Wolters Kluwer

Enablon

Expert Insights

From “pilot error” to root cause: Applying HFACS in aviation safety investigations

About Wolters Kluwer Enablon

BowTieXP and IncidentXP, part of Wolters Kluwer Enablon, are barrier-based risk management and incident investigation software. BowTieXP visualizes how organizations manage risk through clear, structured bowtie diagrams. IncidentXP builds directly on those same bowties to analyze real occurrences, connecting proactive risk assessment and reactive investigation in one system.

Author

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Augusto began his aviation career as an aeronautical engineer in airline airframe and systems departments. He subsequently served as an airworthiness inspector at the Italian Civil Aviation Authority (ENAC), within the Flight Safety Department in Milan. For the past twenty years, he has operated in the flight operations environment, accumulating extensive hands-on experience in line operations, crew resource management, training and operational safety.

Today, alongside his active role as an airline captain, he works as an independent consultant in safety and compliance. Augusto is also a partner and authorized trainer for Enablon.

The problem: Siloed risk assessments and investigation

Ask most heads of safety what happens after an incident, and you'll hear a familiar pattern. An investigation opens, an owner is assigned, findings get written up, a report gets filed. Ask what happens to those findings six months and two incidents later, and the answer is usually: not much. They sit in a different system from the risk assessments that predicted the same failure modes and remain disconnected, hard to search, and easy to lose.

Most incident investigations also stop at the front line. A worker made the wrong call, so the worker is the cause, case closed. That's rarely the full picture, and it's rarely useful for prevention. The conditions that set someone up to make that call, training gaps, staffing decisions, workload, unclear standards, sit further back in the organization. If an investigation doesn't reach them, they stay in place for the next incident too.

What changes when risk assessment and investigation share one system

- Investigations start from the risk assessment that already exists for that hazard, rather than from a blank page, reducing duplication between risk assessment and occurrence analysis.
- Human Factors Analysis and Classification System (HFACS) provides a structured taxonomy that helps investigators classify contributing factors consistently across occurrences, making trends more visible over time.
- Barrier data flows in both directions: the same barriers assessed proactively get evaluated reactively when they're involved in an incident, closing the loop between the two sides of your safety program.
- Individual findings roll up into Safety Performance Indicators that leadership can track over time, not one-off conclusions that get filed and forgotten.

What is HFACS?

The Human Factors Analysis and Classification System is a method for examining human error in occurrences by categorizing it against a structured taxonomy. It was developed for aviation and is now used across different industrial domains.

HFACS is built on a simple premise. In complex socio-technical systems, an accident is rarely the result of one person's mistake. It's the result of multiple contributions, some immediate, some sitting further back in the organization:

1. **Active failures:** errors and violations at the front line, with immediate effect.

2. **Latent failures:** decisions and actions made at the organizational level, with a latent effect that gets triggered later by front-line conditions.

HFACS breaks this down into four levels, from the person level up to the organization level:

HFACS: the four levels, from front-line activities up to decision makers

1. **Fallible decisions** – organizational-level choices, culture, and structure that shape everything below.

2. **Line management deficiencies** – supervisory and planning failures that allow those conditions to exist.

3. **Preconditions for unsafe acts** – the physical, mental, and teamwork conditions that set up the operator to fail.

4. **Unsafe acts** – active failures, the errors and violations committed directly by the operator.

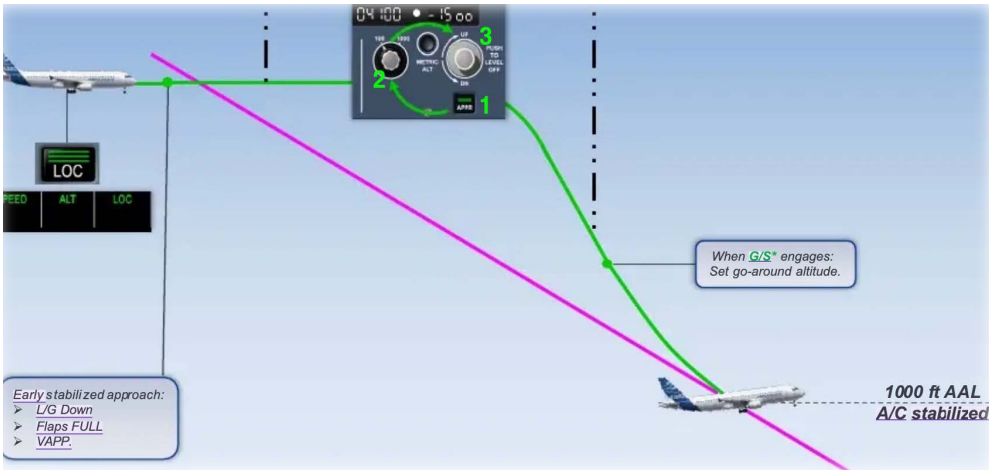
The higher a cause sits in the hierarchy, the closer it is to management and organizational decisions, rather than the person at the controls, with a root cause further back in time.

Seeing it in practice: Colgan Air Flight 3407

Ice forming, viewed from the cockpit

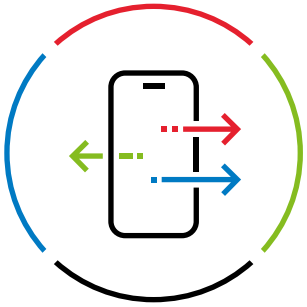
On the night of 12 February 2009, Colgan Air Flight 3407, a Bombardier DHC-8-400, was flying from Newark to Buffalo. There were 49 people on board.

During taxiing, the pilots violated the Sterile Cockpit Rule, engaging in conversation unrelated to flight operations, and continued throughout the flight. During the climb, icing conditions were encountered and the anti-icing system was correctly activated.

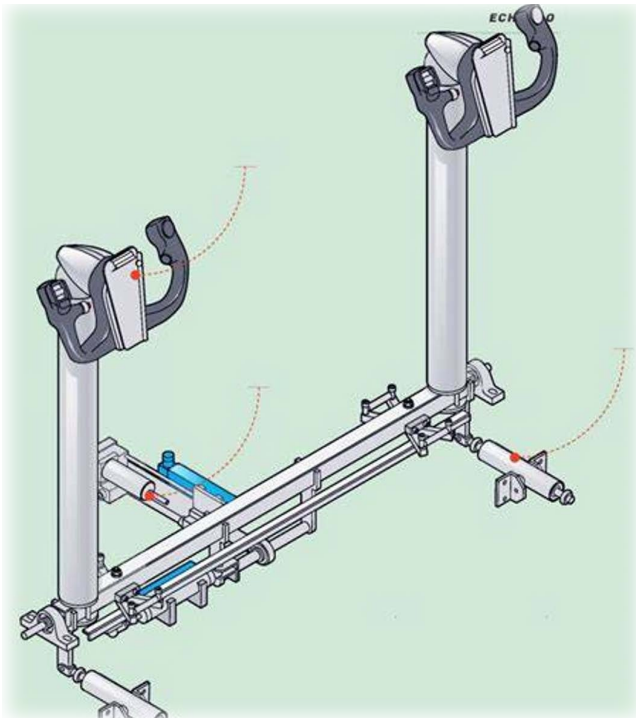


Capture from above procedure, during approach

During the approach briefing, the first officer calculated approach speed for non-icing conditions, when the higher, icing-adjusted speed was required. During descent, the aircraft came in high and fast, compromising the stabilization gate. To recapture the approach path, the crew used a known technique: approach path capture from above, extending flaps and landing gear to increase drag.



The threat with this technique is a drastic reduction in speed that must be closely monitored. That monitoring did not happen.



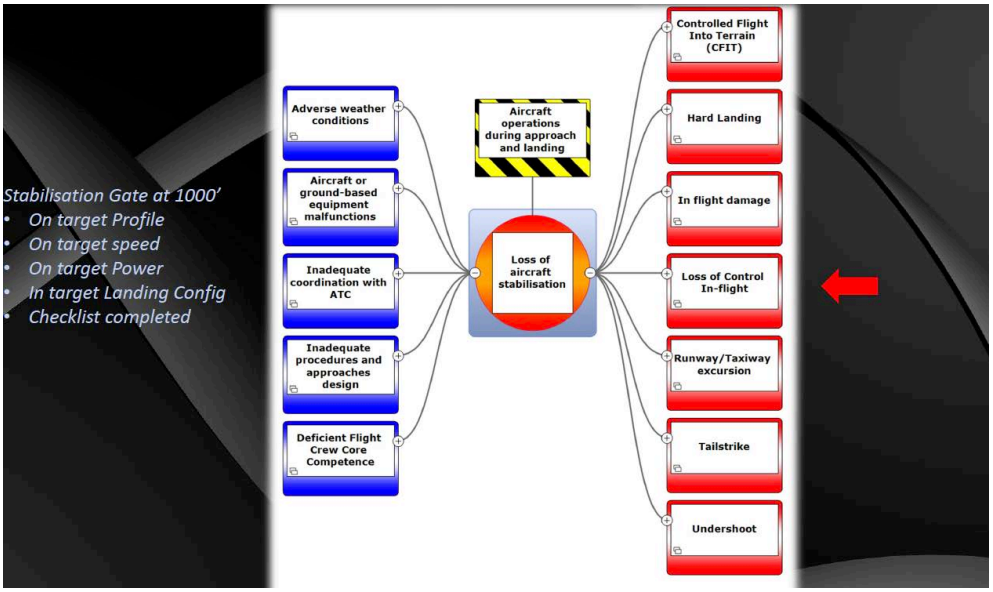
The stick shaker mechanism

As speed decreased, the stick shaker activated. The captain reacted by increasing the angle of attack instead of decreasing it, pushing the aircraft toward a stall. The stick pusher, the last functional barrier, forced the nose down, but the captain overrode it by deactivating it. The aircraft entered a full stall and Loss of Control In-flight (LOC-I). 27 seconds later, it hit the ground. All 49 on board and one person on the ground died.

Read at face value, this looks like a straightforward story: the crew made a series of wrong calls. Easy task, pilots' fault. HFACS is built to test whether that's actually true.

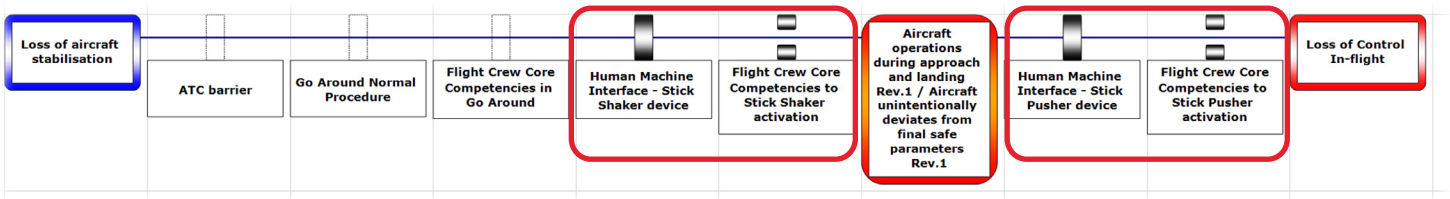
Applying HFACS through IncidentXP

The starting point is the risk assessment already modelled in BowTieXP: loss of aircraft stabilization as a top event, with the threats and barriers meant to prevent Loss of Control In-flight.



BowTieXP risk assessment: loss of aircraft stabilization

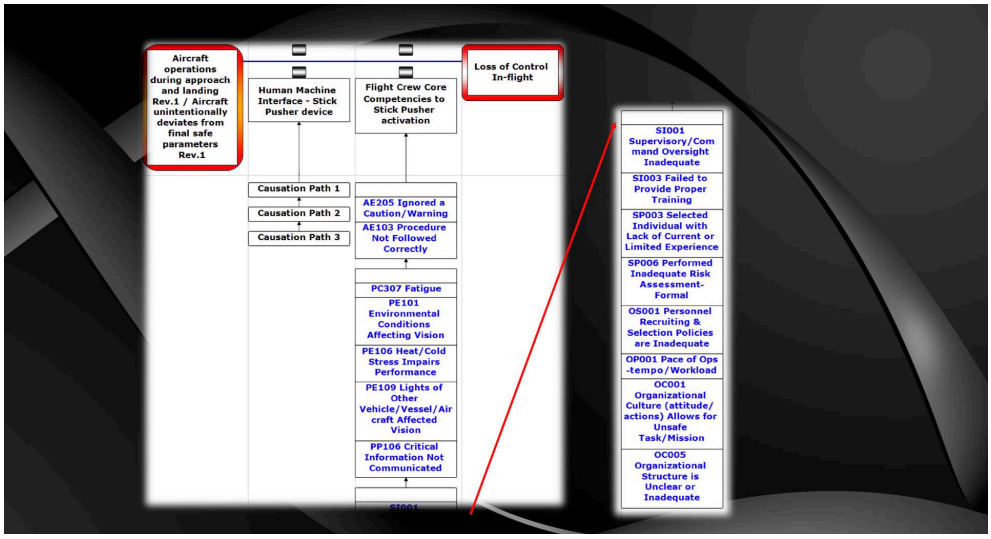
Because that bowtie already exists, IncidentXP can generate the occurrence analysis in a few clicks, rather than starting from a blank page. The occurrence analysis follows the same barriers along the timeline of the flight: the ATC barrier, the go-around procedure, the stick shaker, and the stick pusher. Two of those barriers failed: both the human barrier either at the stick shaker and stick pusher family barrier, and the flight crew's core competencies in responding to them.



IncidentXP occurrence analysis: loss of aircraft stabilization barrier analysis

This is where the question changes.

How do you analyze the failure of a human barrier, as opposed to a technical one? Technical barrier failures can be analyzed with methods like Barrier Failure Analysis (BFA), with Causation Path 1, 2 and 3. Human barrier failures need a different lens, which is where HFACS comes in.



Causation paths tracing the human factor findings, from unsafe acts up to fallible decisions

1. **Unsafe acts.** The performance-based errors are named directly: ignoring a caution or warning and not following the procedure correctly.

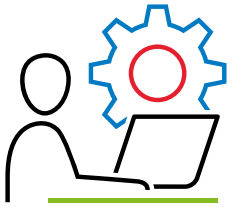
2. **Preconditions.** Working back from those acts, IncidentXP surfaces the conditions that made them more likely: fatigue, reduced mental awareness (not paying attention, distraction, technical or procedural knowledge not retained after training), and a teamwork failure where critical information wasn't communicated between the crew.

3. **Line management deficiencies.** Further back again: inadequate supervisory oversight, failure to provide proper training, selecting an individual with limited current experience, and an inadequate risk assessment at the planning stage.

4. **Fallible decisions.** At the top of the chain: inadequate personnel recruiting and selection policies, workload and pace of operations, and an organizational culture and structure that allowed the conditions above to exist unchecked.

Laid out this way, “pilots' fault” turns out to be the last link in a much longer chain, not the whole story.

Why this matters beyond the investigation



The output of this analysis isn't just a report on one flight. Each of these classified causes - fatigue, inadequate training, poor risk assessment, culture - feed into Safety Performance Indicators (SPIs): the human-factor metrics an organization tracks across its entire operation, not just after something goes wrong.

That's the real value of running HFACS through IncidentXP rather than as a standalone exercise. The same barriers modelled for proactive risk assessment in BowTieXP become the backbone of the reactive investigation. Nothing needs to be rebuilt from scratch, and the human factor findings roll up into indicators the organization can act on going forward.

And because HFACS isn't aviation-specific, this approach applies wherever human barriers sit inside a bowtie, across any industrial domain.

The lesson from Colgan Air isn't that the crew didn't make mistakes. It's that stopping the analysis there would have missed what really needed to change.

Explore how it applies to your operations

BowTieXP and IncidentXP work together so your existing risk assessments become the backbone of every investigation, not a separate exercise. If a barrier fails, you already know where to look, and every human factor finding rolls up into indicators you can track and act on across your organization.

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Sources:

NTSB/AAR-10/01, Colgan Air Flight 3407 Final Investigation Report;

S.A. Shappell & D.A. Wiegmann (2000), The Human Factors Analysis and Classification System;

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Enablon BowTieXP/IncidentXP Manual.