating a serious fire hazard.

With passengers still on board, the crew faced another decision—evacuate immediately or keep them inside. The leaking fuel and overheated brakes posed a major risk, but an evacuation with damaged escape slides could also be dangerous. The crew opted to keep everyone inside until emergency teams secured the situation.

After an hour, once the fire risk was contained, passengers disembarked. All 469 people onboard walked away unharmed.

The incident had major industry repercussions. Rolls-Royce, the engine manufacturer, saw its stock value drop 5.5%, the sharpest decline in 18 months. Qantas grounded its entire A380 fleet. The Australian Transport Safety Bureau (ATSB) launched a thorough investigation.

The ATSB determined that a fatigue crack in a stub oil pipe within the engine was the root cause. The defect, a result of improper manufacturing, led to an oil leak, which ignited and caused the intermediate-pressure turbine disc to shatter.

Following the findings, Rolls-Royce issued a safety bulletin, updating inspection criteria for Trent 900 engines. Forty-five engines were inspected, and several were removed from service.



Figure 5: The failed Rolls-Royce Trent 900 engine of QF32

Repairing the severely damaged A380, VH-OQA, took 535 days and cost over AU\$130 million, making it one of the most expensive aircraft repairs in history.

Beyond the technical challenges, the psychological impact on the crew was profound. Captain de Crespigny later described experiencing moments of deep emotion, including intrusive thoughts and unexpected bouts of weeping. The incident highlighted the immense mental pressure pilots face even when they successfully averted disaster.

The event attracted widespread media attention, leading to documentaries and expert analyses. The Four Corners documentary "*QF32*" provided an in-depth account, while "*Air Crash Investigation S13E10 – Qantas 32: Titanic In The Sky*" featured an episode on the flight. These productions offered valuable insights into the remarkable efforts of the crew and the resilience of the passengers.

The training, experience and coordination of the five pilots were instrumental in managing the emergency. Captain de Crespigny's

competent leadership and methodical problem-solving played a vital role in the successful outcome.

Qantas Flight 32 remains a testament to human skill, safety advancements, and the ability to overcome extreme adversity. It is a powerful reminder that even in dire circumstances, knowledge, teamwork, and composure can prevent catastrophe. Qantas, obviously, is one of the early adopters of competency-based training via EBT and CBTA (and uses US-style AQP).

These are pilot core competencies that we must train airline pilots for.

Getting it Right

A modern airline pilot training program develops pilots with manual flying skills, knowledge, and decision-making abilities to operate in a complex aviation environment. The training vision is built on competency-based training and assessment (CBTA), which ensures that pilots train, achieve and demonstrate specific competencies.

This moves beyond task-based training by focusing on observable behaviors and measurable performance rather than the ability to execute pre-defined tasks combined with having a certain number of flight hours (experience).

Competency-based training integrates into all stages of pilot development, from selection and ab initio training to advanced, command, instructor and examiner training.

The pilot selection process identifies candidates who possess strong ability for manual flying, problem-solving skills, situational

awareness, and effective communication, amongst other core competencies.

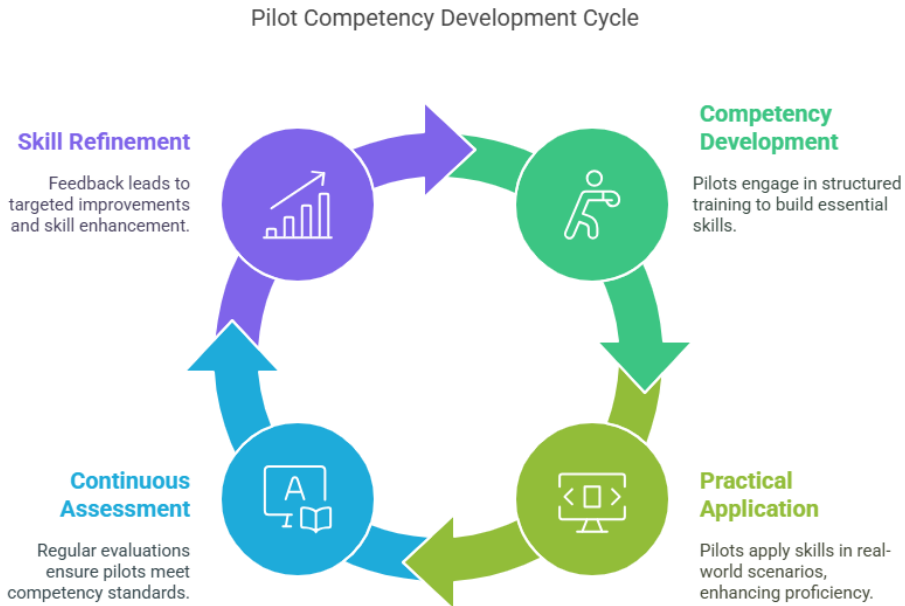


Figure 6: Pilot competency development cycle

Ab initio training builds core flying (manual) skills while already looking at it from a broader perspective of decision-making, workload management, and risk assessment. As pilots progress, training scenarios become more complex, incorporating multi-crew operations, high-stress environments, and emergency situations, including overwhelmingly difficult scenarios, such as those on QF32, that require all competencies to master (during so-called “black swan events”).

Assessments are structured to evaluate pilots based on observable behaviors and performance criteria linked to operational demands.

Basic flying competences remain the fundamental core of pilot training, but a trainee also needs a deeper understanding of how an airline operates and what his position as a pilot will be in the

company. Airline pilot training must include the trainees to be exposed to different airline departments--beyond flight operations.

Learning about cabin crew responsibilities helps pilots understand teamwork in managing passengers, handling emergencies, and ensuring a smooth flight experience. Understanding maintenance enhances pilots via better defect reporting.

Ground operations cover turnaround processes, fueling, and baggage handling, all of which affect flight efficiency. Crew scheduling manages fatigue and dispatch manages flight planning, fuel load calculations, and route optimization, influencing pilot decisions daily. Compliance, safety, and security departments enforce regulatory requirements, and pilots must align with these standards.

The commercial department plays a key role in airline profitability, and pilots need to appreciate how their decisions impact operations, customer satisfaction, and brand reputation. Airlines serve a global customer base, requiring pilots to adopt an inclusive approach to different languages and cultures.

Airline ticket prices are not linked to travel distance or costs to operate the flight. Airline ticket prices are governed by yield management systems, which have become the core of the airline revenue stream. Dynamic pricing, using artificial intelligence, decide the ticket price. But even with advanced yield management, airlines may not make much money operating but may use concepts such as loyalty programs that can outweigh their stock market value. Understanding how the money flows in an airline is important to create a partnership between airline management and its pilots.

Air Traffic Control (ATC) ensures safe and efficient air traffic flow. Controllers provide clearances, instructions, and advisories to pilots. Pilots must develop precise communication skills to interact effectively with ATC, adhering to standard phraseology and protocols. Training includes listening to live ATC communications, practicing in simulators, and managing high-traffic airspace situations. Pilots learn to anticipate ATC instructions, build a mental

picture of the traffic in their vicinity and adapt to changing conditions such as weather deviations. Messaging systems, such as CPDLC (Controller pilot data link communications), change these interactions, while pilots need to learn how to communicate clearly to ATC centers all over the world.

Simulation and virtual reality play a critical role. These tools create a controlled environment where pilots can practice complex scenarios, ensuring exposure to all operational conditions. Simulators allow for training in extreme weather such as crosswinds, or landing in snow, while handling system failures, and executing approaches down to minimum weather conditions or worse. By using simulation, pilots experience high-risk situations in a safe setting, developing decision-making skills without real-world consequences. Repetitive practice in simulators builds confidence and competency, ensuring pilots can handle diverse operational challenges. **Most emergencies are out of reach in real flight training.** Creating overwhelmingly difficult scenarios is out of question for a real aircraft. But these scenarios are an important cornerstone of competency-based training, making sure pilots are resilient.

The training environment in a flight school differs significantly from traditional education or corporate training. Flight training involves theoretical learning, simulator sessions, and real flight experience, all governed by strict regulatory standards. Unlike task-based training programs, competence progression is determined by demonstrated observable behaviors rather than tasks to be executed by set timelines.

Flight schools manage logistics, aircraft, maintenance, instructor training, scheduling, and compliance with regulatory requirements. Students adapt to a rigorous learning environment where performance and competency is continuously assessed. Unlike other industries, **aviation training must prioritize safety over business metrics.**

By implementing competency-based training, a modern pilot training program ensures that pilots are well-prepared for commercial jets.

PILOT CORE COMPETENCIES

The pilots of QF32 were well trained. Any inadequacies in their training, if these even existed, were compensated for by their experience. Having extra pilots at hand to solve the complex scenario helped a lot. A pilot must develop a set of competencies that ensure safe and efficient operations. These competencies integrate technical, procedural, and human factors skills.

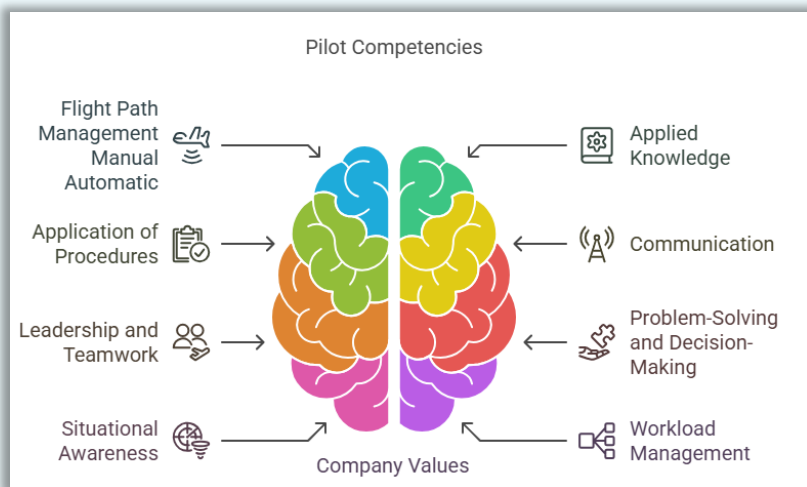


Figure 7: Pilot core competencies

Flight path management through manual control is the basis of any pilot technique and requires direct manipulation of aircraft controls without automation. **Its importance cannot be overstated.** In the current generation of commercial jets (including the most advanced jets such as the B787 and A350) pilots still use fly-by-wire, control surfaces, thrust levers, and other manual inputs to adjust the aircraft's flight path.

Manual flying skills involve smooth handling, methodical and rapid scanning of instruments, precise altitude, speed and heading changes, and appropriate control inputs. Conditions vary in function of the diverse levels of flight control compensations and safety guards in a modern commercial jet (fly-by-wire flight control laws). Pilots practice manual flight in simulators and

actual aircraft, especially during take-off, approach, landing and emergency scenarios.

They learn to manage unexpected conditions, such as system or instrument failures, while maintaining manual control and situational awareness.

Aircraft flight path management with auto flight systems involves monitoring and controlling the aircraft through automated systems. Pilots engage and manage the autopilot, flight management system, and other automated controls to ensure accurate flight. They must verify system inputs, cross-check its performance, and recognize any discrepancies. Effective use of automation reduces workload, but pilots must remain actively engaged, anticipating system behaviour and intervening when necessary. Training includes practicing system failures, automation reversion, and manual control transitions. Those transitions require special attention during the airline pilot training program.

Automation management ensures pilots use automated systems correctly while maintaining manual flying proficiency. Pilots monitor automation behaviour, recognize system limitations, and intervene when necessary. Training covers automation engagement, disengagement, and transition strategies to prevent over-reliance on automated systems.

Applied knowledge is about understanding and applying regulations, physics, airport environment, terrain, weather, performance data, aerodynamics, understanding and managing aircraft systems for normal and non-normal operations. Pilots must know how to operate engines, hydraulics, electrics, avionics, and environmental controls. They monitor weather, alternate airports, and system parameters, identify malfunctions, and apply appropriate checklists. Training covers normal operation, troubleshooting, and emergency responses, such as engine failures, hydraulic loss, or electrical malfunctions.

Application of procedures ensures compliance with operational guidelines, checklists, and standard operating procedures. Pilots follow structured workflows for pre-flight preparation, taxi, take-off, cruise, descent, and landing. This competency includes

executing emergency procedures accurately under pressure. Training reinforces procedural discipline, requiring pilots to practice checklist usage, callouts, and structured responses in high-stress situations. Consistency in procedure execution reduces errors and enhances coordination between crew members.

Communication is critical for coordination within the cockpit and with external entities. Pilots exchange information using standard phraseology with air traffic control, dispatch, and ground personnel. Clear, concise, and timely communication prevents misunderstandings. In the cockpit, pilots use standard callouts, briefings, and confirmations to ensure shared situational awareness. Training focuses on effective message delivery, listening skills, and handling high-pressure conversations, particularly during abnormal or emergency situations.

Leadership and teamwork enable pilots to work effectively with other crew members. The Commander provides guidance, makes decisions, and ensures operational priorities are met. The first officer supports decision-making and monitors the operation. Effective leadership requires assertiveness, decision-making, and the ability to adapt to evolving situations. Teamwork involves cooperation, mutual support, and clear role division. Training scenarios emphasize crew resource management, leadership and support under stress, and role adaptation in dynamic conditions.

Problem-solving and decision-making require analyzing situations, considering options, and selecting the most effective course of action. Pilots must assess risks, weigh operational constraints, and implement timely solutions. This competency applies to weather deviations, system failures, fuel management, and passenger-related issues. Training includes scenario-based exercises that challenge pilots to make critical decisions, evaluate outcomes, and learn from experience.

Threat and error management involves identifying, mitigating, and recovering from operational threats. Pilots analyze potential risks, implement countermeasures, and recognize human errors before they escalate. This competency reduces the likelihood of incidents and ensures resilience in complex environments.

Training emphasizes error recognition, real-time risk assessment, and structured response techniques.

Situational awareness involves understanding the aircraft's position, condition, and external environment. Pilots must continuously process information from instruments, communications, and surroundings. This competency prevents controlled flight into terrain, airspace violations, and operational misjudgments. Training focuses on maintaining an accurate mental model, anticipating future conditions, and detecting subtle changes that may indicate emerging risks.

Workload management ensures pilots prioritize tasks effectively. In high-workload situations, pilots must allocate attention efficiently, delegate responsibilities, and prevent task saturation. This competency is crucial during approach, landing, and emergency handling. Training includes task prioritization exercises, stress management techniques, and structured cockpit workflows to ensure efficiency under demanding conditions.

Company values ensure that the trainee understands and underwrites the airline company values. It provides valuable insights on how the company with its different departments and people works together to accomplish the common goal. Having an understanding how non-pilots contribute to the common goals in the company fosters communication, understanding and teamwork. This also includes how and when to wear the uniform, how to represent the company and address clients.

These competencies form the foundation of pilot training, ensuring readiness for real-world operations. Each competency is reinforced through practice, assessment, and continuous improvement. By focusing on these skills, pilots develop the ability to manage normal and non-normal situations, work effectively with crew members, and maintain safe and efficient flight operations.

EVIDENCE BASED TRAINING

Evidence-Based Training (EBT) is a modern approach to pilot recurrent training in an airline that focuses on developing pilot

core competencies through real-world scenarios, data-driven decision-making, and adaptive learning. Traditional training methods often relied on prescriptive training exercises and regulatory checklists, ensuring pilots met specific task-based criteria.

However, aviation accidents and safety data analysis revealed that these training programs were not adequately preparing pilots for unpredictable, real-world operational challenges. EBT was introduced to address this gap by shifting from a compliance-based approach to a competency-based, risk-focused training model.

EBT is built on data collection and analysis, using insights from flight operations, flight data monitoring (FDM), accident investigations, and safety reports. This data helps identify the most relevant risks pilots face in daily operations, allowing training programs to focus on areas that have a measurable impact on flight safety. The key objective of EBT is to enhance pilot performance in handling unexpected situations rather than training pilots to pass a standardized set of regulatory checklists.

EBT starts by analyzing safety and operational data from airlines, aviation authorities, and industry groups. Data sources include:

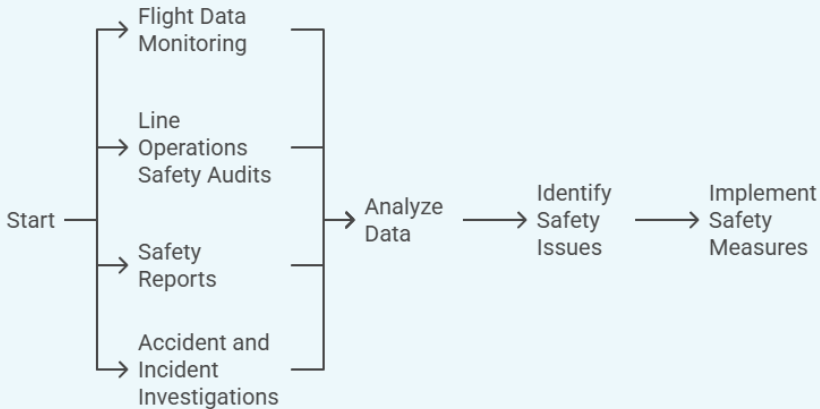
- Flight Data Monitoring (FDM), which tracks real-time aircraft performance of the airline
- Line Operations Safety Audits (LOSA), which assess pilot decision-making and application of procedures in real line flights
- Safety reports, including confidential pilot reports
- Accident and incident investigations, identifying root causes

These sources help define high-risk areas, such as handling automation failures, unexpected weather deviations, or air traffic control miscommunication.

EBT moves away from rote memorization and repetitive task-based training. Instead, it builds on the same core pilot competencies explained in the previous chapter. Pilots are assessed not on their ability to perform a predefined maneuver or

task, but on their ability to manage real-world operational challenges using pilot core competencies.

EBT Data Analysis Process



Traditional pilot training often followed a fixed set of simulator exercises based on regulatory requirements. In contrast, EBT focuses on realistic and dynamic scenarios that replicate the challenges pilots encounter in daily operations. Examples include:

- Automation failure during descent – Pilots must transition to manual flight and reconfigure approach procedures
- Severe weather and unexpected turbulence – Decision-making under pressure while ensuring passenger comfort and safety
- Rejected take-off at high-speed – Executing the correct abort sequence followed by a realistic decision-making process to evacuate the aircraft as required
- Multiple system failures – Handling complex emergencies requiring much more than the application of a single predefined checklist

By using a scenario-based approach, pilots experience a range of unpredictable situations, ensuring they are prepared for the unexpected. EBT replaces traditional pass/fail evaluations with continuous performance assessment. Pilots receive real-time

feedback during and after training sessions, with debriefs focusing on:

Strengths and areas for improvement

Decision-making under pressure

Alternative solutions they could have used.

This feedback loop allows adaptive learning, ensuring pilots improve based on measured performance rather than fixed assessment criteria.

EBT is not limited to individual pilot training. It incorporates multi-crew coordination, ensuring that Commanders and first officers work effectively as a team. Additionally, instructors are trained to observe behaviors and competencies rather than simply checking regulatory boxes.

Airlines must ensure that instructors are calibrated, meaning they apply assessment criteria consistently across training sessions. Standardization programs such as Instructor Concordance Assurance Programs (ICAP) are used to maintain uniform training quality.

Regulatory bodies, including ICAO, EASA, and FAA, support EBT as an alternative to traditional training models. Implementation often follows a phased approach, with airlines first incorporating EBT elements into recurrent training before applying it to full training programs.

Some airlines operate Mixed Implementation Programs, where EBT is integrated with traditional Operator Proficiency Checks (OPC) and License Proficiency Checks (LPC) until full EBT adoption is achieved.

Evidence-Based Training represents a major shift in airline pilot training, ensuring that pilots are not just meeting minimum requirements but actively improving their ability to handle real-world operational challenges. By combining data analysis, scenario-based learning, and continuous assessment, EBT enhances pilot competency, resilience, and safety performance, making it a key component in modern aviation training.

OBSERVABLE BEHAVIOURS

Modern pilot training uses the concept of "observable behaviours" as a central tool for evaluating pilot performance. Observable behaviours are actions that instructors can identify and measure. These behaviours indicate whether pilots can perform their tasks effectively and safely. Rather than relying solely on knowledge tests or subjective assessments, CBTA and EBT focus on practical demonstrations of skills in realistic scenarios. Observable behaviours show if pilots have the necessary Knowledge, Skills, and Attitudes (KSAs) to perform their tasks.

Consider a scenario involving engine failure during take-off. Observable behaviours include how the pilot safely controls the aircraft, identifies the failure, manages the immediate actions required and communicates with other crew members. The trainer observes these actions to determine if the pilot can handle the situation. For each competency, specific behaviours indicate how well the pilot performs.

"Knowledge" encompasses observable behaviours indicating thorough understanding of aircraft systems and limitations. Correctly interpreting and responding to an ECAM message indicating multiple system failures after an engine explosion shows sound knowledge.

"Flight Path Management Manual" observable behaviours focus on maintaining the intended route and altitude with high precision during routine and unexpected events. Controlling airspeed, altitude and heading using accurate and smooth control input and managing configuration changes. A pilot adjusting the aircraft's trajectory accurately when encountering windshear or during a collision avoidance maneuver would also demonstrate proficiency in this area.

"Flight Path Management Automation" involves observable behaviours such as accurately controlling the aircraft automated systems. Successfully executing approach and landing under adverse conditions, such as low visibility approach using 2-dimensional or 3-dimensional guidance, illustrates competency.

The "**Application of Procedures**" competency involves observable behaviours like correctly following standard operating procedures (SOPs). Examples include systematically executing a checklist during a missed approach or accurately performing a pre-flight check.

In the "**Communication**" competency, observable behaviours include clear and precise communication with crew members and Air Traffic Control (ATC), verifying information is understood by others, actively listening, and clarifying instructions when needed. If a pilot repeats the required parts of the instructions to confirm understanding or effectively communicates unexpected problems, these are positive observable behaviours.

Under "**Leadership and Teamwork**," observable behaviours might involve coordinating clearly with the crew, distributing tasks effectively, and maintaining a calm environment under stress. An example of strong leadership during an emergency could be delegating clearly defined responsibilities to each crew member to manage a system failure.

"**Problem Solving and Decision Making**" includes observable behaviours like swiftly identifying the nature of an issue, evaluating options efficiently, and selecting the safest course of action. A pilot demonstrating effective problem solving during an unexpected fuel leak might first secure the aircraft's safety by running the appropriate checklists promptly and then choosing whether to divert or proceed to an alternate airport based on the analysis of fuel loss rate and available options.

"**Situational Awareness**" refers to observable behaviours indicating that a pilot fully understands the current state of the aircraft and environment. Maintaining correct altitude, monitoring fuel levels consistently, and adjusting flight paths proactively based on changing weather and actively looking for missing information illustrate this competency.

In "**Workload Management**," observable behaviours reflect the pilot's capability to manage their tasks effectively without becoming overwhelmed. Demonstrating calm and precise task prioritization during an unexpected diversion due to severe weather is an example.

“**Company Values**” observable behaviours include wearing of the uniform as per company policy, addressing the passengers sharing information and explaining any special occurrences that happen during the flight. Captain de Crespigny of QF32 for example, immediately after the ordeal, went to the terminal to address the passengers to explain what happened and to offer support. This competency also includes how a pilot addresses colleagues from other departments or how the technical log is completed with the correct phraseology so that maintenance understands the technical issues. In the LionAir B737-MAX accident in October 2018, the poor write-up of the crew on the previous flight was a significant factor for the accident to happen (AVM, 2020).

Before we dive into how we can improve ab initio pilot training using the above principles, let’s review how it was done in the past.



*Figure 8: ALSIM's 42 Simulator
for Diamond DA42-VI*

OBSERVABLE VS. UNOBSERVABLE BEHAVIOURS

OBSERVABLE (Behaviour)	• UNOBSERVABLE (Cognitive Actions)
-Any action that others can observe and measure. -walking -talking -gestures	- Not externally visible - thoughts - feelings - emotions - dreams - memories

Figure 9: CBTA/EBT rates observable behaviours



Figure 10: The Wright brothers.

Chapter 2: Flight Training History

1903-1945

Pilot training started with self-education. As these early individuals considered themselves “competent” to become a pilot, self-education concentrated on acquiring the required “skills” to be able to fly. The Wright brothers trained the use of flight controls extensively on the ground with the aircraft at standstill. Imagining the flight and executing the control movements required to handle imaginary (but realistic) situations that a pilot may encounter during flight remains an immensely powerful training aid, even today.

It is called “desk flying” (as it can also be performed behind a desk) and every pilot must spend many hours doing this. Even the most advanced aerobatic teams, such as The Blue Angels of the USN, “desk fly” their routine before every display, to make sure all team members understand and can apply what is required for the upcoming display, even though they did the routine multiple times in the past.

Between 1903 and 1945, training changed significantly due to technological progress, wartime demands, and a growing understanding of flight safety. Training methods evolved from simple hands-on instruction to structured programs incorporating simulators, the introduction of standardized procedures, and an increasing focus on tasks, skills and safety.

Between 1904 and 1914, pilot training primarily focused on practical skills. Students learned by flying with instructors in open-cockpit aircraft, often with little theoretical instruction. The Wright brothers introduced a basic flight simulator to help students develop coordination and balance, but training varied widely between different instructors and schools. There was no standardized curriculum, leading to inconsistent training methods. Early aircraft were unstable, and the absence of structured procedures contributed

to frequent accidents. The fact that someone merely survived such a training environment meant that he was a *competent pilot*.

The onset of World War I from 1914 to 1918 led to an urgent need for more pilots. Military forces expanded flight schools rapidly to meet the demand. Selection used newly developed psychological tests that were designed to measure intelligence and basic motor skills. Training programs became more structured, introducing phased instruction that combined ground school with practical flight training. The British Royal Flying Corps introduced the "Gosport System," which improved communication between instructors and students through a standardized approach. The high casualty rates highlighted the need for safer training methods, leading to improvements in aircraft design and instructional techniques.

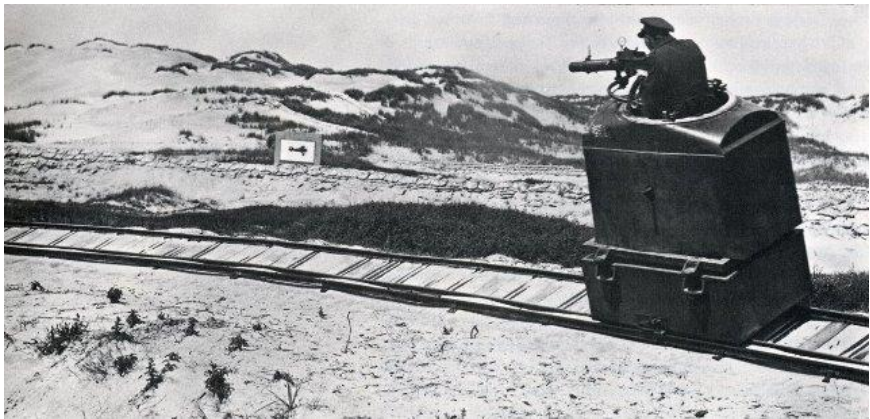


Figure 11: RAF Gunnery School at Rang-du-Fliers in France on 17th July 1918

Between 1918 and 1935, pilot training continued to develop with the introduction of instrument flight simulators. The Link Trainer, developed in 1927, allowed pilots to practice instrument flying in a controlled environment. This innovation reduced the risk of accidents by enabling trainees to improve their skills before operating real aircraft. Ground school instruction expanded to include subjects such as aerodynamics, meteorology, and navigation. Flight schools have

become more organized, with standardized curricula and qualified instructors ensuring more consistent training.



Figure 12: The Link Trainer, the world's first commercial flight simulator

From 1935 to 1945, the demands of World War II again required mass pilot training programs. Pilot selection and training was accelerated, and students received specialized instruction for different aircraft types. Flight simulators became more advanced, replicating specific aircraft models and their systems to improve realism. The war emphasized the need for teamwork in multi-crew aircraft, leading to the development of rudimentary crew resource management (CRM) concepts. Pilots also had to adapt to innovative technologies, including radar, radio navigation, and more complex aircraft systems.

By the end of 1945, pilot selection and training had evolved from simple trial-and-error instruction to structured programs incorporating technology, standardized selection and procedures, and a focus on safety. These advancements laid the foundation for modern pilot training, ensuring that pilots were better prepared to operate aircraft safely and efficiently in increasingly complex environments.



Figure 13: Royal Air Force Cadets going for a training flight on a Harvard

1945-2000

After 1945, pilot training evolved significantly, influenced by technological advancements, regulatory changes, and a greater understanding of human factors in aviation. The transition from military-style training to a structured, standardized approach shaped the way pilots were prepared for commercial airline operations. Over the decades, new aircraft, automation, and simulation technology influenced how pilots were trained, leading to more effective and safety-focused instruction.

Between 1945 and 1960, most airline pilots had military backgrounds, and training reflected military principles. Pilots who had flown in World War II transitioned to civilian aviation, bringing with them disciplined flight training practices. Airlines adopted structured training programs based on military experience, focusing on standard operating procedures, navigation skills, and instrument flying. The introduction of better flight simulators allowed pilots to practice instrument flight and emergency procedures without risking real aircraft. Simulators helped pilots develop skills in handling very low-visibility conditions. The arrival of jet aircraft in the late 1950s required a new training approach. Pilots had to learn about higher

speeds, increased altitudes, and more complex systems. Airlines introduced specialized jet transition courses, emphasizing new handling characteristics and performance. As the industry expanded, structured curricula ensured more consistency in training.

From 1960 to 1980, the focus on crew coordination and human factors increased. Early incidents and accidents highlighted the importance of communication and teamwork in the cockpit. Airlines began to introduce training that emphasized how pilots worked together in multi-crew operations. The growing understanding of human factors led to research on decision-making, workload management, and fatigue. This period also saw more improvements in flight simulation.

Simulators became more advanced, incorporating better visual displays and motion platforms, providing a more realistic training experience. Pilots could practice more complex maneuvers and emergency procedures. Automation started playing a larger role, with aircraft incorporating autopilot and automated navigation systems requiring a new skill set to manage these systems. Pilots had to learn how to use and monitor auto flight systems while maintaining manual flying skills.

Between 1980 and 2000, Crew Resource Management (CRM) became a standard part of pilot training. Research showed that many accidents resulted from human error rather than technical failures. CRM training emphasized communication, teamwork, leadership, and situational awareness. Pilots learned how to coordinate with crew members, make informed decisions, and manage cockpit workload effectively.

The introduction of the Advanced Qualification Program (AQP) in the USA (followed by a similar ATQP program by EASA in Europe) allowed for a more flexible, data-driven training model. AQP focused on scenario-based training for recurrent training rather than repetitive maneuvers. This shift improved pilot proficiency by exposing them to real-world operational challenges.

As air travel became more global, training adapted to new challenges, including cross-cultural communication and international standardization of procedures. Ab initio training programs gained popularity, providing structured training for individuals without prior flying experience. Airlines developed partnerships with commercial flight schools and aviation academics, ensuring a steady supply of well-trained pilots.

The evolution of pilot training from 1945 to 2000 reflects continuous advancements in safety, technology, and instructional methods. Training programs have become more structured, incorporating data-driven learning, simulation advancements, and a focus on human factors. These improvements ensure pilots are better equipped to handle modern aircraft, complex airspace, and evolving operational challenges. The emphasis on continuous learning, adaptability, and scenario-based training has created a safer and more resilient aviation industry.

2000-Today

From 2000 to 2010, Evidence-Based Training (EBT) emerged as a novel approach for airlines. Instead of focusing on regulatory checklists, training programs used data and research to identify key risks pilots faced in actual operations. Airlines adjusted their training programs based on real-world safety data, ensuring pilots were prepared for the most relevant challenges.

After many syllabi stopped including an aerobatic course for airline pilots, Upset Prevention and Recovery Training (UPRT) gained attention due to incidents involving loss of control in flight. Training programs incorporated specific lessons on recognizing and recovering from unusual attitudes, preventing pilots from relying too much on automation and having no aerobatic flight experience. Some airlines expanded their cadet programs, directly sponsoring new pilots to address industry shortages. These programs provided a structured path from flight school to the airline cockpit, ensuring a steady flow of trained professionals.

Pilot training has shifted from a task-based approach to a competency-based model. This change was influenced by advancements in technology, an increased focus on safety, and a better understanding of how pilots learn and make decisions in the cockpit.

Smart instructors already knew for decades that the sum of all tasks and skills of a pilot does not necessarily result in a competent pilot. Someone could be able to handle the required subset of tasks to pass a check but could not be able to handle new and complex situations in real life after qualification. However, it depended on the insights of the instructor corps how much weight was given to pilot competencies in an airline or training organization. I remember numerous discussions when a candidate was able to perform all tasks (barely) within the required limits, but the instructor or examiner had no confidence in the trainee. This pattern became also visible in accident investigations, of which the Saab SF340 accident described in the beginning of the book is an example.

With the development of core pilot competencies that started in the 1990's and gained momentum after 2000, the industry was able to define the pilot core competencies. This made it possible to train any pilot instructor to include those competencies. The use of an observable behaviour provides a transparent and objective way to assess core competencies. That was new. What previously was defined as “a feeling” or “an opinion” of an instructor or examiner became a verifiable behaviour to be demonstrated by the trainee.

After 2010, innovative technologies became available. Virtual reality (VR) and augmented reality (AR) became tools for immersive learning. These technologies allow trainees to experience cockpit environments without needing expensive physical simulators. VR provides a virtual cockpit where pilots can practice pre-flight checks and emergency procedures in a setting identical to real aircraft. AR overlays digital information onto real-world components, enabling pilots to interact with virtual systems superimposed on actual aircraft

parts. This helps them understand system locations and functions, improving familiarity with aircraft operations.



Figure 14: CAE Sprint VR Trainer (CAE, 2025)

Competency-based training focuses on developing core skills. It moves beyond memorizing procedures and encourages pilots to think critically, adapt to different situations, and manage complex scenarios. For example, instead of simply following steps to recover from a stall, pilots learn to identify a wide range of stall conditions, understand the aerodynamic principles, and develop the judgment to prevent any stall. This deeper understanding improves decision-making and reduces errors.

Technology and competencies have led to a data-driven approach. Flight simulators and training devices now collect performance data, allowing instructors to assess strengths and weaknesses. This enables tailored training that focuses on specific areas of improvement. If a pilot frequently deviates from the glideslope during approach, instructors can use this data to pinpoint the issue and design targeted exercises. This ensures that training addresses areas needing improvement.

Data has become a key part of pilot training. Safety departments collect and analyze data from real flights (based on recordings, observers in the flight deck and safety reports) to identify trends and areas needing improvement. This helps airlines refine training programs to address operational challenges. If safety data shows that pilots frequently exceed speed limits during descent, airlines can adjust training to reinforce speed control and procedural compliance.

Human factors training has been an essential part of pilot education for more than half a century. This training focuses on how fatigue, stress, and communication affect performance in the cockpit. Crew resource management (CRM) plays a vital role, emphasizing effective communication, teamwork, and decision-making in a multi-crew environment. CRM training helps pilots coordinate tasks, manage workload, and respond to unexpected situations. In a simulator session a crew might face an engine failure. CRM training ensures that pilots communicate the situation clearly, assign responsibilities, and make coordinated decisions to manage the emergency.

The evolution of pilot training reflects the industry's commitment to improving safety. By integrating recent technologies, adopting competency-based training, and emphasizing human factors, training programs ensure that pilots are well-prepared for the complexities and unpredictable occurrences that are daily business in modern civil aviation.

Is there Something Wrong with the Training Pillars?

Airline pilot training relies on three pillars: instructors, training methods, and training aids. Each pillar supports effective training, and all are essential. Instructors are still the most important pillar, and they can address shortcomings in the other two pillars. They act as role models and serve as the human interface of the training program.



Figure 15: Training pillars

Both ground and flight instructors deliver most of the training content. In many programs, computer-based tutorials now handle (large) part of the instruction in ground school, and there is a clear trend toward using more artificial intelligence for tutorial tasks.

The traditional training method follows a step-by-step approach, progressing from simple tasks to more complex ones and from familiar to new concepts. However, as we will see, this approach has important limitations in today's environment.

Training aids range from textbooks—or their electronic versions on tablets—to brief video tutorials that explain theory, computer-based simulations, full flight simulators and training aircraft. While full flight simulators remain an amazingly effective tool, many training tasks can be managed with a simple computer, a chair, a VR headset, and a very affordable software package. In addition, real flight time on an actual aircraft remains essential.

When I started my B737-300 conversion from the B737-200, the biggest change was the electronic instruments and Flight Management System (FMS) integration in the auto flight system. Our company bought an extremely expensive “FMS trainer”, locked in a dedicated room to train the pilots. Today the hardware coupled to a PC is available for \$125 (WinWing, 2025) and it is much more capable. That is a 99.9% discount. A functional physical A320/B737 flight deck is available for homebuilders at around \$5,000-\$10,000, and a virtual headset for less than \$500 (excluding the PC).



Figure 16: B737NG CDU panel (Control Display Unit) (WinWing, 2025)

Chapter 2: Flight Training History

If pilot training is as advanced as claimed, it is surprising to see “human error” or “pilot error” remain prominent factors in accident investigations. Even worse, accident statistics during training aren’t stellar either, as flight schools suffer incidents and accidents during training missions.

There are several methods to increase safety during flight training, but not all these methods are without problems. Current training does not fully prevent human errors. In the following chapters, let us find out what is wrong with the three pillars and, more importantly, what can be done about it to substantially increase safety.



Figure 17: Homebuilt B737 cockpit

Chapter 3: Instructors

Introduction

OVERVIEW

To become a pilot instructor, you must follow the regulations in Flight Crew Licensing in the applicable jurisdiction. Below is a summary of key requirements.

Pilots that want to become instructor must be at least a certain age, most likely 18 years or more. They need a valid pilot license. They must hold a valid Medical Certificate and must demonstrate English (or other ICAO) language proficiency.

Flight Instructor Airplane (FI(A)) candidates in Europe must have a set amount of total flight time, including Pilot-in-Command time, specific hours on the relevant aircraft category, and cross-country flight experience.

For Instrument Flight Instruction (IR(A)): pilot instructor candidates must complete a minimum amount of instrument flight instruction. They typically must hold at least a CPL(A) (Commercial Pilot License) or meet the CPL theoretical knowledge requirements. They must pass a specific pre-entry flight test with a qualified flight instructor within a set period before starting the course.

Similar requirements (relevant to the type of instruction) exist if pilots want to be a multi engine instructor (ME(I)(A)), helicopter, seaplane or aerobatic instructor.

There is another class of instructors, those mostly used within an airline or for type rating courses in a training organization. These instructors do not teach basic flying on single engine, multi engine or instrument flying courses. They specifically train licensed pilots on a given aircraft type, such as the Airbus A320 or Boeing 737 or any other type rating. These instructors are called Type Rating Instructors (TRI) and those limited to simulator instruction only are called TRI-SFI (Type Rating Instructor – Simulator

Flight Instructor) or TRI-FFS (FFS stands for Full Flight Simulator). Some of them also administer check rides and are called examiners or TRI/E-SFI/E.

A Flight Instructor Training Course typically contains Theoretical Instruction: candidates must complete a minimum number of hours covering teaching methods, technical knowledge, and other relevant subjects. To become an instructor, these pilots must also complete a minimum number of hours of flight instruction, including dual instruction, and pass an assessment that covers both theoretical and practical elements. This training must be conducted at an Approved Training Organization (ATO) according to most regulations.

What is apparent is that for Airline Pilot Training, trainees will initially be trained by basic flying instructors who might not have any airline and commercial jet experience and continue with type rating instructors who might not have any basic flying instruction experience. This split explains why the airline industry sticks to old-fashioned training methods.

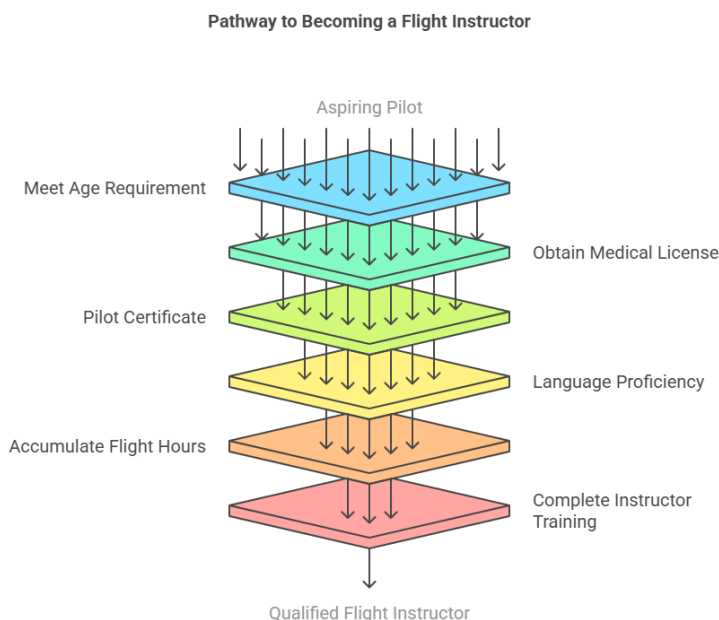


Figure 18: Pathway to become an instructor

An overview of EASA and FAA requirements to become flight instructor:

Requirement	EASA FI(A)	FAA CFI (Airplane SE)
<i>Age</i>	18 years	18 years
<i>Pilot License</i>	PPL(A) or CPL(A)	Commercial Pilot
<i>Medical</i>	Class 1	Third-Class
<i>English</i>	Fluent	Fluent
<i>Flight Time</i>	200 hours	250 hours
<i>PIC Time</i>	150 hours	Not specified
<i>Aircraft Category</i>	30 hours	Not specified
<i>Instrument</i>	Required & 10h IR instruction	Required
<i>Cross-Country</i>	20h as PIC, 300 NM flight	Not specified
<i>Knowledge Test</i>	None	Required
<i>Practical Test</i>	Required	Required

There are differences:

	EASA	FAA
<i>Total Flight Time</i>	Generally, a bit lower, especially for holders of higher licenses	Generally, a bit higher, with a minimum of 250 hours for a Commercial Pilot Certificate
<i>Cross-Country Experience</i>	Stronger emphasis, with a specific long-distance flight requirement	No specific cross-country requirement
<i>Medical Standards</i>	Requires a Class 1 Medical Certificate, which has stricter requirements	Requires a Third-Class Medical Certificate or BasicMed, which have less stringent requirements
<i>Knowledge Tests</i>	No separate knowledge test for the FI(A) certificate	Requires passing the FOI and FIA knowledge tests
<i>Training Structure</i>	More structured training program with specific minimum hour requirements for theoretical and flight instruction	More flexibility in training options, with both Part 61 and Part 141 pathways available
<i>Newly Qualified Instructors</i>	Initially licensed with Restricted Privileges (FI(RP)), with limitations on instruction	No initial restrictions on instructional privileges

Instructor Competencies

The International Air Transport Association (IATA) recommends using two sets of competencies for effective CBTA (Competency Based Training and Assessment) implementation: nine pilot competencies and five instructor/evaluator competencies. These competencies provide a framework for developing and assessing the skills and knowledge required for both pilots and instructors in a CBTA environment.

Instructors that lack these competences do exist. Many years ago, we had a policy of sending all students in the air with instructors on those days that crosswind conditions were prevalent, just to make sure trainees had maximum opportunity to practice crosswind landings.

One of the instructors had a deep love for aviation, but his skills did not entirely match his enthusiasm. His methods were unstructured and unpredictable in an era when a good structure was not yet enforced by the regulators. Instead of clear explanations, he relied on vague statements and exaggerated hand gestures. His approach to teaching was more about “feeling the plane” rather than understanding how to control it. He also had an unfortunate habit of dozing off during pre-flight briefings, leaving his students uncertain and unprepared for what was about to happen.

This trainee was determined but nervous. She wanted to learn, but she struggled with the lack of clear instruction. That day, they were practicing crosswind landings just like the rest of the trainees. As they approached the runway for landing, the wind was more forceful than anticipated. He muttered something about “*compensating more for the wind*”.

The plane started to drift. Her voice became tense as she pointed it out, but he remained unconcerned. He casually mentioned that a little crab angle was normal. The aircraft, however, continued to veer sideways. The upwind wing dipped, and her hands, already tense,

became very rigid. She overcorrected, sending the plane into an unstable motion. He finally seemed to pay attention but gave no clear guidance, mumbling something about adjusting the rudder without specifying how.

The landing was rough. One wheel hit the ground with a force that shook the entire aircraft. She let out a startled scream as the plane bounced. He, however, grinned and called it a "spirited landing," completely ignoring the fact that they were veering off the centerline. The aircraft continued its uneven path, only just avoiding the grass beside the runway before she finally managed to stop it.

He patted her on the back, offering empty praise and suggested that next time she would "*just feel it*" better. She sat in stunned silence for a moment. Without another word, she taxied in did the shutdown, left the cockpit and headed straight to the office of the chief flight instructor of the flight school. She told her story and requested another instructor who, as she put it, "actually knew what he was doing."



Figure 19: Cessna 172 crosswind landing using slip (Fizer, 2022)

This instructor didn't demonstrate his competence to be a good flight instructor. But what are the required competencies?

Based on NASA's research on human factors, the following core competencies are essential for pilot instructors (Renier, 2022) in a CBTA environment (to the nine IATA pilot core competencies, we added airline Company Values as a tenth competency), here are the instructor's competencies:

1. Possessing strong pilot competencies (9 + 1)
2. Management of the learning environment
3. Instruction
4. Interaction with the trainee
5. Assessment and evaluation

Instructors must have a strong grasp of the nine (plus one) **pilot competencies** mentioned earlier.

They are also responsible for **managing the learning environment** by developing and organizing training materials that follow CBTA principles and meet learning objectives. This work involves setting clear goals for each lesson, researching the subject thoroughly, and arranging the material in a logical order. Instructors plan interactive activities that engage students actively. They also provide a written curriculum and schedule regular lessons to ensure steady progress. In addition, they build habits such as “attitude flying” and the correct instrument cross-checking from the start of training.

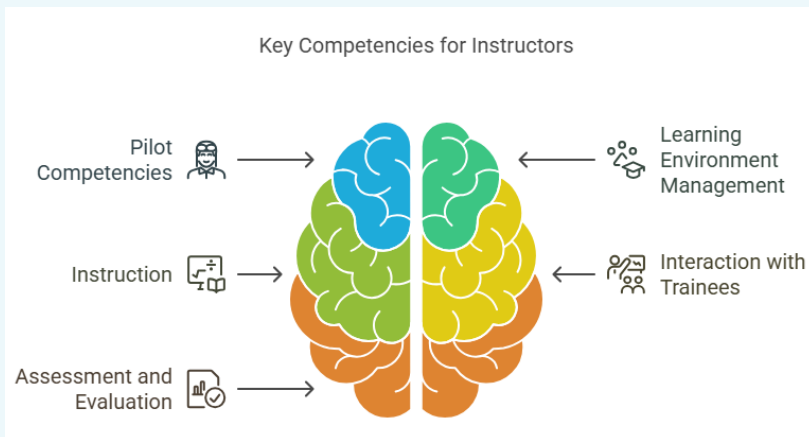


Figure 20: Instructor competencies

Effective instruction uses teaching methods that address different learning styles and keep students engaged. Instructors use clear, concise language and share real-world examples and scenarios. They apply various techniques such as lectures, demonstrations, and simulations and offer students opportunities to practice and apply their knowledge. This encourages students to explore beyond basic understanding and gain a deeper insight.

When **interacting with trainees**, instructors tailor their methods to suit individual learning styles, speeds, and needs. They provide a range of resources, offer personal support, and use flexible assessment methods. They also recognize and address challenges like fear of flying or motion sickness and adjust tasks to suit different preferences. They foster a culture of safety and intellectual freedom where students feel free to ask questions, encourage mutual respect and open communication, and model professional behaviour while supporting students through challenges.

By focusing on each student's goals and needs, instructors create a learning environment that motivates and involves everyone. They set realistic goals, provide regular feedback, and encourage collaboration by relating the training to students' own aspirations.

Assessment and evaluation involve various methods to measure learning and competency development. This includes using oral and written quizzes, performance tests in simulators and aircraft, and assessments that involve student self-reflection. Instructors use simulator evaluations to test competency in a safe setting and conduct formative evaluations to ensure training programs are clear and effective. They provide timely, specific, and behavior-based feedback that balances positive reinforcement with suggestions for improvement. Instructors also use visual aids and simulations to illustrate feedback points and adopt collaborative methods, such as replay, reconstruct, reflect, and redirect, to deepen understanding.

Instructors must continue to develop professionally. They keep up with industry changes, regulations, and best practices by attending seminars, workshops, and conferences, reading industry publications, and engaging with the aviation community. They

also explore modern technologies like VR/AR and remote training methods. Regular self-reflection and seeking feedback help them improve their teaching methods. Finally, they embrace a broad view of professionalism that includes mentoring, acting as role model, and advocating for safety.

Instructor Competencies Discussion

Possessing strong pilot competencies (9 + 1) is an important requirement as the instructor serves as a role model.

At the time, we had an issue with students taxiing too fast. We conducted briefings about taxi speeds, explained the risks of high-speed taxiing, and presented examples of accidents caused by it. We also showed training videos from the airline about proper taxi speed and procedures and discussed it extensively during briefings. However, none of this helped.

It turned out that one instructor had the habit of taxiing much faster than recommended. He often took control of the aircraft and announced, "I have control—never do what I do now," before increasing throttle and lifting the nose gear off the ground during a high-speed taxi. These demonstrations, not part of the lesson plan, influenced trainees far more than any classroom briefing or training material. Even though other instructors set the right example, it was not effective.

A single bad example can undermine the entire training philosophy.

Being a role model as an instructor is essential. However, the best pilots do not automatically make the best instructors. An excellent pilot who learns quickly may underestimate the difficulties faced by a trainee who learns more slowly. A top-performing pilot might excel in the first instructor's competency but might lack the four other competencies.

Managing the learning environment is important for efficient training. Good facilities, high-quality training material, simulators,

and aircraft certainly help, but their importance usually is overrated. And frankly, an effective instructor with less advanced training material is preferable to a less capable instructor with better training aids.

One of the most effective briefings I ever received took place at a small wooden table under poor lighting, with the instructor using only a sheet of paper for some notes and drawings. Creating a simple learning environment using basic tools to explain complex principles in an uncomplicated way is probably one of the most effective teaching methods.

Instructors sometimes highlight the weaknesses of training aids. Even full flight simulators can be poor at realistically simulating landings, particularly during the flare, touchdown, and rollout phases, including braking. I have often intervened when instructors complained about unrealistic simulators. Even if the simulation isn't perfect, it provides key information to the trainee on judging height above the runway, when to flare, and how to brake effectively to exit the runway.



Figure 21: Instructors can make this a highly effective teaching aid.

If a trainee makes a mistake, the instructor should not dismiss it by blaming the simulator. Instead, the instructor should clearly inform the student about the mistakes he made: *“Don’t start your flare at 30 feet; start it at the recommended 15 feet for this aircraft and continue the procedure using brakes, speedbrakes, and reverse thrust until leaving the runway.”*

Surprisingly, the most realistic simulator might **not** be the best training tool.

We once used a simulator that was extremely challenging to fly on one engine due to exaggerated yaw effects and overly sensitive rudder pedals. Its motion system was also poor, sometimes causing trainees to feel seasick. Yet, once trainees mastered precise control in that simulator, transitioning to real aircraft was surprisingly easy.

Simulators that amplify certain characteristics can be **better training devices** than more realistic ones. Some manufacturers understand this and intentionally design their simulators to improve learning. It's important that instructors in that case avoid pointing out the simulator's lack of realism as a **simulator is a training tool, not a copy of the real aircraft**.

Instructors shape the training environment using textbooks, training aids, simulators, and aircraft. They should strengthen this foundation. The best instructors can deliver excellent lessons using the available equipment, even if the equipment has flaws.

There is a difference between undermining the training environment, which should never happen, and pointing out its limitations, which should be clear to the trainee. For instance, engine failures in simulators come with specific parameters, while real engine failures can involve noises, vibrations, and unexpected instrument indications. **Highlighting such differences is an essential requirement** to train competent pilots who will not be surprised when confronted with actual failures that differ from what they experienced during training.

One day, I was auditing a simulator session as part of a type rating course. The session was very well led by the instructor. Some important parts needed to be talked about during the debrief and the instructor used the best facilitator techniques to guide the debriefing. Excellent. Except for one point. When he explained a technical issue, he never used the manual of the aircraft, not

referring to it, as if it didn't exist. The text and drawings he used were perfect, but not from the manual.

In my one-to-one with him I asked him: what did the trainees learn from this session? He was smart so summed up the session goals related to CBTA and described the observable behaviours. "I think they learned something else also," I said. "I think you teach them never to refer to the aircraft manual." "Absolutely not," he replied.

So, I continued to challenge him: "I did not see the aircraft manual during the whole session, including briefing and debriefing. Even when questions were raised that have answers in the manual you didn't use it, you used your own documentation and drawings. What do you think the trainees are doing now? Looking for better drawings and explanations outside the manual! We don't control that kind of information; it could contain serious flaws and worse."

During my own training as instructor, long before CBTA even existed, my tutor told me: "As an instructor, it is your task to 'sell' the aircraft manual. Because after the training, this will be the only reliable reference the pilot has left." Then he told me to always have it on the table during briefing and debrief, just to show them it is the "bible". With a digital copy on an iPad, it is more difficult these days. But at least once every session, you ask trainees to look something up, so that they get the message that professional pilots use the aircraft manual all the time. Learning to use the manuals daily, paper or electronic, **is an essential part of airline pilot training.**

The goal of **instruction** is to lift the trainee through the levels of learning. From root knowledge to understanding to application to correlation.

Instruction needs to address different learning styles. The theory of David Kolb (Kolb, 1984) provides the basis and will also be explained in more detail. How the training method (which may be

gradual or immersive) is delivered to the student must be optimized by the instructor while adhering to the strict training standards.

Implementing training standards is a real headache in most training organizations and most do not invest sufficient time and money in making sure the instructors deliver the standard course, adapted to the student as expected. Lack of training standardization is the result.

Although I must admit that the opposite is probably worse. One organization was so strict about its training standards that its instructors were nearly paralyzed deviating from the published program, even though tailoring the program to the needs of the trainees obviously was the right thing to do. Then trainees lose countless hours being given instruction on stuff they mastered earlier. Boring it is.

When giving instruction, there are important cultural differences in how this is done. When managing different airlines across Europe, we standardized the recurrent training programs on our fleet. I had a fantastic team doing that work and the program was the same in all countries. Aligning “*egos and authorities*” obviously was the most demanding part and when that was accomplished the program was rolled out.

But the same English language in the identical documentation was read differently in every country, even when all were Western European airlines under EASA/UKCAA. In the UK, everything had to be written down and documented or it wasn’t done. In Germany, they followed the program also in detail, but they didn’t want all the granular details because they figured that if it was written down, it had to be done that way, hampering the instructor to individually tailor the program to the needs of the trainee.

Many in Belgium thought of the program as a “nice guideline” of which the key parts must be done and the rest is up to the instructor, resulting in a somewhat less than standard delivery. One part of it was “manual flight

with turns, climbs and descents”, which sounded outrageous to the Belgian pilot population, so it was skipped in its entirety. We had to bring all the instructor together and explain to them how to read the documentation to find a common ground.



Figure 22: Cultural differences (Bath, 2024)

In another case in South America, one airline had the most beautifully printed training syllabus I have ever seen, and the content was top notch. I was impressed by the quality until I joined a briefing and simulator session. The program wasn't even looked at; nobody applied or even understood the content and the simulator session was below par. It turned out that an acquaintance of the manager owned a printing company specializing in printing beautiful glossy brochures...

Organizations working worldwide should invest in having a system to standardize content while considering cultural differences.

Most good instructional methods are not new. Long before aviation even existed, Confucius said: **"Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand."** We use this to improve pilot training.

Any instructor course, as pioneered by the FAA, will have guidance in it for the instructor to be fair, firm and friendly during interaction

with the trainees. That really is the basis of good instruction. It is so evident that many instructor courses skip this, assuming everyone knows it. But it should be given more attention when training and guiding instructors at any level of. If I browse back through the minutes of countless instructor meetings I participated in, way too much of what is said relates to these three things.



Figure 23: Instructor attitude (FAA Instructor Handbook)

Fair means that the instructor must be consistent in the application of standards, regardless of background, personality, or perceived aptitude. While maintaining consistent standards, instructors should acknowledge that each student learns differently. Fair instruction involves adapting teaching methods and pacing to meet individual needs, providing extra support for struggling students and challenges for those who excel. Finding the right balance is key.

Evaluations should be based on objective criteria rather than personal biases. Instructors must offer clear, constructive feedback focused on specific areas for improvement. Treating all students with respect and dignity is essential. Instructors must avoid favoritism, discrimination, or any behavior that creates an unfair learning environment. Maintaining professional boundaries is equally important. Students should understand what is expected and how their performance will be assessed.

Epilogue

If you've made it this far, you've realized that training airline pilots isn't just about ticking regulatory boxes or passing simulator checks. It's about people. It's about building competence, confidence, and resilience in high-stakes, fast-changing environments—doing it with purpose, integrity, and a long view.

This book took you through the entire training landscape—from how we select and teach pilots, to the tools, methods, oversight, and culture that shape the outcome. We looked critically at what we train, how we train, and why some long-standing habits may need to change. Along the way, we examined the pressures, politics, pitfalls, and possibilities that define airline pilot training today.

A friend recently asked me why I care so much. I answered, “How about us stop killing innocent people?”—referring to a recent accident. That's why I authored this book. That's why we work hard to improve training.

We focused on competency-based training, and why the industry should fully implement it—including at the ab initio level. CBTA, and its operational counterpart EBT, are essential to modern pilot training. But their implementation still needs a lot of work. That work is worth doing. Because without it, we won't develop the kind of resilient pilots we need—pilots who can manage the rare, but critical, situations that still pose risks. The industry is already very safe, which makes further improvement harder. But it's not impossible. And not optional.

Pilot training is a system. Its strength lies in how well its parts connect—people, procedures, tools, feedback, and values. There's no silver bullet. But a curious, critical, committed mindset can move the entire system forward.

This book doesn't claim to have all the answers. What it offers is a way to ask better questions. It helps you spot the weak links, challenge the defaults, and focus your energy where it matters most.

Whether you're a new instructor, a seasoned manager, a future pilot, or a regulator, you now hold a broader perspective—not just technical, but cultural and strategic—on what it really takes to improve airline pilot training.

Now it's your turn. Observe. Reflect. Speak up. Improve the training. Share what works. Rethink what doesn't. Keep safety at the heart of everything. Because we don't just train pilots. We shape how aviation moves forward.

Thank you for coming on this journey.

I invite you to provide feedback, ask questions, share a good story from training or about airline management, I'd love to hear from you—feel free to write to me at andre737@gmail.com.

I invite you also to write an honest review online, doing so is helping other readers a lot. Please do so at the site where you did buy the book.

Safe flying and smart training



Figure 156: Sunset aerobatics

Appendix A: Why does CPDLC need training?

Despite its benefits, CPDLC introduces specific safety issues that must be managed through technology, procedures, and training:

Reduced Situational Awareness: A significant concern is the loss of the "party line" effect of voice communications. Pilots using CPDLC cannot passively monitor clearances and instructions issued to other aircraft, reducing situational awareness of the surrounding traffic.

Mitigation: Procedures may dictate preferring voice communication in complex traffic situations or potential conflict scenarios involving multiple aircraft to maintain shared awareness. Pilots must maintain increased vigilance.

Message Handling (Length/Complexity): While CPDLC allows for multi-element messages, which can reduce phonetic errors compared to long voice clearances, they introduce complexity. If a pilot cannot comply with just one element of a multi-element message, the required response is "UNABLE" for the entire message, necessitating further clarification via voice or additional CPDLC exchanges. Long or complex messages can also be ambiguous.

Mitigation: Avoid multi-element messages unless operationally necessary (e.g., for complex clearances). Use sequential single-element messages where possible.

Potential for Wrong Messages/Addressing: The ease of transmitting digital messages increases the risk of controllers inadvertently sending an instruction to the wrong aircraft or transmitting an incorrect clearance. Issues also include the lack of visible callsigns in messages.

Mitigation: Strict adherence to procedures for message reception and verification is required. If an incorrect message is suspected, an

immediate clarification using voice is the preferred method, as attempting correction via CPDLC can lead to further confusion.

Multiple Controlling Units: A potential hazard exists if an aircraft is simultaneously communicating with one ATC unit via voice and connected via CPDLC to a different unit (e.g., during sector transfer). This could lead to conflicting clearances being issued.

Mitigation: Robust procedures are needed to restrict CPDLC usage during transfer phases or before initial voice contact is established with the controlling sector. Data authority management protocols within the CPDLC system are designed to prevent this.

Message Interpretation Errors: Even standardized CPDLC messages can be misinterpreted by flight crews. For example, the message "WHEN CAN YOU ACCEPT FL [XXX]" (a request for information) could be mistaken for a clearance to climb to that level.

Mitigation: Flight crews must carefully read and confirm their understanding of received messages. If any ambiguity exists, clarification should be sought immediately via voice. Controller monitoring of aircraft response and adherence to clearances is crucial. Training should emphasize potential ambiguities in standard messages.

System Performance & Latency: The inherent delay in data link systems means CPDLC is unsuitable for time-critical commands requiring immediate execution.

Mitigation: Controllers must account for potential latency when issuing instructions via CPDLC and revert to voice for urgent situations. Performance monitoring helps ensure the system meets the required transaction times (see Section 3.2, PBCS).

Log-on/Connection Issues: Establishing and maintaining a CPDLC connection can be affected by incorrect log-on parameters, mismatches between filed flight plan data and aircraft inputs, or network issues leading to Provider Aborts (PAs) or unexpected disconnections.

Appendix A: Why does CPDLC need training?

Mitigation: Accurate flight planning and adherence to log-on procedures are essential. ANSPs and Communication Service Providers (CSPs) implement monitoring systems to detect and address connectivity issues.

Limited flight Deck Screen Real Estate: In many commercial jets, CPDLC is an add-on. Currently only the B787/A350 and some A380s have it integrated into the systems of the aircraft. Other jets use dedicated terminals (if you are lucky) for CPDLC communications, but mainstream B737/A320 (and B767/A330) use the flight management computer screen, effectively hijacking half of its pilot interface!

Mitigation: New definition of pilot monitoring/pilot flying roles when CPDLC is in use regarding the programming of the flight management computer and, possibly, pilot area of responsibility.

Acknowledgment of a CPDLC Message is a Single Action: When using voice, the pilot flying will be fully aware of all transmissions by the pilot monitoring and the controller. A CPDLC message is accepted or dismissed by a single action. Any pilot can acknowledge or dismiss a message without the other pilot being aware.

Mitigation: CPDLC messages need to be verbalized. Only after agreement by both pilots, the message/clearance can be accepted (or not).

Cyber security threats: The network structure of ACARS, on which the CPDLC application depends, is prone to cyber-attack. See my book *Skywards: Managing Flight Operations* (Berger, 2025), for details.

Mitigation: Strict adherence to procedures for message reception and verification is required. If an incorrect message is suspected, immediate clarification using voice is the preferred method.

Beyond this list, CPDLC needs specific training **based on (too many) incident reports:**

Specific Message Training: Pilot and controller training programs must explicitly cover the correct meaning, intended use, required responses, and documented potential misinterpretations of known problematic messages, particularly UM148 (*WHEN CAN YOU ACCEPT FL[XXX]*) which is a request, not a clearance and UM79 (*CLEARED TO [position] VIA [route clr]*), which is **not** a direct clearance to the first waypoint, as well as conditional clearances. Simulator scenarios should reinforce correct interpretation and response procedures.

Human Factors Awareness: Training should integrate modules focused on human factors relevant to data link operations, including expectation bias, complacency, managing workload during CPDLC tasks, strategies to maintain situational awareness despite the loss of the voice "party line," and procedures for managing distractions during message review and response.

FMS Interaction Training: Specific training and practice are required on procedures for loading CPDLC clearances into FMS, emphasizing manual reloading requirements for certain message types (e.g., UM79 (*CLEARED TO [position] VIA [route clr]*), with SIDs) and robust verification techniques before execution.

Contingency Procedures: Crews and controllers must be proficient in procedures for handling CPDLC system failures, unexpected disconnections (PAs), and the seamless reversion to voice communication when necessary.

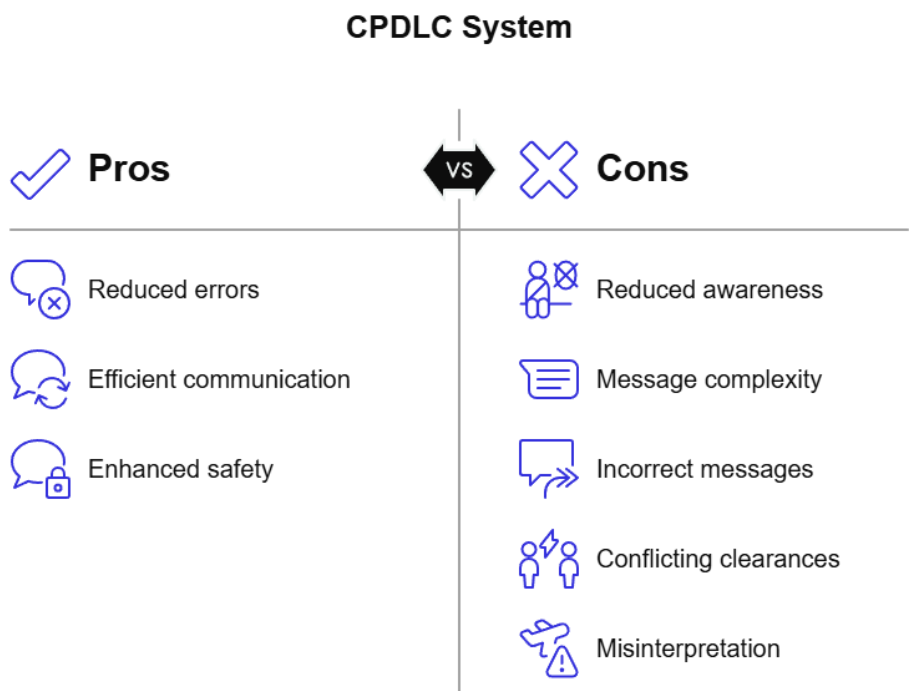


Figure 157: CPDLC

Appendix B: FSTD Core Competency Transfer

This section analyzes in depth the transfer of each of the nine core pilot competencies from the simulator environment to real-world aircraft operations, based on analyzing available open-source evidence. While this book is not about the details of course design, I decided to include it to provide the reader with the method used to assess and adapt any pilot training course. It gives an idea of how I come to the conclusions advocated in this book.

Application of Knowledge (KNO) (PC 0)

- **Simulator Training Focus:** KNO is often assessed implicitly during simulator training through the correct execution of procedures, effective problem-solving in response to simulated malfunctions, and the articulation of understanding during briefings and debriefings. Training scenarios are specifically designed to challenge the pilot's ability to access and apply relevant knowledge under pressure. Simulators provide a context to practice applying knowledge, such as using the Quick Reference Handbook (QRH) during a simulated system failure.
- **Evidence of Simulator Effectiveness:** Simulators, including VR and desktop variants, have shown high effectiveness in training procedural tasks that rely heavily on underlying knowledge. The cognitive fidelity of the simulation – how well it replicates the mental demands of the task – is crucial for training knowledge application.
- **Analysis of Transfer to Real-World Performance:** The transfer of KNO appears to be strong for recalling and applying standardized knowledge, such as aircraft limitations, standard operating procedures, or basic system functions, especially when practiced repeatedly in context. However, a significant challenge lies in transferring the ability to flexibly

synthesize, integrate, and apply diverse sources of knowledge to manage *novel* or complex, unexpected situations, particularly under high stress or workload. The artificiality of the simulator environment may not fully replicate the cognitive pressures influencing knowledge retrieval and application in real emergencies. Methodologies specifically designed to bridge the gap between theoretical knowledge and practical application, integrating cognitive psychology principles, are being explored to enhance this transfer.

- **Insights & Implications:** The effectiveness of transferring Application of Knowledge appears heavily dependent on the training methodology employed. Rote learning of facts or procedures may demonstrate limited transferability compared to scenario-based approaches that compel pilots to actively retrieve, integrate, and apply knowledge within a dynamic operational context. Simulators provide this essential context, but the design of the training scenarios (e.g., complexity, ambiguity) and the quality of debriefing are paramount for facilitating the transfer of applicable knowledge, rather than mere recall. Furthermore, assessing the true transfer of KNO requires evaluating pilot performance not just in repeated scenarios, but in confronting novel situations that demand adaptive knowledge application. This presents a challenge for traditional check-ride formats but aligns with the CBTA/EBT philosophy's emphasis on developing resilience to handle the unexpected.

Application of Procedures & Compliance with Regulations (PRO) (PC 1)

- **Simulator Training Focus:** This competency forms the backbone of much simulator training. Pilots repeatedly practice normal, abnormal, and emergency procedures, checklists, and adherence to operational protocols. Assessment is based on direct observation of procedural execution and adherence to standards.

- **Evidence of Simulator Effectiveness:** Simulators are highly effective platforms for learning, practicing, and reinforcing procedural skills. Studies using TER often show high positive transfer ratios for procedural tasks, indicating significant efficiency gains compared to aircraft-only training. Even lower-fidelity devices like VR and desktop simulators demonstrate potential for training procedural elements. Simulator practice improves procedural memory, making recall and execution more automatic.
- **Analysis of Transfer to Real-World Performance:** There is strong positive transfer for routine procedures learned through repetition in the simulator. Pilots become proficient in the sequence of actions required. However, the transfer of consistent *compliance* in the real world can be less certain. Factors that can negatively impact transfer include simulator limitations or inaccuracies that might lead pilots to adopt slightly modified techniques, or the lack of real-world pressures (time constraints, distractions, stress, ...) potentially affecting adherence to procedures during actual line operations. Effective transfer also depends on pilots understanding the rationale (*why*) behind procedures, not just memorizing the steps (*how*), to enable appropriate adaptation when necessary.
- **Insights & Implications:** While simulators excel at teaching the *mechanics* of procedures, ensuring their consistent and correct application (compliance) under the variable conditions of real-world flight requires more than rote practice. It necessitates integrating procedural knowledge with situational awareness (SAW) and effective problem-solving/decision-making (PSD). Knowing *how* to perform a procedure is distinct from knowing *when* to apply it, *why* it is critical, and how to *adapt* it if the situation demands. Real-world pressures and novel circumstances, which are imperfectly replicated in simulators, can lead to procedural deviations. Therefore, **effective transfer relies on**

integrated, scenario-based training (like LOFT or EBT) that links procedures to the broader operational context. Additionally, the risk of negative transfer exists if simulator fidelity is insufficient or if procedures trained in the simulator diverge, even subtly, from those required in the aircraft. This demands careful simulator qualification, fidelity management, and vigilant instruction.

Communication (COM) (PC 2)

- **Simulator Training Focus:** Communication skills are primarily practiced and assessed during multi-crew simulator sessions, such as Multi-Crew Cooperation (MCC) training, Line-Oriented Flight Training (LOFT), and CBTA/EBT scenarios. This involves interactions between crew members, simulated ATC communications (role-played by the instructor or using automated systems like AI-driven Simulated Air Traffic Control Environments (SATCE)), crew briefings, and post-flight debriefings. Assessment relies on observing clarity, accuracy, timeliness, adherence to standard phraseology, and specific CRM behavioral markers related to communication.
- **Evidence of Simulator Effectiveness:** Simulators provide the essential multi-agent context (fellow crew members, ATC) necessary for practicing and refining communication skills in an operational setting. LOFT is recognized as a key tool for developing and reinforcing effective CRM communication patterns. Emerging technologies like AI-driven Simulated Air Traffic Control Environments (SATCE) aim to further enhance the realism and effectiveness of ATC communication training.
- **Analysis of Transfer to Real-World Performance:** Positive transfer is likely for standardized elements like ICAO phraseology and routine communication protocols that benefit from repeated practice. However, transferring the more nuanced aspects of effective communication – such as

assertiveness, active listening under high workload, conflict resolution, and maintaining clarity under significant stress – presents greater challenges. The inherent artificiality of the simulator environment, particularly the lack of genuine interpersonal consequences and real-world stressors, can limit the transfer of these higher-order communication skills. The quality of instructor facilitation and, critically, the debriefing process, where communication breakdowns or successes are analyzed, is vital for reinforcing effective habits and promoting transfer. Assessing non-technical skills like communication can also exhibit lower inter-rater reliability compared to technical skill assessments.

- **Insights & Implications:** The effectiveness of transferring communication skills is highly dependent on the realism of the *dynamics* simulated, extending beyond the technical presence of another crew member or an ATC voice. Achieving high-fidelity transfer for skills like assertiveness or conflict resolution may require sophisticated role-playing by instructors or advanced AI systems capable of simulating realistic interpersonal interactions. While standard callouts are readily learned, effective communication involves navigating ambiguity, managing gradients, and ensuring mutual understanding under pressure. Simulators often lack the interpersonal pressures and stakes of the real flight deck; transfer relies on high-quality scenarios and debriefings that target these aspects. Assessing communication competency necessitates evaluating not just the content of messages, but also their delivery, reception, and the interaction, requiring trained observers utilizing behavioral markers.

Flight Path Management – Automation (FPA) (PC 3)

- **Simulator Training Focus:** FPA is a fundamental component of type rating training and recurrent checks. Simulator sessions provide extensive opportunities to practice programming the FMS, selecting appropriate

autopilot/autothrust modes for different flight phases, monitoring automated flight progress, intervening when necessary, and managing mode transitions.

- **Evidence of Simulator Effectiveness:** High-fidelity simulators excel at replicating the functionality and interfaces of modern aircraft automation systems. They provide an effective environment for learning the procedural aspects of operating these systems – the "button pushing" and sequence of inputs required for various tasks.
- **Analysis of Transfer to Real-World Performance:** The transfer of the *procedural* aspects of automation management (e.g., how to enter a flight plan, how to select vertical speed mode) is generally considered strong due to the high functional fidelity of modern simulators. Pilots become proficient in manipulating the systems. However, a well-documented challenge lies in the transfer of a deeper, conceptual understanding of automation behavior. Issues related to automation surprises, mode confusion, and inadequate monitoring persist in line operations, suggesting gaps in the transfer of cognitive skills related to FPA. Over-reliance on automation and difficulties in predicting or interpreting its actions, especially during non-normal situations or high workload, indicate that procedural training alone is insufficient. Effective transfer requires not just knowing *how* to use the automation, but *understanding* its underlying logic, limitations, and potential failure modes.
- **Insights & Implications:** Achieving effective transfer for Flight Path Management – Automation necessitates training that extends beyond procedural proficiency. It requires cultivating a deep conceptual understanding of the automated systems and fostering robust monitoring strategies. Pilots must develop accurate mental models of how the automation functions, its different modes of operation, and its limitations. Training solely focused on procedural steps ("buttonology")

may not adequately prepare pilots to anticipate automation behavior, detect subtle anomalies, or intervene appropriately, particularly in non-normal situations. This highlights a potential gap where pilots learn the *mechanics* of automation use in the simulator but may struggle to transfer the *cognitive skills* of effective monitoring, mode awareness, and system understanding to the complexities of real-world operations. Furthermore, the significant variation in automation design philosophies and interfaces across different aircraft types means that FPA skills learned on one type may not readily transfer to another, underscoring the continued importance of type-specific simulator training.

Flight Path Management – Manual (FPM) (PC 4)

- **Simulator Training Focus:** Simulators are extensively used to practice manual flying skills, including takeoffs, landings (normal and crosswind), standard maneuvers (e.g., steep turns, climbs, descents), instrument approaches, stall recognition and recovery, and Upset Prevention and Recovery Training (UPRT).
- **Evidence of Simulator Effectiveness:** Simulators are demonstrably effective for teaching and practicing basic manual handling maneuvers conducted within the normal flight envelope. TER studies confirm positive transfer for many standard flight tasks. For UPRT, simulators are essential, as practicing stall and upset recoveries in actual transport-category aircraft are often impractical or unsafe. Simulator training has been shown to improve pilots' procedural memory for executing recovery actions effectively.
- **Analysis of Transfer to Real-World Performance:** The transfer of manual flying skills is generally strong for procedures and basic handling *within the simulator's validated flight envelope*. However, significant challenges and limitations exist. Transfer is often poor for skills heavily

reliant on subtle sensory feedback, such as the visual and kinesthetic cues needed for judging the landing flare or the tactile feedback (buffet) indicating an approaching stall. Fidelity limitations, particularly in motion cueing and control loading, significantly impact the transfer of skills for maneuvers involving complex dynamics or excursions outside the validated envelope. Inaccurate simulator modeling in these regimes poses a considerable risk of negative transfer, where pilots learn incorrect responses. Lower-fidelity devices like VR or desktop simulators show marked limitations for training aircraft handling tasks compared to procedural ones. If overreliance on automation is the airline policy in line operations (*I strongly advocate against this*), it raises big concerns about the degradation of manual flying skills due to lack of regular practice, making regular simulator-based refresher training crucial.

- **Insights & Implications:** The transferability of manual handling skills is highly contingent on the simulator's fidelity *relative to the specific demands of the maneuver being trained*. Basic instrument flying, relying primarily on visual instrument interpretation and procedural control inputs, may transfer reasonably well even from simulators with limited motion. Conversely, UPRT, which involves complex aerodynamic effects and requires accurate perception of motion and control forces, demands high, specifically validated fidelity, and even then, gaps in transfer related to sensory cues may persist. This difference arises because controlling the aircraft based on instruments involves different perceptual pathways than feeling the subtle cues of an impending stall or managing the dynamic forces during an upset recovery. Low-fidelity devices may suffice for learning the procedural *sequence* of a maneuver but are generally inadequate for developing the nuanced physical *feel* required for effective transfer of handling skills. The requirement for specific FSTD qualification for UPRT reflects these

demanding fidelity needs. Moreover, the potential for manual skill decay due to automation reliance necessitates dedicated, regular practice, likely exceeding minimum regulatory requirements, for which simulators are the primary and often only practical venue.

Leadership & Teamwork (LTW) (PC 5)

- **Simulator Training Focus:** LTW competencies are a primary focus of MCC, LOFT, and EBT simulator scenarios. These sessions place pilots in realistic multi-crew operational contexts where teamwork and leadership are essential for managing tasks and resolving simulated problems. Assessment is typically conducted using behavioral markers linked to CRM principles. Regulatory mandates, such as the FAA's requirement for Leadership, Command, and Mentoring training, often utilize LOFT as a key training and assessment platform.
- **Evidence of Simulator Effectiveness:** Simulators provide the indispensable multi-crew environment required to practice and observe LTW skills in action. LOFT allows instructors and evaluators to see how crews function as a team under pressure, revealing strengths and weaknesses in coordination, communication, and leadership.
- **Analysis of Transfer to Real-World Performance:** Transferring LTW skills learned in the simulator to the actual flight deck presents significant challenges. While the *procedures* associated with teamwork (e.g., conducting briefings, standard callouts) can be effectively practiced and transferred, replicating the *quality* of leadership, the nuances of interpersonal dynamics, and the effects of genuine stress on teamwork is difficult within the artificial confines of a simulator. The lack of real-world consequences can alter crew interaction patterns compared to actual flight. Consequently, the effectiveness of transfer relies heavily on the quality of the scenario design (its ability to elicit relevant CRM behaviors),

the skill of the instructor in facilitating realistic crew interaction, and, crucially, the thoroughness of the debriefing process in analyzing CRM performance against established markers. The persistence of CRM-related issues in accident and incident analyses suggest that gaps in transfer remain.

- **Insights & Implications:** Achieving effective transfer for Leadership and Teamwork competencies seems less dependent on the physical fidelity of the simulator (e.g., motion, visuals) and more reliant on the *quality of the instructional design* – specifically, the scenario's ability to create meaningful challenges requiring crew collaboration and the effectiveness of the debriefing in analyzing and reinforcing desired CRM behaviors. Leadership and teamwork are primarily social and cognitive skills. While the simulator provides the necessary operational *context*, the stimulus for effective LTW often arises from the scenario's complexity and the interpersonal dynamics facilitated by the instructor. Significant learning and reinforcement, leading to potential transfer, occur during the *debrief*, where observed behaviors are explicitly discussed and linked to CRM principles. Thus, instructor competency in CRM facilitation and debriefing is arguably more critical for LTW transfer than the simulator's technical specifications. Furthermore, assessing LTW objectively in a simulator remains challenging due to its inherent subjectivity. It requires well-defined, observable behavioral markers and professionally trained, calibrated instructors or evaluators to ensure consistency and reliability.

Problem-Solving & Decision-Making (PSD) (PC 6)

- **Simulator Training Focus:** PSD is primarily exercised and assessed through abnormal and emergency scenarios presented during LOFT and CBTA/EBT sessions. These scenarios require crews to diagnose problems, evaluate risks, consider options, and implement a course of action. PSD is

often closely intertwined with Situational Awareness (SAW) and Workload Management (WLM). Assessment involves observing the crew's decision-making process (information gathering, communication, rationale) and the effectiveness of the chosen solution.

- **Evidence of Simulator Effectiveness:** Simulators allow for the training of decision-making models (e.g., T-DODAR, FORDEC) and help develop recognition-primed decision skills through exposure to various problem types. Research suggests cognitive reflection ability is a predictor of decision-making performance in simulator scenarios.
- **Analysis of Transfer to Real-World Performance:** The transfer of structured decision-making *processes* learned in the simulator is feasible. Pilots can learn and practice steps like gathering information, identifying options, assessing risks, and communicating decisions. However, guaranteeing the transfer of effective decision-making *under genuine stress, ambiguity, and uncertainty* remains challenging. The psychological fidelity gap – the difference between simulated stress and real-world pressure – can significantly affect decision quality. The persistence of decision errors as contributing factors in accidents suggests limitations in transfer. Effective transfer likely depends on developing underlying cognitive flexibility, managing cognitive biases (which can be exacerbated under stress), and enhancing resilience. Training is specifically designed to improve pilot resilience in the face of surprise aims to bolster PSD capabilities in unexpected events.
- **Insights & Implications:** The transfer of Problem-Solving and Decision-Making skills hinges less on learning specific solutions to pre-defined simulator problems (as real-world issues are often novel) and more on transferring the *underlying cognitive and metacognitive skills*. This includes accurate situation assessment (SAW), robust risk analysis,

creative yet sound option generation, and metacognition – the awareness and regulation of one's own thinking processes, including recognizing potential biases. Real-world problems rarely perfectly mirror simulator scenarios. Therefore, effective PSD relies on adapting knowledge and processes dynamically. While simulators are valuable for practicing the *process* of decision-making, the *quality* of the decision often depends heavily on accurate situational understanding (SAW) and the ability to manage cognitive biases under genuine stress, aspects that are difficult to fully replicate and transfer from the simulated environment. Training focused on resilience directly targets the improvement of PSD in unexpected, high-stress situations. Furthermore, effective PSD training requires simulator scenarios that incorporate genuine ambiguity, conflicting data, and realistic time pressures, coupled with debriefing techniques that meticulously analyze the *decision-making process* itself, including information gathering and risk assessment, rather than solely focusing on the outcome.

Situation Awareness & Management of Information (SAW) (PC 7)

- **Simulator Training Focus:** SAW is implicitly required and trained in nearly all simulator exercises. LOFT scenarios are often designed to challenge pilots' monitoring capabilities, information processing, and anticipatory skills. Assessment involves observing crew actions, communication (e.g., verbalizing threats), decisions made, and using specific probes or questions during debriefing to gauge their understanding of the situation.
- **Evidence of Simulator Effectiveness:** Simulators provide the complex, dynamic environments necessary to practice and develop SAW skills. Research confirms that targeted simulator training can significantly enhance pilots' situational awareness. Studies suggest that SAW can be trained across

distinct levels of simulator fidelity, indicating that high physical fidelity might not be the sole determinant. Visual aids within simulators can also be designed to support the development of SAW. Objective measures, such as eye-tracking, show promise for assessing attentional allocation and potentially SAW in simulators.

- **Analysis of Transfer to Real-World Performance:** SAW is generally considered a transferable skill, as the fundamental cognitive processes of perceiving environmental cues, integrating information, and projecting future states can be practiced effectively in realistic simulated environments. However, several factors can limit or impede transfer. Gaps in simulator fidelity might mean critical real-world cues are missing or misrepresented. The simulator environment itself can introduce artificial attentional demands (e.g., managing the simulator interface) that differ from real flight. Crucially, the lack of genuine risk and consequences in the simulator might affect vigilance and the perceived importance of maintaining high SAW compared to actual flight operations. Studies have also shown that monitoring effectiveness, a key component of SAW, can degrade under specific stressors.
- **Insights & Implications:** The successful transfer of Situation Awareness hinges on the simulator's ability to present the *correct informational cues* at the *appropriate time* with sufficient *cognitive fidelity* to activate the same perceptual and comprehension processes pilots would use in the real aircraft. SAW is about constructing an accurate mental model of the environment based on available cues. If the simulator fails to provide critical cues (e.g., subtle auditory changes, realistic weather depictions, accurate system feedback) or introduces artificial elements, the mental model developed during training may be incomplete or inaccurate, hindering transfer to the aircraft. Therefore, cognitive fidelity is arguably more critical than high physical fidelity for robust SAW transfer. Furthermore, training *metacognitive skills* related to SAW –

that is, training pilots to actively monitor their own level of awareness and recognize when it might be degrading – could be a key factor in improving transfer. This allows pilots to become more adept at identifying and compensating for potential SAW breakdowns in the demanding real-world environment. Effective debriefing techniques play a crucial role in developing this self-monitoring capability.

Workload Management (WLM) (PC 8)

- **Simulator Training Focus:** WLM is addressed through the design of complex LOFT scenarios that deliberately impose high task demands, time pressure, and multiple concurrent activities. Instructors assess WLM by observing task prioritization, delegation, error rates under pressure, communication patterns related to workload, and the crew's strategy for using automation to manage load.
- **Evidence of Simulator Effectiveness:** Simulators provide a platform to safely practice WLM strategies in demanding situations that might be hazardous in actual flight. Workload can be assessed subjectively using tools like the NASA Task Load Index (TLX) and increasingly objectively through physiological measures like functional near-infrared spectroscopy (fNIRS) or eye-tracking metrics within the simulator environment. Training in simulators can lead to improved performance under high workload conditions.
- **Analysis of Transfer to Real-World Performance:** Transferring WLM skills is complex. Pilots can learn and practice specific strategies for task prioritization and resource allocation in the simulator. However, the subjective *perception* of workload and the physiological response to stress can differ significantly between the simulated environment and the actual aircraft. The absence of real-world stressors (e.g., passenger awareness, tangible risk to life and equipment) can mean that the workload experienced in the simulator does not fully equate to the workload felt during a

similar event in flight. Therefore, the transferability of WLM strategies depends not only on the realism of the simulated task demands but also on the pilot's ability to apply those strategies effectively under genuine operational pressure. Interaction with automation is a critical component of workload management in modern cockpits, and how this is trained significantly impacts transfer.

- **Insights & Implications:** Achieving effective transfer for Workload Management requires training pilots not only in the *techniques* for managing tasks (prioritization, delegation) but also in accurately *perceiving* their own workload levels and recognizing their capacity limits under varying degrees of stress. This self-perception aspect is particularly challenging to replicate fully in a simulator due to the inherent psychological safety net. WLM involves both the objective demands of the situation and the pilot's subjective experience and response. While simulators can effectively replicate complex task demands, the subjective feeling of stress and workload might be attenuated compared to real flight. If pilots do not experience realistically perceived high workload in the simulator, the coping strategies they practice might prove less effective when confronted with genuinely high perceived workload in the aircraft. This suggests that training focused on resilience and stress management is intrinsically linked to the effective transfer of WLM skills. Furthermore, the advent of objective workload measurement tools applicable in simulators (e.g., fNIRS, eye-tracking) offers significant potential for improving the understanding and training of WLM, possibly leading to better transfer compared to relying solely on subjective reports or instructor observation.

The Role of Fidelity Revisited

The concept of fidelity, or the degree to which a simulator replicates reality, is central to understanding training transfer. As mentioned

before, the assumption that higher fidelity always equates to better training is an oversimplification.

Research indicates a non-linear relationship between fidelity and learning. While high fidelity might be necessary for expert assessment or complex skill refinement, it can overwhelm novices, potentially hindering initial learning due to excessive cognitive load. Cognitive Load Theory suggests that reducing extraneous load during training can free up resources for learning. Understanding this is key to the design of any “immersive” course, e.g., the Immersive MPL course. As explained previously, immersive training is how younger generations prefer to learn. If the training aid is immersive, the training program and the instructor must compensate for this by initially focusing on simple tasks. If not, medium or even selective low fidelity devices might be better for certain training objectives, particularly early in learning or for procedural tasks.

The increasing focus on transferring complex competencies like PSD and SAW highlights the growing importance of cognitive and psychological fidelity, ensuring the simulator replicates the essential mental challenges and pressures of the operational environment. The optimal blend of fidelity dimensions is not fixed but depends on the specific competency being addressed and the trainee's level of expertise. A one-size-fits-all, maximum-fidelity approach may be neither cost-effective nor pedagogically optimal across the entire training spectrum.

Conclusion

The analysis confirms that FSTDs are playing a critical role in developing and assessing the core competencies. Evidence indicates strong positive transfer for well-defined procedural skills (PRO, KNO application in standard scenarios), basic manual handling within the validated envelope (FPM), and the mechanics of automation use (FPA). Simulators provide the necessary context for practicing communication (COM) and teamwork/leadership (LTW) skills, and for exercising problem-solving/decision-making (PSD),

situational awareness (SAW), and workload management (WLM) in complex scenarios.

However, significant challenges and limitations to transfer exist. The transfer of nuanced manual handling skills requiring subtle sensory feedback (FPM), the application of knowledge to truly novel situations (KNO), and the effective execution of non-technical skills (COM, LTW, PSD, SAW, WLM) under genuine operational stress are less reliably achieved due to inherent simulator fidelity limitations (physical, functional, cognitive, and especially psychological).

Appendix C: Legal Considerations Regarding Use of Cameras in Pilot Training

Navigating the Legal Maze: ICAO

The use of cameras in pilot training is not part of specific ICAO recommendations.

ICAO Annex 13, which primarily addresses Aircraft Accident and Incident Investigation, contains provisions for the protection of cockpit voice recordings (CVRs) and airborne image recordings (AIRs). It stipulates that such recordings should not be made available for purposes other than accident or incident investigation unless a competent authority determines that their disclosure or use outweighs the potential adverse impacts on future investigations. There is an ongoing effort by bodies like IFALPA to broaden the ICAO definition of "cockpit recording" to explicitly include recordings made by any device, including portable action cameras, thereby extending these protections more clearly to such footage.

ICAO Annex 6 (Operation of Aircraft) limits the use of CVR and AIR data from routine operations, generally prohibiting their use for purposes other than ensuring safety and requiring appropriate safeguards when they are used. Furthermore, ICAO Annex 19 (Safety Management) emphasizes the principle of protecting safety data and safety information, stating that it should not be used for purposes other than maintaining or improving safety. It also notes that ambient workplace recordings (which could include action camera footage) are generally governed by national privacy laws.

While ICAO provides a high-level international framework, the specific regulations governing the use of action cameras for training,

especially concerning data privacy, fall largely to national and regional authorities.

European Union (EU)

GDPR (General Data Protection Regulation): The GDPR is a comprehensive data protection law that has significant implications for the use of action cameras in pilot training within the EU, or when processing the personal data of EU residents, regardless of the training organization's location due to its extraterritorial reach. Video footage of identifiable trainees (and instructors) is personal data.

Lawful Basis for Processing: A valid lawful basis is required for processing personal data. For training footage, consent is a primary and often most appropriate lawful basis. GDPR mandates that consent must be freely given, specific (detailing each purpose of processing), informed (providing clear information about the processing), and unambiguous (indicated by a clear affirmative action). Trainees must have the right to withdraw their consent at any time, and this process must be as easy as giving consent. While "legitimate interest" could potentially be argued as another lawful basis, it requires a careful balancing test against the rights and freedoms of the data subjects and is generally more complex to rely upon for routine recording of individuals.

Data Minimization: Only personal data that is necessary for the specified training purpose should be collected. This means footage should be focused and relevant, avoiding unnecessary capture of individuals or information not pertinent to the training objectives.

Purpose Limitation: Data collected must only be used for the specified, explicit, and legitimate purposes for which consent was obtained. Using training footage for marketing, for example, would require separate, specific consent.

Data Subject Rights: Trainees (and instructors) have robust rights under GDPR, including the right to access their personal data, the right to rectification (correction of inaccurate data), the right to

erasure ("right to be forgotten" under certain conditions), the right to restrict processing, and the right to data portability. The Spanish Aviation Safety Agency (AESA), for example, explicitly outlines these rights for the data it processes, which serves as a national example of GDPR implementation.

Data Security: Strong technical and organizational measures must be implemented to protect personal data from unauthorized access, loss, or misuse. This includes measures like encryption, access controls, and secure storage solutions.

Data Retention: Personal data should not be stored for longer than is necessary to achieve the purpose for which it was collected. Clear retention policies for training footage must be established and adhered to. While AESA notes that videos from its promotional events might be kept indefinitely if they remain valid for promoting data protection rights, this context is distinct from individual training footage, which would typically have a more defined and limited retention period tied to the training cycle and assessment needs.

EASA (European Union Aviation Safety Agency) also provides guidance on post-flight debriefing that aligns well with the use of recorded data to enhance learning.

United States of America (USA)

FAA Regulations: In the USA, there is no specific FAA regulation on the use of action cameras for the purpose of flight training debriefs under either 14 CFR Part 61 (for non-certificated schools and independent instructors) or Part 141 (for FAA-certificated pilot schools). However, several general operational and safety rules are pertinent:

Use of Personal Electronic Devices (PEDs): Regulations such as 14 CFR §121.542 also restrict the use of unapproved PEDs by operating crew members during all flight phases. While action cameras are not

classified as typical PEDs like smartphones, the intent to minimize potential electronic interference and distraction is similar.

Camera Mounting and Aircraft Alteration: Attaching a camera to an aircraft is considered an aircraft alteration by the FAA. A minor alteration, which has no appreciable effect on weight, balance, structural strength, performance, powerplant operation, flight characteristics, or other airworthiness qualities, typically requires only an A&P mechanic's logbook entry. A major alteration, which does affect these qualities, requires an FAA Form 337 (Major Repair and Alteration) and sign-off by an IA (Inspection Authorization) mechanic. Most action camera installations using temporary mounts (like suction cups or clamps) are treated as minor, but the Pilot in Command (PIC) remains ultimately responsible for ensuring the attachment is secure and does not pose a hazard.

Privacy Considerations and Airline Policies: Unlike the EU, the USA does not have a single, overarching federal data privacy law analogous to GDPR that broadly governs the collection and use of personal data. Some state laws, like the California Consumer Privacy Act (CCPA) as amended by the California Privacy Rights Act (CPRA), provide extensive privacy rights to California residents, but their direct applicability to flight training footage collected in other states or from non-residents would need careful case-by-case assessment.

Despite the lack of a unified federal privacy law, privacy is a significant concern within the U.S. aviation community. Many major airlines explicitly prohibit unauthorized filming or photography in the flight deck, citing security concerns, compliance risks, and company policy.

Pilot unions, such as the Air Line Pilots Association (ALPA) and the Allied Pilots Association (APA), have opposed mandatory cockpit imaging systems, citing concerns about pilot privacy, the potential for misuse of recordings, and arguing that existing CVR and FDR data are sufficient for accident investigation purposes. They also oppose

the use of cameras during training sessions or data recording from simulator sessions.

Most trainees and instructors will allow the use of cameras in a trusted environment to enhance training and safety.

Africa (Regional and National Examples)

The regulatory landscape in Africa regarding data privacy and specific rules for cockpit recordings in training is evolving.

AFCAC (African Civil Aviation Commission): AFCAC works towards harmonizing aviation safety rules and regulations across its member states. While there is no specific mention of camera use in training in the provided materials, AFCAC's focus on enhancing safety oversight is a relevant backdrop.

Overall, while there is a growing awareness of data protection in many African nations, specific regulations addressing the use of action cameras in pilot training appear to be nascent. General data protection laws, where they exist, would be the primary legal instrument governing such activities.

South Africa (SACAA):

South Africa has a robust data protection framework.

The Protection of Personal Information Act (POPIA) is similar in many respects to GDPR. It requires a lawful basis for processing personal information (often consent), adherence to principles of data minimization, purpose specification, data security, and it grants data subjects rights such as access, correction, and deletion of their data. SACAA's external privacy statement confirms that consent is generally required for processing personal information.

The Promotion of Access to Information Act (PAIA) governs access to records held by public bodies like SACAA, balancing the public's

right to access information with justifiable limitations, including the protection of personal privacy and commercial confidentiality.

While no specific SACAA regulations on cockpit video for training were found in the research, POPIA and PAIA would undoubtedly apply to any personal data contained in such recordings.

Kenya (KCAA)

The Kenya Civil Aviation Authority's (KCAA) privacy policy states that personal information is collected with knowledge and consent, used for specific purposes, retained only as long as necessary, and protected through commercially acceptable means.

KCAA asserts that it does not share personally identifying information publicly or with third parties unless required by law. There is no specific mention of training video policies. It is worth noting an analogy from Australia (CASA, not KCAA), where the authority states it cannot enforce privacy matters, directing such complaints to the police or the Office of the Australian Information Commissioner. This illustrates a common stance where aviation authorities may see privacy enforcement as outside their direct safety remit.

Asia (Regional and National Examples)

Asian countries exhibit a diverse range of approaches to aviation regulation and data privacy.

Singapore (CAAS): Research did not yield specific CAAS policies on action camera use in general pilot training, but the proactive regulatory approach to modern technologies is notable.

India (DGCA): The Directorate General of Civil Aviation in India has taken a notably prescriptive approach.

The DGCA has mandated comprehensive camera monitoring in Flying Training Organizations (FTOs). This includes surveillance of runways, taxiways, apron areas, hangars, classrooms, and

examination rooms, primarily to check malpractices like false logging and to enhance DGCA oversight. Furthermore, student pilot license and radio telephone operator exams must be conducted under camera surveillance with a live feed to the DGCA's Directorate of Flying Training.

Regarding in-flight recording, FTOs operating aircraft with glass cockpits (which often have flight data recording capabilities) are required to monitor, analyze, and maintain this data. FTOs operating aircraft not pre-equipped with glass cockpits must devise a method within 90 days (from the date of the circular in late 2022) for recording and monitoring flights to verify adherence to flight authorizations. This includes installing carry-on equipment that automatically records parameters such as engine start/stop times, flight path followed, and the height and speed of the aircraft.

A separate DGCA circular also mentions the monitoring of CVR recordings by airlines to ensure flight crew occupy their designated seats, which, while focused on operational discipline rather than CBTA-style training debrief from action cameras, demonstrates the DGCA's stance on using recordings for oversight purposes. India's approach is strongly focused on compliance and oversight. The privacy implications of such extensive monitoring are significant.

Australia (CASA): The Civil Aviation Safety Authority of Australia provides detailed guidance on CBTA for flight crew, including definitions of competency and assessment methodologies. CASA's privacy statement indicates adherence to the Australian Privacy Act 1988 and the Australian Privacy Principles, which govern the collection, use, and disclosure of personal information. CASA collects information necessary for its regulatory functions. CASA clarifies that its remit is aviation safety, and it does not enforce privacy-related matters, directing such issues to state police or the Office of the Australian Information Commissioner (OAIC).

Japan (JCAB): The Japan Civil Aviation Bureau has established procedures for various safety regulations. However, specific

information regarding JCAB policies on the use of video recordings in pilot training was not available on their web site.

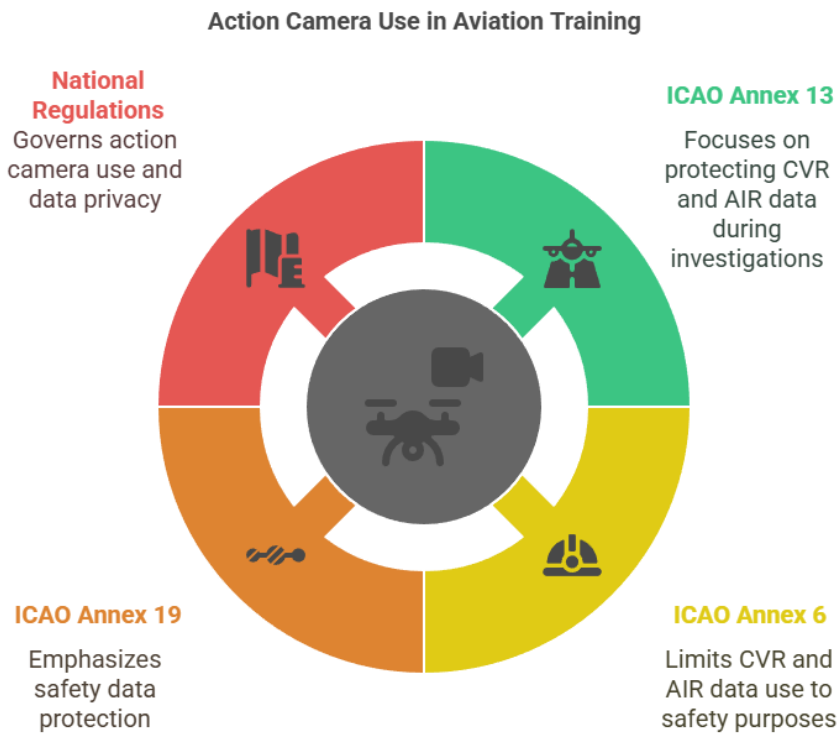


Figure 158: ICAO and action cameras

Appendix D: Decision Making Frameworks

Framework	Key Steps/Components	Primary Focus
T-DODAR	Time (assess available time), Diagnose (identify the problem), Options (generate solutions), Decide (select best option), Assign (delegate tasks), Review (monitor outcome).	Systematic, structured decision-making process, particularly effective under time pressure and in complex situations. Emphasizes thorough problem analysis and option evaluation before action.
COOL	Calm down (manage stress), Observe (gather situational data), Outline (formulate diagnosis), Lead (formulate and execute plan).	Managing the effects of startle/surprise, re-establishing situational overview, and promoting methodical analysis and action.
URP (Unload, Roll, Power)	Unload (control emotions, deep breathing, relaxation), Roll (gather and verbalize observations - see, hear, feel, smell), Power (project situation forward,	Specifically designed for startle/surprise management. Aims to inhibit fight/flight behavior, manage stress, initiate cognitive processing through systematic observation, and encourage critical

	critical thinking about information).	thinking to ensure robust situational understanding before action.
ANC AAM (Aviate, Navigate, Communicate - Assess, Action, Manage)	ANC: Prioritize Aviate (fly the aircraft), then Navigate (terrain, weather, ATC), then Communicate. AAM: After ANC, Assess situation, Action (memory items, checklist), then Manage event (diversion, pax needs).	ANC provides task prioritization. AAM structures the subsequent handling sequence, ensuring critical flight path control is maintained while addressing the non-normal event. Emphasizes continuous re-evaluation if the situation changes.
Fly-Focus-Act	Fly (maintain aircraft control), Focus (understand the situation), Act (take appropriate action).	A fundamental principle for managing unexpected events. Prioritizes aircraft control above all, followed by understanding the problem, then implementing a solution. Aligns with the core tenets of UPRT and other startle management techniques.

Appendix E: Company Training

An “Airline company” course needs to explain important items about how the airline is structured and how the people in the company work together. Many subjects are covered in my book *Skywards: Managing Flight Operations* (Berger, 2025). Below are items that need to be covered (non-exhaustive list):

1. Airline Operational Procedures

- Importance and background of Standard Operating Procedures (SOPs)
- Flight crew, cabin crew, ground crew roles and responsibilities, crew management
- Flight operations engineering
- Sources and philosophy of flight duty time limitations and rest requirements (FTL)
- Onboard technology, electronic flight bags (EFBs), and in-flight connectivity
- Radio Crew, see *Skywards: Managing Flight Operations* (Berger, 2025)

2. Safety and Security Procedures

- Airline Safety Management System (SMS)
- Threat and Error Management (TEM) at airline level
- Emergency procedures, including evacuation, ditching, and firefighting
- Security procedures, including hijack prevention and bomb threat handling
- Sources of Dangerous Goods regulations, references and background

3. Company Structure and Organizational Culture

- Airline management and structure, Management System Manual (MSM)
- Airline history, mission, vision, and values
- Organizational chart and management roles
- Reporting lines and communication flow
- Airline quality management systems and compliance monitoring systems
- Communication, teamwork, and decision-making principles
- Leadership, workload management
- Cross-cultural awareness and company-specific CRM policies
- Unions

4. Company Vision and Values, Policies, Programs

- Company Vision and Values
- Employment and contractual obligations
- Uniform standards and grooming policies
- Professional conduct, ethics, and company reputation
- Company-specific performance evaluation systems
- Health and wellness programs
- Peer support programs

5. Aircraft and Fleet Familiarization

- Fleet vision and projects
- Fleet financing
- Fleet acquisition (See Skywards: Managing Flight Operations (Berger, 2025))
- Actual fleet overview and philosophy, including fleet commonalities and differences
- Aircraft systems, cockpit layouts, and onboard equipment specific to the airline's fleet

Appendix E: Company Training

- Cabin layout, passenger management systems, and cabin crew interactions

6. Aircraft maintenance and engineering

- Fleet maintenance, maintenance costs and financing
- Actual fleet maintenance schedule
- Preventive maintenance programs
- Spare parts management
- Data recording, maintenance defect reporting, and troubleshooting procedures
- Maintenance quality control

7. Documentation and Record-Keeping

- Flight planning documents (e.g., flight plans, NOTAMs, weather briefing packages)
- Operational paperwork and logs (e.g., tech log, voyage reports, journey logs)
- Software and documentation systems (XML, document management, ...)
- Production, sources and structure of manuals (FCOM, QRH, MEL/CDL, OM-A/B/C/D)
- The three levels of documentation (See Skywards: Managing Flight Operations (Berger, 2025))
- Record keeping procedures, manual updating procedures

8. Route and Network Structure

- Airline route structure, hub-and-spoke networks, and point-to-point operations
- Destinations, alternate airports, enroute diversion strategies
- Typical operational scenarios and planning for destination-specific challenges
- Company fuel planning and fuel conservation policies

9. Customer Service and Passenger Handling

- Passenger rights and responsibilities
- Dealing with unruly passengers and special categories (children, medical cases, etc.)
- Company customer service standards and communication protocols
- Passenger announcements and in-flight service standards
- Denied boarding compensation (EU)
- Client differentiation: Business and First-class passengers (if applicable)

10. Sustainability (see *Skywards: Managing Flight Operations* (Berger, 2025):

- Environmental regulations applicable to the airline (EU ETS, CORSIA, noise abatement)
- Company fuel-efficiency policies and sustainability initiatives
- Operational practices to reduce environmental impact (continuous descent operations, reduced-thrust takeoffs, etc.) and their influence
- Impact of CO₂, NO_x, soot particles, contrails, noise, ...

Comprehensive Airline Operations Overview



Figure 159: General overview

Appendix F: Transition to CBTA

These steps provide a structured framework for operators and training organizations to transition an existing training program into CBTA effectively. If you prefer the approach proposed by IATA, these are the 12 steps:

1. Establish an Implementation Team

From a dedicated team responsible for planning, executing, and monitoring the transition to CBTA. This includes training managers, instructors, assessors, subject matter experts, and quality assurance personnel.

2. Define Training Philosophy and Objectives

Clearly define the goals of your training program based on CBTA principles. Align them with safety, operational, and regulatory objectives, and ensure buy-in from leadership and instructors.

3. Identify Operational Context

Analyze the specific operational environment (e.g., type of aircraft, route structure, weather challenges, automation use) to define the context in which pilots must demonstrate their competencies.

4. Develop Competency Framework

Use ICAO/IATA's 9 pilot core competencies as the foundation. Add the Company Values competency. Tailor them with observable behaviors that fit your operational context. Ensure these behaviors are measurable, relevant, and practical.

5. Develop Training and Assessment Plan

Design a curriculum that integrates the competencies into training sessions. Use scenario-based training (normal and non-normal) with clear learning outcomes and behavioral indicators.

6. Develop Training Scenarios

Create realistic, line-oriented training scenarios that allow trainees to demonstrate competencies in context. Include both technical and non-technical elements, such as workload spikes, unexpected events, and CRM elements.

7. Develop Assessment Tools and Grading Criteria

Establish a standardized grading scale (typically a 4- or 5-point scale). Define assessment tools that support evidence-based grading using observable behaviors tied to each competency.

8. Train Instructors and Assessors

Ensure instructors and assessors understand CBTA principles, grading philosophy, and their roles. Training should focus on behavioral observation, facilitation techniques, and minimizing subjectivity.

9. Pilot the Program

Conduct a trial run of the CBTA program with a small group. Gather feedback, assess training effectiveness, and validate your assessment tools and grading processes.

10. Monitor and Evaluate Performance

Implement systems to collect data during training. Use this data to evaluate instructor consistency, trainee progress, and program effectiveness.

11. Refine and Improve

Use feedback from instructors, assessors, trainees, and data analysis to continuously improve the training design, delivery, and assessment processes.

12. Full Implementation and Oversight

Roll out the program fully with compliance monitoring, and performance oversight. Maintain regular reviews to ensure continued alignment with operational needs.

These 12 steps align with IATA's Guidance Material and Best Practices for CBTA Implementation and ICAO Doc 9995. They ensure that training organizations can move from traditional task-based methods to performance-based training focused on developing well-rounded, competent, and resilient pilots.

Appendix G: Competency based pilot selection

A CBTA-aligned pilot selection process must systematically assess the potential for each of the core pilot competencies. For ab initio candidates, the focus is on identifying foundational elements and trainability, rather than expecting fully developed expertise. This involves integrating psychometric testing, behavioral interviews, group exercises, and trainability assessments.

Application of Procedures and Compliance with Regulations (PRO)

- *Psychometric/Aptitude Tests:* Tests measuring attention to detail, accuracy, rule comprehension, and logical reasoning can provide insights.
- *Scenario-Based Interview Questions:* Questions can probe past behaviors related to following rules or detailed instructions. For example: "Describe a situation where you had to follow a complex set of instructions very carefully. What steps did you take to ensure you completed the task accurately?"
- *Group Exercises:* Tasks that include clear rules or procedural steps allow assessors to observe a candidate's adherence to these guidelines, their tendency to seek clarification on rules, and their overall methodical approach to achieving the task objective.
- *Trainability/Rule-Following Tasks:* A simple, novel procedure can be introduced on a basic task trainer or PC-based simulation (e.g., a simplified pre-task setup sequence). Assessing responsiveness to instruction and the ability to follow procedures is a key element.

Communication (COM)

- *Psychometric/Aptitude Tests*: Verbal reasoning tests assess comprehension and logical deduction from written text. Standardized English language proficiency tests, especially where English is not the candidate's first language.
- *Scenario-Based Interview Questions*: "Describe a time you needed to explain a complex idea to someone unfamiliar with the topic. How did you ensure they understood?" Observable behaviors for communication include selecting appropriate communication means, conveying messages clearly, and confirming understanding, which can be translated into interview questions.
- *Group Exercises*: The ability to involve quieter members or summarize discussions also indicates effective communication potential.

Flight Path Management – Automation (FPA)

- *Psychometric/Aptitude Tests*: Standardized tests assessing monitoring and task management are common.
- *Scenario-Based Interview Questions*: "Imagine you are responsible for monitoring a simple automated process on a computer display that has several key parameters. What steps would you take to ensure it is functioning correctly and to identify if something is going wrong?"
- *Trainability/Basic PC-based Automation Tasks*: Candidates can be presented with a basic, non-aviation specific, computer-based task that involves monitoring dynamically changing parameters and making simple inputs based on a set of rules.

Flight Path Management – Manual Control (FPM-MC)

- *Psychometric/Aptitude Tests:* Standardized psychomotor tests assessing hand-eye coordination, tracking ability, multi-limb coordination, and task management are common. Spatial orientation tests are also relevant.
- *Trainability/Simulator Tasks:* This is a key assessment method. Candidates perform basic flight maneuvers (e.g., straight and level flight, climbs, descents, turns) on a generic fixed-base or PC-based flight simulator. Performing a figure eight (turns left and right), with a rated climb and descent are a nice method to verify learning curves. The emphasis is not on initial performance but on the rate and quality of skill acquisition over a brief period following standardized instruction and feedback. Observing how quickly a candidate grasps new concepts, corrects errors, and improves control inputs provides a strong indication of their trainability for the complex motor skills required in piloting manually.

Leadership and Teamwork (LTW)

- *Personality/Psychometric Tests:* Inventories that measure traits such as agreeableness, conscientiousness, extraversion, and empathy can provide insights into a candidate's predisposition towards teamwork and leadership behaviors. The COMPASS CPP, for example, specifically assesses personality traits underlying teamwork and leadership potential.
- *Scenario-Based Interview Questions:* "Describe a time you were part of a team working towards a challenging goal. What was your specific role, and how did you contribute to the team's success or

overcome obstacles?" or "Tell me about a situation where you had to influence a group to adopt your idea, or alternatively, a time you effectively supported another team member's lead."

- *Group Exercises:* Designed to observe LTW behaviors in a dynamic setting. Assessors look for active participation, the ability to build on others' ideas, constructive conflict management, offering and accepting support, and demonstrating initiative or effective followership. The way candidates interact, listen, and contribute to achieving a shared objective, even in non-aviation related tasks (e.g., survival scenarios, planning tasks), reveals their inherent LTW potential more authentically than self-reports.

Problem-Solving and Decision-Making (PSDM)

- *Psychometric/Aptitude Tests:* Cognitive tests that measure logical reasoning, analytical skills, and critical thinking are relevant. Deductive and inductive reasoning tests fall into this category.
- *Scenario-Based Interview Questions:* "Describe a complex problem you've faced, either individually or in a team. How did you approach understanding the problem, what information did you gather, what solutions did you consider, and how did you arrive at your final decision?"
- *Group Exercises:* Presenting the group with a problem (which could be an abstract dilemma, a logistical challenge, or a simplified operational scenario) that requires analysis, solution generation, risk assessment, and a collective decision allows observation of individual contributions to the PSDM process. The focus is on the candidate's *process* of tackling the problem—how they analyze information,

propose solutions, and defend their reasoning—rather than solely on the 'correctness' of the final group decision.

- *Situational Judgement Tests (SJTs)*: These tests present candidates with job-relevant hypothetical scenarios and a set of possible responses. Candidates are asked to rate the effectiveness of responses or choose the most and least effective actions. SJTs can be designed to assess PSDM by requiring candidates to evaluate courses of action in challenging situations.

Situational Awareness (SAW)

- *Psychometric/Aptitude Tests*: Tests measuring attention, concentration, working memory, and information processing speed are foundational. Specific tests like "Monitoring Ability" or "Spatial Memory", and comprehensive tools like WOMBAT or PILOT-360 aim to assess components of SAW.
- *Scenario-Based Interview Questions*: "Describe a situation where you had to monitor several developing factors simultaneously to ensure a positive outcome. How did you keep track of everything?"
- *Group Exercises*: Tasks where information is dynamic, incomplete, or changes during the exercise can reveal how well candidates perceive added information, integrate it into their understanding of the group's situation.
- *Trainability/Dynamic Information Management Tasks*: PC-based tasks that require candidates to monitor dynamic displays (e.g., simulated instrument panels with changing values, tracking multiple moving objects), identify critical changes or patterns, filter relevant cues from distractors, and respond appropriately provide a direct measure of information

processing and attentional skills crucial for SAW. Eye-tracking technology, even in simplified simulated environments, can offer objective data on information acquisition patterns and attentional allocation, indicating SAW potential.

Workload Management (WLM)

- *Psychometric/Aptitude Tests*: Multitasking tests are central to assessing WLM potential. Tests that assess performance under time pressure or measure stress tolerance can also be indicative.
- *Scenario-Based Interview Questions*: "Describe a time you had to juggle multiple important tasks with competing deadlines. How did you decide what to prioritize, and how did you manage your time and resources to complete them?"
- *Group Exercises*: Tasks with tight time limits and multiple components or objectives can reveal how individuals and the group manage workload, prioritize actions, and maintain composure and effectiveness under pressure.
- *Trainability/Dynamic Multi-tasking Scenarios*: PC-based tasks that require the simultaneous management of several inputs or sub-tasks, potentially with increasing complexity, induced time pressure, or mild stressors (e.g., auditory distractions), can assess a candidate's ability to sustain performance and manage their cognitive resources. The key is to observe not just if they can do multiple things, but how they prioritize and adapt when capacity is challenged.

Application of Knowledge (KNO)

- *Psychometric/Aptitude Tests*: Written tests of technical comprehension (e.g., basic physics or

mechanics, focusing on understanding principles rather than rote memorization) can be indicative. Logical reasoning tests, where understanding and applying given rules or information is key to solving problems, also tap into this competency. Knowledge tests in subjects like mathematics and physics have shown predictive validity for pilot training outcomes, partly because they are indicators of motivation and being a "good learner".

- *Scenario-Based Interview Questions:* "Describe a time you had to quickly learn a new technical concept or skill to complete a task or solve a problem. How did you approach the learning process, and how did you apply what you learned?"
- *Situational Judgement Tests (SJTs) with Embedded Information:* SJTs can be designed to present scenarios that include basic technical information or a set of rules that must be understood and applied to choose the most effective course of action.
- *Trainability/Learning Tasks:* A direct way to assess KNO potential is to present candidates with a new, simple technical concept or a set of operational rules, provide a brief learning period, and then test their ability to apply this new knowledge to solve related problems or answer questions about its implications.

Appendix H: Initial Operational Experience IOE Content by Flight Phase

The development of competencies is addressed across all phases of flight during IOE as follows:

Pre-Flight Operations

This phase is critical for safe and efficient flight. The First Officer will demonstrate:

- Applied Knowledge by thoroughly reviewing flight documentation, weather forecasts, NOTAMs, and aircraft technical status. They will participate in flight planning, including fuel calculations and alternate airport considerations.
- Application of Procedures will be evident in the meticulous execution of preflight calculations, the aircraft walk-around, cockpit preparation, and adherence to pre-flight set-up and checklists.
- Communication skills will be developed through clear and concise interactions during the crew briefing, coordination with ground personnel, and dispatch. The briefing will emphasize Leadership and Teamwork, with the First Officer actively contributing to the development of a shared mental model.
- Threat and Error Management begins here, with proactive identification of potential risks for the upcoming flight. Situational Awareness by understanding all factors affecting the flight.
- Workload Management is practiced through organized preparation.
- Company Values are demonstrated by ensuring all preparations support on-time departure (Punctuality), arriving in perfect uniform (company image projection), thoroughness in checks

(Safety), and clear understanding and sharing of flight details (Information).

Taxi-Out and Take-Off

- During taxi, the First Officer will practice Flight Path Management – Manual Control, ensuring accurate aircraft positioning and speed control and assisting the Commander when appropriate. FO demonstrates correct crosswind take off procedure Caution: transferability from light aircraft technique is negative.
- Application of Procedures remains paramount, following standard taxi routes, sterile cockpit procedures, and take-off briefings.
- Effective Communication with Air Traffic Control (ATC) and the Commander, correct use of call-outs.
- Maintaining Situational Awareness of airport signage, other traffic, and ATC instructions.
- Threat and Error Management involves vigilance for runway incursions or incorrect clearances. Workload Management during this busy phase.
- The execution of the take-off, whether as Pilot Flying (PF) or Pilot Monitoring (PM), will be a key focus, emphasizing smooth control inputs and adherence to profiles.
- Company Values of Safety and Punctuality are highlighted through precise execution and on time movement.

Climb and Cruise

In climb and cruise, Flight Path Management – Auto-Flight Systems will be a primary focus. The First Officer will practice engaging and managing the autopilot and Flight Management System (FMS), verifying inputs, and cross-checking system performance.

- Automation Management skills will be honed by understanding system modes, limitations, and practicing transitions between automated and manual flight if required or directed.
- Applied Knowledge of aircraft systems, fuel savings and management, and enroute weather phenomena will be applied.
- Communication with ATC and within the cockpit continues. This phase also provides opportunities for passenger announcements. The First Officer will learn to use the Public Address (PA) system to provide timely updates regarding flight progress, potential delays, turbulence, or weather, using a calm, reassuring tone and friendly yet formal wording, reflecting the company's commitment to client Information and Service.
- Situational Awareness involves monitoring aircraft systems, navigation, alternate airports and weather updates.
- Problem-Solving and Decision-Making may be required for weather deviations or minor system issues.
- Workload Management ensures all monitoring tasks are completed effectively. Reviewing systems, non-normal procedures, and the climatology of the region or terrain is excellent cruise control for the mind. So much better than off-topic reading (to be polite).
- Company Values are reflected in a smooth, comfortable flight (Service) and proactive system monitoring (Safety).



Figure 160: Virtual reality cruise, IOE is the first step to real cruise.

Descent, Approach, and Landing

This phase demands elevated levels of skill and attention. Energy management is crucial. FO must be able to combine FPM with good energy management (cognitive workload management) before the end of IOE.

- Flight Path Management – Manual Control will be emphasized, particularly during the later stages of the approach, flare, landing, roll-out, and taxi-in. This includes managing the aircraft's energy state during descent and approach. Precise control during flare, touchdown, and directional control during roll-out are key. The appropriate use of reverse thrust and manual braking to achieve the intended runway exit point will be practiced. Caution: transferability from light aircraft technique is negative.
- Flight Path Management – Auto-Flight Systems can be used for descent and approach phases (after excellent manual control is acquired during the first stages of IOE), with a strong emphasis on monitoring and timely intervention. Automation Management for smooth and safe transitions from automated flight to manual landing.
- Applied Knowledge of arrival procedures, instrument approach charts layout, symbols and minima, and aircraft performance.
- Application of Procedures, call outs, checklists, briefings, and stabilized approach criteria.
- Clear standard Communication with ATC and the crew.
- Situational Awareness must be excellent, considering terrain, traffic, weather, alternate airports and aircraft state.
- Threat and Error Management focuses on identifying threats like unstable approaches, ATC restriction, weather constraints or system malfunctions early.
- Problem-Solving and Decision-Making managing unexpected events or deviations from the planned approach.

- Workload Management to prevent task saturation.
- Company Values of Safety (stabilized approach, precise landing) and Punctuality (efficient arrival sequencing).

Taxi-In and Post-Flight Operations

After landing,

- Flight Path Management – Manual Control is used for taxiing to the parking stand.
- Application of Procedures includes after-landing checks, shutdown procedures, and post-flight.
- Communication with ground crew and ATC.
- Situational Awareness during taxi in a potentially congested ramp area.
- Workload Management ensures all tasks are completed efficiently.
- The post-flight debriefing, focusing on all competencies and identifying lessons learned.
- Company Values by efficient taxi to the gate (Punctuality) and securing the aircraft (Safety).

Observable Behaviours During IOE

Preflight

Applied Knowledge:

- FO knows the route and airports, including escape routes and alternate airports and terrain.
- FO understands the general climatology and its hazards of the applicable region(s).
- FO has a general overview of the weather systems affecting the flight, both at airport level and during climb, cruise, descent.
- FO accurately interprets weather products (METARs, TAFs, charts) and discusses their implications for the flight.

Appendix H: Initial Operational Experience

- FO relates this to the applicable weather minima at all relevant airports.
- FO correctly identifies, prioritizes in function of importance and discusses relevant NOTAMs affecting the route, departure, arrival and alternate airports.
- FO demonstrates understanding of aircraft technical status by reviewing the logbook and querying any relevant entries.
- FO actively participates in fuel planning, explaining rationale for fuel figures based on flight plan and conditions. Fuel saving strategies are discussed as needed.
- FO quickly and accurately reviews MEL items (if applicable) and locates MEL information.

Application of Procedures:

- FO performs the exterior walk-around inspection according to the company's SOP.
- FO accurately completes cockpit preparation, flows, and checklists according to the SOPs in the correct sequence and without prompting.
- FO strictly adheres to the take-off performance calculation protocol.
- FO correctly programs and verifies FMS and EFB data entries according to SOPs.
- FO consults aircraft or operator manuals as needed and can access official documentation swiftly and accurately. FO does not use non-official references.

Communication:

- FO clearly and concisely articulates their understanding of the flight plan and associated conditions during the crew briefing.
- FO addresses the cabin crew in a formal, friendly manner.
- FO uses standard phraseology when communicating on the radio with ground personnel or dispatch.

- FO actively listens during briefings and asks clarifying questions when necessary.

Leadership and Teamwork:

- FO proactively offers input and shares information during the crew briefing.
- FO supports the Commander by cross-checking information and helping.
- FO maintains a professional and respectful demeanor with all team members.
- FO identifies and verbalizes potential threats (e.g., weather, complex ATC, airport hot spots, aircraft condition) during the briefing.
- FO suggests or discusses mitigation strategies for identified threats.
- FO catches and corrects any errors in calculations, documentation or FMS programming (own or others').

Situational Awareness:

- FO demonstrates awareness of the planned departure time and any factors that might affect it.
- FO articulates an understanding of the overall operational environment, including airport conditions and potential ATC delays.

Workload Management:

- FO organizes flight deck materials and personal items efficiently before starting tasks.
- FO completes pre-flight tasks in a timely manner, without rushing or appearing overwhelmed.

Company Values:

- **Punctuality:** Arrives on time for duty; prepares everything to support on-time departure.
- **Service:** Interacts courteously with ground staff and crew.
- **Information:** Ensures all necessary information for the flight (route, flight time, expected delays if any) is gathered and understood. FO checks for passenger comfort items regarding weather, turbulence, wind, precipitation, temperature and thunderstorms.
- **Safety:** Conducts thorough checks; voices any safety concerns, is pro-active.
- **Respect:** Shows respect for all colleagues, their ethnicity and their input.
- **Efficiency:** Applies fuel saving policy and minimizes environmental impact by optimized use of systems and APU.

Taxi-Out and Take-Off

Flight Path Management – Manual Control (FPM-MC):

- FO maintains or assists to maintain precise taxi, adhering to taxiway centerlines and clearances.
- FO (PF) applies smooth and appropriate control inputs during the take-off roll.
- FO (PF) accurately maintains the target flight path and speed profile after rotation.
- FO (PF) applies correct trim technique during climb.

Application of Procedures:

- FO correctly performs items on the checklist before take-off.
- FO adheres to sterile cockpit procedures.
- FO correctly performs the take-off briefing, including emergency considerations.

- FO adheres to the “Late change of runway” procedure (calculations, change of SID, FMC, ...)
- FO cross-checks runway alignment before commencing take-off.

Communication:

- FO (PM) uses correct and concise ATC phraseology.
- FO uses ACARS for pre departure clearance (PDC).
- FO makes required callouts clearly and at the appropriate times.
- FO confirms understanding of ATC instructions by swift and accurate read-back.

Situational Awareness (SA):

- FO correctly identifies hot spots, taxiways and holding points without prompting.
- FO maintains awareness of other traffic on the airport. FO uses Weather radar as per SOP.
- FO maintains consistently good lookout and monitors alerts during taxi and take-off.

Leadership and Teamwork:

- FO verbalizes any observed deviations from planned taxi route or ATC instructions.
- FO identifies and communicates any unexpected aircraft behavior or alerts.

Workload Management:

- FO manages tasks (e.g., checklist, ATC comms, monitoring) efficiently during taxi.
- FO remains focused and avoids distraction during critical take-off phase.

Company Values:

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- Safety: Adheres strictly to procedures; maintains vigilance for hazards.
- Punctuality: Performs procedures and Taxi efficiently to avoid delays.

Climb and Cruise

Flight Path Management – Manual Control:

- FO (PF) maintains precise and smooth control, adhering to clearances.
- FO (PF) applies appropriate control inputs during turns and level off.
- FO (PF) can execute all tasks when flying manually. FO is not rapidly “overloaded”.
- FO (PF) accurately maintains the target flight path and speed profile.
- FO (PF) applies correct trim technique.
- FO (PF) can trim the three axes as per manufacturer recommendations
- FO (PM) applies correct call outs and intervention techniques as needed.

Flight Path Management – Auto-Flight Systems:

- FO correctly engages and verifies autopilot and FMS modes for climb and cruise.
- FO monitors FMS navigation accuracy and aircraft adherence to the programmed flight path.
- FO makes timely inputs to the FMS/MCP for altitude, speed, and heading as cleared by ATC.

Automation Management:

- FO verbalizes automation modes and expected aircraft behavior in accordance with SOPs.

- FO demonstrates understanding of automation limitations.
- FO smoothly transitions between automation modes.

Applied Knowledge:

- FO reviews fuel consumption relative to the flight plan and makes appropriate adjustments.
- FO monitors aircraft systems (engines, pressurization, electrics, etc.) and parameters.
- FO interprets enroute weather information and airport minima.

Communication:

- FO (PM) makes clear, concise, and timely position reports and requests to ATC applying standard protocols and phraseology.
- FO uses CPDLC as per SOP.
- FO (PM) delivers passenger announcements (if applicable) in a calm, reassuring, and professional tone, providing relevant information.
- FO (PM) manages timely weather updates (as required)
- FO effectively communicates with the Commander regarding flight progress and system status.
- FO communicates formally and friendly with cabin crew respecting their workload.

Situational Awareness:

- FO maintains awareness of current aircraft position, altitude, traffic, terrain and weather.
- FO uses radar as per SOPs and can make optimal use of all radar functions.
- FO maintains awareness of immediate landing options.
- FO monitors fuel status and monitors arrival fuel.
- FO anticipates upcoming ATC clearances or instructions.

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- FO performs descent preparation and briefing to be completed well before top of descent
- FO is aware of TUC (time of useful consciousness) at cruise altitude

Problem-Solving and Decision-Making:

- FO discusses options for weather deviations with the Commander.
- FO assists in analyzing minor system anomalies and consulting relevant checklists.

Workload Management:

- FO effectively balances monitoring tasks, communication, and FMS inputs.
- FO maintains an organized flight deck.
- FO prioritizes looking for vertical profile and horizontal route optimization.
- FO manages “*cruise control for the mind*” with focus on things to learn, reviewing aircraft systems, non-normal procedures, discuss learnings from incidents. No off-topic reading or activities.

Company Values:

- Service: Delivers informative and reassuring passenger announcements contributes to a smooth flight.
- Information: Keeps passengers informed of flight progress or any irregularities.
- Safety: Actively monitors systems and flight path.
- Respect: Communicates respectfully with ATC and crew.

Descent, Approach, and Landing

Flight Path Management – Manual Control:

- FO (PF) demonstrates smooth and accurate manual control of airspeed, descent rate, and lateral path during visual or instrument approaches.
- FO (PF) demonstrates accurate energy management when under manual control
- FO (PF) executes a stable approach, maintaining desired parameters within tolerances.
- FO (PF) performs a smooth flare and touchdown in the designated touchdown zone.
- FO (PF) maintains directional control during roll-out and applies braking/reverse thrust appropriately to achieve the desired runway exit. Assists as PM.

Flight Path Management – Auto-Flight Systems:

- FO correctly programs and manages the FMS as per SOP.
- FO monitors autopilot performance during descent and approach, making timely interventions.
- FO clearly states intentions when changing levels of automation.
- FO (PF) can use all levels of automation with confidence and accuracy.
- FO (PF) demonstrates timely disengagement of autopilot for manual landing.
- FO manages auto-thrust effectively or transitions smoothly to manual thrust control.

Applied Knowledge:

- FO correctly interprets approach charts, altitudes, speeds, and missed approach.
- FO demonstrates understanding of aircraft approach and landing performance and required runway distances.
- FO considers environmental factors (wind, runway condition) for approach and landing.

Application of Procedures:

- FO accurately completes descent, approach, and landing checklists.
- FO accurately completes the required approach, and landing calculations as per SOP.
- FO makes all required callouts (e.g., "stabilized," "minimums," "runway in sight").
- FO adheres to stabilized approach criteria and calls for a go-around if criteria are not met.

Communication:

- FO (PM) clearly communicates with ATC regarding descent clearances, approach instructions, and landing clearance using standard phraseology only.
- FO effectively communicates intentions and observations to the Commander during the approach.

Situational Awareness (SA):

- FO maintains awareness of aircraft position relative to the desired flight path, terrain, and other traffic.
- FO (PF and PM) monitors energy state (airspeed vs. altitude) throughout the descent and approach.
- FO is aware of runway conditions and any reported braking action.
- FO identifies and verbalizes threats such as changing weather, complex approaches, or short runways.

Problem-Solving and Decision-Making (PSDM):

- FO actively participates in decisions regarding approach strategy in challenging conditions (e.g., crosswinds, low visibility).
- FO correctly executes a go-around procedure if required.

- FO promptly identifies and corrects deviations from the desired flight path or stabilized approach criteria.
- FO demonstrates preparedness for a go-around.

Workload Management:

- FO prioritizes tasks effectively during high-workload approach and landing phases.
- FO manages distractions and maintains focus on critical tasks.

Company Values:

- Safety: Prioritizes a stabilized approach and safe landing primarily; willing to go around.
- Punctuality: Manages descent profile efficiently to meet arrival sequence, without compromising safety.
- Information: Clearly communicates intentions and status to passengers (as required)

Taxi-In and Post-Flight Operations

Flight Path Management – Manual Control (FPM-MC):

- FO accurately controls aircraft speed and position while taxiing to the parking stand, following marshaller signals or stand guidance.

Application of Procedures:

- FO correctly performs after-landing checks and shutdown procedures.
- FO completes post-flight documentation accurately and thoroughly.

Communication:

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- FO communicates clearly with ground crew regarding parking and shutdown.
- FO participates constructively in the post-flight debriefing.

Situational Awareness (SA):

- FO maintains awareness of ramp congestion, ground personnel, and equipment during taxi-in.

Workload Management:

- FO completes post-flight tasks efficiently.

All Competencies (during Debrief):

- FO actively listens to feedback from the LTC and takes action to avoid reoccurrence (notes?).
- FO accurately assesses own performance, identifying areas of strength and areas for improvement.
- FO asks clarifying questions and shows eagerness to learn.

Company Values:

- Punctuality: Taxi efficiently to the gate.
- Safety: Ensures aircraft is safely parked and secured.
- Service: Interacts professionally with ground staff.
- Information: Provides accurate information for flight records.
- Respect: Engages respectfully in the debriefing process.

Observable Behaviors Spanning All Phases

Applied Knowledge:

- FO quickly and accurately refers to the applicable OPS Manual section.

- FO demonstrates understanding and system knowledge behind the application of normal, and supplementary procedures.

Application of Procedures:

- FO adheres to SOPs
- FO executes all required checklists accurately and in the correct sequence.
- FO follows prescribed non-normal procedures methodically.

Leadership and Teamwork:

- FO consistently aids the Commander and other crew members when appropriate.
- FO takes initiative (e.g., preparing for the next phase of flight without prompting).
- FO maintains open communication and a collaborative atmosphere in the cockpit.
- FO shows respect for the Commander's authority while also feeling comfortable to voice concerns or ask questions.
- FO adapts to changing roles (PF/PM) smoothly.

Communication:

- FO communicates clearly and respectfully to all parties.
- FO immediately verifies any unclear or doubtful message received
- FO keeps cabin crew and passengers informed as directed by the Commander
- FO does not interfere with, take over or manage communications assigned to the Commander
- FO always speaks up in a clear, respectful way when FO thinks safety is at stake

Problem-Solving and Decision-Making:

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- FO uses a structured approach (e.g., T-DODAR, FORDEC) when discussing or dealing with problems.
- FO considers and prepares diverse options and their consequences.
- FO makes timely decisions when acting as PF and offers timely input to the Commander.
- FO consistently scans for and identifies potential threats throughout the flight.
- FO uses Threat and Error Management tools (e.g., briefings, checklists, callouts) effectively.
- FO acknowledges and corrects own errors without defensiveness.
- FO challenges or questions deviations from SOPs or unsafe situations respectfully but assertively.

Company Values:

- FO consistently wears the uniform to company standards and maintains a professional appearance.
 - FO interacts with all personnel (gate agents, cabin crew, maintenance) in a manner that reflects the company values of respect and teamwork.
 - FO demonstrates an understanding of how their own role contributes to the overall company goals of client satisfaction and safety.
 - FO shows cultural sensitivity in interactions with diverse crew members and passengers.
 - FO manages “Radio Crew” (see *Skywards: Managing Flight Operations* (Berger, 2025), as per company values.
- FO shows respect, understanding and empathy to colleagues working in other departments, being dispatch, scheduling, maintenance, ground operations but also including finance, commercial, ticketing

Observable Behaviors During Non-Normal or Emergency Operations (Simulated or Actual)

Applied Knowledge:

- FO quickly and accurately recalls memory items (if applicable) or locates information in the QRH/FCOM.
- FO demonstrates understanding of the system malfunction and its implications.

Application of Procedures:

- FO executes emergency checklists accurately and in the correct sequence.
- FO follows prescribed non-normal procedures methodically.

Communication:

- FO communicates clearly and calmly to Commander and ATC (e.g., "MAYDAY" calls).
- FO uses standard emergency phraseology.
- FO keeps cabin crew informed as appropriate.

Leadership and Teamwork:

- FO effectively supports the Commander, managing tasks as directed.
- FO provides clear and concise updates on aircraft status.

Problem-Solving and Decision-Making:

- FO uses a structured approach (e.g., T-DODAR, FORDEC) when dealing with problems.
- FO contributes to the assessment of the situation and the decision-making process.
- FO considers all available options and their risks/benefits.

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Situational Awareness:

- FO maintains awareness of critical flight parameters (airspeed, altitude, heading, fuel) despite the distraction of the non-normal event.
- FO remains aware of the time and options available (e.g., nearest suitable airport).

Workload Management:

- FO prioritizes actions effectively (e.g., "Fly, Focus, Act").
- FO delegates or accepts tasks as appropriate to manage workload.

Company Values:

- Safety: All actions are prioritized towards the safety and well-being of passengers and crew.
- Information: Provides clear information for relevant parties as the situation allows.

Appendix I: ADDIE Model

The ADDIE model (Analyze, Design, Develop, Implement, Evaluate) developed by ICAO (ICAO, 2025) provides a structured and iterative approach that aligns well with Competency-Based Training and Assessment (CBTA) methodologies. The CBTA framework demonstrates a practical application of ADDIE principles in aviation training:

Analyze This phase involves identifying the gap between current and required pilot competencies. The developer uses industry evidence, regulatory requirements, and operational insights to determine which competencies are essential for safe and effective performance. This includes analyzing data from incidents, feedback, and assessments.

Design In this phase, the training is mapped out using a Pilot Competency Framework (PCF). Learning objectives are defined, assessment methods chosen, and instructional strategies tailored. CBTA emphasizes aligning course content with competency outcomes, specifying measurable objectives and structuring training around both technical and non-technical skills such as communication and decision-making.

Develop Here, training materials are created. This includes scenario-based simulator sessions, manuals, briefings, and digital content. The course designer integrates performance-based assessments into the training materials, ensuring that evaluation is continuous and competency-focused. Videos, guided self-assessments, and flight scenarios are built to reflect operational challenges.

Implement Training is delivered using a combination of classroom instruction, simulators, and on-the-job training. The CBTA model includes building blocks—from familiarization and manual handling to complex scenario-based training and qualification checks—ensuring progressive competency development.

Evaluate This phase ensures the effectiveness of the training program. The standard is to use a 5-point grading scale with

observable behaviors and a detailed rubric. Competency data is analyzed through tools like the Performance and Training Analytics Platform (PTAP) to refine training strategies and ensure continuous improvement.

In summary, the ADDIE model serves as the underlying structure for CBTA development, ensuring that training is evidence-based, performance-focused, and continuously improved through data analysis and feedback loops. The model ensures content delivery and competency assessment are tightly integrated throughout the training lifecycle.

Stages of CBTA Training Material Development

ADDIE Phase	Key Activities for CBTA Material Development	Key Outputs	Example for a Flight School
Analyze	Conduct Training Needs Analysis (TNA) focusing on operational roles and tasks. Identify target pilot competencies (e.g., ICAO 9). Analyze existing trainee competency levels and identify gaps. Review regulatory requirements and safety data.	Training Specification document, Competency Gap Analysis Report, Defined Target Competencies.	Analyze training syllabus against ICAO competencies. Identify common student errors in crosswind landings (PC4: Manual Flight Path Mgt.) from instructor feedback and safety reports.
Design	Develop/adapt detailed competency model with performance criteria and observable behaviors. Design learning pathways. Create assessment strategy and plan (formative/summative). Define clear, measurable learning outcomes for each module/competency.	Competency Model (with Performance Criteria), Training Plan (Syllabus Outline), Assessment Plan, Learning Outcomes.	Design specific performance criteria for crosswind landing competency (e.g., "maintains runway centerline," "corrects for drift effectively"). Plan simulator sessions and flight lessons for practice.
Develop	Create all training materials: courseware (manuals, e-learning), presentations, briefing	Draft Training Materials (Courseware, Presentations,	Develop a ground school presentation on crosswind

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	guides, video demonstrations, simulator scenarios, flight lesson plans, assessment tools (rubrics, checklists, exams). Ensure materials are mapped to competencies.	Videos, Sim Scenarios, Lesson Plans), Assessment Tools.	theory, a video demonstrating correct technique, a simulator scenario with varying crosswinds, and a rubric for assessing performance.
Implement	Deliver the training program. Train instructors on CBTA principles and use of new materials/assessment tools. Conduct pilot testing of materials with a sample trainee group. Gather initial feedback.	Trained Instructors, Pilot Test Feedback Report, Initial Trainee Performance Data.	Instructors use the new crosswind landing materials. A small group of students undergoes the revised training module. Instructor and student feedback is collected.
Evaluate	Collect and analyze trainee performance data, instructor feedback, and course completion data. Assess achievement of learning outcomes and competency standards. Review material effectiveness and identify areas for improvement.	Course Evaluation Report, Recommendations for Revision, Updated Training Materials (if revised).	Analyze student performance in crosswind landings using the new rubric. Review instructor feedback on material usability. Compare pass rates/proficiency levels with previous methods.

Appendix J: Instructor Selection

This framework outlines selection standards and methodologies for flight instructors across all core phases of pilot development: theoretical knowledge, core flying skills, multi-engine transition, instrument rating and jet handling in FSTDs, and advanced airline training including type rating and IOE/LIFUS/Line Training. Built on ICAO's Instructor/Evaluator Core Competencies (IECs), the guide aligns with EASA regulations and CBTA/EBT principles.

A. Theoretical Knowledge Instructors (TKIs)

TKIs establish the theoretical foundation for ab initio pilots. Effective TKIs must combine deep subject knowledge with the ability to translate abstract concepts into practical, operationally relevant insights.

Key Competencies

- **IEC 1 (Pilot Competencies):** Comprehensive and current knowledge across ATPL subjects. Instructors must apply theory to operational scenarios (e.g., linking meteorology to decision-making). Mastery of EASA Area 100 KSA is critical, integrating pilot competencies like communication and decision-making into theoretical training.
- **IEC 2 (Learning Environment):** Ability to manage varied classroom or virtual settings using tools like LMS, CBT platforms, and VR/AR. The environment should support diverse learning needs.
- **IEC 3 (Instruction):** Lessons must follow adult learning principles. Instructors should design sessions that promote active engagement, critical thinking, and retention.

- **IEC 4 (Trainee Interaction):** Must build rapport, encourage participation, respond to questions, and adapt to learners' varying knowledge levels.
- **IEC 5 (Assessment):** Ability to construct, administer, and interpret a range of assessment types, including scenario-based evaluations and group exercises, beyond simple multiple-choice tests.

Selection Process

- **Phase 1:** Verify qualifications under EASA ORA.ATO.110(c) or national equivalents. Consider academic background (e.g., physics, engineering).
- **Phase 2:** Conduct written exams on intended teaching subjects, a KSA 100 module, and interviews covering, CBTA, and instructional experience.
- **Phase 3:**
 - **Test Lecture** on a complex ATPL topic with integrated KSA competencies.
 - **Scenario-Based Exercise** simulates trainee misunderstandings or operational applications.
 - **(Optional) Group Facilitation** to assess small-group management and interaction skills.

TKIs must demonstrate the ability to make theory engaging and meaningful to learners with limited flight experience.

B. Flight Instructors – Core Flying Skills (FI(A))

FI(A)s teach initial flying skills in single-engine aircraft and help shape early attitudes toward flight safety and airmanship.

Key Competencies

- **IEC 1:** Precise demonstration of all maneuvers from the instructor seat, including decision making and risk management skills.
- **IEC 2:** Maintains a structured and safe environment from pre-flight briefings to debriefings. Manages student stress during early flights.
- **IEC 3:** Provides clear instruction, briefings, real-time corrections, and guided fault analysis.
- **IEC 4:** Communicates calmly and clearly under workload. Demonstrates empathy, patience, and strong mentorship.
- **IEC 5:** Evaluates student performance against company and legal standards, identifying and correcting root causes of performance gaps.

Selection Process

- **Phase 1:** Confirm regulatory FI(A) qualifications (for EASA: FCL.915.FI, FCL.930.FI), current medical, and single engine experience. Include a pre-entry flight test. Verify airline experience.
- **Phase 2:** Assess instructional knowledge, scenario-based responses to learning challenges, and awareness of common student anxieties.
- **Phase 3:**
 - **Observed Flight Session** with the assessor acting as a student, simulating errors.
 - **Technical Interview** covering aircraft systems, regulations, and common instructional issues.
 - **Scenario Discussion:** "What-if" in-flight situations, student management, or weather-based decision-making.

The selection must identify instructors who combine excellent flying skills with an ability to inspire, build trust, and coach through early training challenges.

C. Multi-Engine Instructors (MEI)

MEIs extend core skills into the multi-engine environment, emphasizing systems complexity, performance, and asymmetric handling.

Key Competencies

- **IEC 1:** Demonstrated ability to fly all ME maneuvers to standard, especially engine-out procedures and asymmetric flight.
- **IEC 2 & 4:** Maintains a calm, supportive environment during high-workload exercises. Guides student through high-stress scenarios safely.
- **IEC 3:** Explains ME-specific aerodynamics (e.g., V_{mc} , critical engine) and flight techniques clearly.
- **IEC 5:** Diagnoses weaknesses in understanding of asymmetric flight and provides corrective strategies.

Selection Process

- **Phase 1:** Confirm CRI(MEP) or FI(A) with ME privileges, ME flight experience, and regulatory qualifications. Verify airline experience.
- **Phase 2:** ME knowledge exam focusing on asymmetric flight theory, systems, and emergency handling.
- **Phase 3:**
 - **Flight or Simulator Session:** Engine-out drills and instruction in realistic ME scenarios.
 - **Interview:** Emphasizes performance calculations, V_{mc} factors, and instructional approach.

- **Scenario Discussion:** Engine malfunctions, EFATO, and drift-down scenarios to test decision-making and teaching approach.

D. SFI/TRI – IR and Basic Jet Training in FSTD

These instructors guide the transition from piston aircraft to jets, building IR and jet-handling competence in FSTDs.

Key Competencies

- **IEC 1:** SFIs require deep knowledge of generic jet ops; TRIs must be type-rated and current. Both must understand automation, FMS, and IR flight.
- **IEC 2:** Must manage Instructor Operating Station (IOS), create realistic training environments, and operate under time pressure.
- **IEC 3:** Must teach complex topics like automation, SOPs, and resilience through scenario-based training.
- **IEC 4:** Strong debriefing and facilitation skills that encourage reflective learning and performance improvement.
- **IEC 5:** Applies CBTA/EBT grading standards. Must identify behavioral indicators and diagnose learning challenges.

Selection Process

- **Phase 1:** Verify TRI/SFI credentials (FCL.915), recent experience in FSTD or aircraft. Verify airline experience.
- **Phase 2:** Knowledge test covering automation, jet systems, CBTA, and MCC concepts.
- **Phase 3:**
 - **Observed FSTD Session** on IR or jet transition topics with a full scenario, use of IOS, and post-session debrief.

- **Interview:** Assesses systems knowledge, scenario design thinking, and automation philosophy.
- **(Optional) Scenario Design Exercise** to evaluate instructional creativity and threat management.

E. Airline Instructor Pilots – TRI / LTC (Advanced Jet & Line Training)

TRIs and LTCs deliver the most operationally complex training—type ratings, base training, and IOE/LIFUS. They shape airline SOP adherence, safety culture, and final competency readiness.

Key Competencies

- **IEC 1:** Must be type-rated, current, and deeply experienced. Mastery of all pilot competencies in multi-crew ops.
- **IEC 2:** Ability to manage real-world complexity during LOFT and line training. Balances instruction with operational pressures.
- **IEC 3:** Expert use of CBTA and EBT, facilitation of CRM/TEM, coaching during non-normals, and line instruction.
- **IEC 4:** Nuanced mentoring for both ab initio FOs and experienced pilots. Role model for safety and professionalism.
- **IEC 5:** Conducts objective, high-stakes assessments. Proficient in CBTA/EBT evaluation and diagnosing root causes.

Selection Process

- **Phase 1:** Confirm TRI/LTC credentials, extensive operational experience, and endorsements from flight ops. Ensure regulatory compliance (For EASA: ORO.FC.231, FC.146). Verify airline experience.

- **Phase 2:** Advanced knowledge assessment including case studies, EBT/CBTA application, SOP interpretation, and CRM/TEM integration.
- **Phase 3:**
 - **FSTD LOFT Session:** Assesses ability to facilitate CRM/TEM, manage scenarios, and debrief using CBTA markers.
 - **Simulated or Observed IOE Sector:** Applies instruction in a real or mock operational environment.
 - **Panel Interview:** Probes decision-making, mentorship, conflict management, and commitment to safety culture.
 - **Assessment of Competence (AoC):** Formal evaluation (For EASA per FCL.935.)

Effective TRI/LTCs must do more than fly well. They must teach the “why,” not just the “what,” and develop pilots who can manage complexity with confidence. Selection must probe instructional depth, professionalism, and their ability to embody and transfer the airline’s safety and operational values.

Appendix K: Light Aircraft Emissions

Secondary Emission for Avgas 100LL – Piston Engines

Emissions – Avgas (Lycoming engines)

<i>Flight Phase</i>	<i>CO (g/kg)</i>	<i>HC (g/kg)</i>	<i>NOx (g/kg)</i>
<i>Takeoff/Climb (rich)</i>	1000–1440	18–32	1–3
<i>Cruise (lean)</i>	90–280	3–10	30–46
<i>Cruise (rich)</i>	750–1100	13–21	4–9
<i>Approach</i>	940–1430	22–34	1–3
<i>Idle</i>	>1000	>1000	—

- Soot:
 - FOCA reports: 40–100 mg/kg fuel (0.04–0.1 g/kg)
 - CARB data: 20.7 g Total PM/kg fuel, with EC (soot) at 2.66 g/kg

Note: FOCA and CARB use different measurement approaches. CARB’s figure, based on full TPM analysis, is used for soot (EC) estimates here.

Mixture Control Impact: Rich mixtures (used in takeoff/climb) produce high CO and HC due to incomplete combustion. Lean mixtures (used in cruise) reduce CO/HC but raise NOx due to higher combustion temps. Pilots control this via the mixture lever.

Secondary Emission for Jet A-1 (Diesel Piston Engines)

Take-off and Landing Emissions (based on 1.6 kg fuel burn, FOCA data for TAE-125-01 Centurion 1.7):

- HC: 3.13 g/kg
- CO: 11.88 g/kg

- NO_x: 18.75 g/kg
- Soot: 56 mg/kg

Cruise Emissions (based on 14.1 kg fuel burn):

- HC: 1.56 g/kg
- CO: 6.45 g/kg
- NO_x: 26.45 g/kg
- Soot: 57 mg/kg

Compared to Avgas engines, modern diesel engines *produce far less CO and HC*—up to 100 times lower. NO_x levels, however, remain high, especially during cruise. Soot levels are low and like Avgas values, suggesting similar measurement methods focused on black carbon.

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Acknowledgements

My sincere thanks go first to the many friends and colleagues who contributed to this book by helping me train, develop, test, and validate the ideas presented here. Throughout my career, countless individuals have shared their insights. Attempting to list them all would be both impossible and unfair, as human memory inevitably leaves someone out.

I am deeply grateful to my colleagues at Sabena, Sobelair, TUI Airlines, Jet4You, ECAir and many others. They provided me with a solid understanding of how first-class flag carriers are training their pilots. Sabena excelled in operating under challenging conditions, always maintaining exceptional training and safety standards. Its bankruptcy taught me a lesson: even outstanding training and flight operations personnel cannot overcome poor commercial results. Notwithstanding this setback, many from Sabena and Sobelair went on to hold top positions globally.

I owe special thanks to *Capt. Paul Vandingenen*, my initial instrument training instructor (IFR). His training significantly impacted my career direction, especially crucial as I was new to aviation. But listing every instructor, influential leader and postholder that I met at Sabena and Sobelair would much better illustrate their collective impact.

My initial Boeing 737 training was under the outstanding guidance of *Jos Baeten* and *Capt. Jan Evens*, supervised by *Capt. Frans Gernay* and later *Capt. Guy Liesse*. They were visionaries, decades ahead in-flight training insights. *Capt. Jan Evens* has remained a constant, invaluable mentor, always helping me stay on track with his sharp and accurate insights.

Capt. Jacques Drappier deserves special recognition for his exceptional abilities in flight training, and management. His instructional and “people skills” are extraordinary, always happy to share his knowledge and experience. *Captains Jean Declercq* and *Y.*

Delplancke provided my instructor training on commercial jets, influencing my perspective thoroughly in a way that certainly is reflected in this book.

Early this century, joining the TUI Belgium startup team was another pivotal moment. With *Annemie* and *Bart Brackx*, *Elie Bruyninckx*, *Gunther Hofman*, *Geert Somers*, and *Wim Van Besien*, we successfully established a thriving airline. High quality training was key to our success and as a result we had more than 20 years of operations without any major incident. In this team, nobody ever asked how we could decrease or “optimize” the training budget. The only question I ever got was: “Are you confident we are doing enough?”. In how many board rooms is that the focus?

Many people joined me on this journey, and *Stephanie Verhoeven* consistently went beyond expectations, significantly enhancing our effectiveness in training and flight operations, especially during critical situations that often arose outside regular working hours.

Working with the *international TUI team*, including many skilled postholders, instructors, and pilots, was both enjoyable and educational. The training after the grounding of the B737Max and the COVID pandemic completely changed the way we did things but also offered invaluable lessons captured in this book.

Special appreciation goes to *Capt. Stuart Gruber*, now at Boeing, for the countless conversations and for taking time out of his busy schedule to read the manuscript.

Finally, my heartfelt gratitude goes to my family for their constant support. My oldest son, *Tim Berger*, himself an instructor these days, critically reviewed the manuscript, offering insightful feedback that enhanced the book.

Many others also contributed their perspectives, helping refine the definitive version.

About the Author

The Journey of André Berger started with advanced mathematics studies in the late seventies, followed by engineering, though he soon pivoted himself to pursue a career as a pilot. Pilot training in the early eighties was challenging, especially during a time when airlines in his country, Belgium at the time, were not hiring novice pilots. European pilot licenses were country-specific, EASA and standardization did not yet exist. The only large jet-operating airline he aspired to join was the national flag carrier, Sabena, but due to hiring freezes and the closure of the Civil Aviation School, he had to gain experience through diverse roles: ground handler, aircraft cleaner, mechanic, flight engineer, dispatcher, scheduler, banner-towing pilot, air taxi pilot, flight instructor, caterer, and even driving instructor, before finally being offered a first officer role on the B737-200 at Sabena.

What initially seemed like a challenging, frustrating path ultimately provided him with valuable insights into the holistic workings of an airline, beyond just the flight deck. Within four months as a B737-200 first officer, he was appointed as a simulator flight instructor, which soon extended to aerobatic instruction and training on the SF260 Marchetti and Embraer Xingu (E121) in the ab initio program. He became involved in structuring and rewriting the training manuals, covering all stages of flight training up to instructor courses on commercial jets. He was assigned to Arizona as Chief Flight Instructor to establish Sabena's new ab initio pilot training program, laying the foundation for what is now one of the largest training centers globally, operated by CAE.

In the mid-nineties, he became Managing Director of the Belgian Aviation School and then joined Sobelair, the leisure airline within the Sabena Group, to resolve regulatory issues. As Crew Training Manager, he developed Belgium's first certified Type Rating Training Organization (TRTO) under emerging JAA and EASA standards. He also supported the setup of a new airline, Mondair in Morocco.

Following Sabena's bankruptcy in 2001 and Sobelair's demise 2 years later, he established the flight operations department for TUI Airlines Belgium, then known as JETAIRFLY, part of the TUI Group. This role extended to consulting with other TUI Group airlines and to establishing JET4YOU in Morocco, pioneering interoperability between EASA and non-EASA carriers. Over time, he took on responsibilities as Head of Flight Operations and Head of Training across TUI's five AOCs, creating interoperability between AOC's, heading fuel efficiency and sustainability, renewing the training department, conducting numerous operational and training audits of airlines and training organizations in Europe, the USA, the Caribbean, Russia, and the Far East.

His career as a pilot includes over 23,000 flight hours, primarily on Boeing aircraft (B737, B767, B787), with experience in all pilot roles (first officer, captain, instructor, examiner) worldwide. His first true love was the good old DC-10, on which he served as flight engineer. He has also experience as a simulator instructor on the Bae146 and Airbus A320/A330, and he has been a long-term qualified instructor on some of the most demanding airports (e.g., Innsbruck, Samos, Funchal, Chios,...) and routes (Himalaya's, Atlantic, Pacific, Polar routes ...).

Under his leadership, the B787 specs were refined, and the aircraft was successfully introduced for TUI on the European continent. In the B737MAX project, he was chairing the flight deck specifications team for flight operations, training, he attended all pre-launch Boeing "working together" conferences on the B737MAX and he served as the TUI launch pilot for that model. He also oversaw its grounding and managed its return to service nearly two years later.

As a Chief Flight Instructor and CEO/accountable manager for several Approved Training Organizations (ATOs), he introduced *Immersive Training in Multi-Pilot License (MPL)* programs, streamlining training by canceling traditional but less effective steps like *single-engine instrument flying* and *multi-engine piston training*.

Recently, he implemented *Competency-Based Training and Assessment* (CBTA) across all type rating and ab initio pilot training courses, enhancing crew selection and training while accommodating modern airline requirements.

André Berger also is an experienced technical writer fluent in English and French, albeit his native language is Dutch. He specializes in creating operational manuals, guidelines, and procedures for major aviation corporations. He is a member of a distinguished global group of experts working with leading airlines, training organizations, manufacturers like Boeing, Airbus, Embraer, as well as simulator manufacturers and regulators. The aim is to enhance safety, training, and operational efficiency in the aviation industry.

Currently based in the Middle East with his family, André is actively involved in pilot training, flight operations, and exploring advanced technologies such as virtual reality and artificial intelligence in aviation. His passion lies in shaping the future of crew training by employing innovative tools to enhance the learning experience and skills of the next generation of pilots and cabin crew.

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