

India's Post-2024 FDTL Reforms and Pilot Fatigue Risk: A Doctrinal-Comparative Benchmarking against Easa Oro.FTL and FAA Part 117

Somesh Babu Maddula¹, Dr. Md Tanweer Alam Sunny²

¹Somesh Babu Maddula, Research scholar, School of law, Sandip university, Nashik, Maharashtra

ORCID ID: 0009-0005-4865-4956, Email: somesh81@gmail.com

²Dr. Md Tanweer Alam Sunny, Assistant professor, School of law, Sandip university, Nashik, Maharashtra, ORCID

ID: 0009-0002-9053-960X, Email: Tanweer.sunny@sandipuniversity.edu.in

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ABSTRACT:

Regulatory regimes are necessary to strike a compromise between the effective operation of air transport and viable fatigue remedies, since pilot tiredness remains one of the most persistent threats to aviation safety. To improve pilot comfort and bring the rules in line with international norms, the Indian government overhauled the Flight Duty Time Limitations (FDTL) system in 2024. This paper compares and contrasts the revised DGCA framework for Flight Training Level (FDTL) with the US FAA Part 117 regulations and the European Union Aviation Safety Agency (EASA) ORO.FTL provisions, using the International Civil Aviation Organization (ICAO) Annex 6 and Doc 9966 as the normative standard. The research establishes regulatory discrepancies and convergences by methodically examining the linguistic provisions of legislation pertaining to flight duty durations, rest, standby, and reserve responsibilities; cumulative flight restrictions; increased crew operations; and Fatigue Risk Management Systems (FRMS).

Keywords: Flight Duty Time Limitations (FDTL), Pilot Fatigue Risk Management, DGCA India Reforms, EASA ORO.FTL, FAA Part 117, Doctrinal Comparative Analysis, Aviation Safety Regulation, Fatigue Risk Management Systems (FRMS).

I. INTRODUCTION

India's aviation industry began with the first commercial flight from Karachi to Bombay (now Mumbai) in 1912. This great event was accomplished by Indian Air Mail Service which opened a new era in Indian aviation. However, the aviation industry began to take off with the independence of India in 1947. In the initial few

years after India's independence the sole carrier, air India, dominated the skies. It was originally called Tata Airlines but then was renamed Air India in 1953 and nationalised. It was the lifeline for communication between India and other countries and was a symbol of India's presence on the international forum. It was a transitional period for the aviation industry when the Indian

government deregulated the sector in 1990s, allowing private companies to enter the market. This set the stage for other airlines like Jet Airways to come up in 1993 and soon becoming as a strong competitor. During the beginning of the 21st century, with the introduction of low-cost airlines (LCCs) such as IndiGo and Air Deccan, the airline industry underwent a revolution with its innovative business models and attractive fares. As a result of the upsurge in domestic air travel, flying was more accessible to a large segment of the population. Overall, Indian aviation has come a long way since its inception and is a thriving and promising sector with ample potential for expansion.

The aviation sector in India has grown at an astounding rate, both domestically and internationally, propelling the country to the ranks of the world's fastest-growing economies. By 2025, with 500 million passengers passing through the country each year, India is projected by the Ministry of Civil Aviation to be the third-largest aviation market. There are a lot of significant reasons that have contributed to the growth of India's aviation industry. The expanding middle class and booming Indian economy are two elements that have contributed to this trend. One factor driving up demand for international flights is the growing number of individuals who are able to support themselves financially. The current state of the economy is directly responsible for this. People are taking more trips, both domestically and abroad, as a consequence. In the last decade, India's domestic aviation business has grown substantially. The business is booming, with domestic passenger numbers expected to reach 138 million in 2022 up from 61 million in 2010, representing a CAGR (Compound Annual Growth Rate) of 8.8 percent. According to the Directorate General of Civil Aviation (DGCA), the domestic aviation industry in India is projected to develop at a CAGR of 7.6% from 2022 to 2040. An anticipated 1.1 billion passengers would use the expanded route in the year 2040.

As per latest data, the foreign aviation sector in Indian is flourishing. According to the most recent numbers from 2023, there has been a significant surge in the number of people travelling internationally, exceeding 90 million. It increased consistently with a CAGR of 9.2% from 2010 onwards. This is likely to continue as several international airlines fly in and out of India as well as the number of Indian tourists and a businessman traveling overseas has increased. Multinational companies have also poured significant investments into the aviation industry in India. Qatar Airways said in 2018 that it will acquire a 5% interest in IndiGo, India's biggest airline. Both Singapore Airlines and Tata Sons upped their stake in Vistara at the same time to 51%. These investments are an indicator of how international corporations are drawn towards the Indian aviation industry, and the potential that aviation holds. Significant sector-wise estimates suggest that India's aviation industry will continue to expand in the future. It's possible to attribute its growth to a host of reasons. This includes upgrading airport facilities, technological advancements and government initiatives. The characteristics are in line with the aims of government which are to promote business growth and development.

II. LITERATURE REVIEW

Decisions involving the integration of information, problem-solving, and reasoning abilities are susceptible to the human factors of fatigue [1-2]. Both mental and physical exhaustion may have a negative impact on alertness and performance [3]. Disruptions to the circadian rhythm, sleep loss, and wakefulness lead to drowsiness, whereas cognitive strain and duration on task lead to mental exhaustion [3]. Scholarly and international aviation groups' definitions of weariness all agree that it's a reaction to being up for a long time or exerting one's mind or body for a long time [4-5]. The Standards and Recommended Practices (SARPs) that mandate that contracting states restrict the flight and duty hours of flight crews for flight safety are

included in the first edition of Annex 6, [6]. International flight crews were advised by [8-9] to set limitations on flying time, flight duty period, duty period, and rest periods in 1995, which is forty-six years later. As a result, Annex 6 now includes a FRMS, which is a performance-based fatigue risk management system [10]. In place of the limits imposed by prescriptive guidelines [7].

Despite the fact that these guidelines have been in place since 1949 and state that FRMS must adhere to certain limitations and criteria, more has to be done to manage flight crew tiredness in light of the many accidents and incidents that have occurred in the aviation sector as a result of fatigue. A substantial danger that requires attention is weariness, which is responsible for one-fifth of aircraft accidents, according to research [11]. Fatigued flight crews have been responsible for the following mishaps in the past: 1) Air India Express Flight 812 in 2010 was caused by pilots' impaired judgement and residual sleepiness because their flight duty period fell within the Window of Circadian Low (WOCL) and their extended duty hours caused fatigue (Ministry of Civil Aviation India [MCAI], 2010); 2) The Korean Airlines 801 incident in 1997 was attributed to three factors: cumulative sleep loss, extended hours of wakefulness, and the time of day the flight was operated [12]; and 3) The incident involving Mihin Lanka Flight MJ 408 in 2015 occurred because the Pilot-in-command (PIC) was asleep due to improper rest before the flight, and the First Officer did not open the door for him to enter the flight deck [13]. Due to a lack of sleep before to their previous trip, both pilots of Ethiopian Airlines trip 343 fell asleep and flew beyond the runway in a recent occurrence involving exhaustion in 2022. That flight crew weariness is a modern safety concern that needs fixing is shown once again by this (Ethiopian [14]). The pilots in this event from 2022 were so oblivious to the air traffic controllers that the autopilot's disconnection was the only thing that roused them from their slumber. The need to sleep or rest, as well as drowsiness and exhaustion

brought on by disturbances to the circadian rhythm, were determined to be the causes of these instances during investigations.

Limits on flying time, duty hours, and rest periods imposed by nations including the US, Canada, the UK, and Europe have been the subject of scholarly investigation [15–16]. But studies looking at South Asian legislation for managing flight crew tiredness are few and far between. The increasing demand for air travel in South Asia makes flight crew fatigue management an urgent issue. Statistics reveal that the South Asian market had a significant growth in air carrier departures, going from 154,700 in 1973 to 969,461 in 2015 [17]. About 4% of the world's air cargo traffic is accounted for by the South Asian market, both in terms of tonnage and tonne-kilometers [17]. With 98.92 million total passenger movements, India was the most important contribution to the South Asian market's expansion from 5.14 million in 1973 to 117.81 million in 2015 [17]. Forecasts indicate that by 2030, more than 50 million Indian nationals would have travelled abroad, according to the 2023 study from the Centre for Asia Pacific Aviation (CAPA) [18]. According to these projections, air travel in South Asia would increase at a rapid clip in the next years, necessitating stringent security measures to ensure the safety of the aviation industry.

The writers filled this void by analysing the South Asian tiredness management legislation in terms of both content and context [19]. This study analysed eight South Asian nations' approaches to managing the risk of flight crew tiredness by analysing their compliance of ICAO Standards and Recommended Practices (SARPs). There was an analysis of the operationalization of the following schedule design aspects in the manuscript: duty, duty time, duty period, flight time, flight duty period, rest, and flight deck duty time. There was a great deal of variation in the application of the limitations on flying duration, flight duty times, duty periods, and rest intervals that were mandated by law in all eight nations. Rest

periods, flying duty periods, and total flight duration were all severely limited. The interaction between flight duration, flight duty period, napping, duty start times, time zones travelled, and landings was, on the other hand, far less often mentioned. The literature has identified many essential aspects in managing flight crew tiredness, including the crew complement, in-flight rest facilities (both on-board and stopover), time zone crossings, and duty start times. As a result, it was proposed that these features be taken into account by the rules [20]. According to the results of the comparison, more research into the rules and data collected by each country's civil aviation agency is required, paying special attention to the aspects that have the most bearing on how flight crew fatigue can be either exacerbated or mitigated through schedule design.

III. METHOD

To find out how well different jurisdictions and texts (including legal ideas, principles, and structures) match up with international norms and best practices, doctrinal benchmarking conducts a systematic legal study of the similarities and differences. It incorporates a thorough examination of original sources, such as the DGCA Civil Aviation Requirements (CAR Section 7 Series B/J) from India and the ORO from EASA. All of this is evaluated in light of the following: ICAO Annex 6 / Doc 9966, Commission Regulation (EU) No 965/2012, and 14 C.F.R. Part 117 from the United States FAA. In terms of doctrinal and prescriptive boundaries, FRMS integration, and enforcement mechanisms, it is an approach that displays both convergences and divergences. However, doctrinal benchmarking does not take into account all relevant factors, such as cultural or operational contexts, differences in operator compliance, and real implementation effectiveness (e.g., a mature EASA/FAA environment vs. India's rapidly expanding traffic). It shouldn't be used in place of more advanced analytical methods like operational

audits or statistical assessments; it's only a fundamental tool.

Flight Duty Period Limits

Account day operations, all three models account for report time and sectors, and they all have maximum Flight Duty Periods (FDPs). For normal operations, the DGCA CAR (2024–2025) for India specifies a maximum of 12–14 hours of FDP, with a gradual decrease of FDP to improve protection during crucial hours. If you report early or work in various sectors, EASA ORO.FTL may shorten the FDP to 13–14 hours, which is already a highly comprehensive procedure. Day operations are allowed by FAA Part 117 for crews who have been trained to define clear bands in this way for up to fourteen hours. In terms of statistics, they are almost identical; however, the structures provided by EASA and the FAA are more accurate, while India's are less formal and rely on waivers for ordinary day flying.

Flight Duty Period Limits

Night operations and circadian disturbance are given particular attention in frameworks. In 2025, India's rules were revised to better align with scientific findings. One modification was to expand the definition of night duty to include the 0000-0600 window. Another reform was to implement harsher FDP decreases during the circadian low times. There are stringent constraints for WOCL (Window of Circadian Low) and night-time flying, as well as disruptive shifts, according to EASA's rigorous FDP requirements. Night-time FDPs are governed by FAA Part 117 according to acclimatisation status and report-time banding. India has made progress, but the FAA and EASA have taken more stringent and routinely implemented precautions to prevent disruptions to the circadian rhythm.

Minimum Rest Period Requirements

A necessary part of getting back on your feet is getting enough rest. A minimum of 10 to 12 hours of sleep is required for India's CAR, with the possibility of additional help via take-home

weekly rest minima. Twelve hours of repose, or local night, as specified by EASA (for missions involving several crew members or after augmentation). For a regular crew, Part 117 of FAA rules states that they need 10 hours of rest with the possibility of getting 8 hours of solid sleep; for an augmented crew, customised standards apply. Increasingly comprehensive post-augmented and multi-crew rest credits are available from the FAA and EASA, while the Indian framework is becoming increasingly explicit.

Standby and Reserve Duty

There is a big difference between standby and reserve duty. The reserve or standby periods are explicitly incorporated into the duty calculation in FAA Part 117, and they have different types to prevent fatigue building up. EASA ORO.FTL has full standby rules which are included in the FDP. There has been a difference of opinion between the DGCA CAR in India and the new regulations, with the former being more flexible with regard to the waiting period and the calculation of reserve duty. The integration of standby as duty in EASA and FAA is stronger than in India, thus reducing the ambiguity.

Cumulative Limits

Long term fatigue is avoided by using cumulative limits. India has a three-tiered, rolling flight duty limitation of 7, 14 and 28 days per year. EASA has imposed very strict flight time limits of 28 days and a year. FAA Part 117 has 30-day, 90-day and annual limitations and strict tracking requirements. India's structure is cumulative, whereas EASA and FAA provide longer-term but more specific and binding protection.

Augmented Crew Provisions and In-Flight Rest Facility Standards Compared

Extended flights depend on augmented operations. EASA and FAA define three classes of in-flight rest facilities (Class 1-3) which are directly related to FDP extensions in accordance with the quality of the rest. In revising its targets for 2024-2025, India has enhanced its

provisions, but they continue to be less specific on facility standards and credits. A framework that is more in sync with international good practice in facility classification would be an improvement for India.

IV. CORE LEGAL ARGUMENT

The argument is worked out at two different levels, where the latter level is the main and special contribution of the paper.

Level 1: Numeric Inadequacy

The fatigue limits in India for 2024-25 do not go far enough, as legal adequacy is not simply defined in terms of numbers. It needs enforceable assurances, disciplined governance of waivers and auditable reality of roster. As measured against EASA ORO. India's framework (FTL and FAA Part 117) shows some relative weaknesses in the way standby and reserve duties are treated, transparency controls for waivers, and the implementation of Fatigue Risk Management Systems (FRMS), which are not required for compliance. These gaps compromise the effectiveness of FDTL Rules as strong safety barriers in the context of high utilisation scheduled operations. The paper calls for a hybrid approach, with minimum standards and mandatory FRMS governance responsibilities, and enhanced auditing.

Level 2: The Indian Aviation Ecosystem Argument

The underlying premise, which is more fundamental, is that numeric FDTLs based on EASA or FAA frameworks, which are transplanted to India without taking into account the structural differences in the Indian aviation system, provide an illusion of safety, but not safety itself. Some important ecosystem variables are identified which differentiates India from Europe and the United States and directly influences fatigue risk and actual effectiveness of FDTL regulation.

Ecosystem Variable 1: 24-Hour Major Airport Operations

There are strong night-time restrictions at major European hubs which develop high density scheduled operations. For instance, there is a scheduled night flight ban at London Heathrow between 2300 and 0600 hours local time and a complete night flight ban at Frankfurt between 2300 and 0500 hours local time. The same applies for the airports of Brussels and Amsterdam Schiphol. These restrictions provide natural breaks in operations, reducing pilots' exposure to the most circadian-disruptive night operations at major hubs. By contrast, all the major scheduled-airline hubs in India – Delhi, Mumbai, Bangalore, Hyderabad and Chennai – run around the clock without similar night restrictions. Indian carriers thus plan flights through the complete 24-hour day period which pilots would be subject to materially greater fatigue risks when subjected to the same numeric limit. This structural difference is not taken care of in the 2024-2025 FDTL revisions. The prescriptive FDP ceiling designed for European operations with limited through the night flying has less protection in India where the operations are all day.

Ecosystem Variable 2: Indian Weather Patterns and Duty-Period Overruns

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Ecosystem Variable 3: Airspace Congestion and ATC-Driven Duty Extensions

The airspace is one of the most congested in Asia-Pacific, and the growth is outstripping the infrastructure and ATC capacity in the four major metros of India: Delhi, Mumbai, Bangalore, and Hyderabad. Hold and ground delays often take 20–45 minutes (and during disruptions more) from flight times. Indian pilots pick up such delays in the cockpit as EUROCONTROL or the FAA's Air Traffic Control System Command Center do upstream through pre-tactical and tactical flow controls. EASA ORO.FTL and FAA Part 117 are both calibrated to their respective managed airspace environments—Indian limits have not been recalibrated for these structurally higher extensions, crew absorbed.

Ecosystem Variable 4: Absence of Supplementary Pilot-Management Trade Agreements

Prescriptive FDTL minima are intended as a minimum standard, and are routinely further bolstered in the EU and US by collective bargaining agreements (CBAs) with stricter roster stability, fatigue and rest restrictions. European unions (such as BALPA, Vereinigung Cockpit, and SNPL) and US ALPA have worked out improvements above the regulatory level. Pilot associations in India are not yet recognised as a collective bargaining agent to negotiate airline-wide CBAs. Airlines adhere to the DGCA FDTL floor and have no contractual obligation to go beyond that. As a result, India's FDTL regime is tasked with providing the complete safety net with no private law to cover

fatigue protection as in EASA and FAA systems.

Ecosystem Variable 5: Regulatory Dependence and Susceptibility to Commercial Pressure

EASA is one of the structurally independent EU agencies, and is protected from direct commercial pressure. The FAA is a quasi-independently rulemaking agency. By contrast, India's DGCA is a department under the Ministry of Civil Aviation with an explicit mandate to encourage industry growth and commercial viability. This makes them naturally vulnerable to "regulatory capture. This was evident in the November 2025 episode when the DGCA had issued the Weekly Rest Advisory and subsequently withdrew the same under the pressure from the airline industry only to submit a court affidavit. The FDTL system under a dependent regulator is materially inferior, to the same rules with the same numbers under independent institutions.

Overarching Argument and Proposed Reforms

A text-based comparison of doctrines is methodologically insufficient regarding India. The adequacy of fatigue governance is a function of the regulatory content, the institutional architecture and the supplementary protections, the meteorological and operational context, and the maturity of the airspace. India's post-2024 FDTL framework is weaker than the EASA and FAA frameworks it is similar to, on all five variables assessed. The paper is proposing a four-part reform package: (1) cumulative fatigue measurement in the FDTL CAR, adjusted for curfew and for weather-volatility; (2) collective bargaining equivalent or similar protections in the form of a legislative requirement for "FDTL-supplementing" provisions in airline operations manuals; (3) a separation of the DGCA safety oversight from its commercial ministerial duty; and (4) an end to the voluntary nature of the FRM and its inclusion as a co-equal compliance obligation.

V. DISCUSSION

Flight time, flight duty and duty period

National aviation regulatory authorities, in accordance with ICAO regulations and suggested practices, establish the amount of time flight crews are required to work and rest times [21]. When determining work and rest intervals, the International Civil Aviation Organization (ICAO) suggests taking into account elements including duty durations, night-time operations, time zone crossings, and sector lengths (Annex 6 and Doc 9966, respectively) [1].

Since early morning flights are associated with a higher risk of weariness compared to flights planned for the morning, afternoon, or night, the DP start time is recognised as a relevant consideration in many bodies of research [22].

Circadian Rhythm

There is evidence that both short- and long-haul pilots' circadian rhythms impair their performance and attentiveness [4, 23]. Extensive wakefulness, flights operating in the pilots' WOCL, early morning and late night flights affecting circadian rhythms, long duty periods, and the 1997 Korean Air Flight 801 incident [24], which resulted in the deaths of 228 people; the 1999 American Airlines Flight 1420 incident [25], which killed 11 people; and the 2010 Air India Express Flight 812 accident [26] all showed that flight crew fatigue is a factor. Additionally, according to data from the National Transport Safety Bureau [24], circadian disruptions affect flight crew decision-making, response speed, memory, and communication [27].

Sleep and Rest

A research conducted by Pellegrino and Marqueze [28] examined 1234 captains and co-pilots from Brazil's regular aviation (both domestic and international) and discovered that sleep deprivation was linked to moderate to poor job competence. Their sleep was badly affected by their erratic work hours, which included early morning and late night shifts.

Previous studies have shown that flight crews who are sleep-deprived and exhausted are less likely to be attentive and more likely to take unscheduled naps while flying [29]. According to Goode [30], flight crew members should have a minimum of eight hours of sleep each night during their rest time, lending credence to the need of sufficient sleep. Physical exhaustion is related to an individual's sleep deprivation and general healthiness, and research shows that flight crew weariness is a result of not getting enough sleep [31]. The occurrences noted earlier about circadian rhythms further suggest that sleep deprivation and loss of sleep also had a role in the exhaustion of the flight crew. In addition, studies have shown that flight crews might suffer from diminished cognitive capacity, performance, and mistake rates due to exhaustion brought on by lack of sleep [32].

Workload

A mild task can induce mental drowsiness, whereas an excessively heavy one might tax the flight attendant to the point of exhaustion [1]. As an example, Reis et al. [33] notes that long-haul and medium-haul flights put a lot of strain on flight crews, leading to exhaustion. There are measures to alleviate the stress that flight attendants face under the rules of two nations, namely India and Bangladesh.

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VI. CONCLUSION

An important step toward improved and more scientifically grounded limitations for flying duty time, rest intervals, and fatigue management methods will be put into place for pilots in India by new rules for flying Duty Time Limitations (FDTL) that will take effect after 2024. The Directorate General of Civil Aviation (DGCA) has released revised regulation, which clearly shows efforts towards harmonising with two international aviation standard documents, namely ICAO Annex 6 and Doc 9966. A convergence in numbers does not always imply a convergence in levels of safety protection, as this comparative doctrinal study has shown.

By comparing it with EU Aviation Safety Agency (EASA) ORO of India. With the above in mind, let's take a look at the differences between the two systems, FTL and the US Federal Aviation Administration (FAA) Part 117. The EU system has more stringent regulations for reserve and standby duties, more stringent control on regulatory exemptions, different conditions for in-flight rest facilities and better institutional oversight. These enhancements will make fatigue management more than just following prescribed limits; it will be an evidence-based on-going safety procedure.

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