# Analysis of Runway Incursion from a Human Factors Perspective

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# Overview



01 Systematic Review

02 Epidemiology Study

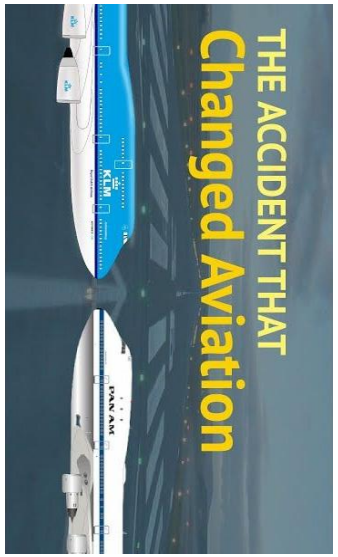
03 In-depth Interview

# Runway Incursion

"*Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take off of aircraft*"

(FAA, 2008, p.37)

- The crash of the century – Tenerife airport disaster
- 2024 Haneda Airport runway collision



# Study Background

- Despite technological advances, Pilot Deviations (PDs) remain the leading cause of RIs, accounting for approximately 62% of incidents in fiscal year 2024.
- Human Factors

# Research Aims

- Systematically investigate pilot-related causes of RIs from a human factors perspective.
- Examine historical data on pilot-related causal factors contributing to RIs.
- Explore nuanced interactions between human factors and aviation systems, drawing insights from aviation professionals.

# 01. Systematic Review

# SYSTEMATIC REVIEW

## Identify what are the gaps in the current research. |

- What are the justifications for further research into pilot-related contributing factors to RIs?
- What are the leading contributing factors associated with pilot behaviours?

# DATABASES

**Eight electronic databases:**

ScienceDirect, Scopus, Web of Science, Emerald Insight, EBSCO, ARC Aerospace Research Central, ProQuest, and ProQuest Science & Technology.

## KEYWORDS

| |
|---|
| Runway incursion OR runway incursions (runway incursion*) |
| Human factor OR human factors (human factor*) |
| Human error* OR pilot error* |
| Human risk factor OR human risk factors |
| Human performance* OR pilot performance* |

# INCLUSION CRITERIA

1. Written in English

2. Published in a peer-reviewed journal and conference proceedings

3. Published between January 1,1985 and January 1, 2021 (all inclusive)

4. Studies that identified the causal factors of runway incursions with a focus on the pilot role in the incident

5. Studies that analysed runway incursions or presented a case study of runway incursions from a human factor perspective related to pilot behaviour

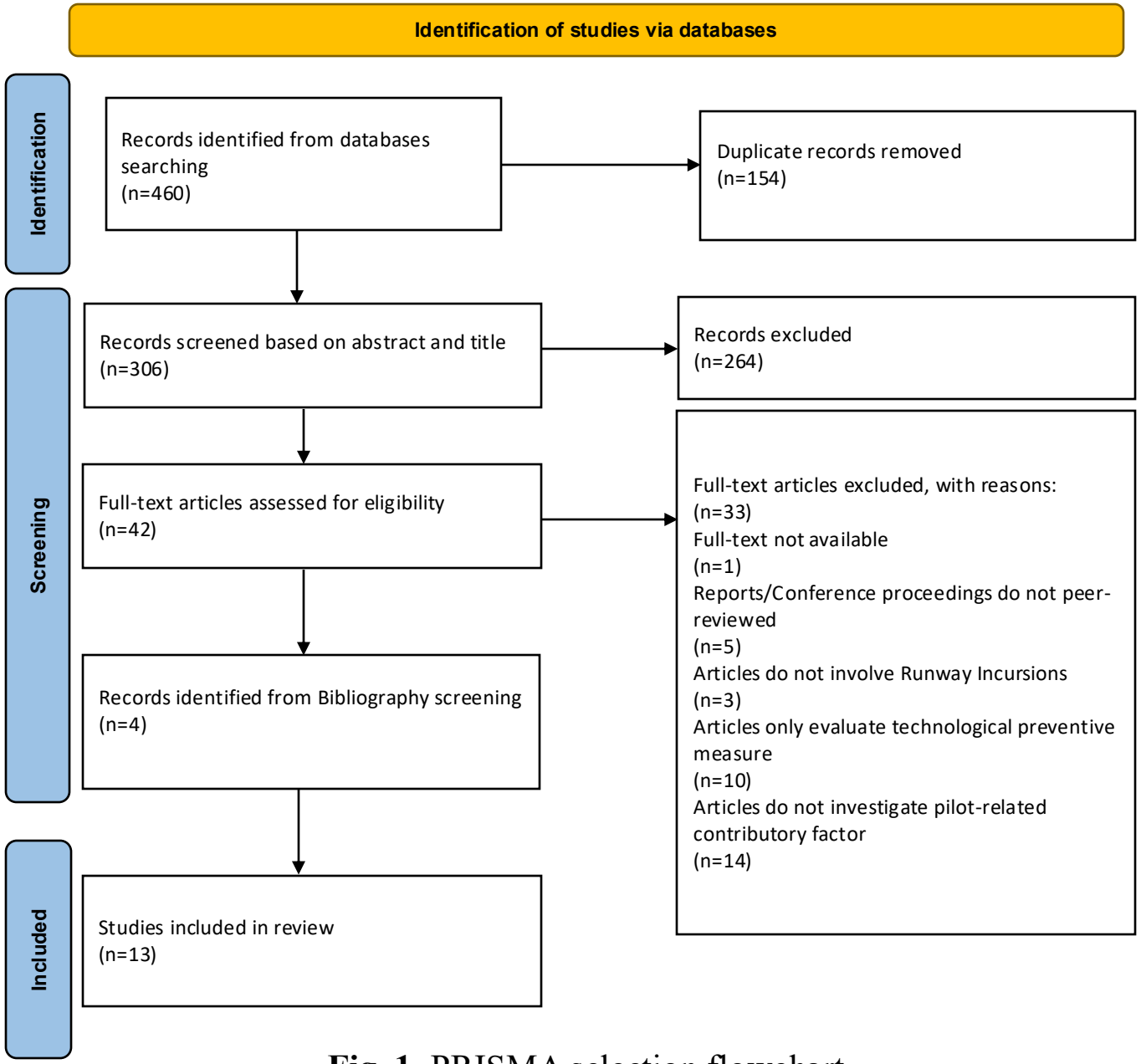
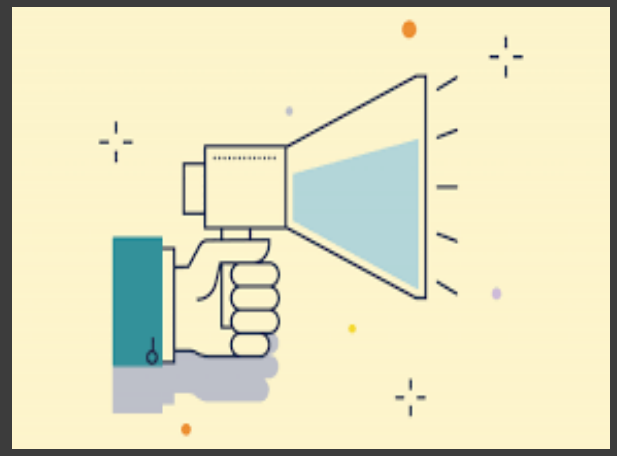
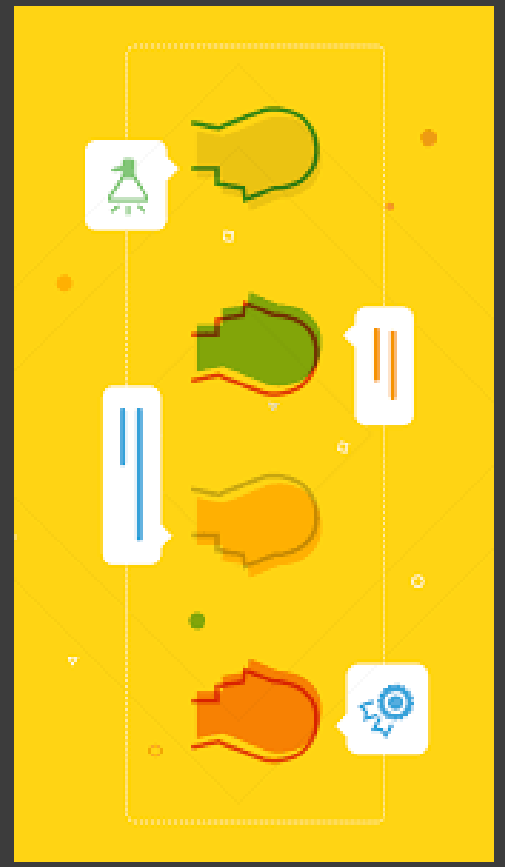



**Fig. 1.** PRISMA selection flowchart

# MISCOMMUNICATION

- Miscommunication occurred between pilots and controllers, and between pilots and pilots in the same cockpit.
- Readback and hearback errors
- Use of improper phraseology
- False expectations
- Timing of the critical information
- Communication system failures

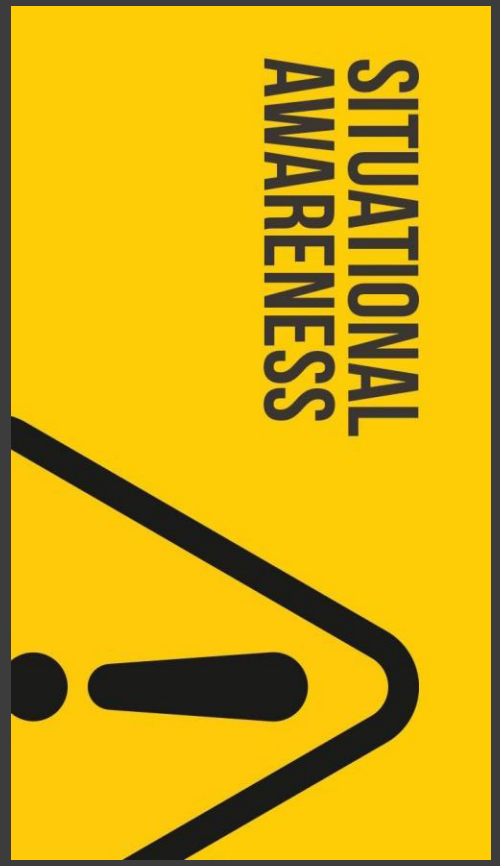




# SITUATIONAL AWARNESS

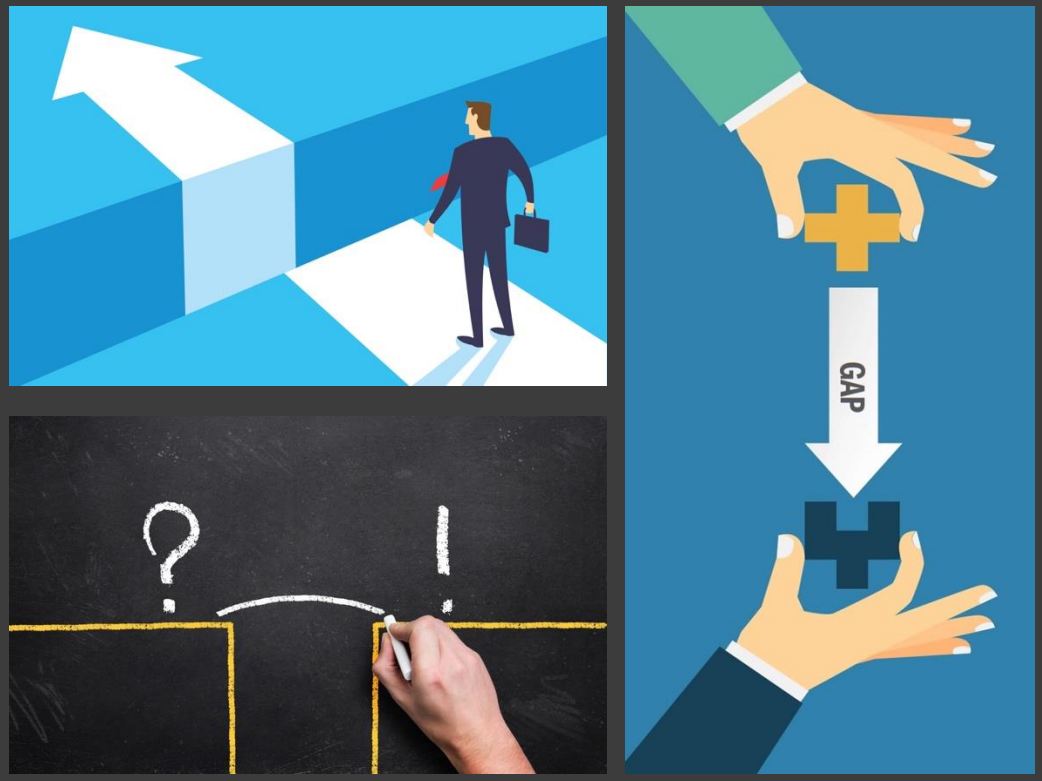
- Definition (Endsley, 1988)
- Pilots missing a turn
- Turning in the wrong direction
- Incorrectly identifying their positions on the Surface movement areas
- Pilots' attention, focus, and information Processing were diverted from their normal tasks.





# GAPS

- Focused on the risk frequency and severity of the incursions and have not assessed preventive measures.
- Focused on technological mitigations (e.g., Movement Area Safety System (AMASS); Aircraft Surface Detection Equipment Model X (ASDE-X); and Controller-Pilot Data Link Communication (CPDLC).
- Comprehensive preventive measures related to mitigating pilot unsafe acts remains largely unexamined.




Review Article

**A systematic review of pilot-related runway incursions from a human factors perspective**

Yan Yan, Soufiane Boufous & Brett R. C. Molesworth

Pages 1-19 | Published online: 14 Sep 2023

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# 02. Epidemiology Study

# Building on the systematic review

Investigating the real-world data

Understanding the role of pilot in RIs

An in-depth analysis of incident and accident reports from 1993 to 2021, sourced from both Australia and the United States was employed.

**Inclusion Criteria:**

- 1/1/1993-1/1/2021
- Final/Completed report
- RI occurrences with pilot-related causal factors

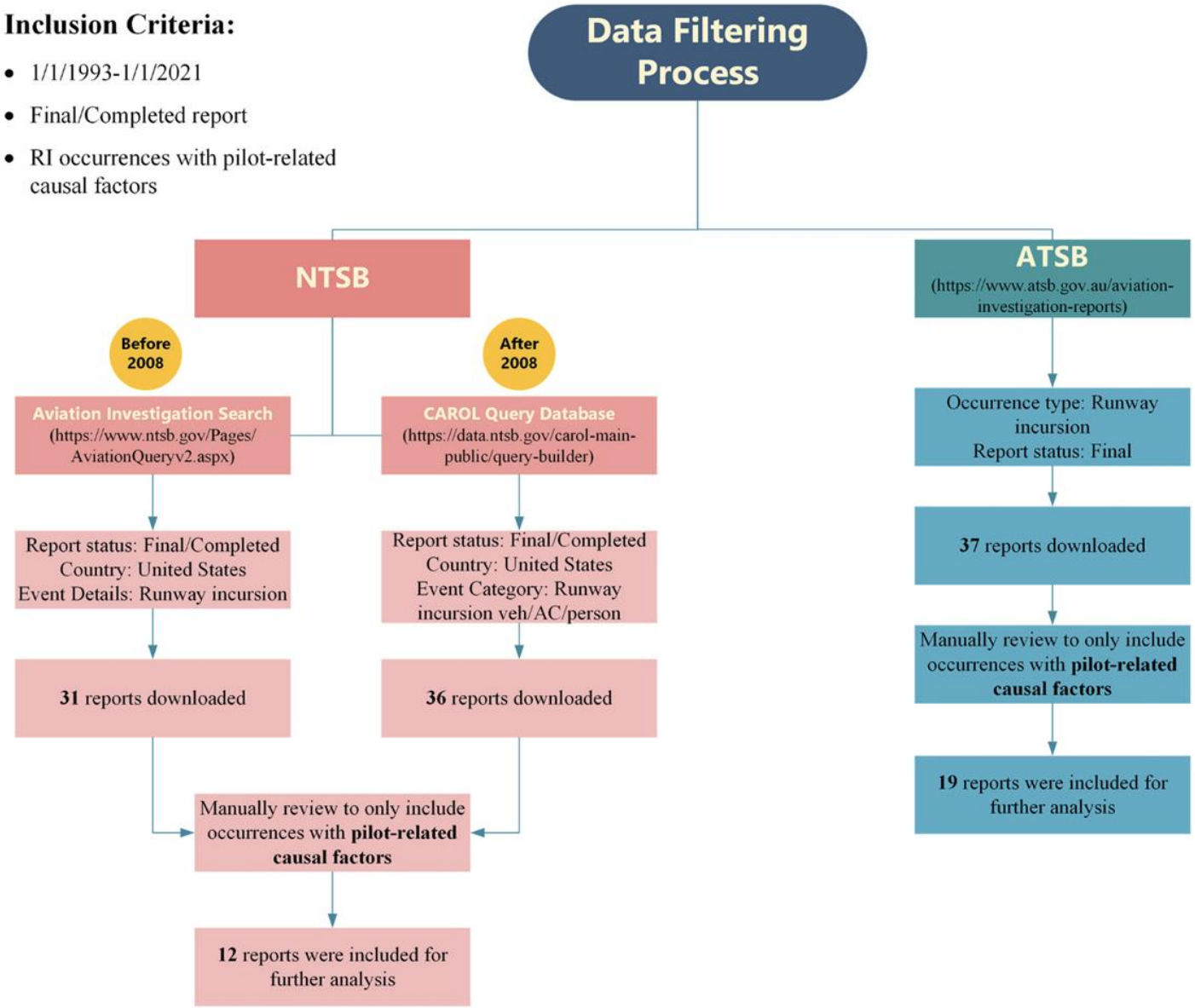


**Figure. 2.** Visualisation of the data filtering process.

# Data Analysis

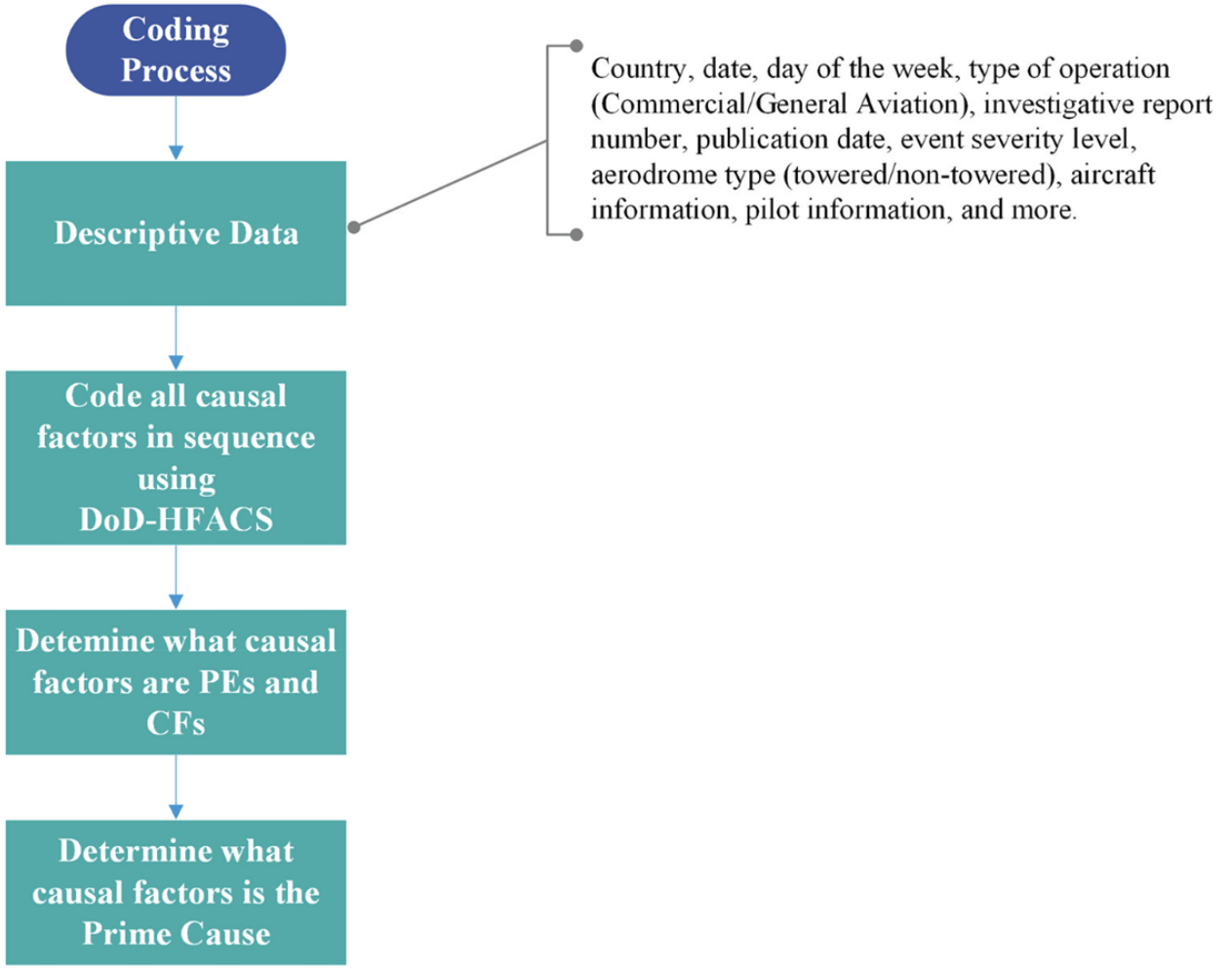


**Figure. 3.** Visualisation of the coding process.

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# Data Analysis

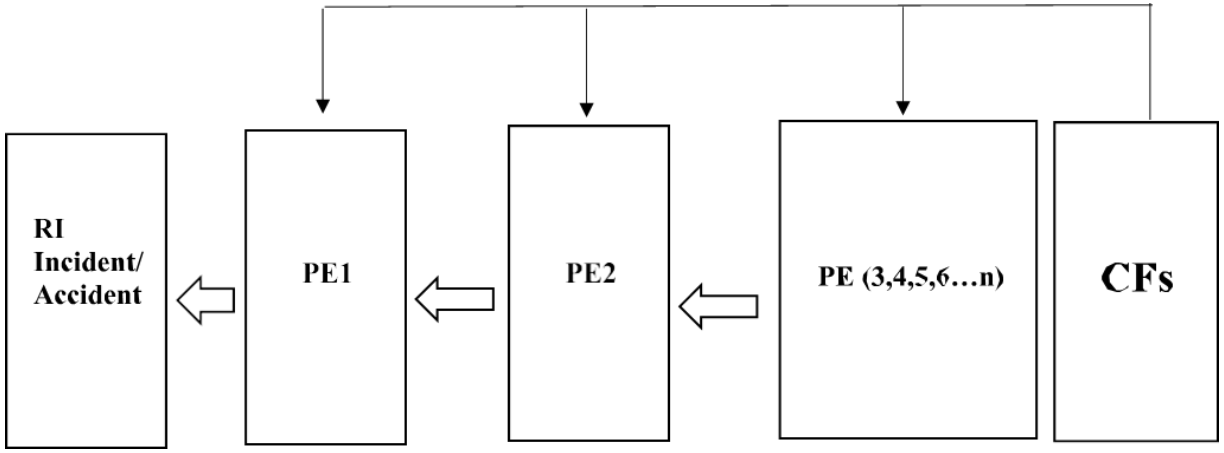


**Figure. 4.** Schematic representations of the precursor events (PE) and contributing factors (CFs) sequence for RIs.

- **Precursor events (PEs):** are defined as "*discrete events that played a role in the occurrence of the incident and were linked in time*" (Mitchell et al., 2015, p. 164), with PE1 being the event closest to the incident and PE2 occurring prior to PE1 in the temporal sequence.
- **Contributing Factors (CFs):** are defined as "factors, circumstances, actions or conditions that pre-existed before the precursor event sequence began. CFs are factors that occurred at an earlier time point that contributed to the incident occurring." (Mitchell et al., 2015, p. 165)
- **Prime Cause:** is defined as "either a PE or CF which if had not occurred, would have prevented the incident from occurring" (Mitchell et al., 2016, p. 187).

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# Analysis of RI Severity by Airport Operational Classification (Towered/non-Towered)



**Figure. 5.** Distribution of RI severity by country.

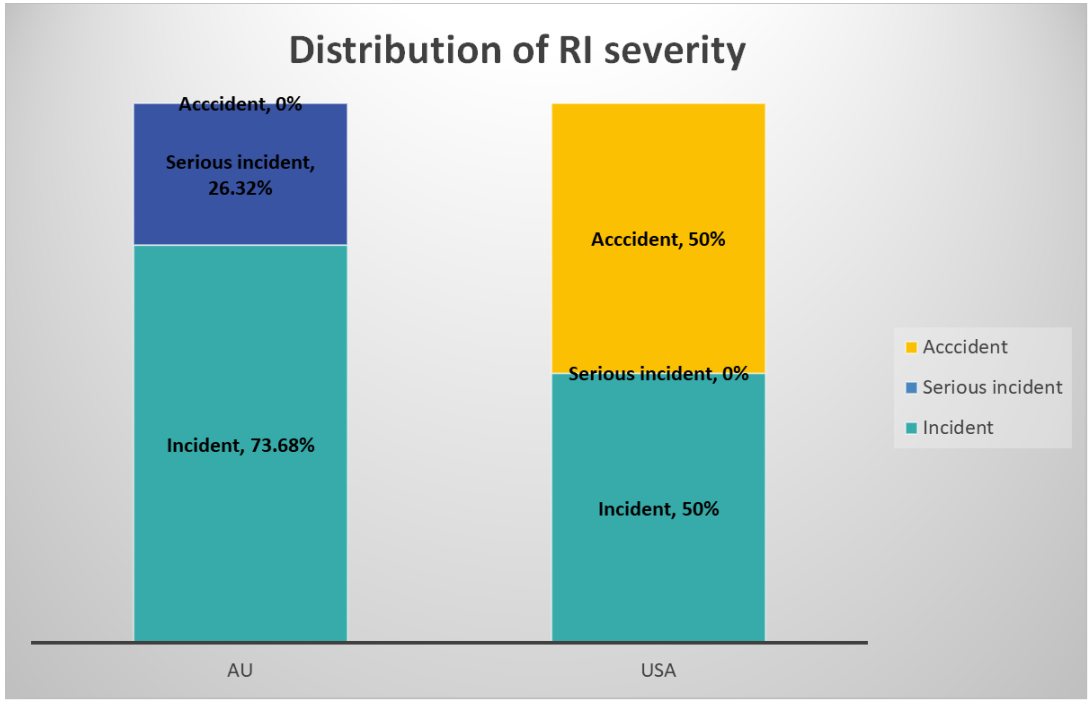


**Table 1.** Distribution of RI severity by airport operational classification.

| | Incident | | Serious incident | | Accident | | Total |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n |
| Towered Aerodrome | 15 | 75% | 2 | 40% | 1 | 16.67% | 18 |
| Non-towered aerodrome | 5 | 25% | 3 | 60% | 5 | 83.33% | 13 |
| Total | 20 | 100% | 5 | 100% | 6 | 100% | 31 |

A significant relationship was identified between RI severity and airport operational classification, $p < .03$.

Incidents at a towered aerodrome were 15 times more likely to occur than accidents which are more serious, approaching significant $p = .018$.

At a non-towered aerodromes, incident and accident rates were the same.

# Distribution of Causal Factors Using DOD HFACS



## Precursors Event (PEs)

- Among all RIs, a large proportion exhibited two or three PEs (35% and 26%, respectively)
- PE1 (closest to the event): Miscommunication & Radio congestion
- PE2: Inaccurate Expectations
- PE3: Procedure Not Followed Correctly

## Contributing Factors (CFs)

- 35% RIs had CFs identified
- Organizational Program/Policy Risks not Adequately Assessed was most frequently cited

## Prime Cause (Root Cause Analysis – RCA)

- Miscommunication : Failure to Communicate Effectively and Communication Equipment Inadequate

# Implications

- **Miscommunication** is one of the most critical pilot-related causal factors of RI which is consistent with previous studies (Kim & Yang, 2012; Wang et al., 2018; Yan et al., 2024).
- **At non-towered aerodromes, pilots face greater risks.** Enhanced training and awareness are essential to ensure pilots adopt best practices in these challenging environments.
- Commonly cited contributing factors:

  **Radio congestion** and **miscommunication**, resulting in incomplete or misunderstood information and unrealistic **expectations**, often leading to **non-compliance** with procedures.

  A strong focus on cockpit tasks, particularly during take-off and landing, can reduce **situational awareness**, causing pilots to miss critical environmental cues.
- Effective interaction and positive synergy between pilots and controllers are essential for improving daily communication protocols and enhancing overall aviation safety.


Research Article

**Pilot-Related Factors Involved in Runway Incursions: An Epidemiological Approach**

Yan Yan, Soufiane Boufous & Brett R. C. Molesworth

Published online: 24 Jan 2025

Cite this article https://doi-org.wwwproxy1.library.unsw.edu.au/10.1080/24721840.2025.2452443 Check for updates

# 03.

# In-depth Interview

Aims to provide a comprehensive understanding of how miscommunications and other contributing factors manifest during daily operations, thereby offering mitigation strategies from a human factors perspective.

56 aviation professionals from various experience levels, including trainees, instructors, airline pilots, and air traffic control officers (ATCOs).

# Methodology

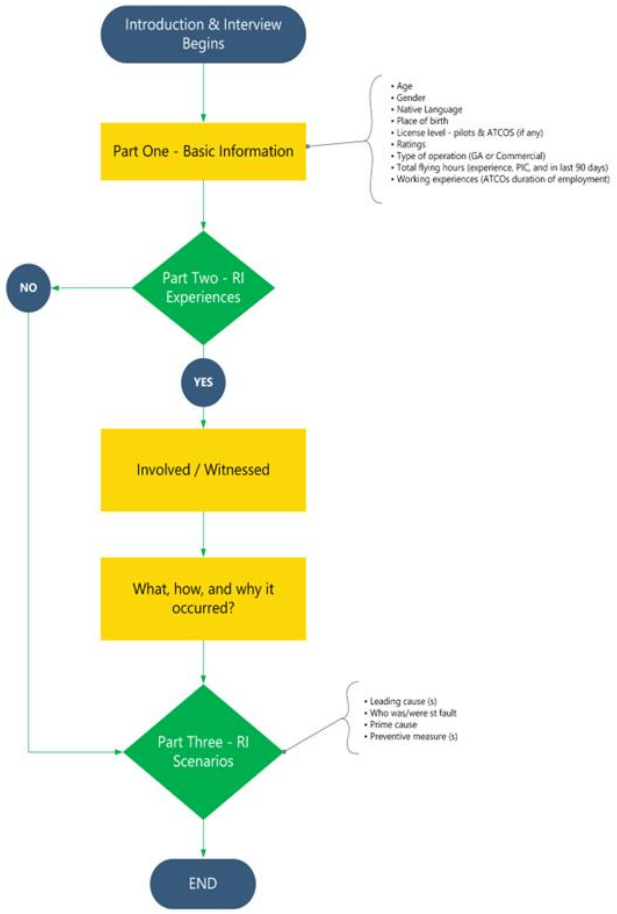


**Fig. 1**. Overview of interview structure.

## Platform & Ethics

- Conducted via Microsoft Teams at mutually convenient times
- Informed consent obtained prior to interviews (Ethics approval: HC220266)
- All sessions recorded and anonymised

## Participants & Duration

- Interviews lasted 30–90 minutes
- Participants did not need prior RI involvement

## Interview Protocol

- Personal experiences and perceptions of RI
- Two real-life RI scenarios from ATSB (Australia) presented to all
- 4 scenario-based questions included
- Scenarios shown in counterbalanced order to avoid bias

## Process

- Participants first asked about direct RI experiences
- If not involved, scenario questions were presented directly

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# Reliability

## Interrater Reliability of Coding Process

- To ensure **reliability**, responses were independently coded by **three expert raters**.
- The first **14 participants** (25% of the sample) were coded on responses to **four scenario-based questions**.

## Initial Agreement (Fleiss' Kappa):

- $\kappa$ = **0.923**
- 95% CI: **0.884 to 0.961**
- $p < 0.001$

## After Consensus Discussion:

- Discrepancies were reviewed and resolved.
- Achieved **perfect agreement**: $\kappa$ = **1.000,** 95% CI: **0.961 to 1.039**

# Participants Demographic

**Table 1**
Participant characteristic (pilot & ATCO).

| Participant group | Total | Age | | Gender | | NES (%) | Operation | | Flying Hours | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pilot | | Mean | σ | Male | Female | | GA | Commercial | Experience | | PIC | | Last 90 days | |
| | | | | | | | | | Mean | σ | Mean | σ | Mean | σ |
| Trainee | 15 | 22.7 | 2.66 | 13 | 2 | 60% | 100% | / | 188.75 | 78.89 | 68.13 | 42.55 | 16.73 | 13.67 |
| Instructor | 18 | 28.22 | 4.98 | 16 | 2 | 89% | 94% | 6% | 1923.86 | 1050.56 | 1566.07 | 981.49 | 111.99 | 50.52 |
| Airline Pilot | 12 | 41.83 | 12.23 | 12 | 0 | 92% | 67% | 33% | 8214.33 | 10512.95 | 4265.92 | 3492.33 | 54.30 | 62.85 |
| | | | | | | | **Pilot License (Yes)** | **Duration of Employment (Years)** | | | | | | |
| | | | | | | | | Mean | σ | | | | | |
| ATCO | 11 | 41.55 | 13.07 | 9 | 2 | 91% | 6 | 15.55 | 7.93 | | | | | |

*NES: Native English Speaker.
*PIC: Pilot in Command.

# Experiences with RIs (pilot & ATCO)

- Five pilots (representing 11 % of all interviewed pilots; consisting of 1 trainee, 3 instructors, and 1 airline pilot) recounted their roles as non-compliant pilots in previous RIs due to non-compliance with procedures.

- Among those pilots who suggested possible contributing factors, miscommunication was identified as the predominant issue,

- Specifically, four sub-themes were highlighted under miscommunication: **(1) readback/hearback error, (2) radio congestion, (3) language barrier, and (4) Hesitancy in asking for clarifications from ATCO.**

# Miscommunication: Key Themes and Perspectives

**Universal Issues:**

**Radio Congestion & Callsign Confusion:** Frequent problems for both trainees and instructors.

**Over-Transmissions:** Lead to missed readbacks and truncated instructions for ATCOs.

**The Assumption Trap:** Both pilots and ATCOs are prone to believing they heard correctly, even if mistaken.

**Trainee Focus:**

**Unfamiliarity with Airport Layout & Procedures:** A particularly significant hurdle.

**Airline Pilot Experiences (Major International Airports):**

**Language Barriers:** Complications with international crews.

**Phraseology Inconsistencies:** Variations in standard communication across different airports.

**Air Traffic Controller (ATCO) Insights:**

**Shared Concerns with Pilots:** Views on miscommunication align closely, likely due to experience at major airports.

**Language barriers** (requiring extra vigilance with NNES crews, slower speech, strict adherence to standard phraseology).

Pilot unfamiliarity with airport layouts/procedures.

# Opinions on standard & non-standard phraseology

**Table 4**
Attitude distribution toward standard phraseology.

| Category | Description | Percentage | | | |
|---|---|---|---|---|---|
| | | Trainees | Instructors | Airline pilots | ATCOs |
| Conditional | Supports standard phraseology under specific conditions but acknowledges exceptional situations where deviations are permissible or necessary. | 45% | 47% | 50% | 64% |
| Indifferent | Flexible about using either standard or non-standard phraseology; does not express strong preferences. | 50% | 50% | 50% | 0% |
| Always | Advocates for consistent use of standard phraseology without exceptions. | 5% | 3% | 0% | 36% |

**Airline Pilot (AP6):**

*Your scenario reminded me of a situation I encountered in… after executing a safe landing, the tower controller asked us to 'confirm you're assured.' I hadn't heard that term before, but the captain had. It simply meant to confirm that we were sure of landing and would be able to vacate as expected. As we landed between taxiways C9 and C6 and were decelerating safely, the tower cleared the other aircraft for take-off on runway 06. This threw me a bit because it resembled a LAHSO (land and hold short operation), which is uncommon at (airport name) and usually restricted to (airport name).*

**ATCO (ATCO4):**

*With local pilots, communication tends to be more flexible. For example, when speaking with another Australian pilot, I might use a few different phrases because there aren't any accent issues. Since we're both native English speakers, there's no difficulty in understanding different accents, which makes the conversation smoother.*

**ATCO (ATCO9):**

*The more critical the situation, the more critical the use of standard phraseology, in my opinion.*

# Inclination to Ask for Clarification



**Pilots' Responses (Three Categories):** Comfortable, Hesitant, and Uncomfortable.

**Majority Comfortable Asking for Clarification:**

Trainees: 67%, Instructors: 89%, Airline Pilots: 92%

**ATCOs' Responses (Two Categories):** Comfortable, Somewhat Uncomfortable

Most ATCOs were comfortable when pilots asked for clarification, though a minority felt somewhat uncomfortable.

**Trainee (T10):**

*Asking for clarification can be challenging, especially at my current level of flight training. Personally, since I'm still learning, I feel there's a bit more leniency when I make mistakes; it's somewhat expected as I'm a student. Normally, having a flight instructor on board makes me more comfortable making assumptions about what might be said. Instead of potentially causing confusion, I prefer to confirm with my instructor whether I understood a command correctly.*

**ATCO (ATCO8):**

*I'd much prefer that they ask for clarification rather than assume they understood my intentions. As a general rule, I won't be annoyed, especially at a place like (aerodrome name), which is a training aerodrome. Part of our job here is education as well. A helpful approach is for pilots to inform us if they're unfamiliar with the aerodrome. When pilots let us know they're not familiar, as controllers, we can provide much clearer instructions and guidance. If they repeatedly say, 'say again,' I might assume they didn't hear or the transmission was clipped and just repeat myself. However, if they say 'don't understand,' I'll rephrase my instructions to make them clearer.*

**ATCO (ATCO3):**

*At certain points, the response really depends on the scenario. For example, if I have given instructions and someone consistently asks for clarification despite the instructions being clear, then I might get a bit annoyed. However, if they need clarification just once, I think it's not only good, but actually very helpful.*

# Perception of the signage

## Levels of Satisfaction

**Satisfied:** Just over 50% (including ATCOs with pilot licenses)

**Moderately Satisfied:** 36% found signage sometimes confusing or unhelpful, depending on airport and experience

**Unsatisfied:** 9% gave entirely negative feedback

## Key Themes for Improvement

**Enhanced Visibility & Clarity:**

Suggestions included better visibility from a distance and in low visibility Painting additional signage on the ground as a safety measure

**Maintenance Needs**

Regular upkeep required; signs sometimes worn or obscured (e.g., by grass)

**Innovative Suggestions**

Technological solutions: colour-changing signs, real-time digital updates

# Challenges in using stop bars

## Challenges Identified

**Frequent False Alarms:** Increase workload and stress for ATCOs (reported by 7 ATCOs and 4 airline pilots)

One participant emphasised that the primary motivation for participating in the study was to express concerns and frustrations regarding the use of stop bars.

**Timing & Reactivation Issues:** Stop bars can "time out" and reactivate unexpectedly, leading to operational confusion and safety concerns for pilots

**Loss of System Control:** Over 60% of ATCOs reported experiencing system issues (false alarms, reactivation, control problems)

**Financial Barriers:** High costs pose challenges for smaller airports

**Airline Pilots (AP4):**

*The ATCOs might turn off all the stop bars, but they can time out. For example, if you're taxiing and approaching the delta point, the stop bars might reactivate*

**Airline Pilots (AP3):**

*Quite often, the stop bar issues occur for two main reasons. First, someone may activate the button to turn the stop bar green or make it disappear, but by the time you reach it, the timer has expired and it reactivates. Secondly, if it's early in the taxi and the crew is still conducting their briefing or standing up, a sudden red stop bar can force us to slam on the brakes, which might injure the crew if they fall over. So, we have to be very cautious*

# Study in press

The interview study provides valuable insights into the complex factors contributing to pilot-related RIs involving aircraft by engaging with a diverse group of aviation professional.

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Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety


## Speaking of human factors: an interview study on the causes and prevention of runway incursions with aviation professionals

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# THANK YOU

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