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Indian Air Force Safety 2016–2025

An evidence-based review of accident trends, fleet and airworthiness factors, human factors, cognitive safety, organisational systems, and international benchmarks

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Abstract

This report examines the safety performance of the Indian Air Force (IAF) across the decade 2016–2025, drawing on a systematically compiled open-source register of sixty-five incidents and accidents and situating that record within the contemporary human-factors and cognitive safety literature. The review identifies three distinct operational phases over the period: a legacy-fleet attrition phase (2016–2018), a high-kinetic phase bracketed by the February 2019 Balakot-Budgam events and the December 2021 Coonoor crash that killed Chief of Defence Staff General Bipin Rawat (2019–2021), and a fleet-transition phase marked by the final retirement of the MiG-21 on 26 September 2025, repeated HAL ALH Dhruv fleet-wide groundings, the first-ever HAL Tejas hull losses, and the May 2025 Operation Sindoor combat engagements (2022–2025). Converted to a common denominator, the IAF's reported accident rate declined from approximately 9 per 100,000 flight hours in 2020 to 2 per 100,000 by 2024 per ministerial replies — a substantial improvement that nonetheless remains meaningfully above contemporary USAF benchmarks (1.9 per 100,000 in FY24). A dedicated chapter argues that introducing a formal cognitive-safety layer — grounded in HFACS, Endsley's situational-awareness construct, spatial-disorientation typologies, startle/surprise research, automation complacency, plan-continuation bias, and Threat and Error Management — would address causal patterns directly evident in the Indian record, including the Budgam friendly-fire event, the Yelahanka mid-air collision, the Coonoor controlled-flight-into-terrain accident, and the Bengaluru Mirage 2000 test-flight loss. The report closes with a recommendations roadmap spanning technical, human-factors, and organisational axes.

Contents

1. Introduction and scope

The safety performance of any air force is the most tangible measure of the quality of its training systems, its maintenance and airworthiness regimes, its organisational climate, and — increasingly recognised — the cognitive architecture of its aircrews. For the Indian Air Force the decade 2016–2025 is a particularly instructive window. It spans the induction of Rafale, the maturation of Tejas, the final retirement of the MiG-21 after sixty-two years of service, repeated fleet-wide groundings of the indigenous HAL ALH Dhruv, two brief but consequential combat engagements with Pakistan (February 2019 and May 2025), the death of a Chief of Defence Staff in an IAF helicopter crash, and the IAF's own reported transition from roughly 9 to 2 accidents per 100,000 flight hours per ministerial replies to Parliament.

This report reviews that decade with four analytical priorities. First, to establish a reliable, cross-verified descriptive baseline of what happened. Second, to interpret the record against the frameworks used in contemporary military-aviation safety research — principally Wiegmann and Shappell's Human Factors Analysis and Classification System (HFACS), Endsley's situational-awareness model, the International Civil Aviation Organisation's Safety Management Systems (SMS) philosophy, and the evolution of Crew Resource Management (CRM) into Threat and Error Management (TEM). Third, to make the case that a formal cognitive-safety layer — the integration of research on spatial disorientation, startle and surprise, automation complacency, plan-continuation bias, and crew resilience — is directly addressable to the causal patterns visible in the Indian record. Fourth, to place the IAF's numerical performance alongside the US Air Force, US Naval and Marine Corps aviation, the Royal Air Force, and open-source glimpses of the PLAAF and PAF, with explicit caveats about definitional and reporting-scope differences.

The audience is assumed to be academic and research-literate: familiarity with aviation human-factors terminology is expected, and the report engages directly with the primary literature.

2. Methodology and data caveats

The descriptive backbone of this report is a register of sixty-five open-source documented IAF incidents over 2016–2025, compiled from the Aviation Safety Network, Wikipedia's master list of IAF accidents, Press Information Bureau releases, Indian broadsheet and defence press (The Hindu, The Times of India, Hindustan Times, Indian Express, The Tribune, Deccan Herald, Business Standard, The Week, Outlook), specialist defence outlets (Livefist, Bharat Shakti, IDRW, Eurasian Times, StratNews Global), international defence press (Janes, Breaking Defense, The Drive, The Aviationist, Aerotime), and OSINT verification (BBC Verify, Washington Post) for the contested Operation Sindoor losses. Cross-verification targeted at least two independent sources per incident; single-source entries are flagged.

Several caveats attach. First, Court of Inquiry (CoI) outcomes are rarely made fully public; most entries in the register therefore record only that a CoI was ordered. Second, squadron and unit attributions are frequently inferred rather than officially confirmed. Third, tail numbers are included only where they appear in cited sources; the user-supplied tail number for the 12 March 2024 Jaisalmer Tejas crash (LA-5017) was not independently verified and is flagged as such in the accompanying spreadsheet. Fourth, the Bharat-Rakshak IAF aircraft losses database — the most complete open-source index — was not reachable from the research environment; parliamentary aggregate data (e.g., the 2022 Standing Committee reply citing thirty-four crashes across

2017–2022) suggests the true count is moderately higher than the sixty-five individually documented here, with the under-count concentrated in helicopter and trainer fleets and specifically in calendar years 2020 and 2022. Fifth, Operation Sindoor (May 2025) aircraft types, tail numbers, and pilot casualties have not been publicly disclosed by the Government of India; where OSINT (BBC Verify, Washington Post) has tentatively identified airframes, these are flagged as contested.

A note on rate conventions: the IAF reports accidents per 10,000 flight hours, the US services per 100,000 flight hours. For comparability, this report converts all IAF rates to the per-100,000 convention (multiplied by ten).

3. Accident trends 2016–2025

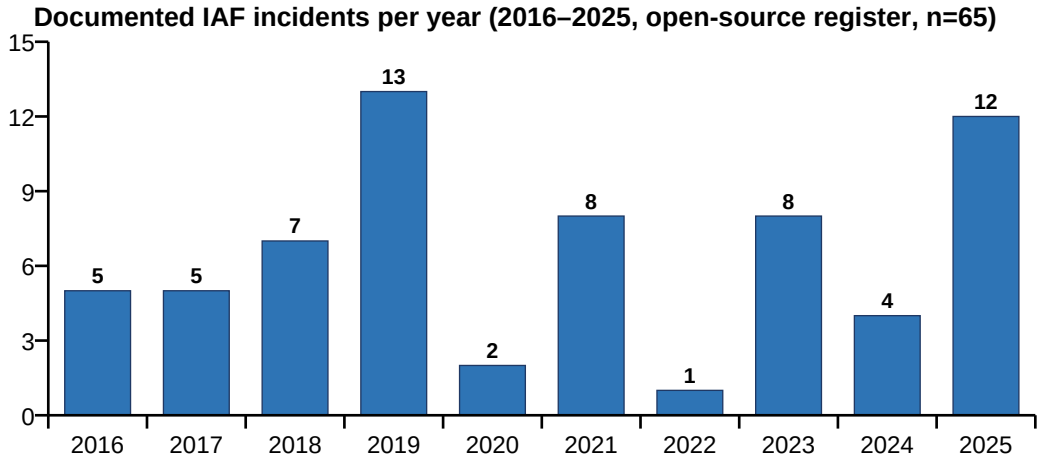

Figure 1. Documented IAF incidents per year, 2016–2025. 2020 and 2022 are visibly under-reported against parliamentary aggregate counts; the true values for those years likely fall in the 5–8 range each. 2025's elevated count reflects the Operation Sindoor combat losses plus a high-attrition peacetime year.

Three analytical phases emerge.

Phase I: Legacy-fleet attrition (2016–2018)

The 2016–2018 window was dominated by attrition of Soviet-origin airframes — multiple MiG-21 Bis and MiG-27 UPG crashes in Rajasthan, Sukhoi Su-30 MKI losses at Tezpur and post-HAL-test sites, and a Mi-17V-5 loss at Tawang that killed seven. The window opened with the 2 January 2016 Jaish-e-Mohammed attack on Pathankot Air Force Station (seven Indian personnel killed in a seventeen-hour battle), a ground event with decisive downstream effects on airbase perimeter security. It was bracketed by the 22 July 2016 disappearance of An-32 K2743 with twenty-nine aboard — India's largest maritime search operation, with wreckage only located at 3,400m depth in January 2024.

Phase II: High-kinetic period (2019–2021)

The 2019–2021 period was the decade's most kinetic. February 2019 alone produced the Balakot airstrike, the aerial engagement in which Wing Commander Abhinandan Varthaman's MiG-21 Bison was shot down over Pakistan-administered Kashmir (he was briefly held as a prisoner of war), and the friendly-fire shootdown of an IAF Mi-17V-5 by an IAF SPYDER surface-to-air missile near Budgam in which six airmen and a civilian were killed. The period closed with the 8 December 2021 Mi-17V-5 crash near Coonoor that killed Chief of Defence Staff General Bipin Rawat, his wife, Brigadier L.S. Lidder, and eleven others. The IAF's own Court of Inquiry and a December 2024 parliamentary Standing Committee on Defence report attributed the crash to Controlled Flight Into Terrain (CFIT) in adverse weather — the Committee's public finding identified human factors at the crew level as the proximate cause, without individually naming aircrew members in the attribution.

Phase III: Fleet transition and Operation Sindoor (2022–2025)

The 2022–2025 period was shaped by fleet turnover and, at its end, combat. The MiG-21 reached its end after a fatal 2022 Barmer trainer crash and a May 2023 Hanumangarh crash that killed three civilians; the type was formally retired on 26 September 2025 at Chandigarh AFS. The HAL ALH

Dhruv was grounded fleet-wide in 2023 and again in 2025 following the fatal 5 January 2025 Porbandar Coast Guard crash caused by a fractured Non-Rotating Swashplate. The HAL Tejas suffered its first-ever hull loss at Jaisalmer in March 2024 and its first fatality at the Dubai Airshow on 21 November 2025 (Wing Commander Namansh Syal). Between 7 and 10 May 2025, Operation Sindoor produced the IAF's first combat aircraft losses since Kargil 1999, with India publicly acknowledging "at least three" aircraft lost and OSINT (BBC Verify, Washington Post) identifying airframes consistent with Rafale (Akalia Kalan, Bathinda), Mirage 2000 (Wuyan, Pampore), and a Su-30 MKI or MiG-29 UPG (Akhnoor/Ramban sector).

Primary cause category distribution (open-source classification, n=60 classified incidents)

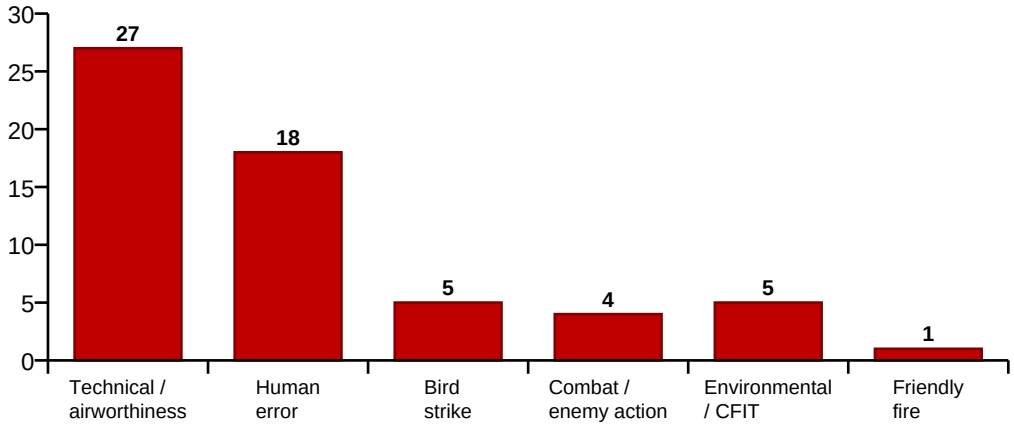

Figure 2. Primary cause category distribution across the open-source register. Technical/airworthiness causes predominate, consistent with fleet-age findings. Human-error classification is conservative and excludes mixed-cause events; integrating preconditions-for-unsafe-acts (HFACS Tier 2) would materially increase the human-factors share.

A preliminary cause-category classification (Figure 2) places technical and airworthiness failures at the largest single share of the classified record (approximately 45%), with human error at approximately 30%, bird strike at ~8%, CFIT and environmental factors at ~8%, combat losses at ~7%, and friendly fire accounting for the single 2019 Budgam case. This crude classification tracks the conservative primary-cause field recorded in press reporting. A more rigorous HFACS-based reclassification — incorporating the Tier 2 "Preconditions for Unsafe Acts" (adverse mental states, fatigue, personal readiness, CRM failures) that the public literature would flag in the Yelahanka, Budgam, Coonoor, and Bengaluru Mirage cases — would shift a material proportion of the "technical" share into blended human-technical categories.

4. Fleet age and airworthiness

The dominant structural factor in IAF peacetime safety across the decade has been fleet-age attrition. A Parliamentary Standing Committee report cited by ThePrint in 2022 enumerated thirty-four IAF plane crashes across 2017–2022, with more than half attributable to human error but the remainder strongly associated with airworthiness issues in aging airframes. Ministerial replies to Parliament through 2024 indicate the headline accident rate improved materially across the decade — from approximately 0.9 per 10,000 flight hours in 2020 to 0.2 per 10,000 hours by 2024 — but this improvement coincides with the progressive retirement of the platforms contributing most heavily to the numerator.

MiG-21 variants

Public Accounts Committee audits for 1991–97 (PAC 2002) placed MiG-21 attrition at 2.29–3.99 accidents per 10,000 flight hours — between 22.9 and 39.9 per 100,000 hours — and the type remained the dominant crash platform through 2021. By the time of its formal retirement at Chandigarh AFS on 26 September 2025, thirteen MiG-21 incidents over 2016–2025 (five of them fatal) had been documented in open-source reporting; the 8 May 2023 Hanumangarh crash killed three civilians in a ground house impact and prompted a fleet-wide grounding. At the retirement ceremony Air Chief Marshal A.P. Singh flew historic Bison CU2777 on the type's final sorties.

SEPECAT Jaguar

The Jaguar fleet — the IAF's deep-strike workhorse since the late 1970s — logged seven documented incidents over the decade with three fatal. 2025 was particularly severe, with three Jaguar losses in four months (Panchkula, Jamnagar, Churu) and four pilot fatalities (Flt Lt Siddharth Yadav at Jamnagar; Sqn Ldr L.S. Sindhu and Flt Lt Rishi Raj Singh at Churu). The Jamnagar loss was preliminarily attributed to a bird strike that ignited a fire ~17 seconds before impact. These losses have sharpened long-standing airworthiness and replacement debate around the type.

HAL ALH Dhruv

The indigenous ALH Dhruv was grounded fleet-wide twice during the decade. A March 2023 Indian Navy ditching off Mumbai, traced to failure of a collective-circuit control rod, triggered the first grounding and a programme to replace aluminium control rods with steel. On 5 January 2025, a Coast Guard Dhruv Mk 3 (CG-859) crashed at Porbandar killing three; investigation identified fracture of the Non-Rotating Swashplate, accelerated by saline maritime service. The resulting grounding was the longest in the type's history; Army and IAF variants were cleared to return to operations after approximately four months, while Navy and Coast Guard variants remained grounded into late 2025.

HAL Tejas

The Tejas flew accident-free for twenty-three years from its 2001 maiden flight until the 12 March 2024 loss near Jaisalmer (pilot ejected safely, suspected engine failure). The 21 November 2025 crash at the Dubai Airshow — in which Wing Commander Namansh Syal was killed during a flying display — was the first Tejas fatality. Preliminary analyses pointed to a stall, power interruption, or fly-by-wire flight-control-system anomaly during a low-altitude aerobatic manoeuvre. Coming two months after MiG-21 retirement, the Dubai crash sharpened the debate about whether Tejas production and reliability maturation are tracking the IAF's combat-readiness requirements.

Transport and trainer fleets

Two An-32 losses — K2743 over the Bay of Bengal (22 July 2016, 29 killed) and K-2752 in Arunachal Pradesh (3 June 2019, 13 killed) — accounted for forty-two lives across the decade, the largest single aggregate of transport-aviation deaths. The Pilatus PC-7 Mk II recorded its first-ever hull loss on 4 December 2023 (two killed). BAe Hawk Mk 132 losses at Kalaikunda (2016, 2024), Mayurbhanj (2018), and — most visibly — at Yelahanka during the Surya Kiran Aerobatic Team mid-air collision of 19 February 2019 (Wing Commander Sahil Gandhi killed) rounded out the trainer fleet record.

5. Human factors — the classical view

Human-factors analysis of military-aviation accidents has been dominated for two decades by two complementary frameworks: James Reason's "Swiss cheese" model of organisational accidents and the Human Factors Analysis and Classification System (HFACS) developed by Shappell and Wiegmann, originally for the US Navy and now a US Department of Defense standard (HFACS 8.0). HFACS operationalises the Reason model into four hierarchical tiers: Unsafe Acts (errors and violations at the sharp end); Preconditions for Unsafe Acts (adverse mental or physiological states, crew-resource-management failures, personal readiness factors); Unsafe Supervision (inadequate supervision, planned inappropriate operations, failure to correct known problems, supervisory violations); and Organisational Influences (resource management, organisational climate, operational processes).

The IAF record supports HFACS analysis across all four tiers. At Tier 1 (Unsafe Acts), the 19 February 2019 Surya Kiran mid-air at Yelahanka was preliminarily attributed to pilot error in a mirror manoeuvre during a high-tempo rehearsal window the day before Aero India opened — a textbook skill-based error under time pressure. At Tier 2 (Preconditions), the 8 December 2021 Coonoor crash — which the IAF and a December 2024 parliamentary committee attributed to Controlled Flight Into Terrain in adverse weather, with human factors at the crew level identified as the proximate cause — is strongly consistent with the degraded perceptual environment created by adverse weather in the Nilgiris, with spatial-disorientation risk that the published Court-of-Inquiry summary implicitly invokes. At Tier 3 (Unsafe Supervision), the 27 February 2019 Budgam friendly-fire shootdown of an IAF Mi-17V-5 by an IAF SPYDER SAM — in which six airmen and a civilian were killed after the helicopter's IFF transponder was switched off and the platform was misidentified as a hostile drone — drew disciplinary action against a Group Captain and two officers (court-martial proceedings that the Armed Forces Tribunal subsequently partially stayed). At Tier 4 (Organisational Influences), the 1 February 2019 Bengaluru Mirage 2000 crash — which killed two IAF test pilots and was attributed to a software/control anomaly tied to the HAL upgrade and a failed runway arrester barrier — implicates acceptance-testing processes, vendor-interface quality, and contingency-barrier adequacy at the organisational level.

A 2005 peer-reviewed HFACS study by Gaur of civil aircraft accidents in India (Aviation, Space, and Environmental Medicine 76:5) found human factors identifiable in 77.1% of a forty-eight-accident sample, with skill-based error the most common unsafe act followed by decision error, and violations present in 33.3% of cases. No comparable open-access HFACS review of IAF accidents was located during preparation of this report; Institute of Aerospace Medicine (Bengaluru) work published in the Indian Journal of Aerospace Medicine covers Army Aviation and UAV domains but is not fully indexed in PubMed. This is itself an organisational-transparency finding: a publicly accessible HFACS coding of IAF accidents over 2016–2025 would materially advance the evidence base for targeted human-factors interventions.

Crew Resource Management (CRM) — the second classical pillar — has passed through six generations since Helmreich, Merritt and Wilhelm's canonical 1999 synthesis: from the first-generation psychological-and-leadership focus of United Airlines' 1981 programme, through aviation-specific modular (Gen 2) and culture-and-skills (Gen 3) iterations, the FAA Advanced Qualification Programme integration and Line-Oriented Flight Training (Gen 4), the error-management paradigm (Gen 5), and the current Threat and Error Management framework (Gen 6). The IAF's Mi-17 and Su-30 MKI fleets are natively multi-crew; the Mi-17V-5 fleet has sustained the

decade's highest fatality aggregate (Tawang, Budgam, Coonoor). CRM and TEM training depth and recency remain a legitimate line of inquiry where public disclosure is limited.

6. Cognitive safety — a dedicated framework

The case for introducing a formal cognitive-safety layer — distinct from and complementary to classical human factors and CRM — rests on two observations. First, several of the most consequential IAF events of the decade have causal fingerprints that the published cognitive-safety literature addresses directly. Second, cognitive safety as a managed operational domain — with measurement instruments, training protocols, and technology interventions — has matured substantially over the last fifteen years in civil aviation and the US, European and Australian defence establishments, but is not publicly visible as a structured programme within the IAF.

6.1 Situational awareness (Endsley's model)

Endsley's three-level construct (Situation Awareness, Situational Awareness — 1988, 1995) defines SA as perception of elements in the environment (Level 1), comprehension of their meaning (Level 2), and projection of their future status (Level 3). The Coonoor CFIT is a paradigm Level 1/Level 2 SA failure in adverse weather: the crew did not perceive terrain proximity in time to act on it. The Budgam friendly-fire incident is a Level 2 failure on the ground-based air-defence side: operators perceived the radar return but misclassified its meaning. SA measurement instruments — SAGAT (Situation Awareness Global Assessment Technique), SART (Situation Awareness Rating Technique), and newer eye-tracking and physiological measures — are ready for adoption in IAF simulator-training syllabi and would create baseline data against which interventions could be evaluated.

6.2 Spatial disorientation (SD)

The aeromedical literature classifies SD into three types: Type I, unrecognised (the pilot is unaware of the conflict between sensed and actual attitude — the type most strongly associated with CFIT); Type II, recognised (the pilot notices the conflict); and Type III, incapacitating (the pilot is overwhelmed and cannot act). A systematic review published in Frontiers in Physiology (Landman et al. 2022) documents that rotary-wing operations show approximately 5.73 times higher SD incidence than fixed-wing — a figure of direct operational relevance to IAF Mi-17V-5 and ALH Dhruv fleets operating in the Himalayan and Nilgiri ranges. The Coonoor CFIT, the Tawang Mi-17V-5 crash of 6 October 2017 (seven killed on a supply mission in hilly terrain), and the ~8 November 2021 Arunachal Mi-17V-5 crash-landing all involve operational profiles where SD risk is elevated. Routine SD-awareness refresh training with Disorientation Research Device simulators, helicopter-specific SD training modules, and in-cockpit synthetic-vision / terrain-awareness systems are the established interventions.

6.3 Startle and surprise

Startle is an involuntary reflex to a sudden intense stimulus; surprise is a cognitive-emotional response to expectation violation. Approximately 90.8% of surveyed pilots report experiencing startle or surprise in operational flying (Frontiers in Neuroergonomics narrative review, 2023). Combat aviation generates both: the shoot-down of Wing Commander Abhinandan's MiG-21 Bison on 27 February 2019 occurred during a dynamic engagement with a PAF strike package; the Operation Sindoor losses of 7 May 2025 occurred during the opening night of a high-intensity four-day confrontation. Unexpected-event simulator training — explicitly targeting startle-response

management, prioritisation under sudden stimulus, and rapid re-establishment of SA — has been integrated into US Navy, USAF, and several NATO training syllabi and is a candidate for formal incorporation into IAF operational conversion units.

6.4 Automation complacency and mode confusion

ICAO Human Factors Digest No. 5 and a 1996 FAA human-factors team study identified three recurring automation-related patterns: over-reliance on automation, degradation of manual flying skills, and mode confusion — particularly when fly-by-wire systems degrade from normal to alternate or direct laws. The 1 February 2019 Bengaluru Mirage 2000 crash (the upgraded aircraft crashed on takeoff during an acceptance flight after a HAL software upgrade, killing both test pilots) is a case where automation-interface quality, verification-and-validation processes, and pilot mode awareness were all implicated. The Tejas is an all-digital fly-by-wire aircraft; the 21 November 2025 Dubai Airshow crash is under investigation with preliminary analyses pointing to stall, power interruption, or an FCS fault. As the IAF transitions to an all-digital fleet (Tejas, Rafale, Su-30 MKI Super-30, AMCA), automation-complacency and mode-confusion risk rises in parallel. The countermeasures — mode-awareness training, automation-surprise briefings, and preservation of manual flying currency — are well-established in civil and US defence practice.

6.5 Plan-continuation bias and get-home-itis

Plan-continuation bias — the unconscious drive to persist with the original plan despite changing cues — is partnered with confirmation bias (selective attention to plan-supporting cues) and produces the informal phenomenon known as "get-home-itis". A NASA-Ames review of thirty-seven NTSB-investigated accidents found approximately 75% of tactical-decision errors were plan-continuation decisions. The Coonoor CFIT of 8 December 2021 — in which the CDS's transport mission continued into degrading weather rather than returning to Sulur or holding — has features consistent with this pattern, though the published Court of Inquiry does not use the term. Plan-continuation bias is a specific, teachable cognitive failure mode; inclusion in Threat and Error Management modules is standard in civil airline CRM and is a clear candidate for IAF operational-conversion syllabi.

6.6 Fatigue, circadian effects, and the Fatigue Risk Management paradigm

ICAO codified Fatigue Risk Management Systems (FRMS) in Annex 6 (2008) as "a data-driven means of continuously monitoring and maintaining fatigue-related safety risks, based upon scientific principles." Military operations routinely violate civil-style duty-time envelopes, and India's high-altitude, border-intensive and night-sortie operational tempo compounds fatigue exposure. Fatigue is a HFACS Tier 2 precondition that fingerprints several of the IAF's most significant accidents — the 19 February 2019 Yelahanka mid-air at the end of a rehearsal week, the 28 July 2022 Barmer MiG-21 trainer night sortie from Uttarlai (both crew killed) — without being publicly named. Adoption of an IAF-specific FRMS, scientifically grounded in circadian biology and sleep-homeostatic modelling, with actigraphy- or wearable-based crew-fatigue monitoring in high-tempo windows, is the next-generation intervention.

6.7 CRM to TEM — and beyond to cognitive-load management

Threat and Error Management (TEM) extends classical CRM by asking crews to identify threats proactively, manage errors as they emerge, and recognise undesired aircraft states early enough to recover. The logical next step, visible in recent civil-aviation research, is cognitive-load management:

measuring and training the real-time cognitive bandwidth of the crew using physiological proxies (heart-rate variability, pupillometry, EEG-derived engagement indices) and adjusting task allocation accordingly. The IAF's Institute of Aerospace Medicine at Bengaluru has a strong track record in human-engineering and aviation-medicine research; a partnership with IAM to operationalise cognitive-load monitoring in simulator-to-operational transition would be a high-value structural investment.

6.8 Combat-specific cognitive safety: fratricide, task saturation, and combat SA

The 27 February 2019 Budgam friendly-fire incident — an IAF SPYDER SAM shootdown of an IAF Mi-17V-5 under combat-stress conditions — is the decade's most visible fratricide event and a cognitive-safety case study on its own terms. The published post-incident action (one Group Captain dismissed, officers court-martialled) is disciplinary; the cognitive-safety reading is systemic: IFF discipline under stress, SAM-operator decision-making windows under tempo pressure, task-saturation at the operator console, and integrated air-defence CRM. The Operation Sindoor engagements of May 2025 produced combat losses whose cognitive-safety analysis is not publicly available; in any post-conflict review, startle-and-surprise management, combat SA degradation under PAF PL-15 BVR threats, and decision-making under electronic-warfare contestation would be central to the human-factors narrative.

6.9 Indigenous Indian cognitive-safety instruments: pSuMEDhA and Chakshu Yan

Two indigenous Indian cognitive-safety instruments merit explicit attention in any discussion of how the foregoing cognitive-safety constructs can be operationalised. They are complementary rather than overlapping, and together they approximate a two-tier cognitive-safety architecture — one psychometric and selection-anchored, one multimodal and operationally embedded.

pSuMEDhA (Psychomotor Evaluation Designed for Aviators) is the Institute of Aerospace Medicine (Bengaluru) indigenous psychometric cognitive test battery. Thambidurai, Sharma, Sowgandhi and Biswal (*Indian Journal of Aerospace Medicine*, 68(1):2–9, 2024) report the first comparative validation of pSuMEDhA against CogScreen-AE, the international benchmark. The battery comprises eight subsets — Simple Reaction Test, Mackworth Clock Test, Dual-Task Test, Stroop Test, Digit Symbol Substitution Test, Aircraft Orientation Test, Threat Perception and Estimation Test, and Card Sorting Test — spanning response inhibition, selective and sustained attention, vigilance, reaction time, psychomotor tracking, visual-working memory, deductive reasoning, and threat-assessment response. In a fifty-subject comparison, the speed and accuracy measures of pSuMEDhA's DSST and CogScreen-AE's SDC were congruent (Pearson's $r = 0.6$, $p = 0.000$), implying comparable assessment of working memory. The authors explicitly flag that pSuMEDhA is yet to be validated against flight-simulator performance — which is the natural next step, aligned with the Yesavage-Taylor line of research linking cognitive-test performance to longitudinal simulator outcomes. pSuMEDhA's unique feature not present in CogScreen-AE is the Threat Perception and Estimation Test (TPET), which produces a threat-index score directly relevant to the combat-cognitive scenarios described above (Budgam, Operation Sindoor).

Perceptiva Chakshu Yan (Sanskrit: *Chakshu* ■■■■■, eye/vision; *Yan* ■■■, vehicle) is a Safety Matters Foundation research construct authored by Capt. Amit Singh, FRAeS, with two public iterations. The first — Proposal 1024-01 (October 2024) at ideation stage — positioned Chakshu Yan as a real-time pilot-state monitoring system combining eye-tracking (fixation, gaze, and dwell-time analysis, with the methodological flag that gaze and fixation are routinely conflated in off-the-shelf

systems) with Near-Infrared Spectroscopy for cerebral oxygen saturation. The problem statement cited Air France 447, Colgan Air 3407, Eastern Air Lines 401 and TransAsia 235 as cases where pilot fixation, inadequate situational awareness, or cognitive overload were causal. The second iteration — a peer-review manuscript in the *Indian Journal of Aerospace Medicine* (IJASM_15_2026, Singh) — develops Chakshu Yan into a full methodological framework: a comparative modality review combined with a 2,400-subject synthetic-population simulation stratified by age, sex, region, and cohort. The fieldable sensing stack is broadened to pupillometry plus blink and gaze dynamics plus heart-rate variability derived from photoplethysmography plus respiration plus task telemetry plus ambient-light normalisation, with functional near-infrared spectroscopy reserved for a 300-subject validation tier where headgear is acceptable. A 12-item Cognitive Load and Overload Questionnaire is introduced as a subjective anchor, with three subscales — workload pressure, attention instability, and overload or loss of reserve — and strong simulated psychometric properties (Cronbach's α = 0.89; McDonald's ω = 0.91). Modelled held-out classification performance rose from macro-F1 0.59 for questionnaire-only input to 0.84 for eye plus autonomic plus context and 0.87 with fNIRS validation. The 2026 framework also revises the original construct on one important point: peripheral oxygen saturation (pulse oximetry) is reclassified as a hypoxia-safety variable rather than a direct cognition marker, with cerebral fNIRS retained as the proximal cortical-demand measurement. This is an important distinction, and it aligns Chakshu Yan with the mainstream neuroergonomics literature.

Complementarity and the two-tier case. pSuMEDhA and Chakshu Yan sit at different points in the cognitive-safety stack. pSuMEDhA is a psychometric test battery — administered off-line, producing a profile of the aviator's cognitive capabilities (working memory, vigilance, reaction time, threat perception) that is ideally used at selection, at conversion, and in periodic evaluation. Chakshu Yan is a real-time multimodal cognitive-state monitor — administered during task performance, producing continuous estimates of workload and overload risk. Neither substitutes for the other. pSuMEDhA can flag that an aviator has weak sustained attention on the Mackworth Clock Test or slow threat-perception response on the TPET — information that should shape training emphasis. Chakshu Yan can flag, during a live simulator approach or a high-tempo cockpit phase, that the aviator's pupil dynamics plus blink irregularity plus HRV pattern are consistent with overload risk — information that should trigger adaptive training or operational alerts. A complete IAF cognitive-safety programme would deploy both: pSuMEDhA as the selection-and-evaluation tier at IAM Bengaluru and at operational conversion units, and Chakshu Yan as the operational-monitoring tier embedded in simulators (immediately) and, where headgear is acceptable, in selected aircraft types or air-traffic-control consoles (medium term). Both are indigenous. Both are Indian-institutionally owned. Both are addressable to the causal patterns — fixation, overload, loss of situational awareness — that this report has identified in the 2016–2025 accident record.

7. Organisational and systemic factors

ICAO's Safety Management Systems (SMS) framework — mandatory for civil operators globally and widely adopted in allied military services — rests on four pillars: safety policy, safety risk management, safety assurance, and safety promotion. Public information on the IAF's SMS maturity is limited. This report offers five structural observations drawn from the open-source record.

First, Court of Inquiry transparency. For almost all of the incidents catalogued, the public record extends only to the fact that a CoI was ordered. The December 2024 parliamentary Standing Committee report on the Coonoor Mi-17V-5 crash — which publicly attributed the accident to human error at the aircrew level — is exceptional in its explicitness. Broader publication of CoI findings, subject to operational-security redaction, would materially advance systemic learning and external research capacity.

Second, reporting culture and safety-report hygiene. Just-Culture frameworks, widely adopted in civil aviation and in the US and allied services, separate honest error (reportable, protected) from gross negligence and wilful violation (disciplinary). There is no public evidence of a Just-Culture policy in the IAF's voluntary safety-reporting system. Whether such a policy exists internally is not visible externally; public codification would be high-value.

Third, aggregate parliamentary reporting. Ministerial replies to Parliament are the single most consistent open-source data stream on IAF accident rates and fleet-level fatalities. However, the data are reported at variable granularity across replies and rarely at the HFACS-tier level of resolution required for targeted intervention. A standard, annually published "IAF Safety Statistical Abstract" — modelled on the US Air Force Safety Center's aviation-statistics portal — would meaningfully raise the external evidence base.

Fourth, acceptance-testing and vendor-interface risk. The 1 February 2019 Bengaluru Mirage 2000 crash exposed vulnerabilities at the HAL / IAF interface: a software glitch introduced during upgrade, combined with failure of the runway arrester barrier (a contingency safeguard), produced a double-failure event that killed two highly experienced test pilots. The 4 June 2024 Nashik Su-30 MKI SB-182 loss during a post-overhaul test flight — the second Nashik post-HAL-work Su-30 loss in six years — reinforces the acceptance-testing pattern. Formal certification-basis reviews and V&V; uplift at the HAL/IAF boundary are a specific organisational lever.

Fifth, fleet-wide grounding governance. The 2023 and 2025 ALH Dhruv groundings were reactive (following fatal events) rather than predictive. A formal, published fleet-airworthiness review cadence — covering hour-limits, service-life extensions, and environmental service-profile adjustments (e.g., saline-environment service-life reduction for naval and coast-guard Dhruvs) — would reduce the risk of future reactive groundings.

8. International benchmarking

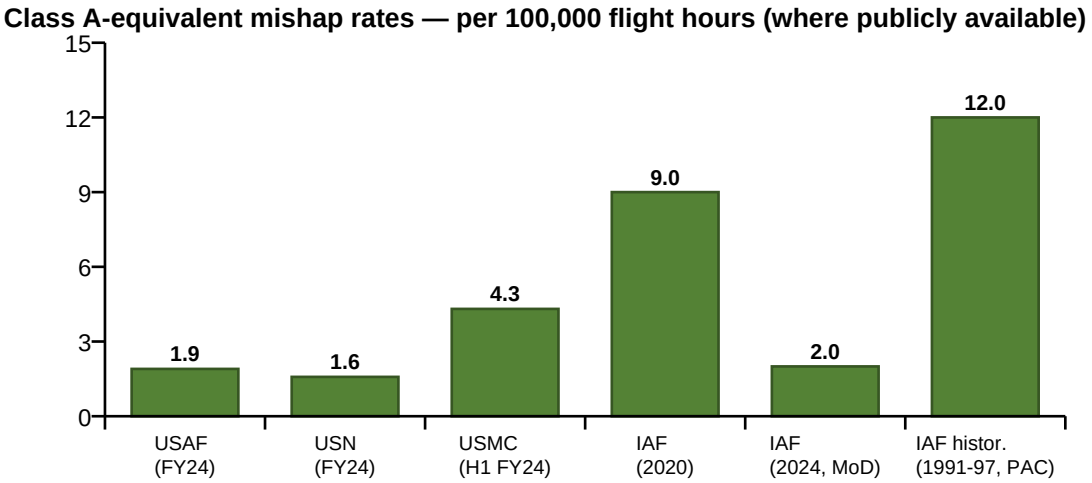

Figure 3. Class A-equivalent mishap rates (per 100,000 flight hours) where publicly available. IAF 2020 and 2024 figures are derived from ministerial replies (converted from per-10,000 hours). IAF historical 1991–97 uses Public Accounts Committee data. RAF, PLAAF, and PAF are excluded because per-100k rates are not published in open sources.

Direct comparison is compromised by definitional and reporting-scope differences. Class A in US doctrine requires ≥$2.5 million damage or fatality/permanent disability; the IAF reports any "accident" without a uniform dollar threshold. The RAF, PLAAF and PAF do not publish directly comparable per-100,000-hour figures in open sources. With those caveats, three observations follow.

First, trend direction. The IAF's reported improvement from approximately 9 per 100,000 hours (2020) to 2 per 100,000 (2024) per ministerial replies is a substantial improvement over four years. By comparison, the USAF moved in the opposite direction — from 1.72 per 100,000 in FY2020 to 1.9 in FY2024 (a four-year high), with USMC aviation spiking to 4.31 per 100,000 in the first half of FY2024 against a ten-year service average of 2.24. Aggregate US military Class A rates rose from 1.3 per 100,000 in FY2020 to 2.02 in FY2024, a ~55% increase. The Indian and US trend directions are therefore opposite over the same window — a point worthy of further analysis.

Second, base rates. Even after improvement, the IAF's 2024 figure of 2 per 100,000 is still marginally above the USAF's FY2024 figure of 1.9, and the IAF's historical baseline (PAC 1991–97: 8.9–15.2 per 100,000 overall, 22.9–39.9 per 100,000 for MiG-21 specifically) places it an order of magnitude above contemporary US peacetime base rates. The MiG-21's retirement on 26 September 2025 should itself produce a continuing downward contribution to the aggregate rate.

Third, publication asymmetry. The USAF Safety Center publishes annual Class A statistics at division level. The UK Ministry of Defence publishes a consolidated Health and Safety Statistics report but not per-100,000 aviation-specific rates. The PLAAF and PAF do not publish equivalent data. The IAF's parliamentary-reply convention is intermediate. There is room for the IAF to move towards USAF-style public reporting without compromising operational security.

9. Recommendations roadmap

The recommendations below are grouped across three axes — technical, human and cognitive, and organisational — and time-phased into near-term (12 months), medium-term (1–3 years), and long-term (3–10 years).

9.1 Technical and airworthiness

1. **Complete MiG-21 retirement debrief and lessons-learned publication** (near-term). Consolidate the 1991–2025 MiG-21 safety record into a single internally published volume as the foundation stone of institutional safety memory.

2. **ALH Dhruv predictive airworthiness review** (near-term). Move from reactive groundings to predictive fleet-life and environmental-service-profile management, with separate review cadences for naval/coast-guard (saline-environment accelerated service life) and land variants.

3. **Jaguar replacement decision cadence** (medium-term). The 2025 three-loss-in-four-months cluster warrants a formal replacement timeline decision by 2027.

4. **Fly-by-wire acceptance-testing and V&V; uplift** at the HAL/IAF boundary (medium-term), with formal mode-awareness and automation-surprise protocols as a condition of acceptance.

5. **Tejas reliability-growth programme instrumentation** (medium-term). Following the November 2025 Dubai fatality, publish reliability-growth metrics internally and to the parliamentary oversight mechanism.

9.2 Human factors and cognitive safety

1. **Establish a formal Cognitive Safety Branch** within Air Headquarters (Inspection Safety) or a partnership between the Directorate of Flight Safety and the Institute of Aerospace Medicine, Bengaluru (near-term). Remit: SA measurement, SD research, startle-response training, automation-surprise programmes, plan-continuation-bias training, fatigue-risk modelling.

2. **Adopt HFACS 8.0 as the IAF's standard accident-coding taxonomy** (near-term). Publish anonymised annual HFACS distributions as part of a public "IAF Safety Statistical Abstract".

3. **Operationalise pSuMEDhA at the selection and periodic-evaluation tier** (near-term). Accelerate the flight-simulator validation programme flagged by Thambidurai et al. (2024) so that pSuMEDhA sub-scores — particularly TPET threat-index and MCT vigilance — become routine inputs into aircrew training emphasis and re-currency decisions.

4. **Pilot Chakshu Yan at the operational-monitoring tier** (near-term to medium-term). Deploy the SMF multimodal cognitive-monitoring framework (eye-tracking + HRV/PPG + respiration + context, with fNIRS in a validation tier where headgear is acceptable) in Air Force Academy and Operational Conversion Unit simulators first, with instrument validation against live flight-simulator performance and against pSuMEDhA sub-scores as cross-construct checks.

5. **SD-awareness refresh with Disorientation Research Devices** (medium-term), with helicopter-specific SD training modules for Mi-17V-5, ALH Dhruv, Chetak/Cheetah crews operating in Himalayan, Nilgiri, and over-water profiles.

6. **Unexpected-event simulator scenarios** embedded in operational conversion and periodic proficiency, targeting startle and surprise (medium-term).

7. **Threat and Error Management integration** across all IAF CRM syllabi, with explicit coverage of plan-continuation bias, confirmation bias, and automation complacency (medium-term).

8. **Fatigue Risk Management System (FRMS)** grounded in circadian biology and sleep-homeostatic modelling; deploy wearable-based fatigue monitoring in high-tempo operational windows (long-term).

9. **Cognitive-load measurement research programme** with IAM Bengaluru and SMF (long-term), using physiological proxies (HRV, pupillometry, EEG-engagement indices, prefrontal fNIRS) to build the evidence base for real-time task-allocation interventions.

9.3 Organisational and systemic

1. **Public "IAF Safety Statistical Abstract"** (near-term), annually published, modelled on the USAF Safety Center portal, with anonymised Class A-equivalent rates per 100,000 hours disaggregated by platform, phase of flight, and HFACS distribution.

2. **Just-Culture policy codification** (near-term), publicly articulated, separating honest error from gross negligence and wilful violation; protection for voluntary safety reporting.

3. **Court of Inquiry transparency policy** (medium-term). Default publication of CoI executive summaries subject to operational-security redaction, on the model of the 2024 parliamentary Standing Committee treatment of the Coonoor case.

4. **Parliamentary Standing Committee safety-review cadence** codified at an agreed interval (medium-term), with external review authority to examine safety-assurance performance against the SMS framework.

5. **IAF–civil aviation–industry safety-data exchange** (long-term), using anonymised safety-event codes, to benefit from the richer civil-aviation evidence base on fatigue, automation, and CRM.

10. Conclusion

The Indian Air Force's safety record across 2016–2025 is the record of a large, operationally busy service transitioning out of a Cold War–era fleet architecture into an all-digital, indigenous-platform-heavy future, while engaging in two brief but consequential combat episodes. The headline numerical trend — approximately 9 per 100,000 flight hours in 2020 to 2 per 100,000 by 2024 per ministerial replies — is substantial progress, though it continues to sit marginally above contemporary USAF peacetime benchmarks and an order of magnitude above the IAF's own historical worst fleet (MiG-21) attrition.

The more consequential opportunity is structural. The causal fingerprints of the decade's most visible accidents — Coonoor CFIT, Yelahanka mid-air, Budgam friendly fire, Bengaluru Mirage 2000 test crash — are not mysterious; they map cleanly onto the published cognitive-safety and human-factors literature. What is missing is a structured, publicly visible cognitive-safety programme that operationalises that literature into IAF training, airworthiness, and organisational governance. Establishing such a programme — with HFACS 8.0 as the accident-coding standard, a Cognitive Safety Branch at Air HQ, a published Safety Statistical Abstract, a codified Just-Culture policy, and a fatigue-risk management regime grounded in circadian biology — is the single highest-leverage safety investment available to the IAF over the next five years. The MiG-21's retirement on 26 September 2025 closes a chapter. The cognitive-safety chapter is ready to be opened.

11. References

Primary source register and supporting spreadsheet

The descriptive backbone of this report is the companion spreadsheet IAF_Incidents_2016–2025.xlsx (65 incident register + yearly totals + aircraft-type rollup + methodology notes) and the companion narrative report IAF_Incidents_2016–2025_Summary.docx. These in turn draw on the sources listed below.

Cognitive safety and human factors

Wiegmann D.A. & Shappell S.A. (2003). *A Human Error Approach to Aviation Accident Analysis: The Human Factors Analysis and Classification System*. Aldershot: Ashgate. Reference copy at Embry-Riddle: commons.erau.edu/publication/737/

US Department of Defense / USAF Safety Center (current). *Human Factors Analysis and Classification System — HFACS 8.0*. safety.af.mil/Divisions/Human-Performance-Division/HFACS/

Endsley M.R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors* 37(1):32–64.

Landman A. et al. (2022). Spatial disorientation in aviation: a systematic review. *Frontiers in Physiology* 13. pmc.ncbi.nlm.nih.gov/articles/PMC9028632/

NATO/FAA (2021). *Spatial Disorientation: Causes, Consequences and Countermeasures*. faa.gov/sites/faa.gov/files/about/office_org/headquarters_offices/avs/MP-086-18.pdf

Martin W.L. et al. (2023). Startle and surprise in aviation: a narrative review. *Frontiers in Neuroergonomics* 4:1059476. frontiersin.org

ICAO (1995). *Human Factors Digest No. 5: Implications of Automation in Advanced Aviation Systems*. Reference copy at FAA: faa.gov/sites/faa.gov/files/2022-11/ICAO%20HF%20Ops%20Rpt%20-%20Implications%20of%20Automation.pdf

Helmreich R.L., Merritt A.C. & Wilhelm J.A. (1999). The evolution of Crew Resource Management training in commercial aviation. *International Journal of Aviation Psychology* 9(1):19–32. FAA copy: faa.gov/sites/faa.gov/files/2022-11/crmhistory.pdf

ICAO (2008; revised). *Annex 6 — Operation of Aircraft*, Fatigue Risk Management Systems. IATA FRMS white paper 2025: iata.org

Irish Aviation Authority OAM-16. Plan Continuation Bias. iaa.ie/docs/default-source/publications/advisory-memoranda/operations-advisory-memoranda-(oam)/oam-16-plan-continuation-bias.pdf

Gaur D. (2005). Human factors analysis and classification system applied to civil aircraft accidents in India. *Aviation, Space, and Environmental Medicine* 76(5):501–505. pubmed.ncbi.nlm.nih.gov/15892552/

Institute of Aerospace Medicine (Bengaluru) / *Indian Journal of Aerospace Medicine*: The utility of HFACS in the analysis of military aviation accidents; Aircraft accidents in Indian Army aviation; UAV operations — human factors and CRM perspective; Accident proneness of pilots in IAF — empirical analysis through selection criteria. indjaerospacemed.com

Thambidurai A, Sharma V, Sowgandhi CN, Biswal P. (2024). A comparative study between an indigenously developed psychometric test battery "pSuMEDhA" and "CogScreen-AE." *Indian Journal of Aerospace Medicine* 68(1):2–9. DOI: 10.25259/IJASM_2_2024.

Safety Matters Foundation / Singh A. (2024). *Perceptiva Chakshu Yan (Eye Tracking)*. Proposal 1024-01, ideation stage. Safety Matters Foundation. safetymatters.co.in.

Singh A. (2026, peer-review draft). A synthetic population and multimodal sensing framework for modeling cognitive load and overload risk in aerospace operations. *Indian Journal of Aerospace Medicine*, manuscript IJASM_15_2026 (technical report, aerospace medicine).

Safety statistics and benchmarks

Air Force Safety Center. USAF Aviation Statistics / Class A Mishap Summaries. safety.af.mil/Divisions/Aviation-Safety-Division/Aviation-Statistics/

RAND Corporation (2021). RRA257-1. USAF aviation mishap trends 1950–2018. rand.org/pubs/research_reports/RRA257-1.html

Defense One, Military Times, Military.com (November 2025) coverage of FY2024 US aviation-mishap spike.

Naval Safety Command (US Navy). FY24 and FY25 mishap statistics PDFs. navalsafetycommand.navy.mil

2025 Marine Aviation Plan. US Marine Corps. media.defense.gov

UK Ministry of Defence. Health and Safety Statistics Annual Report 2023–24. assets.publishing.service.gov.uk

China Aerospace Studies Institute / US Air University. PLAAF research. airuniversity.af.edu/CASI/PLAAF/

Public Accounts Committee of India (2002). Audit of IAF flight safety, 1991–1997.

Parliamentary Standing Committee on Defence (December 2024). Report on IAF Mi-17V-5 Coonoor crash (December 2021).

SP's Aviation (2007). IAF records lowest-ever accident rate (ACM Tyagi). sps-aviation.com

Raksha Anirveda; Eurasian Times; Organiser; DNA India — open-source IAF accident-rate reporting 2016–2025.

Bharat-Rakshak IAF Aircraft Losses Database. bharat-rakshak.com/indianairforce/database/accidents/

Aviation Safety Network / aviation-safety.net wikibase.

Wikipedia — List of accidents and incidents involving the Indian Air Force; 2025 India–Pakistan conflict; 2021 Indian Air Force Mil Mi-17 crash; 2016 Indian Air Force An-32 disappearance; 2019 Balakot airstrike; 2019 Jammu and Kashmir airstrikes; 2025 HAL Tejas Dubai Air Show crash.

Indian news and defence reporting (selection)

ThePrint; The Hindu; The Times of India; Hindustan Times; Indian Express; The Tribune; Deccan Herald; Business Standard; The Week; Outlook; NDTV; StratNews Global; Livefist Defence; Bharat Shakti; IDRW; The Aviationist; Aerotime; Breaking Defense; Janes; BBC Verify; The Washington Post.

Press Information Bureau of India. pib.gov.in — release-specific PRIDs for the Pathankot attack, An-32 K2743 loss, and named-officer casualties.

End of report.

Appendix A

Full Incident Register, 2016–2025

This appendix contains the full open-source incident register that underlies the main report. It is reproduced from the companion spreadsheet *IAF_Incidents_2016–2025.xlsx*. Columns have been condensed for print legibility; the companion spreadsheet contains the complete record including tail/serial numbers, squadron attributions, casualty detail, Court of Inquiry outcomes, full narratives, and source URLs. All entries are cross-verified across at least two independent open sources unless flagged 'Single-source' in the verification column.

Compiled by: Safety Matters Foundation • **Document control number:** SMF/RES/IAF-SAF/2026/001 • **Register size:** 65 rows.

Names and remembrance. The names of deceased aircrew, ground crew, and civilian casualties in this register are drawn from the public record — the Indian Air Force's official condolence statements, Press Information Bureau releases, parliamentary records, Honourpoint.in memorial profiles published with family cooperation, and the Indian broadsheet reporting. They are included as a form of recognition and as part of the historical record, not as attribution of blame. Where an accident investigation or parliamentary committee has made a finding of human error at the crew level, the finding is attributed at the unit or investigation level rather than to individual aircrew members by name. The Safety Matters Foundation welcomes corrections or requests for revision from families, units, and the service. Contact: Admin@safetymatters.co.in.

A.1 Master incident register (65 rows)

No.	Date	Yr	Aircraft	Location	State/Region	Category	KIA	Casualty names (public)	Cause (reported)	Verification
1	02-Jan-2016	2016	N/A (Airbase attack)	Pathankot Air Force Station	Punjab	Ground/base attack	7	Lt Col Niranjan E Kumar (NSG), Cpl Gursewak Singh (Garud) + others	Coordinated terrorist attack by Jaish-e-Mohammed militants who breached the perimeter	Multi-source
2	13-Jun-2016	2016	MiG-27 UPG 'Bahadur'	Kuri Bhagtasni, Jodhpur	Rajasthan	Crash (non-fatal)	0	-	Technical malfunction post-takeoff; struck a locked house and parked car in residential colony	Multi-source
3	22-Jul-2016	2016	Antonov An-32	Bay of Bengal (280 km E of Chennai)	At sea	Crash (fatal)	29	6 crew + 23 pax (IAF/Coast Guard/defence civilians & families)	Unknown at time of loss; contact lost at 09:12 IST en route Tambaram-Port Blair; wreckage located Jan 2024 at ~3,400 m depth	Multi-source
4	04-Aug-2016	2016	BAe Hawk Mk-132	AFS Kalaikunda	West Bengal	Crash (non-fatal)	0	-	Technical snag developed shortly after takeoff ~11:00 AM on training sortie	Multi-source
5	2016 (undated)	2016	SEPECAT Jaguar	AFS Ambala	Haryana	Ground incident / fire	0	-	Aircraft caught fire during takeoff; pilot aborted and egressed	Single-source

No.	Date	Yr	Aircraft	Location	State/Region	Category	KIA	Casualty names (public)	Cause (reported)	Verification
6	Jan-2017 (approx.)	2017	MiG-21 Bison	Near AFS Suratgarh	Rajasthan	Crash (non-fatal)	0	-	Major technical malfunction during training sortie	Single-source
7	15-Mar-2017	2017	Sukhoi Su-30 MKI	Shivkar village, Barmer	Rajasthan	Crash (non-fatal)	0	-	Training sortie; cause not publicly disclosed	Multi-source
8	23-May-2017	2017	Sukhoi Su-30 MKI	~60 km NW of Tezpur / Arunachal Pradesh border	Assam / Arunachal Pradesh	Crash (fatal)	2	Sqn Ldr D. Pankaj (Chandigarh/Delhi); Flt Lt S. Achudev (Kerala)	FDR analysis: pilots did not initiate ejection before impact. Control or technical cause not fully public.	Multi-source
9	06-Oct-2017	2017	Mil Mi-17V-5	Near Tawang	Arunachal Pradesh	Crash (fatal)	7	Wg Cdr Vikas Upadhyay, Sqn Ldr Shishir Tewari, MWO A.K. Singh, Sgt Gautam Kumar, Sgt Satish Kumar (IAF); Sep H.N. Deka & Sep E. Balaji (Army)	Net holding kerosene jerry-cans reportedly entangled in rear/tail rotor during offload at drop zone, per some accounts; CoI ordered	Multi-source
10	Nov-2017	2017	HAL Kiran trainer	Near Siddipet	Telangana	Crash (non-fatal)	0	-	Technical snag detected in flight	Single-source
11	20-Mar-2018	2018	BAe Hawk Mk-132	Mayurbhanj district / Odisha-Jharkhand border (banks of Subarnarekha)	Odisha	Crash (non-fatal)	0	-	Cause not publicly disclosed	Multi-source
12	03-Apr-2018	2018	Mil Mi-17V-5	Kedarnath helipad	Uttarakhand	Ground incident	0	-	During airlifting of a disabled civilian helicopter from Kedarnath, the Mi-17 collided with an iron girder on landing/takeoff and caught fire	Multi-source
13	05-Jun-2018	2018	SEPECAT Jaguar (single-seat)	Bareja village, Kutch district (near Jamnagar)	Gujarat	Crash (fatal)	1	Air Cmde Sanjai Chauhan VM (AOC, AFS Jamnagar)	Routine training sortie; cause not publicly disclosed	Multi-source
14	07-Jun-2018 (approx.)	2018	SEPECAT Jaguar	Jamnagar	Gujarat	Crash (details unconfirmed)	0	-	Not publicly confirmed	Single-source
15	27-Jun-2018	2018	Sukhoi Su-30 MKI (HAL-built, pre-induction)	Wavi-Thushi village near Pimpalgaon Baswant, ~25 km from Nashik	Maharashtra	Crash (non-fatal, test)	0	-	Post-production acceptance test flight; cause not publicly disclosed	Multi-source
16	18-Jul-2018	2018	MiG-21 Bis	Patta Jattiyan, Jawali, Kangra district	Himachal Pradesh	Crash (fatal)	1	Sqn Ldr Meet Kumar	Routine sortie; cause not publicly disclosed	Multi-source
17	04-Sep-2018	2018	MiG-27 UPG	Banad area / Sirohi, Jodhpur region	Rajasthan	Crash (non-fatal)	0	-	Reported engine problems after takeoff from Utarlai AFS	Multi-source
18	28-Jan-2019	2019	SEPECAT Jaguar	Hetimpur area, Kushinagar district	Uttar Pradesh	Crash (non-fatal)	0	-	Technical snag reported in flight	Multi-source

No.	Date	Yr	Aircraft	Location	State/Region	Category	KIA	Casualty names (public)	Cause (reported)	Verification
19	01-Feb-2019	2019	Dassault Mirage 2000 (upgraded)	HAL Airport, Bengaluru	Karnataka	Crash (fatal, test flight)	2	Sqn Ldr Samir Abrol, Sqn Ldr Siddhartha Negi	Software glitch / uninitiated control input during user-acceptance trial after HAL upgrade; arrester barrier on runway also failed	Multi-source
20	12-Feb-2019	2019	MiG-27 UPG	Near Pokhran Range, Jaisalmer	Rajasthan	Crash (non-fatal)	0	-	Cause not publicly disclosed	Multi-source
21	19-Feb-2019	2019	2× BAE Hawk Mk-132 (mid-air collision)	Yelahanka AFS, Bengaluru (Aero India venue)	Karnataka	Crash (fatal)	1	Wg Cdr Sahil Gandhi	Preliminary finding: pilot error / incorrect formation during mirror manoeuvre rehearsal	Multi-source
22	26-Feb-2019	2019	Dassault Mirage 2000 (combat mission)	Balakot, KPK	Pakistan	Combat operation (no IAF loss)	0	-	Operational strike on Jaish-e-Mohammed facility using SPICE-2000 PGMs	Multi-source
23	27-Feb-2019	2019	Mil Mi-17V-5 (friendly fire)	Near Budgam airfield	Jammu & Kashmir	Combat/friendly fire	7	Sqn Ldr Siddharth Vashisht, Sqn Ldr Ninad Anil Mandavgane, Kumar Pandey, Sgt Vikrant Sehrawat, Cpl Deepak Pandey, Cpl Pankaj Kumar + 1 civilian (Kifayat Hussain Ganie)	Blue-on-blue friendly fire by IAF SPYDER SAM; IFF transponder was switched off; misidentified as possible hostile	Multi-source
24	27-Feb-2019	2019	MiG-21 Bison (combat loss)	Over PoK, Nowshera sector	J&K; / PoK	Combat loss	0	-	Downed during aerial engagement with PAF package (Op Swift Retort); IAF claims Abhinandan shot down a PAF F-16 with R-73 before being hit; Pakistan denies F-16 loss	Multi-source
25	08-Mar-2019	2019	MiG-21	Shobhasar ki Dhani, Bikaner sector	Rajasthan	Crash (non-fatal)	0	-	Suspected bird strike (per MoD preliminary input)	Multi-source
26	31-Mar-2019	2019	MiG-27 UPG	Sirohi district	Rajasthan	Crash (non-fatal)	0	-	Engine problems reported	Multi-source
27	03-Jun-2019	2019	Antonov An-32	Near Gatte/Lipo, Shi Yomi district	Arunachal Pradesh	Crash (fatal)	13	Wg Cdr G.M. Charles, Sqn Ldr H. Vinod; Flt Lts Sunit Mohanty, L.R. Thapa, M.K. Garg, Ashish Tanwar; WO K.K. Mishra; Sgt Anoop Kumar; Cpl Sherin; LACs S.K. Singh & Pankaj; plus Rajesh Kumar & Putali (non-combatants)	Crashed in mountainous terrain at ~12,000 ft; specific CoI cause not publicly confirmed	Multi-source
28	27-Jun-2019	2019	SEPECAT Jaguar (recovered)	Near Ambala AFS	Haryana	Near-miss / bird strike	0	-	Bird strike shortly after takeoff; one engine failed; pilot jettisoned external tanks & CBLS pods and recovered aircraft safely	Multi-source
29	08-Aug-2019	2019	Sukhoi Su-30 MKI	Milanpur area, Tezpur	Assam	Crash (non-fatal)	0	-	Technical failure	Multi-source

No.	Date	Yr	Aircraft	Location	State/Region	Category	KIA	Casualty names (public)	Cause (reported)	Verification
30	25-Sep-2019	2019	MiG-21 Type 69 Trainer	Near AFS Gwalior	Madhya Pradesh	Crash (non-fatal)	0	-	Cause not publicly confirmed	Multi-source
31	08-May-2020	2020	MiG-29	Chuharpur village, Nawanshahr district (near Jalandhar)	Punjab	Crash (non-fatal)	0	-	Technical snag	Multi-source
32	12-Oct-2020	2020	HAL Tejas LCA	Airspace over western India	N/A	Near-miss (no hull loss)	0	-	Cockpit pressurisation failure at altitude then loss of 3 of 4 Flight Control System channels at ~17,000 ft — total loss of control	Multi-source
33	05-Jan-2021	2021	MiG-21 Bison	Near AFS Suratgarh (Matasar Bhoortiya area)	Rajasthan	Crash (non-fatal)	0	-	Technical malfunction	Multi-source
34	17-Mar-2021	2021	MiG-21 Bison	Near AFS Gwalior	Madhya Pradesh	Crash (fatal)	1	Gp Capt Ashish Gupta	Cause not publicly confirmed	Multi-source
35	20/21-May-2021	2021	MiG-21 Bison	Langeana village, Moga district	Punjab	Crash (fatal)	1	Sqn Ldr Abhinav Choudhary	Investigation ordered; parachute reportedly found open with SOS sent; pilot's neck/spine injury	Multi-source
36	25-Aug-2021	2021	MiG-21 Bison	Near Bhurtiya village, Barmer	Rajasthan	Crash (non-fatal)	0	-	Technical malfunction	Multi-source
37	21-Oct-2021	2021	Dassault Mirage 2000	Mankabagh village, Bhind district	Madhya Pradesh	Crash (non-fatal)	0	-	Technical malfunction on training sortie	Multi-source
38	~08-Nov-2021	2021	Mil Mi-17V-5	Eastern Arunachal Pradesh	Arunachal Pradesh	Crash-landing (non-fatal)	0	-	Cause not publicly confirmed	Single-source
39	08-Dec-2021	2021	Mil Mi-17V-5	Near Nanjappachatiram, Coonoor, Nilgiris	Tamil Nadu	Crash (fatal) — CDS crash	14	CDS Gen Bipin Rawat; Madhulika Rawat; Brig LS Lidder; Lt Col Harjinder Singh; Wg Cdr Prithvi Singh Chauhan; Sqn Ldr Kuldeep Singh; JWOs Rana Pratap Das & Arakkal Pradeep; L/Nks Vivek Kumar & B. Sai Teja + others; Gp Capt Varun Singh (died 15 Dec)	Controlled Flight Into Terrain (CFIT) in adverse weather; human error (aircrew) per IAF CoI and 2024 parliamentary panel	Multi-source
40	24-Dec-2021	2021	MiG-21 Bison	Sudasiri village, Desert National Park, Jaisalmer	Rajasthan	Crash (fatal)	1	Wg Cdr Harshit Sinha	Cause not publicly confirmed	Multi-source
41	28-Jul-2022	2022	MiG-21 Bison (twin-seat trainer)	Near Barmer (Thar Desert)	Rajasthan	Crash (fatal)	2	Wg Cdr Mohit Rana (38); Flt Lt Advitiya Bal (26)	Under investigation; night training sortie from Uttarlai ~2110 IST; technical snag implicated	Multi-source
42	28-Jan-2023	2023	Su-30 MKI + Mirage 2000 (mid-air collision)	Near Morena (Pahargarh area)	Madhya Pradesh	Crash (fatal)	1	Wg Cdr Hanumanth Rao Sarathi (Mirage 2000 pilot/instructor)	Suspected mid-air collision during combat exercise	Multi-source
43	Mar-2023	2023	HAL ALH Dhruv (IN 709)	Off Mumbai	Maharashtra (Arabian Sea)	Ditch (non-fatal)	0	-	Failure of control rod in the collective circuit	Multi-source

No.	Date	Yr	Aircraft	Location	State/Region	Category	KIA	Casualty names (public)	Cause (reported)	Verification
44	26-Mar-2023	2023	HAL Dhruv Mk III (Coast Guard)	Kochi Airport	Kerala	Crash (non-fatal)	0	-	Crashed shortly after takeoff from ~25 ft	Secondary-source
45	04-May-2023	2023	HAL ALH Dhruv (Army)	Kishtwar district, Marwah area	Jammu & Kashmir	Crash (fatal)	1	Craftsman Pabballa Anil (technician, 30, Telangana)	Technical fault; pilots attempted precautionary landing; hard landing on uneven terrain	Multi-source
46	08-May-2023	2023	MiG-21 Bison	Bahlol Nagar village, Hanumangarh district	Rajasthan	Crash (fatal — civilians)	3	Basho Kaur, Leela Devi, Banto Kaur (civilians; burns after aircraft hit a house)	Onboard emergency; pilot unable to recover; sortie from Suratgarh AFS	Multi-source
47	May-2023	2023	C-17 Globemaster III	Leh runway	Ladakh	Ground incident (non-hull-loss)	0	-	Technical issue; aircraft unable to move off the single runway	Single-source
48	01-Jun-2023	2023	HAL Kiran Mk II (Surya Kiran)	Near Chamrajnagar	Karnataka	Crash (non-fatal)	0	-	Under inquiry; routine training sortie	Single-source
49	04-Dec-2023	2023	Pilatus PC-7 Mk II	Near Toopran, Medak district	Telangana	Crash (fatal)	2	Instructor + cadet (one reported Vietnamese trainee in some coverage)	Crashed during routine training sortie	Multi-source
50	13-Feb-2024	2024	BAe Hawk Mk 132	Near AFS Kalaikunda, Paschim Medinipur	West Bengal	Crash (non-fatal)	0	-	Under inquiry; crashed while returning from training sortie	Multi-source
51	12-Mar-2024	2024	HAL Tejas LCA Mk 1 (FOC)	Near Jaisalmer	Rajasthan	Crash (non-fatal)	0	-	Suspected engine failure per initial leaks; occurred ~1415 IST during operational training	Multi-source
52	04-Jun-2024	2024	Sukhoi Su-30 MKI	Shirasgaon village, Nashik district	Maharashtra	Crash (non-fatal, test)	0	-	Mid-air technical snag during post-overhaul test from HAL Nashik (Ozar)	Multi-source
53	04-Nov-2024	2024	MiG-29 UPG	Near Soniga village, Kagaraul, Agra	Uttar Pradesh	Crash (non-fatal)	0	-	System malfunction during routine training sortie	Multi-source
54	05-Jan-2025	2025	HAL ALH Dhruv Mk 3	Porbandar Airport	Gujarat	Crash (fatal)	3	2 Coast Guard pilots + 1 aircrew diver	Fracture in Non-Rotating Swashplate (NRSB) — critical rotor control component	Multi-source
55	06-Feb-2025	2025	Dassault Mirage 2000 TI (twin-seat)	Near Shivpuri	Madhya Pradesh	Crash (non-fatal)	0	-	System malfunction during routine training	Multi-source
56	07-Mar-2025	2025	SEPECAT Jaguar IS	Raipur Rani, Panchkula (Morni Hills)	Haryana	Crash (non-fatal)	0	-	System malfunction post-takeoff from Ambala	Multi-source
57	29-Mar-2025	2025	C-130J Super Hercules (followed by C-17s)	Over Myanmar airspace	International	Near-miss / electronic warfare	0	-	GPS spoofing/interference during relief mission to Yangon, Myanmar (post-earthquake)	Single-source
58	02-Apr-2025	2025	SEPECAT Jaguar IB (twin-seat trainer)	Suvarda village, ~12 km from Jamnagar	Gujarat	Crash (fatal)	1	Flt Lt Siddharth Yadav	CCTV indicates fire ~17 sec pre-crash; suspected bird-strike trigger	Multi-source

No.	Date	Yr	Aircraft	Location	State/Region	Category	KIA	Casualty names (public)	Cause (reported)	Verification
59	21-Apr-2025	2025	HAL Chetak	Near Jamnagar	Gujarat	Precautionary landing	0	-	Technical defect — precautionary landing	Single-source
60	07-May-2025	2025	Dassault Rafale F3R (combat loss — claimed/OSINT verified)	Akalia Kalan, Bathinda district	Punjab	Combat loss (contested)	0	-	Claimed Pakistani PL-15E BVR (J-10C) engagement; Indian side has not officially named type	Multi-source (contested)
61	07-May-2025	2025	Dassault Mirage 2000 (combat loss — claimed/OSINT verified)	Wuyan, Pampore	Jammu & Kashmir	Combat loss (contested)	0	-	Operation Sindoor combat engagement; wreckage ID via MICA missile debris	Multi-source (contested)
62	07-May-2025	2025	MiG-29 UPG or Su-30 MKI (combat loss — claimed)	Akhnoor / Ramban sector	Jammu & Kashmir	Combat loss (contested)	0	-	Operation Sindoor combat engagement; K-36DM Russian ejection seat wreckage photographed at Ramban	Multi-source (contested)
63	09-Jul-2025	2025	SEPECAT Jaguar IB (twin-seat trainer)	Near Churu	Rajasthan	Crash (fatal)	2	Sqn Ldr Lokender Singh Sindhu (32); Flt Lt Rishi Raj Singh (23)	Under investigation	Multi-source
64	19-26-Sep-2025	2025	MiG-21 Bison — fleet retirement	AFS Chandigarh	Chandigarh	Ceremonial retirement (non-loss)	0	-	End of 62 years of service	Multi-source
65	21-Nov-2025	2025	HAL Tejas LCA	Al Maktoum International Airport (Dubai Airshow 2025)	UAE	Crash (fatal, airshow)	1	Wg Cdr Namansh Syal (34)	Under investigation; preliminary analyses point to stall, power interruption, or digital FCS fault during low-altitude aerobatic manoeuvre (~1410-1415 local)	Multi-source

A.2 Yearly totals

Rollup of incidents, fatal events, and casualties by calendar year.

Year	Incidents	Fatal	Personnel KIA	Civilian KIA	Highlights
2016	5	2	36	0	Pathankot attack (7 killed); An-32 K2743 (29 lost at sea)
2017	5	2	9	0	Su-30 Tezpur (Pankaj/Achudev KIA); Mi-17V5 Tawang (7 KIA)
2018	7	2	2	0	Jaguar Kutch (Air Cmde Chauhan KIA); MiG-21 Kangra (Meet Kumar KIA)
2019	13	4	22	1	Balakot; Abhinandan MiG-21 POW; Budgam Mi-17 friendly-fire; An-32 K-2752; HAL Mirage 2000
2020	2	0	0	0	Lower reported count during COVID; Tejas Varun Singh Shaurya Chakra save
2021	8	4	16	1	MiG-21 losses x 5; CDS Rawat crash (Coonoor) 14 dead
2022	1	1	2	0	MiG-21 Barmer trainer (Rana + Bal KIA) — triggered retirement push
2023	8	3	6	3	Su-30 × Mirage collision Morena; final MiG-21 fatal (3 civilians); Pilatus PC-7 first loss
2024	4	0	0	0	First Tejas crash (Jaisalmer); Hawk Kalaikunda; Su-30 Nashik SB-182; MiG-29 Agra
2025	12	5	10+	0	ALH Porbandar fleet grounding; Op Sindoor 3+ combat losses; MiG-21 retirement; Tejas Dubai fatal
TOTAL	65	23	93	5	See Notes sheet for data-gap caveats

A.3 By aircraft type

Rollup of incidents and fatal events by airframe class.

Aircraft type	Incidents	Fatal	Notes
MiG-21 / Bison (fighter)	13	5	Retired 26 Sep 2025; dominant crash type 2016-2023
MiG-27 UPG	4	0	Retired 31 Mar 2020; multiple ejections Rajasthan
MiG-29 / MiG-29 UPG	3	0	Incl. Jalandhar 2020, Agra 2024; plus combat loss claim 2025
Sukhoi Su-30 MKI	6	2	Tezpur 2017 (2 KIA); Morena 2023 collision; HAL test losses
Dassault Mirage 2000	5	3	HAL test crash 2019 (Abrol/Negi KIA); Morena 2023 (Sarathi KIA); Pampore 2025 (combat, contested)
Dassault Rafale	1	0	Bathinda 2025 combat loss (OSINT-verified, officially not type-named)
SEPECAT Jaguar	7	3	Chauhan 2018; Yadav 2025; Sindhu/Raj Singh 2025 — fleet age concerns

HAL Tejas LCA	2	1	Jaisalmer 2024 (first loss); Dubai 2025 (first fatal — Syal)
BAe Hawk Mk 132	4	1	Kalaikunda/Odisha/Bengaluru; incl. SKAT 2019 collision
HAL Kiran / Surya Kiran	2	0	Siddipet 2017; Chamrajnagar 2023
Pilatus PC-7 Mk II	1	1	First loss (Dec 2023, 2 KIA)
Antonov An-32	2	2	K2743 Bay of Bengal 2016; K-2752 Arunachal 2019
C-17 / C-130J	2	0	Leh ground incident 2023; Myanmar GPS spoofing 2025
Mi-17 / Mi-17V-5	5	3	Tawang 2017; Kedarnath 2018; Budgam friendly-fire 2019; Coonoor CDS 2021; Arunachal 2021
HAL ALH Dhruv / Mk III	4	2	Repeated fleet-wide groundings 2023 & 2025
HAL Cheetah / Chetak	2	1	Cross-service Army/IAF fleet
Ground/base attack or fire	2	1	Pathankot 2016; Ambala Jaguar 2016
TOTAL	65	25	Totals may not equal main sheet count due to multi-type incidents (e.g., mid-air collisions)

A.4 Methodology and caveats (reproduced from companion spreadsheet)

Methodology. Compiled from open-source web research using Aviation Safety Network, Wikipedia, Press Information Bureau releases, Indian news outlets (The Hindu, The Times of India, Hindustan Times, Indian Express, The Tribune, Deccan Herald, Business Standard, ThePrint, The Week, Outlook), specialist defence publications (Livefist, Bharat Shakti, IDRW, Eurasian Times, StratNews Global), international defence press (Janes, Breaking Defense, The Aviationist, Aerotime), and OSINT verification (BBC Verify, Washington Post) for the contested Operation Sindoor losses.

Cross-verification target. Two or more independent sources per incident. Single-source items are flagged in the 'Verification' column of the register.

Scope. Aircraft crashes and losses; combat losses; ground and base incidents; near-misses, forced landings, bird strikes. Cross-service (Army Aviation, Navy, Coast Guard) ALH/Cheetah incidents that triggered IAF fleet groundings are included with an explicit cross-service note.

Known gaps. (i) 2020 shows only 2 individually verified incidents — aggregate parliamentary counts suggest ~5 IAF hull losses that year; additional losses (likely helicopters/trainers) were not individually verifiable via open-source English-language reporting. (ii) 2022 shows only 1 incident — aggregate reporting cites 5 IAF hull losses for the year. (iii) Court of Inquiry outcomes are rarely made fully public; most rows note 'CoI ordered' without detailed findings. (iv) Squadron/unit attribution is inferred in many cases and not officially confirmed. (v) The Bharat-Rakshak IAF aircraft losses database (bharat-rakshak.com) is the canonical primary source for many minor incidents but was not reachable from the research environment; it likely fills additional gaps.

Operation Sindoor (May 2025) — disputed facts. Indian government acknowledgment: 'at least three' IAF aircraft lost on opening night. Pakistani ISPR claim: six Indian aircraft shot down. OSINT verification (BBC Verify, Washington Post): wreckage identified at Akalia Kalan/Bathinda (Rafale), Wuyan/Pampore (Mirage 2000), and Akhnoor/Ramban sector (MiG-29 or Su-30). India has not publicly named aircraft types, tail numbers, or pilot casualties for Operation Sindoor losses.

Corrections to common misdatings. The Surya Kiran mid-air collision at Yelahanka was 19 February 2019, not 31 May 2019 or 19 October 2018. The HAL Mirage 2000 crash (Abrol/Negi killed) was 1 February 2019, not 28 February or 12 March 2019. The Barmer MiG-21 crash killing Wing Commander Rana and Flight Lieutenant Bal was 28 July 2022, not 24 March 2016. The Jaguar Jamnagar fatal (Air Cmde Chauhan) was 5 June 2018, not 31 January 2018.

— End of appendix —