2.3 & 2.4 Aeroplane Flight Path Management

Managing the flight path involves cognitive processes and behavioral techniques by both pilots. Each pilot is responsible for being aware of the current and desired flight path; and each pilot must be capable of manually flying the aircraft with automation and in manual control.

Flightpath: the trajectory (lateral, longitudinal, and vertical) and energy state of the aircraft. "Flightpath" includes "ground path" if the aircraft is in motion on the ground. [i]

Flight Path Management: Automation: Controls the aircraft flight path through automation, including appropriate use of flight management system(s) and guidance

Automation

The word **automation**, in the context of flight deck operation, refers to the replacement of a human function. This can be done as either a manipulation of:

- aircraft function- the autopilot controlling the longitudinal or lateral direction of the aircraft, or;
- cognitive function - monitoring the health status of the aircraft systems.

As technology advances, automation reliability and functionality have improved. Automation is intended to support the pilot; therefore, the pilot must fully understand the capabilities of the automation and select the appropriate level of automation for various phases of flight.

Automation should be used at an appropriate level that

1) enhances safety and
2) supports the mission (passenger comfort, crew workload and efficiency).

Automation can dramatically reduce the pilot workload, especially in single pilot operations. Emphasis should be placed that while automation can enhance safety, efficiency, and situational awareness, it has the potential to cause incidents when misunderstood or mishandled. Mismanaging the automation could result in an undesired state. Therefore, automation management is a core competency in all levels of flight deck training.

Managing the flight path with the use of automation is such a critical focus, that it is recognized

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as a standalone ICAO competency with 6 observable behaviors.

FPA **Observable Behaviors** [ii]	**FPA 1**	Uses appropriate flight management, guidance systems and automation, as installed and applicable to the conditions
	FPA 2	Monitors and detects deviations from the intended flight path and takes appropriate action
	FPA 3	Manages the flight path safely to achieve optimum operational performance
	FPA 4	Maintains the intended flight path during flight using automation while managing other tasks and distractions
	FPA 5	Selects appropriate level and mode of automation in a timely manner considering phase of flight and workload
	FPA 6	Effectively monitors automation, including engagement and automatic mode transitions

These OBs can be classified in two areas:

- 1,3,5: Positively using appropriate levels of automation for optimum performance
- 2,4,6: Avoiding automation concerns by monitoring, intervention, and reversion to manual flight if necessary.

Levels of Automation

Technological advancements have resulted in highly automated and integrated flight decks. Some examples of integrated avionics systems with automation include:

- Flight management system (FMS)
- Flight director
- Electronic display system (EDS)
- Autothrottle
- Terrain awareness and warning system (TAWS)
- Head Up Display (HUD)
- Autopilot
- Autoland Operations
- Autobrakes

Pilots are responsible to understand the operation of these systems, how they relate to each other, how to control the aircraft flight path, and how to manage a failure of any of these systems. In some circumstances, the safest move is to revert to a lower level of automation.

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There are four levels of automation.[iii]

Level	Flight Director & Autothrottle (if installed)	Autopilot	Flight management system
1	N	N	N
2	Y	N	N
3	Y	Y	N
4	Y	Y	Y

Level 1 – no automation (raw data).

In this level, the pilot would be hand-flying the aircraft. All pilots must be fully capable of operating the aircraft in this level of automation.

This level could be used in the following scenarios:

- during any unexpected response or misbehavior from the automation
- during moments of mode confusion
- wind shear recovery
- responding to traffic avoidance
- responding to an unusual attitude (upset recovery)
- responding to the terrain avoidance system
- descending breakout during certain approach procedures

Level 2 –flight director and autothrottle (if installed).

The pilot is hand-flying using the flight director for heading and/or navigation guidance while the autothrottle (if installed) are used for energy management.

This level of automation is often used during:

- takeoff
- initial climb out
- landing

Level 3 –flight director, autothrottle (if installed)**, and autopilot.**

The pilot is no longer hand-flying in this level of automation. The pilot is controlling the aircraft through inputs to the autopilot. The aircraft speed, vertical and lateral flight paths are controlled through the autopilot. The flight director may be coupled to basic modes, such as altitude (ALT) and heading (HDG).

This level of automation is often used when being vectored by Air Traffic Control.

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Level 4 – flight director, autothrottle (if installed), **autopilot, and FMS**

Similar to level 3, but additionally, the Flight Management System (FMS) is controlling the vertical and/or lateral axis of the aircraft. The modes utilized by the pilot are LNAV for lateral navigation or VNAV for vertical navigation.

This level of automation is often used during a standard instrument departure (SID) procedure, cruise, standard arrival route (STAR), and during some approaches. This level of automation is used often to reduce crew workload, examples being:

1) cruise phase of flight,
2) in the terminal environment during low visibility for instrument approaches,
3) during holding procedures, and
4) during non-normal conditions where crew cognition is needed elsewhere.

There are various *modes* that can be used within these levels of automation. For example, both flight level change (FLC) and vertical speed (VS) can be used to control the aircraft's climb or descent. Similarly, the modes navigation (NAV) and heading (HDG) can control the direction of the flight path.

The term *mode awareness* refers to the pilot having situational awareness to the current and desired automation functions. When a pilot does not have awareness of the automation mode, we can refer to this phenomenon as *mode confusion*. It is important for pilots to understand the various levels of automation and when each mode is appropriate to use.

To promote mode awareness and avoid mode confusion, changes in modes should be announced by and acknowledged by the flight crew based on their company's established and documented operational procedures. Any auto flight system it should be disengaged if it malfunctions or operates in an unexpected way. This is often accompanied by the phrase: "what's it doing now?" A pilot opting to change the level of automation should consider:

- *Time available* -is this a normal selection or a last-minute change?
- *Phase of flight* – takeoff, departure, enroute, arrival, approach, etc.
- *Duration of automation* – is this a short-term choice while responding to a traffic advisory, for example; or a long-term strategic decision, for example while heads-down programming the Flight Management System?

In some cases, reverting to a lower level of automation or hand-flying manually may be the safest action. The Pilot in Command (PIC) will always retain the ultimate authority and responsibility to determine the correct level of automation for a given circumstance.

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Manual Control

Equally relevant to flight path management, is a pilots' skills in manual control. Part of ensuring pilot proficiency in *stick-and-rudder* skills, ICAO has created a competency on flight path management while under manual control and provided the following observable behaviors.

Flight Path Management: Manual: Controls the aircraft flight path through manual flight, including appropriate use of flight management system(s) and flight guidance systems.

FPM Observable Behaviors [iv]		
	FPM 1	Controls the aircraft manually with accuracy and smoothness as appropriate to the situation
	FPM 2	Monitors and detects deviations from the intended flight path and takes appropriate action
	FPM 3	Manually controls the aeroplane using the relationship between aeroplane attitude, speed and thrust, and navigation signals or visual information
	FPM 4	Manages the flight path safely to achieve optimum operational performance
	FPM 5	Maintains the intended flight path during manual flight while managing other tasks and distractions
	FPM 6	Uses appropriate flight management and guidance systems, as installed and applicable to the conditions
	FPM 7	Effectively monitors flight guidance systems including engagement and automatic mode transitions

It is important to note that manual flying is not the opposite of automation. Manual flying refers to hand-flying the aircraft; it does not directly correspond to a level of automation, nor which mode is being used. It does however occur more often when flying in level 1 or 2 automation. There are several points to consider when discussing manual flying:

- **FPM 1: Smooth handling** as mentioned requires motor skills of hands on the controls but could also include to any abrupt mode changes that cause an abrupt change in movement.
- **FPM 3,6:** Show the technical knowledge required for: the relationship between attitude, speed and thrust; navigation; and automation mode selection.
- **FPM 2, 5, 7:** Discuss effective monitoring and mode selection, while managing distractions and other tasks.

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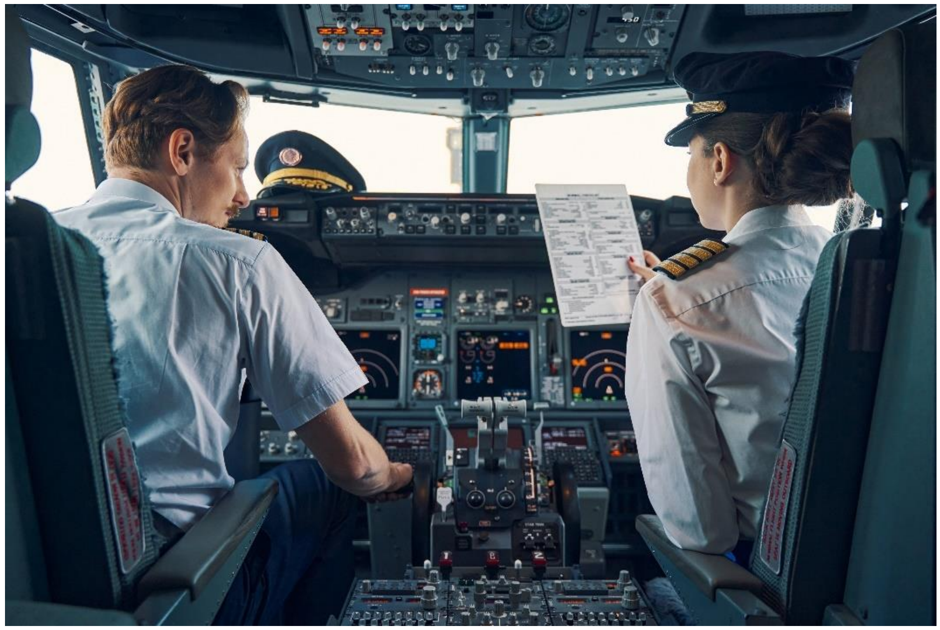
Monitoring

Regardless of the level of automation being utilized or which mode is selected, it is always the responsibility of the pilots to monitor the flight path during all phases of flight.



Effective monitoring is vital to flight safety. In recent years pilots on a flight deck might have been called pilot flying, and pilot not flying. However, this naming gave the impression that one pilot would do everything while the other did nothing. This is obviously not good Crew Resource Management. Therefore, the flight deck crew are now named Pilot Flying (PF), who manages the flight path, and Pilot Monitoring (PM), who ensures that either the automation and/or pilot flying inputs is appropriate for the phase of flight. Either pilot must be capable of intervening if necessary.

Pilot Flying (PF)[v]: The pilot whose primary task is to control and manage the flight path. The secondary tasks of the PF are to perform non–flight path related actions (awareness of radio communications, aircraft systems, and other operational activities, etc.) and to monitor other crewmembers.

Pilot Monitoring (PM): The pilot whose primary task is to monitor the flight path and its management by the PF. The secondary tasks of the PM are to perform non–flight path related actions (radio communications, aircraft systems, other operational activities, etc.) and to monitor other crewmembers.

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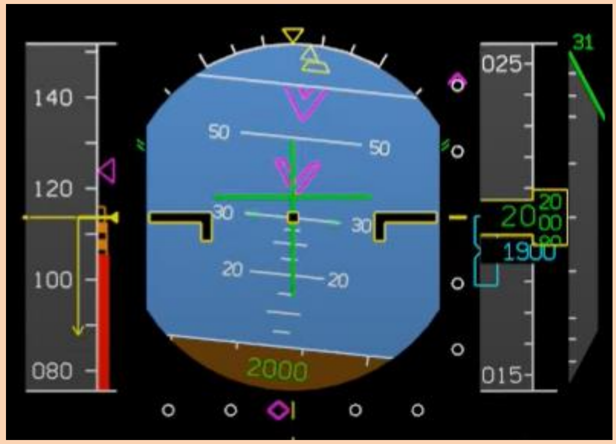
Air France Flight 7512[vi]

On 20 December 2019, an Airbus 318 operated by Air France attempted an Instrument Landing System (ILS) approach to Runway 5 at the Toulon-Hyeres Airport. Automation was being used and the autopilot captured a false secondary glideslope. The pitch attitude increased significantly to 30 degrees nose up, decreasing the airspeed, reaching a minimum of 96 knots. The stall protection system was then activated.



Air Traffic Control issued a go around, but the flight crew were unresponsive. Recovery of the undesired aircraft state was eventually made, and the crew went around. The aircraft landed with no damage or causalities.

An investigation was conducted by the French Civil Aviation Accident Investigation Agency determining that insufficient monitoring by both the PF and PM was a major contributory factor. This event reminds us of the importance of monitoring automation and cross-checking.

Automation Dependency

This case study, and many more, show the dangers of overreliance on automation, and the importance of flight path monitoring.

Flight path monitoring[vii]

- "…the observation and interpretation of the flight path data, aircraft-configuration status, automation modes and on-board systems appropriate to the phase of flight.
- It also includes continuous awareness of both the trajectory and energy state of the aircraft."

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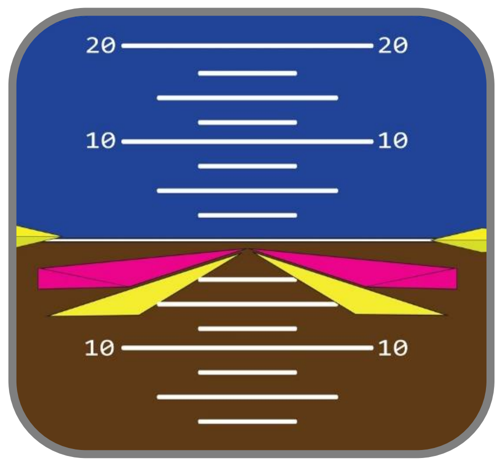
A pilot is responsible for being aware of the current and desired flightpath and must be fully capable to manually fly the aircraft to match the desired flightpath. When one is too reliant on the automation, this is a phenomenon known as automation dependency.

> ***Automation Dependency***[viii]
>
> "Automation Dependency has commonly been described as a situation in which pilots who routinely fly aircraft with automated systems are only fully confident in their ability to control the trajectory of their aircraft when using the full functionality of such systems. Such a lack of confidence usually stems from a combination of inadequate knowledge of the automated systems themselves unless all are employed and a lack of manual flying and aircraft management competence."



Sometimes referred to as the "children of the magenta," automation dependency has been an important topic in aviation safety for several decades. The term "children of the magenta" traces back to 1997 when an American Airlines captain was sharing his concern that pilots were becoming too dependent on monitoring the magenta lines in the flight deck (automation) rather than actually flying the airplane.[ix] This concern is not merely theoretical. A 2016 academic study of 126 airline pilots revealed that manual flying skills are subject to erosion due to a lack of manual flying on long-haul fleets.[x]

Critics of enhancing automation might say that poor human performance leads to advancements in automation, which worsens human performance, which results in more automation.[xi]

On the other hand, automation has proven to drastically reduce workload, enhance safety and efficiency, and increase situational awareness.

There is a necessary balance between automation and human performance both in understanding the potential risks of automation dependency (overreliance, intimidation to intervene, complacency, etc.) and in maintaining pilot ability to manually control the aircraft. Training pilots on the pros and potential cons of automation must be included in a flight path management training program.

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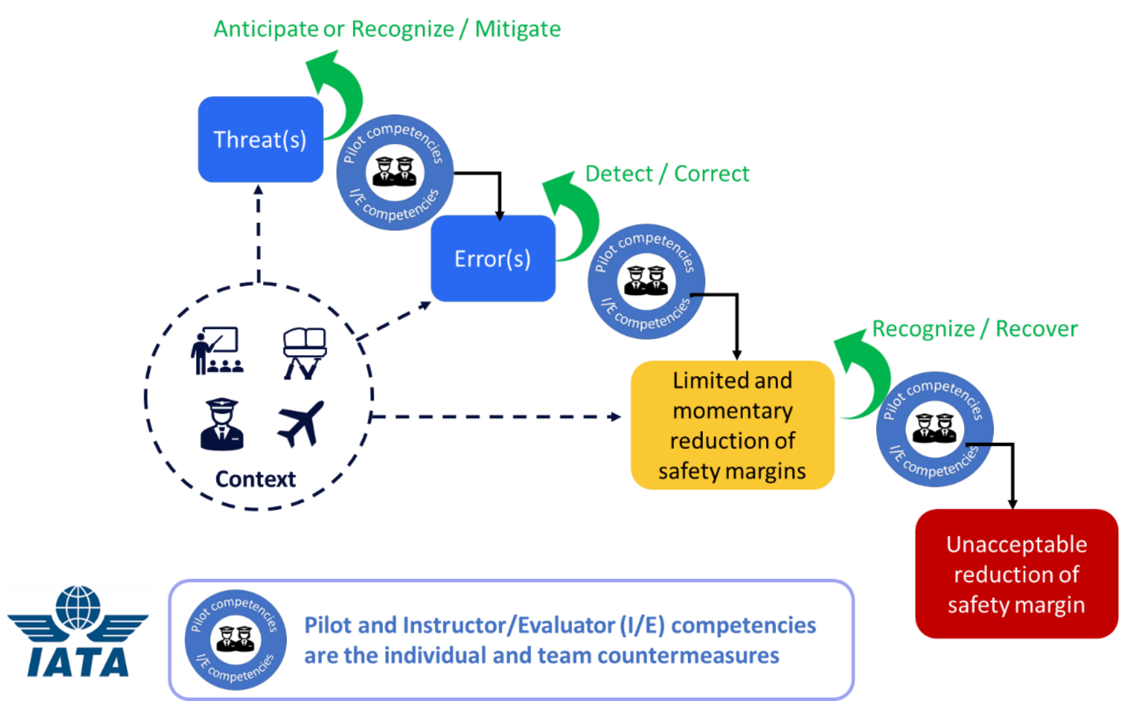
Threats and Potential Errors

While it is clear that proper use of automation can reduce workload, it is also evident that improper monitoring can lead to an undesired aircraft state. In addition to this concern, there are other automation interaction issues worth noting.

- Overuse of the autopilot can lead to a decline in basic manual flying skills. With a lack of practice and a lack of feel for the aircraft, basic *stick and rudder* skills can deteriorate.
- Pilots interacting with automation can become distracted from flying the aircraft. There are times when it may be safer to revert to lower level of automation.
- Unanticipated situations that require the manual override of automation could create a surprise or startle effect.
- Data entry errors (mistake or slip errors) can cause the automation to do things that pilots were not expecting, such as crossing restrictions, airspeed changes…
- Automation failures leading to degraded performance may task pilots with a higher workload.
- Human factors issues, such as complacency, dependency, intimidation to intervene, and/or passivity can occur.
- Pilots will react to their mental representation of the situation, which may conflict with the realities of the situation.

Special emphasis should be given to the importance of training pilots how to recognize an automation issue and how to respond to an automation failure.



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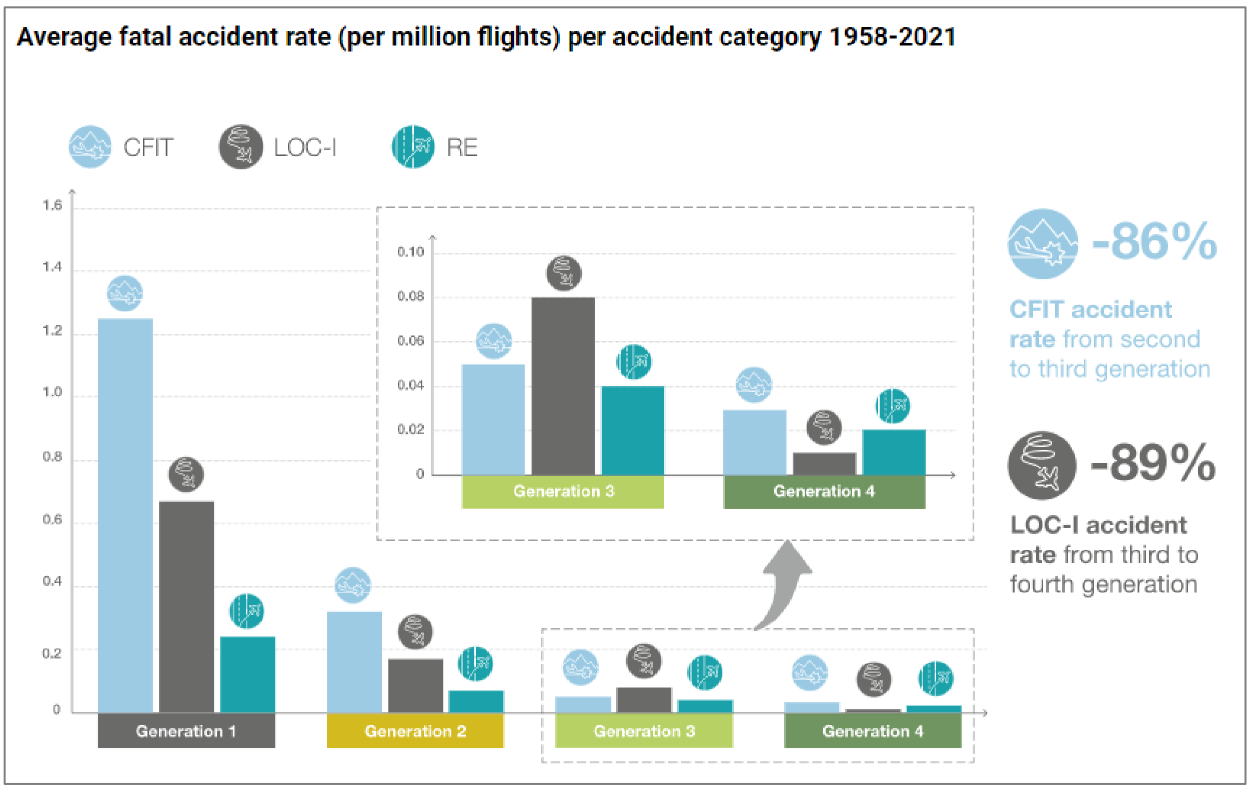
Automation Philosophy

Beyond manufacturer guidance, flight manuals, and company SOPs, the pilot is free to choose level of automation that is the most comfortable for the given task. The choice of level will be impacted by the automation philosophy that the systems are programmed with.

Each aircraft manufacturer is free to establish their own automation philosophy, but generally there are two categories, dependent on what the automation will do if the aircraft is pushed outside the nominated flight envelope:

1. Automated systems will not allow it and automatically recover the aircraft to within the limits
2. Pilot controls override automation and therefore automation turns off.

These cannot be considered right and/or wrong, but simply different, and it is imperative that pilots understand what automation philosophy is used in their aircraft to appropriately manage the systems.



Statistics from Airbus show that increased automation to include flight envelope protection philosophies, have reduced accident rates of both Controlled flight into terrain (CFIT) and Runway excursions (RE). As well as making a massive 89% reduction in the Loss of Control in flight (LOC-I) accident rate.[xii]

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Summary

- Pilots must not only be familiar with all 4 levels of automation but be proficient in transitioning smoothly and safely between the levels at any time during any given flight.
- Mode awareness is vital and requires effective communication between pilots.
- Announce all changes in accordance with standard calls defined in standard operating procedures Standard Operating Procedures.
- Automation dependency must be guarded against, by creating a balance between manual and automation flying.
- Automation, correctly used, will ease pilots' workload, and increase the safety and efficiency of the flight.

Further Reading

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