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Methods for Preventing the Degradation of Manual Flying Skills in an Automated Cockpit Environment

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Abstract: Modern commercial aviation increasingly relies on advanced automation, which helps to reduce pilot workload and improves overall flight safety. However, the growing reliance on automation has reduced pilots' opportunities for manual flying practice, leading to a degradation of those skills. This article analyzes recent data on Loss of Control In-flight (LOC-I) cases and human factors, highlighting that insufficient manual flying experience has been a contributing factor in several incidents and accidents. An original methodology is proposed to maintain and improve airline pilots' manual flying skills through balanced automation use, regular manual flying exercises in training sessions, and during line operations under safe conditions. The Results section provides a detailed structure of the training program including Upset Prevention and Recovery Training (UPRT), exercise examples, and mathematical models of skill degradation. The Discussion compares the proposed approach with leading aviation organizations (ICAO, FAA, EASA, IATA, Airbus, Boeing), highlighting implementation strategies and potential outcomes. The findings confirm the need to revise simulator and line training programs for pilots with a greater focus on manual flying skills, which will help prevent further competency erosion and reduce LOC-I accident risk.

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Introduction

Automatic flight control systems have significantly transformed pilot operations over the past decades. Modern aircraft are equipped with autopilot systems, electronic displays, and integrated decision-support tools that handle many routine piloting tasks. These advancements have reduced crew workload and improved trajectory accuracy, thereby enhancing overall flight safety. However, a high level of automation also presents a downside. Pilots are now less frequently engaged in manual flying, resulting in fewer opportunities to maintain and refine their manual flying skills. According to ICAO (2019), although automation has generally increased safety levels, it has also led to a lack of manual flying practice and the potential degradation of corresponding skills among pilots. The U.S. Federal Aviation Administration (FAA, 2013), concluded that continuous use of autopilot does not promote the retention of manual flying proficiency. On the contrary, over-reliance on automation may weaken a pilot’s ability to promptly regain aircraft control in non-standard or emergency situations.

One of the critical issues related to the decline in manual flying skills is a category of accidents known as Loss of Control In Flight (LOC-I), defined as situations where the aircraft unintentionally deviates from its intended flight path due to loss of control over pitch, roll, airspeed, or altitude parameters. Despite major advancements in avionics, LOC-I remains the leading cause of fatal air accidents. According to IATA (2020), during 2012-2016, only about 3% of all aviation incidents were attributed to loss of control, yet these accounted for nearly one-third of all fatal accidents. Over those five years, there were 30 LOC-I accidents, 27 of which involved fatalities, resulting in 949 deaths. Airbus (2022) identified loss of control in flight as the leading cause of fatal incidents in commercial aviation over the past two decades. Although modern next-generation aircraft equipped with fly-by-wire control systems feature protections to prevent exceeding safe flight parameters, the LOC-I problem remains highly relevant. This is largely because such accidents are typically not caused by equipment failure, but rather by human factors—namely, incorrect actions by the flight crew in critical situations (Airbus, 2022; ICAO, 2019). Incident reports involving LOC-I frequently cite insufficient monitoring of flight parameters or improper manual actions by pilots following the failure of automated systems (ICAO, 2019, 2020). Experts note that in many accidents, the outcome could have been different if the pilots had possessed stronger manual flying skills and better situational awareness at the critical moment (Airbus, 2022).

While substantial research exists on Loss of Control in General Aviation contexts, commercial aviation presents distinct challenges due to higher levels of automation, different crew composition, and varied training paradigms. General aviation LOC-I incidents often stem from visual flight conditions transitioning to inadvertent instrument meteorological conditions (IMC), spatial disorientation, and low-time pilot error (Boyd, 2015; Gibb et al., 2010; Mortimer, 2019). Nevertheless, fundamental principles of manual skill degradation identified in GA research—such as the importance of regular practice and scenario-based training—remain applicable to commercial operations. The transfer from GA to commercial aviation training reveals that pilots with diverse flight experience, including extensive hand-flying in GA aircraft, often demonstrate stronger foundational manual skills when transitioning to automated cockpits (Koglbauer, 2016; Winter et al., 2015).

The degradation of pilots' manual skills due to automation is evident not only in incident statistics but also in studies on psychophysiology and human factors. Different types of flying skills decay at different rates. Classic research from the 1970s showed that after a breaks from flying, pilots generally retained motor skills related to instrument flight if those skills had been well-developed (Prophet, 1976). In contrast, cognitive skills—such as executing procedures from memory, calculating parameters, and maintaining spatial awareness—deteriorated significantly after just a few months without practice. Recent experiments by Casner et al. (2014) confirm these findings in the context of the modern *glass cockpit*. In one NASA study, experienced pilots flew a Boeing 747 simulator under varying automation levels. When navigation systems were disabled, there was a sharp decline in cognitive task performance. Pilots struggled to maintain situational awareness and diagnose problems quickly. However, manual flying performance—such as maintaining altitude and heading—remained largely unaffected, even after extended periods without hands-on flying. Fundamental manual flying skills (aircraft stabilization, basic instrument scan) are more resistant to skill decay, whereas mental skills—situational awareness, mental computation, and planning without automation—are much more vulnerable when not regularly practiced. This phenomenon poses a unique challenge. In an automated cockpit, a pilot may remain confident in physical control abilities but may be unprepared to rapidly comprehend the situation and make the correct decisions following an automation failure (Ebbatson et al., 2010; Schutte & Trujillo, 1996). Recent studies have observed that while high levels of automation improve average flight path accuracy and reduce workload, they also lead to reduced pilot alertness. Simulation experiments under different automation modes revealed that pilots who placed full trust in the autopilot exhibited decreased attention to key instruments such as attitude indicators and engine parameters (Causse et al., 2024; Dehais et al., 2012). There are growing concerns that excessive automation may dull pilots' active flight monitoring skills.

Aviation authorities and the professional community are well aware of the risks associated with declining manual flying proficiency. As early as 2013, the European Union Aviation Safety Agency (EASA) issued a dedicated Safety Information Bulletin emphasizing manual flying skills importance. The agency recommended incorporating manual flying exercises into every pilot's recurrent training program and, where operationally feasible, encouraged line pilots to manually fly during routine operations. EASA's objective was promoting appropriate balance between automated systems use and manual flight control skills maintenance (EASA, 2013). In the United States, regulatory attention intensified following several incidents, including the 2009 crash of a DHC-8 near Buffalo, where incorrect manual inputs during stall recovery resulted in a fatal accident. The FAA increased focus on this issue through various directives and safety alerts. The FAA (2013) explicitly emphasized the need to provide pilots with opportunities to fly manually and to train in properly managing the transition between automated and manual flight modes. In 2017, the FAA issued a Safety Alert for Operators (SAFO) recommending pilots be allowed and even encouraged to disconnect the autopilot as often as safely and operationally possible during regular flights. Major aircraft manufacturers support these initiatives. Airbus (2020) stated that considers critically important for pilots to regularly fly manually during line operations to reduce overreliance on automation and strengthen their ability to manage abnormal situations. Boeing (2019), in its safety reports and simulator-based LOC-I prevention training materials, underscores the key role of the human factor and the necessity of high-quality flight training to prevent loss of control in flight (FAA, 2022).

Current Training Requirements and Assessment

Current regulatory frameworks establish baseline training requirements for commercial pilots. Under FAA Part 121 operations, pilots must complete annual proficiency checks including simulator evaluations and line checks conducted by qualified check airmen. EASA requires pilots to undergo recurrent training and proficiency checks for type rating revalidation every 12 months. ICAO Annex 1 establishes international licensing standards that member states incorporate into national regulations. Since 2019, Upset Prevention and Recovery Training (UPRT) has become mandatory in both initial type rating and recurrent training programs (EASA, 2019; FAA, 2019). However, current requirements do not specifically mandate regular manual flying practice intervals shorter than annual proficiency checks, nor do they consistently assess manual flying proficiency independently of automation management. While simulators are used to evaluate emergency procedures, the emphasis often remains on proper automation management rather than sustained manual flight capability. Line checks, conducted every six to twelve months depending on jurisdiction and operator, primarily assess standard operating procedure compliance and crew resource management rather than pure manual flying skill. This creates a significant gap. Pilots may demonstrate competence during brief manual flying segments in annual checks while lacking sustained practice throughout the year. Manual skill assessment is typically brief and incorporated into larger scenarios rather than evaluated as a standalone competency domain (FAA, 2022; ICAO, 2019).

Thus, the problem of pilot manual skill degradation due to increasing automation is supported by both accident statistics and empirical research. This growing trend has raised concerns among regulatory authorities and industry stakeholders, as a flight crew's ability to manage abnormal situations—when automation fails or behaves unpredictably—depends directly on their manual flying proficiency. The purpose of this paper is to justify the need for actively maintaining manual flying skills and to propose a comprehensive training methodology aimed at preventing further decline in these critical abilities. To achieve this objective, the study addresses the following key areas:

1. A review of current data on the impact of automation on pilot competence and the frequency of LOC-I incidents;
2. An overview of existing countermeasures, including regulatory requirements and training programs developed by leading aviation organizations;
3. The development of an original manual flying training program, featuring specific techniques and exercises;
4. An analysis of the expected outcomes of implementing such a program, along with potential challenges.

This research is based on an interdisciplinary approach—drawing from flight safety analysis, human factors, and learning theory—and aims to enhance aviation safety by optimizing flight crew training and skill retention.

Methodology

Materials and Methods

This study is an applied scientific investigation in the field of flight safety, with specific focus on commercial passenger airline operations utilizing turbine-powered transport category aircraft with advanced automation systems. The primary methods employed include analysis of accident statistics, a comprehensive review of academic and regulatory literature, and synthesis and modeling of a flight training methodology.

In the first stage, statistical reports from IATA, ICAO, Boeing, and Airbus were analyzed to identify causes of aviation incidents over the past 15 years (2010-2024), with a specific focus on Loss of Control In Flight (LOC-I) and the role of human factors. Simultaneously, a review was conducted of scholarly publications in human factors, ergonomics, and pilot psychology examining the effects of automation on pilot skills and proposing solutions to skill decay. The literature review employed the following methodology:

1. Database searches: Web of Science, PubMed, Google Scholar, and EBSCO Aviation Database
2. Search terms: 'manual flying skills,' 'automation dependency,' 'pilot skill retention,' 'LOC-I,' 'upset recovery training,' 'cognitive skill degradation'
3. Inclusion criteria: Publication date 2010-2024, English language, peer-reviewed articles or official regulatory/manufacturer reports, focus on commercial aviation or transferable findings
4. Exclusion criteria: Non-empirical opinion pieces, studies focused solely on ab initio training, research on military aviation without commercial applicability

This systematic search yielded 47 relevant sources, of which 28 were included in the final analysis. Special attention was given to recent studies reflecting the current state of the aviation industry.

In the second stage, existing recommendations and requirements from various aviation authorities regarding the maintenance of manual flying skills were compared. Documents analyzed included EASA (2013) and FAA (2017, 2022) bulletins on manual flying, ICAO guidance, Commercial Aviation Safety Team (CAST) working group findings, Flight Safety Foundation reports, and training materials from aircraft manufacturers including Airbus’s Upset Recovery manual and Boeing's Statistical Summary of Commercial Jet Airplane Accidents. This stage involved qualitative content analysis, comparing key points, justifications, and areas of applicability across different sources. This methodology provided foundation for identifying a wide range of proposed measures—from revisions in recurrent training programs to airline-level policies on automation use.

The third stage involved the development of a custom-designed manual flying training methodology, based on the identified problem areas and best industry practices. Program design principles were formulated, and appropriate training modules and exercises were selected. To justify the recommended frequency of training sessions, findings from scientific research on skill retention and forgetting were incorporated (Casner et al., 2014; Prophet, 1976). Simplified mathematical modeling of skill dynamics under different training intensities was also conducted.

Exponential skill decay models (analogous to forgetting curves) were used to estimate the required frequency of practice sessions necessary to maintain a target proficiency levels. Elements of the expert evaluation method were applied trough informal discussions with active pilot-instructors in professional settings. Their feedback and recommendations were considered during methodology refinement.

Data Collection and Sample Characteristics

Statistical safety data were sourced from publicly available IATA and Airbus safety reports concerning commercial passenger jet operations from 2010 through 2024. Specifically, the following reports were analyzed:

1. IATA Safety Report (annual editions 2011-2023)
2. IATA Aircraft Handling and Manual Flying Skills Survey Report (2020)
3. Airbus A Statistical Analysis of Commercial Aviation Accidents (2018-2022 editions)
4. Boeing Statistical Summary of Commercial Jet Airplane Accidents (2015-2019 editions)
5. ICAO State of Global Aviation Safety reports (2015-2023)

These reports collectively cover approximately 450 million flight hours and encompass worldwide commercial jet operations. From this data, 73 LOC-I incidents and accidents were identified over the 15-year period. Of these, 41 incidents (56%) cited manual flying skill deficiency, delayed recognition of aircraft state, or improper control inputs as contributing factors. It should be noted that isolating the precise quantitative impact of manual skill erosion on accident rates is difficult due to the complex interplay of contributing factors. Therefore, this study relies on indirect indicators—such as LOC-I incident frequency and the prevalence of manual skill references in accident reports. The scope is limited to commercial passenger jet operations equivalent to FAA Part 121 or EASA Air Operator Certificate standards.

Analysis Methods

To process the literature, comparative analysis was conducted by organizing information into thematic categories: (1) the role of manual flying skills in flight safety; (2) the impact of automation on pilot competence; (3) recommended measures for skill maintenance. Accident statistics were consolidated and analyzed descriptively. Skill retention modeling was carried out using the exponential decay formula:

$$R_{(t)} = R_{(0)} \cdot e^{-\lambda t} \quad (1)$$

where $R_{(t)}$ is the notional skill level (proficiency coefficient) after time t without practice, and λ is the forgetting rate constant. Parameter values were estimated based on research data. Specifically, Casner et al. (2014) found that cognitive skills related to manual flight showed approximately 30% decline over four months without practice. Prophet's (1976) classic study on pilot skill retention indicated motor skills decay more slowly than cognitive skills, with significant motor skill retention observed even after six months without practice. From these empirical findings, decay coefficients were derived for modeling purposes. The minimum acceptable skill threshold of 80% ($R_{min} = 0.8R_{(0)}$) represents a conservative standard commonly used in training effectiveness research and is consistent with proficiency maintenance goals established in aviation training literature (FAA, 2022; Ericsson et al., 1993). The resulting curves were used to derive training frequency recommendations.

Results

Literature Review Findings

The systematic literature review revealed several consistent themes regarding automation effects on pilot manual flying skills. First, multiple studies documented measurable decline in manual control proficiency among pilots with limited recent hands-on flying experience (Casner et al., 2014; Ebbatson et al., 2010; Koglbauer, 2016). Second, cognitive skills—particularly situational awareness, mental calculation, and manual flight path planning—were found to degrade more rapidly than basic motor skills (Prophet, 1976; Schutte & Trujillo, 1996). Third, automation dependency was identified as creating monitoring complacency, where pilots become passive observers rather than active participants in aircraft control (Causse et al., 2024; Dehais et al., 2012). Fourth, scenario-based training incorporating realistic automation failures showed effectiveness in maintaining manual skills and improving pilot confidence (Bainbridge, 1983; Landman et al., 2017; Lenhart et al., 2021).

Analysis of safety data from 2010-2024 revealed that LOC-I incidents disproportionately occurred during phases requiring manual intervention following automation discontinuation. Table 1 presents the distribution of LOC-I incidents by flight phase and contributory factors.

Table 1

LOC-I Incident Analysis from Safety Reports (2010-2024)

Flight Phase	Incidents (n)	% of total	Manual Skill Factor
Cruise/high altitude	18	25%	12 (67%)
Approach	31	42%	19 (61%)
Go-around	14	19%	7 (50%)
Other phases	10	14%	3 (30%)
Total	73	100%	41 (56%)

Note: Data compiled from IATA Safety Reports (2011-2023), Airbus Statistical Analysis (2018-2022), Boeing Statistical Summary (2015-2019), and ICAO State of Global Aviation Safety reports (2015-2023). Manual Skill Factor indicates incidents where manual flying deficiency, delayed recognition, or improper control inputs were cited as contributing factors.

These findings informed the design of the proposed training program, particularly the emphasis on high-altitude manual control scenarios, approach stabilization without automation, and go-around execution under manual flight conditions. The data reveal that manual flying skill deficiency contributes to over half of LOC-I incidents, providing strong justification for systematic manual skill maintenance programs.

Proposed Training Program Structure

Based on the conducted analysis, a comprehensive training program was developed to support and maintain manual flight control skills. This methodology is designed for implementation within airline training systems and can be integrated both into recurrent simulator training programs and into line operations under favorable conditions.

Overall Program Concept

The primary objective is preventing loss of pilots' manual flying skills and the associated cognitive abilities, such as situational awareness. The methodology is based on the well-established *use it or lose it* principle, which applies to both motor and cognitive skills. The core idea is systematically creating regular opportunities for pilots to practice manual aircraft control in a variety of flight conditions. The program consists of two complementary components: (1) Simulator-Based Training including scheduled sessions on full-flight simulators (FFS) focusing on manual control in non-normal, degraded, or emergency scenarios; (2) Line Practice involving manual flying of specific flight segments during real-world operations when safe and compliant with standard operating procedures. An important component is theoretical refresher training and structured briefing sessions reinforcing fundamental principles of flight control, aerodynamics, energy management, and limitations of highly automated systems. This integration of hands-on practice, structured simulation, and cognitive reinforcement forms a holistic approach to preserving and improving manual flying proficiency in the age of increasing cockpit automation.

Training Modules

The training program is designed around a notional one-year cycle integrated into recurrent training schedules. It is divided into five modules, each addressing specific manual flying competencies.

Module A: Core Manual Flying Skills. Frequency: Quarterly (every 3 months). Format: Simulator-based. This module focuses on foundational manual flying exercises performed without autopilot or flight director guidance. Scenarios include maintaining straight-and-level flight using basic instruments, standard rate turns with coordinated control, climb and descent at specified vertical speeds, low-speed maneuvering, and heading/course tracking without navigation aids (raw data flying). The objective is maintaining and reinforcing pilots' muscle memory and basic instrument scan coordination. These exercises act as a skill calibration to ensure continued competence in basic aircraft handling without automation.

Module B: Advanced Handling and Unexpected Scenarios. Frequency: Annually (minimum). Format: Standalone simulator session or integrated into regular proficiency checks. This module incorporates Upset Prevention and Recovery Training (UPRT) elements, focusing on non-routine, high-risk scenarios where pilots must rely solely on manual flying skills. Training includes stall recovery at high altitude with autopilot disengaged, upset scenarios involving abrupt pitch or roll changes, manual recovery from unusual attitudes, flight with complete automation failure requiring manual control of pitch, roll, and thrust in adverse conditions, and non-precision or precision approaches flown without autopilot or flight director.

The objective is developing and reinforcing pilots' ability to manage the aircraft manually in degraded, high-stress environments while maintaining proper flying technique, situational control, and calm response under pressure.

Module C: Cognitive Skills and Monitoring. Frequency: Annually or semi-annually. Format: Classroom or simulator-based. This module focuses on maintaining the pilot's mental workload skills essential in the absence of automation or visual cues. Key elements include mental navigation exercises where pilots track aircraft position without moving maps or electronic displays using conventional tools, manual descent planning without FMS or automated descent profiles to enhance situational awareness, flight monitoring training where Pilot Monitoring identifies deviations during manual flight. The objective is sharpening situational awareness, attention management, and mental modeling of aircraft performance.

Module D: Line Flying with Manual Flight Elements. Frequency: Ongoing in regular line operations. Format: Integrated into real-world flight activity. This module promotes manual flying use during live operations in accordance with company policy and regulatory guidance. Based on FAA (2017) recommendations, companies are encouraged to adopt policies supporting safe manual flying during suitable flight phases. Examples include manual takeoff followed by initial climb, manual descent and approach to landing under visual meteorological conditions, full hand-flown approaches without autopilot or autothrottle in low-complexity environments. The aim is to fostering positive safety culture where pilots feel comfortable disengaging automation when appropriate.

Module E: Data Analysis and Individualized Feedback. Frequency: Continuous Format: Ongoing monitoring and targeted coaching. This module integrates Flight Operational Quality Assurance (FOQA) data to monitor pilot manual flying performance and engagement. Core activities include tracking manual flight metrics based on approach stability, control smoothness, and deviation management; trigger-based interventions when pilos show limited manual flying activity; and structured debriefing after each simulator or training session where instructors provide detailed feedback. The objective is enabling personalized skill development through evidence-based feedback, fostering continuous improvement and awareness of individual performance trends.

Mathematical Justification for Training Intervals

The program defines specific intervals for simulator sessions (e.g., quarterly, annually), and these intervals are grounded in research on skill degradation rate over time. Using the exponential decay model described in the Methodology section (Equation 1), we can derive optimal training frequency. To ensure skill does not fall below the minimum acceptable threshold, we solve for the maximum allowed interval without practice:

$$\Delta t = \frac{1}{\lambda} \cdot \ln\left(\frac{R(0)}{R(t)}\right) \quad (2)$$

Studies suggest motor skills decay slowly and can be retained for several months, while cognitive skills degrade more quickly. Casner et al. (2014) documented that cognitive skills related to manual flight planning and situational awareness showed approximately 30% decline after four months without practice. If cognitive skills drop to 50% after 4 months, λ is estimated as:

$$\lambda = \frac{-\text{In}(0.5)}{4} \approx 0.17\ \text{month}^{-1} \tag{3}$$

Assuming R_{min} = 0.8 (representing an 80% minimum acceptable skill threshold based on industry training standards), the maximum permissible interval is:

$$\Delta t = \frac{1}{0.17} \cdot \ln\left(\frac{1.0}{0.8}\right) \approx 1.3\ \text{months} \tag{4}$$

This result suggests that for cognitive skills, retraining should ideally occur every 1–1.5 months to retain at least 80% of the trained proficiency. Since such frequent training may not be operationally feasible, the program compensates by focusing quarterly simulator sessions on motor skills (which degrade more slowly), integrating cognitive exercises into both simulator and classroom environments, encouraging ongoing manual practice during line operations, and supporting this with data monitoring and individual coaching (Module E). These measures allow the program to maintain an acceptable overall level of pilot proficiency without imposing unrealistic training burdens.

Table 2 presents sensitivity analysis demonstrating how training interval recommendations vary with different decay coefficients. This analysis accounts for individual variability in skill retention based on pilot experience, recency of practice, and learning characteristics.

Table 2

Sensitivity Analysis of Training Intervals Based on Decay Coefficients

Decay Rate λ	50% Loss (months)	Training Interval	Pilot Characteristics
0.10	6.9	4-5 months	Experienced, recent practice
0.173	4.0	2.5-3 months	Average (base case)
0.25	2.8	1.5-2 months	Limited experience, rare practice

Note: Training interval calculated for 80% minimum retention threshold. Decay coefficients represent variability based on pilot populations. Even with ±40% variation in decay rates, quarterly training (3 months) remains appropriate for maintaining acceptable proficiency levels.

Table 3 presents degradation dynamics of pilots' motor and cognitive skills without practice, illustrating the differential decay rates that inform the training program structure.

Table 3

Degradation Dynamics of Pilots' Motor and Cognitive Skills Without Practice

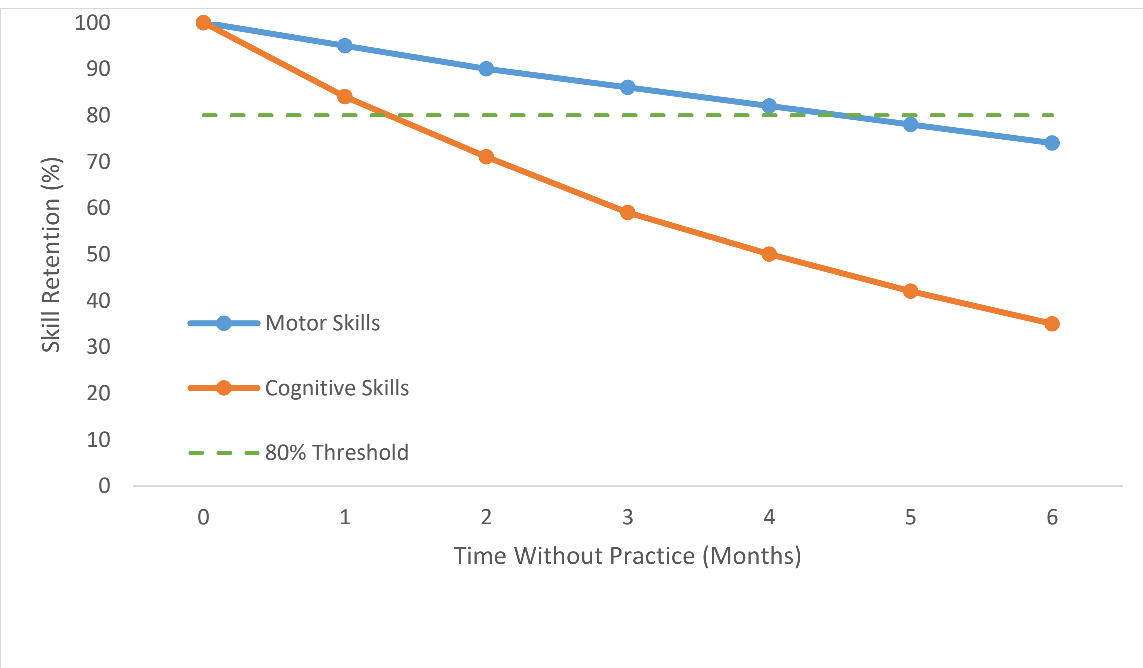
Time (Months)	Motor Skills (%)	Cognitive Skills (%)
0	100	100
1	95	84
2	90	71
3	86	59
4	82	50
5	78	42
6	74	35

Note: Theoretical model based on exponential decay equation with motor skill decay λ = 0.05 and cognitive skill decay λ = 0.173 per month. Parameters derived from Casner et al. (2014) and Prophet (1976). Values represent percentage of initial skill level retained.

Figure 1 provides graphical representation of the exponential skill degradation model, illustrating the more rapid decline of cognitive skills compared to motor skills and the 80% threshold that determines training interval recommendations.

Figure 1

Exponential Degradation of Pilot Skills



To ensure pilots maintain both motor and cognitive manual flying skills, basic training exercises (Module A) are scheduled every three months. While motor skills alone may not require such frequent refreshers, quarterly simulator sessions provide essential reinforcement of cognitive abilities related to manual control. Advanced and high-stress scenarios (Module B) are conducted annually. This frequency reflects logistical considerations and the fact that once the skills required to recover from unusual attitudes are initially acquired, annual reinforcement is generally sufficient. Nevertheless, where possible, UPRT elements should ideally be practiced every six months, a frequency already adopted by some airlines. Thus, the proposed schedule represents a balanced compromise, leaning toward more frequent training than traditional programs while remaining operationally feasible.

Discussion

Alignment with International Aviation Practices

The methodology proposed in this paper aligns closely with global aviation initiatives aimed at addressing degradation of manual flying skills. In recent years, concerns over automation dependency have gained traction at the highest levels of the aviation community. The ICAO Assembly (2019) formally recognized this issue and issued recommendations encouraging member states to support manual flight trajectory management by defining core competencies and updating training standards. In Europe, efforts to mitigate LOC-I have been integrated into EASA regulations. Since 2019, UPRT has become a mandatory in both ATPL training and airline simulator programs, aligning directly with our Module B of this proposed methodology (EASA, 2019). In the United States, several high-profile incidents prompted regulatory review resulting in FAA Advisory Circular 120-123 (2022), which establishes the Flight Path Management framework emphasizing balanced proficiency in manual flying, automation management, and monitoring skills. The circular states that manual flight is the foundation upon which all other technical flying skills are built (FAA, 2022). This philosophy reflects the core principle of our program: manual control is not ancillary but foundational to pilot competence. Additionally, the FAA (2017, 2022) recommends operators revise their policies to encourage varied combinations of manual flying, including operations without autopilot, autothrust, or flight directors — an approach directly mirrored in our training Modules A, B, and D of this training program.

Comparison with Existing Training Programs

To contextualize the proposed methodology, Table 4 compares its key features with traditional recurrent training approaches and current regulatory requirements.

Table 4

Comparison of Proposed Training Program with Current Industry Standards

Element	Traditional Approach	Current UPRT Requirements	Proposed Program
Training Frequency	Annual proficiency check	Annual UPRT module	Quarterly basics + Annual advanced
Manual Flight Focus	Limited, automation-centric	Upset scenarios only	Comprehensive across all modules
Cognitive Skills Emphasis	Minimal	Some situational awareness	Strong emphasis (Module C)
Line Integration	Often discouraged	Not addressed	Actively encouraged (Module D)
Individual Feedback	Limited, standardized	Standard debriefing	Data-driven, personalized (Module E)
Theoretical Component	Minimal ground school	Some theory included	Regular cognitive refreshers

Note: Comparison based on typical Part 121/EASA commercial airline training programs as of 2024. Individual airline implementations may vary.

The comparison reveals that the proposed program offers several novel elements: increased training frequency for foundational skills, explicit cognitive skill development, integration of manual flying into line operations, and data-driven individualized feedback. These features address gaps in current training approaches where manual flying may be relegated to brief annual checks without sustained practice throughout the year.

Expected Outcomes and Implementation Challenges

The implementation of this methodology is expected to yield several tangible benefits. Improved pilot proficiency through regular manual flying practice should enhance pilot confidence. According to a global IATA (2020) survey, 96% of pilots agreed that strong manual skills are essential for flight safety, yet 55% reported having very limited opportunities to hand-fly in routine operations. This program is designed to address that gap. Reduction in automation-related incidents is anticipated. The frequency of events like airspeed decay at altitude or inappropriate stall recovery responses should decline. Although LOC-I incidents are statistically rare, simulator assessment scores and indirect indicators should reflect measurable improvement. Better crew coordination is expected when one pilot flies manually and the other actively monitors, reinforcing CRM and mutual awareness. IATA (2020) found that 67% of pilots believe manual flying enhances crew coordination, a benefit this program explicitly targets.

Some risks and concerns must be addressed:

- Potential for parameter deviations exists, as increased manual flying could lead to minor altitude or heading deviations. This risk is mitigated by rigorous simulator-based preparation before any operational application.
- Training costs including simulator time and pilot release incur expenses. However, these are minimal compared to the financial and human costs of a major incident. Moreover, regulatory mandates already require dedicated UPRT time. This proposal primarily reorganizes existing training, possibly adding just one additional simulator session per year.
- Instructor readiness is essential. Instructors must exemplify strong manual flying and possess modern instructional skills, potentially necessitating dedicated seminars and refresher courses.
- Variable pilot performance means some pilots may show rapid improvement while others struggle. Management must provide additional support and patience, including remedial simulator access.

Approaches to manual skill retention vary globally. In the U.S., following the Colgan Air (2009) and Asiana (2013) accidents, regulatory reforms included stricter hour and skill requirements for Part 121 pilots and mandatory stall recovery training. In Europe, EASA has issued UPRT bulletins and supported LOC-I research programs. In Asia, some carriers revised training programs after incidents like Asiana 214 (2013), where incorrect autothrust configuration and weak visual approach skills led to late recognition of airspeed decay and a fatal crash. While ICAO has introduced standardized UPRT requirements, operator culture still varies. North American pilots often come from general aviation backgrounds with extensive manual flying experience, while in some regions pilots train directly on highly automated jets, leading to reduced manual exposure. The proposed methodology is flexible and regionally adaptable, but its rollout may vary in scope depending on local pilot experience and cultural norms.

This methodology reflects a modern, safety-oriented approach to pilot development. It complements—not contradicts—the benefits of automation. As aviation experts note, automation is most effective when pilots retain the skills and awareness to supervise and, when necessary, override it (Boeing, 2019). The expected benefits—better-prepared crews, fewer LOC-I risks, and a return to the art of flying—justify the investment. Ultimately, the goal is clear: to ensure that pilots do not lose the ability to fly, even when commanding the most advanced aircraft ever built.

Conclusion

This paper addresses the increasingly relevant issue of manual flying skill degradation among commercial airline pilots in the context of rising cockpit automation. The analysis reveals that growing reliance on automated systems may lead to a decline in pilots' practical ability to control the aircraft manually. In critical situations, this loss of proficiency increases the risk of Loss of Control In-Flight events. Despite their relative rarity, LOC-I accidents remain the leading cause of fatalities in commercial aviation (Airbus, 2022; IATA, 2020). Incident investigations consistently show that in many cases, pilots failed to intervene effectively due to a lack of recent experience with manual control.

To counter this threat, we propose a comprehensive training methodology for maintaining and enhancing manual flying skills, designed for implementation by airlines and training centers. The core features of this approach include regularity through scheduled training every few months, scenario diversity from basic maneuvers to emergency situations, line integration promoting manual flying during actual operations where feasible, and progress monitoring through data analysis and individualized debriefing. Particular emphasis is placed on cognitive proficiency—the pilot's ability to make autonomous decisions and maintain situational awareness without relying on automated prompts. These high-order skills tend to degrade the fastest when automation dominates flight operations (Casner et al., 2014). The proposed methodology is grounded in learning theory principles, including the concept of skill decay. Mathematical modeling demonstrates that scheduling training at three-month intervals helps sustain proficiency at high levels while remaining operationally feasible.

This study systematically addressed the four objectives established in the Introduction. First, a comprehensive review of current data on automation's impact and LOC-I frequency was conducted, analyzing 73 incidents from 2010-2024 and revealing that 56% cited manual skill deficiency as a contributing factor. Second, an overview of existing countermeasures was provided, comparing regulatory requirements and training programs from ICAO, FAA, EASA, and major manufacturers. Third, an original manual flying training program was developed featuring five complementary modules addressing motor skills, advanced scenarios, cognitive abilities, line operations, and individualized feedback. Fourth, analysis of expected outcomes and implementation challenges was presented, including comparison with existing approaches and discussion of operational, cost, and cultural considerations.

Our methodology is aligned with the latest international standards and regulatory guidelines from organizations such as ICAO, EASA, and FAA, enhancing its feasibility and relevance. It complements existing UPRT programs and promotes a consistent strategy for sustaining pilot competence across all career phases. While implementing this system requires organizational commitment, the anticipated benefits—higher-quality manual flying, reduced incident rates, and improved operational safety—make it highly relevant. Additionally, the program fosters a stronger operational culture where pilots are engaged and active participants in aircraft control rather than passive monitors of automation. This shift supports greater professionalism and a heightened sense of responsibility.

The primary conclusion of this study is that advanced cockpit automation does not eliminate the need for a highly skilled pilot. Automation is a powerful tool whose effectiveness depends on how and when it is used by the flight crew. A pilot who retains manual flying proficiency and a solid understanding of flight dynamics can make optimal use of automation and take control when required. Conversely, a loss of manual skill can reduce the pilot to a bystander of technology, undermining safety. To prevent this, we must rethink conventional training paradigms. Automation training must be integrated with the ongoing development of manual flying abilities. The methodology presented here contributes to this effort by offering a structured action plan. These recommendations can be adopted by flight schools, airline safety departments, and regulatory authorities when revising training requirements. However, it is also important to acknowledge the limitations of this study. These constraints qualify our conclusions and point to areas that require further investigation.

Limitations

An important limitation of this research is that the proposed training methodology remains conceptual and has not undergone empirical validation through controlled implementation. The projected effectiveness is based on established learning theory, existing research on skill retention (Casner et al., 2014; Prophet, 1976), and alignment with current regulatory best practices. However, actual pilot performance data demonstrating improved manual flying proficiency following this specific training program has not yet been collected. The methodology has not been tested through pre- and post-training assessments, controlled comparison with traditional approaches, or long-term tracking studies. Future research should include controlled pilot implementation studies with performance assessments, comparison of trained versus control groups, and cost-benefit analysis of implementation. Additionally, the mathematical model parameters represent average estimates. Individual pilots may experience faster or slower skill degradation depending on factors such as total flight experience, recency of manual flying practice, aircraft type differences, and individual learning characteristics. The literature review was limited to English-language sources primarily published after 2010. While the proposed methodology incorporates proven components from established UPRT programs and aligns with current regulatory trends, its effectiveness remains a hypothesis requiring empirical validation.

Future Research

Future research should focus on empirical validation of the proposed training methodology through controlled implementation studies. Recommended approaches include:

- Pilot implementation study: Deploy the program at a partner airline and conduct pre- and post-training assessments of manual flying proficiency using standardized simulator evaluation protocols
- Controlled comparison: Compare pilot groups receiving the proposed training versus those following traditional recurrent training, measuring performance on manual flying tasks, situational awareness, and incident rates
- Long-term tracking: Monitor manual flying proficiency metrics over 2-3 year periods to validate predicted decay rates and optimize training interval recommendations
- Cost-benefit analysis: Quantify implementation costs (simulator time, instructor training, scheduling) versus safety benefits (incident reduction, insurance impacts, pilot confidence)
- Individual variability studies: Investigate how pilot experience level, aircraft type, and personal learning characteristics influence skill decay rates, enabling more personalized training recommendations

Additionally, research could explore optimizing the balance between time spent on automation training and manual skill development, tailored to pilot experience level and aircraft type. Integration of emerging technologies such as virtual reality home simulators, adaptive training systems, and biometric feedback could further enhance program effectiveness.

To conclude, aviation has always been—and remains—a domain that places exceptional demands on the human element. While technology continues to evolve, the responsibility for flight safety still rests with the pilot. Maintaining and advancing pilot craftsmanship—including the ability to confidently fly the aircraft manually—remains a non-negotiable prerequisite for accident prevention. The proposed training framework is designed to ensure that every pilot, sitting at the controls of a highly automated airliner, remains above all a pilot—capable of taking command and ensuring a safe outcome under any circumstances.

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