WE SHOULD ALWAYS HAVE IT BOTH WAYS

Original Equipment Manufacturers (such as Aircraft Manufacturers) and airline pilots live in a state of flux between established work-as-done and rigorous work-as-imagined. In this article **Jean-Jacques Speyer** describes experience of WAI-WAD from an OEM perspective.

KEY LEARNING POINTS

1. **Exploring Work-as-Imagined (WAI) following incidents it is proposed that there is no room for undocumented tips: only operational advice from the OEM.**
2. **Reviewing Work-as-Done (WAD) after incidents can reveal double binds for pilots facing the option to step out of established SOP's.**
3. **Back and forth communication between WAI and WAD is indispensable for the sake of the aviation system.**

Recently reading my weekly Flight International copy, I came across the work experience story of Captain Kate McWilliams, who had just taken her command on Airbus A320's.

"The thing I love most is the unknown that comes with every day. Each day I work with a new crew and I fly to a different destination which brings with it varying challenges such as weather, different approach procedures or air traffic restrictions. No two days are ever the same." (Flight International, Jan 10-16, 2017).

The kind of attitude that was always necessary to attract 'the right stuff'. Hopefully this media statement includes a sense of readiness for events that reveals the potential contrast that emerges between work-as-imagined (by aircraft manufacturers) and work-as-done (by airline pilots).

Having personally spent most of my own career with an original equipment manufacturer (OEM) on both the flight certification and the operational support side of the business I tend to look at the two sides of the coin (WAI-WAD), as illustrated with two cases.

Exploring work-as-imagined following an incident

In April 2004 an A340-300 overran an 11,110 feet runway on take-off from Johannesburg at night by roughly 490 feet before getting airborne in narrowing visibility. The aircraft hit approach lighting and was seriously damaged (flaps damaged and locked, gear and fuselage damaged), but managed to return for a safe landing and no injuries.

The airline's training and rostering practices came under scrutiny. Both pilots were making their second flight on type. The captain did his first flight in command, was pilot flying and used an erroneous take-off technique, which he had heard as a training tip for achieving accurate rotation. The tip was to move the Sidestick Order Indicator to the +9° angle indicator on the Primary Flight Display (PFD). As the airplane started to pitch up, this would trigger release of stick pressure counteracting rotation. This tip delayed rotation, preventing the airplane from getting airborne.

Following this unfortunate incident, the OEM decided to explore the gaze of pilots (where they are actually looking) during take-off, particularly the critical period from V1 to rotation. The timing and sequence of gaze fixations on the PFD and other instruments, and the runway, were analysed over a range of visibility and runway conditions typical to line operations. The project was conducted in an A340 full motion simulator.

Six pilots (five males, one female) participated in this engineering experiment on the A340 simulator: four test pilots, one training supervisor and one airline pilot. Five take-off conditions were simulated: 1. daylight 100% visibility; 2. daylight 200m visibility; 3. night 100% visibility; 4. night 200m visibility and bad runway; 5. night 200m visibility and side wind. Each of the subjects performed three trials for each condition in a more or less random order for a total of 15 take-offs per individual.

Head, eye and cabin movements were measured and the PFD was recorded, along with sound and video.

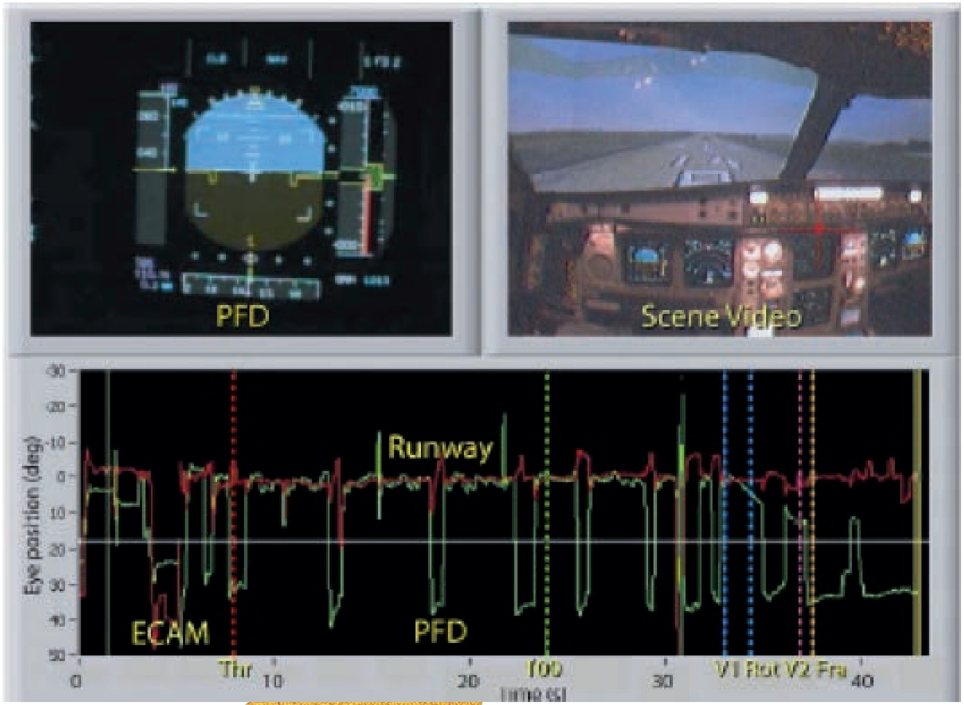
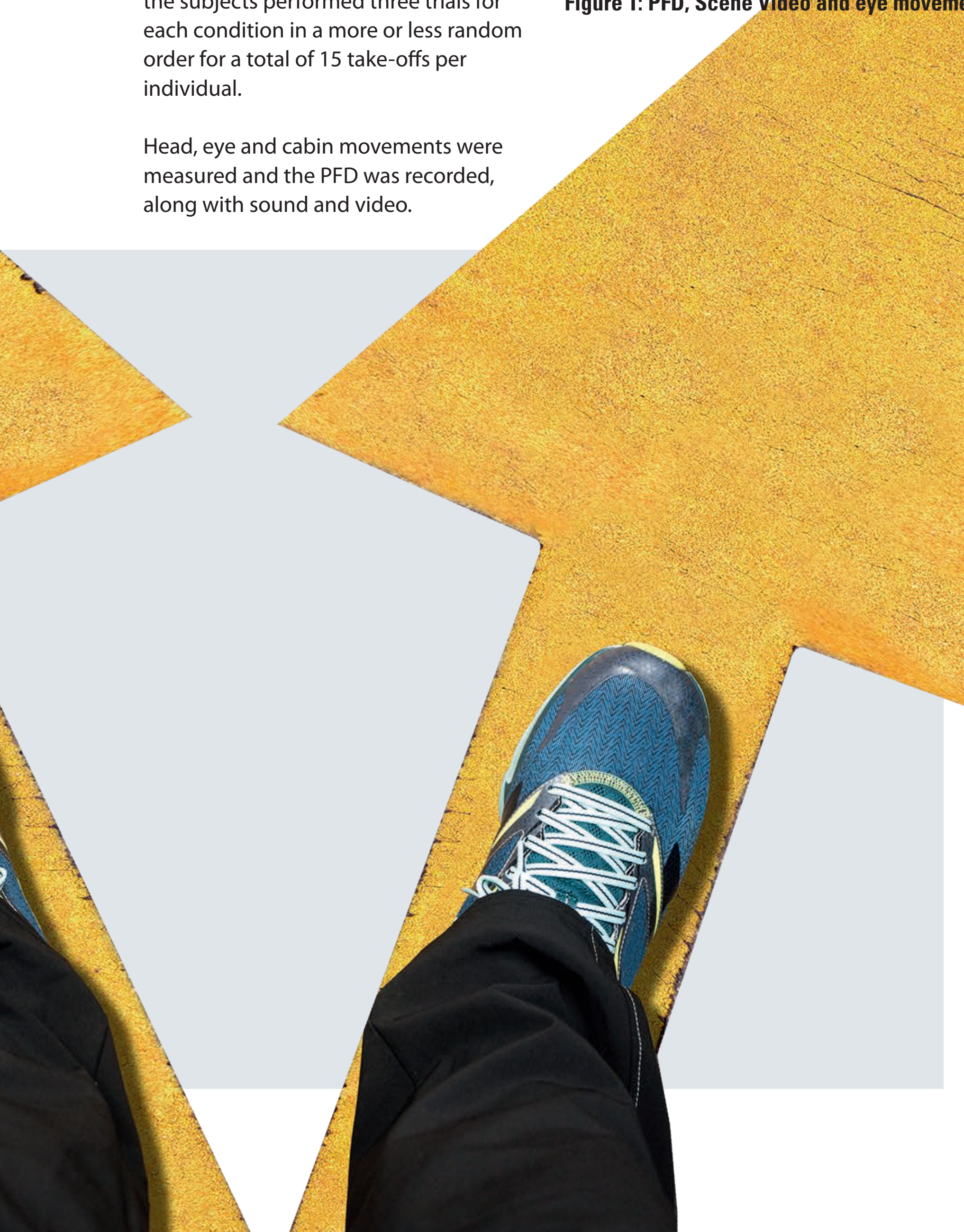


Figure 1: PFD, Scene Video and eye movements



Although the number of participants was small, some significant observations emerged from this experiment on work-as-done, with two main effects being noted:

1. individual differences linked to training,
2. visibility, especially at night.

One participant primarily utilised instruments during the entire take-off regardless of visibility, possibly linked to his background as a naval aviator. The other five subjects, however, looked mainly at the runway prior to rotation. In the 10 seconds period centred on the rotation call, all subjects looked back at the PFD within a few seconds of rotation. This consistent re-fixation on the PFD follows a 40 second period of primarily looking at the runway, with occasional glances down at the instruments, occurring rapidly (within a second of rotation) in poor visibility. Bad runway and side wind conditions did not exert noticeable influence on results.

There is no room for undocumented tips from the corridor: only operational advice matters for 'work-as-imagined' from the OEM perspective. The duty for documentation and procedures resides solely with the manufacturer who is responsible for testing and evaluating procedures, and for writing and updating flight crew operating manuals. In this particular case the OEM decided to examine pilot scanning procedures under narrowing visibility. In accordance with standard operating procedures (SOP's), rotation has to be performed smoothly using a continuous pitch rate (this refers to rotation rate and not to sidestick input) to a pitch of 12.5° with the speed reference system pitch command bar to be followed but after lift-off.

Reviewing work-as-done after an incident

In November 2003, shortly after takeoff from Baghdad, Iraq, an A300B4-200F cargo aircraft was hit on its left wing tip by a surface-to-air missile, causing fire and complete loss of hydraulic flight control systems. Since the inboard left wing fuel tank was full, there was no fuel-air vapour explosion but the left outboard fuel tank was pierced and leaking. Returning to their departure airport, the crew brought their crippled aircraft safely back, using differential engine thrust in spite of major damage to a wing, total loss of hydraulic control, approaching at a much faster than normal speed followed by a runway veer-off.

After being hit, the aircraft was pitching rapidly up and down into a rocky phugoïd (long period oscillation). Remembering the Sioux City DC-10 case, the Captain used thrust to modify pitch, speed and altitude, varying throttles asymmetrically to control yaw and turn the aircraft. Early deployment of the gear was critical to increase drag safely which helped reduce speed and stabilize the crippled Airbus.

In some 10 minutes of experimentation, the crew learned to understand how to fly turns, climbs and descents. What is less known from this mishap is that the captain was proactive enough to stop his flight engineer from executing the fuel leak procedure that required to close the cross-feed cock. This would have isolated both wings from each other. Since both engines had to stay running, this would cover the risk of left engine flameout if the left tank had run out of fuel. Pilots were also aware that they could not retard throttles before touchdown without risking the nose or a wing pulling the aircraft down. This brilliant step aside is reminiscent of yet another dramatic incident that was to happen years later in 2010 on an A380 off Singapore. The Captain choose to refocus crew efforts from solely firefighting never-ending failures to dealing with what was still working.

Work-as-imagined by the OEM had never foreseen these cascading scenarios nor overall procedures to cover those. As says Erik Hollnagel, "unusual human performance and unusual circumstances are almost always the result of unanticipated interactions of multiple phenomena that, if they were to occur individually, would be considered relatively benign." And he goes on to say: "It is practically impossible to design for every little detail or every situation that may arise, something that procedure writers have learned to their dismay".

WAI versus WAD: A balancing act for all in the system

These two examples illustrate the need for back and forth communication between WAI and WAD, both feeding each other in a two-way 'return of experience' dialogue. Because of the dynamic character of the aviation system, we must continue the back and forth communication.

OEM's operations engineering aim to stabilise the system, maintaining a permanent dialogue with operators by means of flight operations monitoring methods using recorders, incident reporting (including human factors and air safety reports) and operational liaison (audits, visits, conferences).

For pilots, it is difficult. They are balancing between rigorous procedures and adapting to unexpected events. This is called the 'resilience paradox'. The paradox is that they must strictly adhere to SOP's but also be able to step out and do that non-standard thing that will save the day – a 'double bind'.

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