ISSN 1648-7788 / eISSN 1822-4180

VILNIUS TECH Vilnius Gediminas Technical University

AVIATION

2026
Volume 30
Issue 2
Pages 181–188
https://doi.org/10.3846/aviation.2026.26879

Review Article

LEARNING FROM HEALTHCARE: A PERSPECTIVE REVIEW ON INCORPORATING SOFT CONSTRAINTS INTO AVIATION MAINTENANCE SCHEDULING

Yeojin KIL [1], Solomon O. OBADIMU [2], Kyriakos I. KOUROUSIS [2]✉, Anna V. CHATZI [1]

[1]*Faculty of Education and Health Sciences, University of Limerick, Limerick, Ireland*
[2]*School of Engineering, Faculty of Science and Engineering, University of Limerick, Limerick, Ireland*

Article History:
- received 2 February 2026
- accepted 23 March 2026

Abstract. A key consideration in effective aviation maintenance scheduling is the satisfaction of maintenance personnel in relation to allocating tasks and work scheduling. Research that reflects the satisfaction of aviation maintenance staff is limited. Studies focusing on soft constraints in aviation maintenance are nearly non-existent. Soft constraints encompass flexible factors such as employee preferences, workload distribution, and work environment, which significantly impact employee satisfaction and job performance. Aircraft maintenance optimisation needs to consider both hard and soft constraints. Soft constraints have been extensively studied in healthcare and, as this perspective review argues, this can provide valuable insights for aviation maintenance scheduling management. Specifically, aviation maintenance requirements, such as task-based scheduling, necessitate the development of tailored tools to efficiently accommodate the sector's particularities. This perspective review of aviation maintenance scheduling literature was focused on identifying gaps in the consideration of soft constraints. While there are some studies on incorporating soft constraints into an effective fatigue management system, there is a paucity of research in this area in aviation maintenance. Conversely, the reviewed literature reveals that hard constraints have received greater attention in modelling. This perspective review proposes the development of designated soft constraints to measure the satisfaction of aviation maintenance personnel.

Keywords: aviation maintenance, shift scheduling, soft constraints, staff satisfaction.

✉Corresponding author. E-mail: *kyriakos.kourousis@ul.ie*

1. Aviation maintenance overview

Maintenance of aircraft and aeronautical products is required to ensure airworthiness and operational and technical safety (Niu et al., 2023). According to the International Air Transport Association (2024), while the overall number of accidents has historically decreased, fatal accidents continue to occur, even with highly reliable equipment, including the redundant systems that aircraft are designed with (Obadimu et al., 2020). Therefore, aviation maintenance plays an important role in proactively preventing accidents, as well as ensuring the punctuality of aircraft for airline flight schedules (Xue et al., 2022). Aviation maintenance operates under strict safety regulations, requiring highly skilled technical staff and specialised equipment (Yan et al., 2004). However, airlines face significant challenges related to costs and scheduling of aviation maintenance, which can impact the overall efficiency in operational and technical operations (Shaukat et al., 2020). The cost of aircraft maintenance constitutes a substantial proportion of the expenses associated with aircraft operations (Niu et al., 2023; Shaukat et al., 2020). Subsequently, given the low profit margin of commercial air transport business, airlines have explored methods to ensure the quality of aircraft maintenance while minimising maintenance costs to achieve economic benefits (Shaukat et al., 2020; Xue et al., 2022).

Line maintenance includes relatively simple but essential tasks that are routinely performed on the aircraft (Shaukat et al., 2020), including the examination of critical components such as the landing gear, engines, and control surfaces (Sriram & Haghani, 2003). These tasks ensure that minor maintenance needs are addressed before the scheduled flight (Shaukat et al., 2020) and are typically completed within a short time before departure and/or after arrival (Yan et al., 2004). Base maintenance, on the other hand, compromises of more complex and time-consuming tasks, as dictated by a more comprehensive maintenance schedule.

Maintenance operators schedule aircraft inspections according to flight cycles or flight hours (Albakkoush et al., 2020). However, substantial costs emanating from subsequent aircraft maintenance are incurred due to aircraft downtime, the need for skilled labour, and the consumption of materials and spare parts (Shaukat et al., 2020). Additionally, when unexpected situations occur, such as aircraft component failures, they necessitate unscheduled maintenance, with increased costs, (Albakkoush et al., 2020) and flight delays (Sachon & Paté-Cornell, 2000). This highlights the critical importance of timely and efficient maintenance. Therefore, optimising maintenance scheduling is crucial for ensuring operational efficiency while maintaining high safety standards. However, the challenge in aviation maintenance manpower lies in the use of complex maintenance checklists and work cards, and inaccurate estimates of the number of technicians needed (Albakkoush et al., 2020).

Although previous studies have primarily focused on strategies to improve the efficiency of maintenance manpower scheduling through mathematical programming models (Niu et al., 2023; Shaukat et al., 2020; Yan et al., 2004), there has been little focus on how technicians are satisfied with the scheduling system.

2. Aircraft maintenance optimisation

The potential application of mathematical models to optimise aircraft maintenance activities has been in a constant state of triage since the early 1980s. Interestingly, Grant (1986) was one of the first to discuss the idea of employing artificial intelligence (AI) models in aircraft maintenance optimisation. Grant discussed the potential combination of AI with computer-aided maintenance management. The researcher noted that "*an AI-based CMMS will no longer be limited to numeric data, but will be able to represent knowledge gained from experience. In particular, it will be able to give expert advice and justify its reasoning*."

Interestingly, over 30 years later, what had once seemed like a concept has finally come to fruition and become a prevalent topic of further study and research. Weide et al. (2022) investigated the impact of scheduling on base maintenance, highlighting that airlines rely heavily on manual scheduling and frequent revisions. To address this challenge, they proposed a genetic algorithm (GA) model, which streamlines airline operations and minimises costs. Following validation via case studies, they have found that the GA model was capable to reduce base maintenance checks by 7% and increase aircraft utilisation by 4.4%. A previous study by Deng et al. (2021) proposed a novel decision support system (DSS) to address challenges associated with aircraft maintenance check schedules and task allocation per aircraft. The DSS combines scheduling, task allocation, and shift planning into a unified framework to address the complexities arising from reliance on maintenance planners' experiences. Following collaboration with a major European airline to validate the application of the novel system, it was found that the DSS can deliver a three-year optimised maintenance plan within thirty minutes, saving airlines in maintenance costs and improving aircraft utilisation.

Unlike the studies highlighted above with a robust planning and decision-making framework across fleet or time scale, the work of Pimapunsri et al. (2021), instead, focused on the operational-level scheduling of maintenance tasks during heavy maintenance using algorithmic task sequencing and resource allocation strategies. It was found that the former and the latter will efficiently allocate limited resources, including facilities, labour and tools, while addressing the complexities associated with maintenance planning. Vianna and Yoneyama (2018) focused their research on predictive maintenance optimisation for aircraft systems. Their work emphasises the high availability expectations of aircraft systems, especially between flights, with a focus on redundant systems. Hence, they proposed a multiple model (MM) approach using the Extended Kalman Filter (EKF) for prognostics, integrated with an optimisation algorithm to address challenges associated with:

- The integration of prognostics and health management (PHM) techniques with maintenance decision-making to ensure the combination of PHM results with the operational aspects of an airline.
- The optimisation of maintenance strategies to minimise operational costs associated with flight delays, flight cancellations and other costs driven by component failures.
- The development of a prognostic method for systems with multiple wear profiles by implementing MMs.
- Developing a model to identify degrading aircraft components under varying operational intervals and conditions.

Vianna and Yoneyama (2018) validated the model's effectiveness through a case study using hydraulic pump leakage data, which showed reduced costs and improved maintenance planning. Overall, they found the model to:

- Optimise maintenance activities by minimising overall operational costs while satisfying airline operational and resource constraints.
- Identify wear profiles, including linear, stationary, and polynomial trends, using a MM approach integrated with the EKF.
- Estimate degradation and remaining useful life (RUL) of aircraft components, accounting for varying wear dynamics and uncertainty.

Furthermore, Memarzadeh et al. (2024) attempted to address airline operational cost challenges, particularly coping with unforeseen flight disruptions and their associated uncertainties. As a result, they proposed a two-stage scenario-based robust optimisation (TSRO) model applied to the integrated Aircraft Maintenance Routing and Crew Rostering (AMRCR) problem. The model incorporates both initial resource assignments and adjustable decisions for dealing with disruptions, optimising operational costs while adhering to various constraints, rules and regulations. Additionally, the model considers multiple scenarios, including flights per week, delay time, cancelled flights, and profit under disruption to ensure that each aircraft is maintained within its specified timeframe, affirming significant improvements over conventional methods. They found that while the TSRO model showed robust performance for small-scale problems, its computational efficiency is limited for large-scale instances when compared to the Column Row Generation (CRG) method – another method proposed by Memarzadeh et al. (2024) for a more robust aircraft maintenance optimisation programme, including solving the AMRCR problems. It is also noted that De Bruecker et al. (2014) have previously proposed a similarly robust model called the two-phase Tabu Search method for the optimisation of large-scale and complex aircraft maintenance activities.

3. Aircraft maintenance workforce scheduling

A study published by the United Kingdom (UK) Civil Aviation Authority (CAA) (Civil Aviation Authority, 2003) noted the impact of shift work on maintenance personnel following a detailed questionnaire-based research. This research study focused on understanding the correlation between fatigue and productivity. They highlighted that the start and end times of a shift can affect productivity and elevate fatigue. Hence, implementing time limits per shift, including not starting morning shifts too early – before 06:00 a.m. – and finishing night shifts by 08:00 a.m., will significantly reduce fatigue-induced maintenance errors. Additionally, the report published by CAA highlighted the importance of educational programmes to create awareness about potential problems associated with working shifts. They also noted the importance of maintenance personnel's input in shift planning and giving at least 28 days' advance notice of their work schedule. Interestingly, building on the same premise as the CAA report (Civil Aviation Authority, 2003), a report published by the United States (US) Federal Aviation Administration (Hobbs et al., 2011) employed a different approach to studying how fatigue affects productivity. Instead of the survey-based approach, the FAA report focused on analysing existing policies and best practices, drawing from, among others, interviews and case studies. They noted that organising maintenance tasks according to an individual's fatigue level will reduce the overall impact of fatigue on productivity, especially during detailed inspections, including structurally significant aircraft components. Overall, the FAA report (Hobbs et al., 2011) noted that maintenance planners and scheduling personnel are at the core of influencing fatigue management strategies when planning for upcoming maintenance tasks, as their planning decisions could either exacerbate or minimise the impact of fatigue on productivity.

In an attempt to address the aforementioned fatigue concerns in the aviation industry, Santos and Melicio (2019) acknowledged the fact that recent technological advancements will facilitate a more data-driven approach to studying maintenance personnel's exposure to stress and fatigue, noting a potential increase in safety margin when providing aircraft maintenance services. Yielding to this, Yildiz et al. (2017) proposed a revised Three Process Model of Alertness for the crew pairing problem. Following testing and validation, the model was found to reduce fatigue significantly with a relatively small increase in cost. Yildiz et al. (2017) argue that directly modelling fatigue can be more cost-effective than current industry rules and regulations. Interestingly, Dawson et al. (2011) argue otherwise. They reviewed and assessed existing bio-mathematical models of fatigue (BMMF), with a focus on their efficacy in predicting personnel fatigue. They concluded that while fatigue models can be valuable tools for risk management, they should be employed as an element or component within a comprehensive fatigue risk management system, instead of being used as a stand-alone tool.

Furthermore, Wang and Liu (2014) focused on reducing the fatigue state within aircraft maintenance personnel, modelling fatigue as a dynamic system and employing a mixed-integer programming approach. Wang and Liu (2014) proposed a biomathematical fatigue model, focusing on creating shifts that reduce fatigue among maintenance personnel while considering their preferences and relevant government or company regulations, among others. Following validation of the scheduling model, the researchers showed that the proposed model can enhance the overall well-being of shift workers and organisational performance without compromising operational requirements. Similarly, De Bruecker et al. (2014), who introduced a two-phase Tabu Search approach, confirmed the efficacy of mathematical models in tackling challenges associated with aircraft maintenance workforce scheduling, whilst still being cost-effective and compliant with relevant regulations.

4. Hard and soft constraints in scheduling

Shift work scheduling involves constraints, including organisational policies, rules and practices, and staff preferences, such as fair shift distribution (Rahimian et al., 2017). When creating a roster, factors such as legal regulations, organisational policies, personnel data, and individual preferences must be considered (Abdennadher & Schlenker, 1999). These constraints are categorised into hard and soft constraints depending on the inherent characteristics of the problem (Rahimian et al., 2017). Hard constraints are non-negotiable and must be strictly satisfied to ensure regulatory compliance and operational feasibility (Abdullah et al., 2025; Rahimian et al., 2017). These constraints are enforced by external factors such as legal requirements, industry regulations, or organisational policies (Abdullah et al., 2025). For example, work-hour limits, staffing levels, and mandatory rest periods, are hard constraints that must be fulfilled to avoid legal or operational issues. On the other hand, soft constraints are flexible and can be adapted (Abdullah et al., 2025). These constraints reflect organisational preferences and workforce considerations (Abdennadher & Schlenker, 1999; Abdullah et al., 2025), such as employee preferences, fair distribution of shifts, or balanced workload, which contribute to the overall quality of the roster (Solos et al., 2013).

Table 1. Hard and soft constraints (Abdullah et al., 2025; Dawson et al., 2011; Laesanklang et al., 2015; Memarzadeh et al., 2024; Rahimian et al., 2017; Shaukat, 2015; Wang & Liu, 2014; Yildiz et al., 2017)

Type of Constraints	Category	Description
Hard Constraints	Maximum working hours/shifts	▪ No more than 48 hours per week ▪ Maximum 12-hour shift duration ▪ At most one shift per 24-hour period ▪ Weekly quota restrictions ▪ Minimum/maximum break, maximum time away ▪ Maximum flight legs/time per crew
	No overlapping shifts	▪ Single shift assignment per day ▪ Scheduled maintenance per week ▪ Clear separation between consecutive shifts ▪ No concurrent duty assignments
	Minimum rest periods	▪ No concurrent duty assignments ▪ 16 hours minimum between shifts ▪ 24 hours after night shifts ▪ Extended rest after consecutive night shifts
	Physician qualifications	▪ Specialty-specific assignments ▪ Experience level requirements ▪ Training/skills/qualification/certification compliance
	Labour law and regulatory compliance	▪ National working time directives ▪ Local regulations ▪ Manpower/resource requirements ▪ Cannot extend deadlines without approval ▪ Maximum daily aircraft utilisation
Soft Constraints	Workload balance	▪ Equal distribution of shifts ▪ Fair allocation of night/weekend duties ▪ Balanced overtime assignments ▪ Flexible deadlines
	Employee preferences	▪ Preferred shifts/days off ▪ Region/location preferences ▪ Vacation requests
	Fair shift distribution	▪ Equitable weekend assignments ▪ Balanced holiday coverage ▪ Even distribution of unpopular shifts
	Operational continuity	▪ Minimised handoffs ▪ Consistent employee assignments ▪ Flexible operational adjustments ▪ Cancel/reschedule flexibility for disruptions

Similarly to the work of Abdullah et al. (2025) and Rahimian et al. (2017), Shaukat (2015) has previously identified two distinct categories of constraints in aviation maintenance: soft and hard constraints. According to Shaukat (2015), hard constraints in aviation maintenance include, among others, processing times, flight scheduling and scheduling conditions. However, any changes to those mentioned above, although possible, must go through official channels. In contrast, soft constraints are more flexible in terms of prioritisation and execution. Wang and Liu (2014) shared a similar view by naming company or government regulations and labour requirements as the non-negotiables of hard constraints, while soft constraints depend on workers' preferences, according to the authors. Interestingly, Laesanklang et al. (2015) categorised hard constraints as skill and qualification, travel time feasibility, and working hours limit, among others. While job assignments, worker availability and working region preferences were categorised as soft constraints. Although not explicitly categorised as hard and soft constraints by the researchers, Dawson et al. (2011) noted the importance of a combination of flexibility (soft) and regulatory (hard) constraints in an effective fatigue management system. Flexibility involves employees negotiating acceptable rosters or schedules rather than following rigid rules. Regulatory constraints, on the other hand, require the acceptance of fatigue modelling as part of aviation safety regulations. Yildiz et al. (2017) and Memarzadeh et al. (2024) share a similar view, noting that focusing only on hard constraints when modelling fatigue is insufficient; thus, they recommend integrated modelling of both hard and soft constraints. The hard and soft constraints identified above are summarised in Table 1.

5. Discussion

5.1. Importance of hard/soft constraints

Despite the important role of shift work scheduling in aviation maintenance, it evident from the literature reviewed that research on the application of hard and soft constraints remains limited and scarce. Most studies have been focused on developing mathematical models to support effective workforce planning in airlines as evidenced in the previous sections and also stressed by Niu et al. (2023) and Xue et al. (2022), however, there is paucity of research that explicitly address the distinction between hard and soft constraints in the aviation maintenance industry. This gap highlights the need for further research, considering the strict regulatory environment of the industry (Yan et al., 2004). Since both aviation maintenance and healthcare are highly regulated safety-critical industries, healthcare scheduling strategies offer valuable insights for addressing challenges in aviation maintenance that are of a similar nature (Abdullah et al., 2025). A useful point of reference for further understanding scheduling constraints can be found in healthcare, where hard and soft constraints have been widely explored. The hard and soft constraints from the perspective of physician shift scheduling have been presented in Abdullah et al.'s (2025) study.

The hard and soft constraints from both aviation and healthcare are presented in Table 1. These constraints are not unique to healthcare and also appear to be similar for aviation maintenance scheduling. For example, in aviation maintenance, hard constraints include regulatory requirements, such as mandatory rest periods between shifts to comply with safety regulations and task allocation based on technicians' license/authorisation requirements. On the other hand, soft constraints can include factors such as fair shift distribution, technicians' shift preferences, and workload balance, all of which contribute to improving technicians' satisfaction.

Incorporating soft constraints in shift work scheduling is important for ensuring the quality of a roster. In healthcare, low-quality rosters that violate soft constraints, such as unbalanced workloads or excessive stress on staff, can lead to suboptimal performance and negatively impact patient care (Bruni & Detti, 2014).

5.2. The need to explore soft constraints in aviation maintenance

While some researchers have stressed the need to incorporate both soft and hard constraints in an effective fatigue management system, studies focused on these constraints in aviation are very limited, with more studies on hard and soft constraints conducted in healthcare, particularly with physicians and nurses (Abdullah et al., 2025; Uhde et al., 2020). However, findings from healthcare are not directly applicable to aviation maintenance owing to the difference in operational demands between the two fields. In healthcare, shift work is often patient-care oriented, focusing on continuity of care and individual workload balance (Ryan, 2022). In contrast, aviation maintenance scheduling is task-based, with strict turnaround times, variety of work locations (outdoors/indoors), and operational constraints driven by airline flight schedules (Niu et al., 2023; Sriram & Haghani, 2003). These differences, along with the limited research on soft constraints in aviation maintenance, highlight the need for aviation-specific research on soft constraints in scheduling.

Due to the scarcity of studies on soft constraints in aviation maintenance, the authors of the present work have turned to the healthcare sector as a point of reference. Although the organisational context differs, healthcare has extensively studied shift work scheduling that incorporates staff satisfaction (Peters et al., 2009). Therefore, it will serve as a useful starting point for conceptualising and evaluating soft constraints in scheduling.

Irregular working hours are integral part of shift work, as part of the unwanted/unpopular shifts (night/weekend/public holidays). This element of shift work is included in the soft constraints of scheduling, as per Table 1. Additionally, one study used interviews to examine healthcare workers' satisfaction with shift scheduling systems, specifically in terms of fairness (Uhde et al., 2020). Fairness is again an important element in scheduling (see Table 1) (Abdullah et al., 2025).

Looking closely at the reviewed literature, it is evident that different elements of soft constraints of scheduling are present in shift workers' satisfaction and feedback projects (also illustrated in Table 1). Therefore, a wholistic approach in the search of feedback/satisfaction (explicit for specialised shiftwork) would dictate the identification and measurement of the totality of the soft constraints in scheduling. As the present paper is focused on aviation maintenance, identifying and shaping the relevant soft constraints in scheduling is the designated starting point, to enable further research in their measurement and analysis.

Healthcare and aviation maintenance have many high-level commonalities as they are both highly regulated, intense and complex industries (Kil et al., 2024). However, the low-level elements of the two industries (such as the subject matter, physical environment, constant change of requirements etc.) differ. For this reason, the soft constraints in aviation maintenance scheduling, can use the ones proposed within the healthcare research as basis for adaptation, to accurately reflect the aviation maintenance particularities and requirements.

In particular, aviation maintenance is more task-oriented work environment. Therefore, staff preferences should be sought on their allocation to tasks and their team-members, and whether they are required to work outdoors/indoors while exposed to the elements (and for how long), as these are key elements of soft constraints in scheduling. Another important soft constraint category is the fair workload allocation within shifts. Satisfaction on fair allocation of tasks within weekday and less desired/unpopular shifts (night/weekend/public holidays) should be explored. Furthermore, aviation maintenance staff are required to work in small/simple and more extensive/complex tasks (both in time and effort) and to move between different locations (on the same aircraft or across different aircraft). Considering these particularities, maintenance staff should be able to indicate the satisfaction on whether their scheduling provides opportunities for efficient task

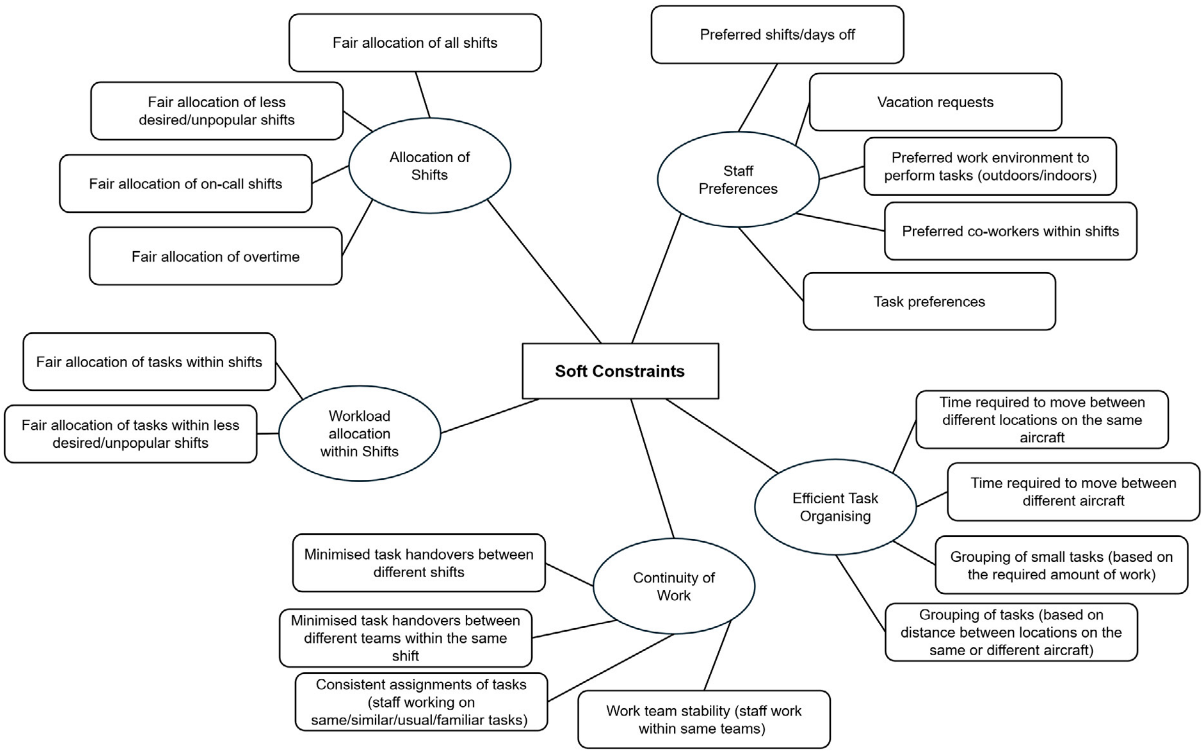

Figure 1. Soft constraints in aviation maintenance scheduling

organising. Also, the continuity of work, as it is again related to the aviation maintenance tasks, is an important soft constraint category. In this category, staff satisfaction needs to be established on tasks stretching over multiple shifts, amount of handover of tasks, assignment of tasks (staff working on same/similar/usual/familiar tasks), and work team stability (staff work within same teams). The totality of all discussed soft constraints is summarised in a thematic network by applying the methodology proposed by Attride-Stirling (2001). In particular, as shown Figure 1, soft constraints form the thematic network's central global theme, and we derive the basic themes that correspond to the five organising themes (allocation of shirts, staff preferences, workload allocation within shifts, efficient task organising and continuity of work).

6. Conclusions

6.1. Key findings

This perspective review establishes that, while modelling hard constraints in aviation maintenance scheduling is relatively mature, the explicit definition, measurement, and operationalisation of soft constraints remain largely unaddressed. Drawing insights from healthcare, another regulated, safety-critical domain where soft constraints have been more extensively studied, it should be emphasized that aviation-specific soft constraints must be identified, adapted, and embedded into aviation maintenance scheduling. This will improve staff satisfaction, reduce fatigue risks, and ultimately enhance safety and operational performance.

6.2. Novelty and contribution

Based on our review of the literature, constraints were identified and tailored for aviation maintenance, structured into five primary themes: allocation of shifts, staff preferences, workload allocation within shifts, efficient task organising, and continuity of work. Thus, pathway was set out for the framework that can capture soft constraints directly applicable to aviation maintenance staff.

6.3. Practical implications for aviation maintenance

Soft constraints can be embedded directly into software-based scheduling tools used to allocate aviation maintenance staff to shifts and tasks. Each soft constraint may be converted to measurable inputs for this tool, such as perceived fairness or unpopular shifts, handover burden, and exposure to outdoor work, and display them alongside hard constraints in the scheduling interface. These inputs can also be represented as weights in the scheduling logic so that the software-based scheduling tool can balance, and effectively, optimise cost, workforce utilisation, compliance with working-time company rules, fatigue risk, and maintenance staff satisfaction.

6.4. Future work

The gap identified by this perspective review highlights the necessity of a tailored instrument to provide empirical insights into how scheduling decisions impact aviation maintenance technicians. Such an instrument is essential to understand and measure how soft constraints impact the satisfaction of aviation maintenance technicians. The instrument can take the form of a mix-methods questionnaire, that will enable qualitative and quantitative analysis of surveyed aviation maintenance staff. A research project is currently being undertaken by the authors of the present paper and other collaborators, to devise the requirements for such a questionnaire instrument and following on to test its suitability for use within the aviation maintenance sector. Consequently, this work will culminate in a validated questionnaire instrument.

Funding

This work was supported financially by QOCO Systems Ltd.

Author contributions

AVC and KIK conceptualised the study. YK, SOO and AVC were responsible for the methodology. YK, SOO and AVC performed the data curation and formal analysis. YK, SOO, AVC and KIK performed the investigation and validation, and obtained the resources. AVC and KIK performed the visualisation. YK, SOO and AVC wrote the original draft. YK, SOO, AVC and KIK reviewed and edited the draft. AVC and KIK acquired funding for the study, administered and supervised the project.

Disclosure statement

The authors do not have any competing financial, professional or personal interests to declare.

References

Abdennadher, S., & Schlenker, H. (1999). Nurse scheduling using constraint logic programming. In *Proceedings of the sixteenth national conference on Artificial intelligence and the eleventh Innovative applications of artificial intelligence conference innovative applications of artificial intelligence* (pp. 1–6), Orlando, Florida, USA. AAAI.

Abdullah, N., Ayob, M., Lam, M. C., Sabar, N. R., Kendall, G., & Razali, M. K. M. (2025). Optimization techniques for physician scheduling problem: A systematic review of recent advancements and future directions. *IEEE Access*, *13*, 5203–5218. https://doi.org/10.1109/ACCESS.2024.3524599

Albakkoush, S., Pagone, E., & Salonitis, K. (2020). *Scheduling challenges within maintenance repair and overhaul operations in the civil aviation sector*. In *TESConf 2020 – 9th International Conference on Through-life Engineering Services* (pp. 1–8). SSRN. https://doi.org/10.2139/ssrn.3718006

Attride-Stirling, J. (2001). Thematic networks: An analytic tool for qualitative research. *Qualitative Research*, *1*(3), 385–405. https://doi.org/10.1177/146879410100100307

Bruni, R., & Detti, P. (2014). A flexible discrete optimization approach to the physician scheduling problem. *Operations Research for Health Care*, *3*(4), 191–199. https://doi.org/10.1016/j.orhc.2014.08.003

Civil Aviation Authority. (2003). *Work Hours of Aircraft Maintenance Personnel* (CAA Paper 2002/06). CAA. https://www.caa.co.uk/publication/download/12349

Dawson, D., Ian Noy, Y., Härmä, M., Åkerstedt, T., & Belenky, G. (2011). Modelling fatigue and the use of fatigue models in work settings. *Accident Analysis & Prevention*, *43*(2), 549–564. https://doi.org/10.1016/j.aap.2009.12.030

De Bruecker, P., Van den Bergh, J., Belien, J., & Demeulemeester, E. (2014). *A Tabu search heuristic for building aircraft maintenance personnel rosters*. SSRN. https://doi.org/10.2139/ssrn.2464033

Deng, Q., Santos, B. F., & Verhagen, W. J. C. (2021). A novel decision support system for optimizing aircraft maintenance check schedule and task allocation. *Decision Support Systems*, *146*, Article 113545. https://doi.org/10.1016/j.dss.2021.113545

Grant, T. J. (1986). Maintenance engineering management applications of artificial intelligence. In D. Sriram & R. Adey, *Applications of artificial intelligence in engineering problems* (pp. 1097–1121). Springer. https://doi.org/10.1007/978-3-662-21626-2_88

Hobbs, A., Bedell Avers, K., & Hiles, J. J. (2011). *Fatigue risk management in aviation maintenance*: *Current best practices and potential future countermeasures* (OK-11-0024-JAH). Semantic Scholar. https://doi.org/10.1037/e621172011-001

International Air Transport Association. (2024). *IATA Annual Safety Report – 2024*. https://www.iata.org/en/publications/safety-report/executive-summary/

Kil, Y., Graham, M., & Chatzi, A. V. (2024). Examination of personality types as predictors of safety attitudes/behaviours, in support of enhancing safety in healthcare: A scoping review. *International Journal of Health Governance*, *29*(4), 323–341. https://doi.org/10.1108/IJHG-06-2024-0075

Laesanklang, W., Landa-Silva, D., & Castillo-Salazar, J. A. (2015). Mixed integer programming with decomposition to solve a workforce scheduling and routing problem. In *Proceedings of the International Conference on Opeartions Research and Enterprise Systems* (*ICORES-2015*) (pp. 283–293). Scitepress. https://doi.org/10.5220/0005223602830293

Memarzadeh, K., Kazemipoor, H., Fallah, M., & Moghaddam, B.-F. (2024). A two-stage scenario-based robust optimization model and a column-row generation method for integrated aircraft maintenance-routing and crew rostering. *Computer Modeling in Engineering & Sciences*, *141*(2), 1275–1304. https://doi.org/10.32604/cmes.2024.050306

Niu, B., Xue, B., Zhong, H., Qiu, H., & Tianwei, Z. (2023). Short-term aviation maintenance technician scheduling based on dynamic task disassembly mechanism. *Information Sciences*, *629*(2), 816–835. https://doi.org/10.1016/j.ins.2023.01.137

Obadimu, S. O., Karanikas, N., & Kourousis, K. I. (2020). Development of the minimum equipment list: Current practice and the need for standardisation. *Aerospace*, *7*(1), Article 7. https://doi.org/10.3390/aerospace7010007

Peters, V. P. J., de Rijk, A. E., & Boumans, N. P. G. (2009). Nurses' satisfaction with shiftwork and associations with work, home and health characteristics: A survey in the Netherlands. *Journal of Advanced Nursing*, *65*(12), 2689–2700. https://doi.org/10.1111/j.1365-2648.2009.05123.x

Pimapunsri, K., Weeranant, D., & Riel, A. (2021). Genetic algorithms for the resource-constrained project scheduling problem in aircraft heavy maintenance. *Suranaree Journal of Science and Technology*, *28*(6), Article 010083. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85130588829&partnerID=40&md5=ae5da44f7f4a38c8a48062079343dc42

Rahimian, E., Akartunalı, K., & Levine, J. (2017). A hybrid integer and constraint programming approach to solve nurse rostering problems. *Computers & Operations Research*, *82*, 83–94. https://doi.org/10.1016/j.cor.2017.01.016

Ryan, T. (2022). Facilitators of person and relationship-centred care in nursing. *Nursing Open*, *9*(2), 892–899. https://doi.org/10.1002/nop2.1083

Sachon, M., & Paté-Cornell, E. (2000). Delays and safety in airline maintenance. *Reliability Engineering & System Safety*, *67*(3), 301–309. https://doi.org/10.1016/S0951-8320(99)00062-9

Santos, L. F. F. M., & Melicio, R. (2019). Stress, pressure and fatigue on aircraft maintenance personal. *International Review of Aerospace Engineering* (*IREASE*), *12*(1). https://doi.org/10.15866/irease.v12i1.14860

Shaukat, S. (2015). *Aircraft line maintenance scheduling optimisation-a heuristic approach* [Masters Thesis, UNSW Sydney]. UNSW Sydney Library.

Shaukat, S., Katscher, M., Wu, C.-L., Delgado, F., & Larrain, H. (2020). Aircraft line maintenance scheduling and optimisation. *Journal of Air Transport Management*, *89*, Article 101914. https://doi.org/10.1016/j.jairtraman.2020.101914

Solos, I. P., Tassopoulos, I. X., & Beligiannis, G. N. (2013). A generic two-phase stochastic variable neighborhood approach for effectively solving the nurse rostering problem. *Algorithms*, *6*(2), 278–308. https://doi.org/10.3390/a6020278

Sriram, C., & Haghani, A. (2003). An optimization model for aircraft maintenance scheduling and re-assignment. *Transportation Research Part A*: *Policy and Practice*, *37*(1), 29–48. https://doi.org/10.1016/S0965-8564(02)00004-6

Uhde, A., Schlicker, N., Wallach, D. P., & Hassenzahl, M. (2020). Fairness and decision-making in collaborative shift scheduling systems. In *CHI '20*: *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1–13), Honolulu, HI, USA. ACM Digital Library. https://doi.org/10.1145/3313831.3376656

Vianna, W. O. L., & Yoneyama, T. (2018). Predictive maintenance optimization for aircraft redundant systems subjected to multiple wear profiles. *IEEE Systems Journal*, *12*(2), 1170–1181. https://doi.org/10.1109/JSYST.2017.2667232

Wang, T.-C., & Liu, C.-C. (2014). Optimal work shift scheduling with fatigue minimization and day off preferences. *Mathematical Problems in Engineering*, *2014*(1), Article 751563. https://doi.org/10.1155/2014/751563

Weide, T. M. J. van der, Deng, Q., & Santos, B. F. (2022). Robust long-term aircraft heavy maintenance check scheduling optimization under uncertainty. *Computers & Operations Research*, *141*, Article 105667. https://doi.org/10.1016/j.cor.2021.105667

Xue, B., Qiu, H., Niu, B., & Yan, X. (2022). Improved aircraft maintenance technician scheduling with task splitting strategy based on particle swarm optimization. In Y. Tan, Y. Shi, & B. Niu (Eds), *Advances in Swarm Intelligence*. *ICSI 2022*. *Lecture Notes in Computer Science* (Vol. 13344). Springer. https://doi.org/10.1007/978-3-031-09677-8_18

Yan, S., Yang, T.-H., & Chen, H.-H. (2004). Airline short-term maintenance manpower supply planning. *Transportation Research Part A*: *Policy and Practice*, *38*(9–10), 615–642. https://doi.org/10.1016/j.tra.2004.03.005

Yildiz, B. C., Gzara, F., & Elhedhli, S. (2017). Airline crew pairing with fatigue: Modeling and analysis. *Transportation Research Part C*: *Emerging Technologies*, *74*, 99–112. https://doi.org/10.1016/j.trc.2016.11.002