**A Framework to Minimize Environments Risks and to Identify Repurposing Operations in the Commercial Aviation Sector**

**Abstract**

This article proposes a risk management framework based on the Project Management Institute (PMI) risk management knowledge area to minimize threats in risk environments and identify repurposing operations in commercial aviation. The research method comprises three main steps: (i) the identification of repurposing and risk management methodologies applicable to commercial aviation through a literature review; (ii) the adaptation of the risk management framework for coronavirus disease 2019 (COVID-19); and (iii) a proposed framework for risk management. The developed framework identifies repurposing areas and highlights relative weaknesses that are overlooked in commercial aviation. Thus, it reduces the impact of risk environments such as pandemics, and it emphasizes the importance of considering previous historical events or lessons when generating strategies for new risk situations. Commercial aviation applies repurposing operations and promotes cooperation between supply chain actors in only a few areas. This article provides a methodology for subgroups of airlines and passengers, showing different effects between risk categories to benefit commercial aviation industry subgroups. Moreover, it contributes to risk management and decision-making in commercial aviation. The article’s proposed risk management framework identifies whether a risk environment is local, national, or global. It also allows us to reflect on the sectors involved in commercial aviation, and it recommends forming risk committees to jointly coordinate and monitor risks in order to generate global strategies and identify both areas for repurposing operations and the financial capacity needed to meet demand.

**Keywords**

Risk management framework, repurposing operations, commercial aviation, practical analysis

**1. Introduction**

Commercial air transport is one of the most important sectors worldwide. This mode of transportation moves a large amount of people and things in less time than other modes. However, it is one of the sectors most vulnerable to risk environments (pandemics, terrorism, economic changes, etc.). During the 2019 coronavirus disease (COVID-19) outbreak, some countries closed their borders to reduce the spread of the virus (Ellis 2020; British Broadcasting Corporation News 2020a; Al Jazeera 2020). This measure caused passenger flights to decrease by more than 60% by 2020 (International Air Transport Association 2020a; Cabrera 2016). Airlines with less funding were unable to maintain operations (Warnock-Smit et al. 2021); others reduced their fleets and flights, and some even declared bankruptcy (Gholami 2021). To reduce monetary losses, some airlines modified their passenger aircraft to use them as freight aircraft. This change was called *repurposing*. This framework was intended to reduce companies’ losses and return to normal production after exiting a risk environment—in this case, COVID-19. During the pandemic, repurposing was applied to many fields, such as medicine (Malik et al. 2022), circular economies (Schulz et al. 2020; Schulz-Mönninghoff et al. 2021), and air transit (Wu et al. 2022).

Published empirical research shows that repurposing operations have been studied in terms of new product introductions (NPIs) (Lopez-Gomez et al. 2020), frameworks based on multi-criteria decision-making (MCDM) techniques and expert opinions integrating industry 4.0 (Pansare and Yadav 2022; Ho et al. 2022), digital platforms and tools such as Operator 4.0, risk planning tools (Soldatos et al. 2021), resource redeployment (Kapoor et al. 2021), and barriers (Okorie et al. 2020; Poduval et al. 2021). COVID-19’s impact revealed that companies were unprepared for a global pandemic despite a recent influenza pandemic in 2009 (H1N1).

Aviation-related research has covered COVID-19’s impact on aviation (Sun et al. 2021), travel patterns (Christidis and Christodoulou 2020), the evaluation of travel measures (Bielecki et al. 2021), lessons learned (Belhaaddi et al. 2021), and strategic responses (Kilinaivoni et al. 2022; Kim et al. 2022). Most proposals have emphasized the importance of a systemic risk approach, the identification of risk types, and risk mitigation strategies. According to Hong et al. (2022), airline risk management systems constitute an organizational weakness. Some published strategies have covered the operational and regulatory aspects of repurposing passenger cabins to transport cargo (Škurla et al. 2022), the challenges and costs of passenger-to-freighter conversion (Spells and Tan 2022), and the initiatives undertaken to move people when international transit is blocked (Wu et al. 2022). Based on the above, this paper’s objective is to propose a risk management framework based on the Project Management Institute's (PMI) risk management knowledge area to minimize threats due to risk environments and identify commercial aviation repurposing operations. To achieve this objective, the following steps were undertaken:

1. Based on the PMI’s risk management knowledge area, a risk management framework applicable to commercial aviation was formulated to minimize risk environments’ impacts.
2. A hypothetical case using the risk management framework to identify commercial aviation repurposing operations was described.
3. Some strategies that could be applied during different phases of future commercial aviation emergencies were identified.

The risk management framework proposed in this paper offers a structure that is easy to implement and recognizes the level at which a risk environment must be managed (local, national, or global). This proposal will allow the commercial aviation industry or any other industry to identify the groups involved and their level of commitment, as well as the extent of communication and information they require. The theoretical contribution of this paper will contribute to risk management and decision-making in commercial aviation.

The remainder of this paper is structured as follows. Section 2 presents a literature review of risk management, the main methodologies, and repurposing. Section 3 details this study’s research methodology; it describes the proposed risk management framework and explains the study’s data collection and analysis. Section 4 presents a hypothetical case to which the proposed framework was applied. Section 5 summarizes the results concerning the identified repurposing operations for airline and passenger subgroups. Finally, Section 6 presents the study’s conclusions, limitations, and recommendations.

**2. Literature Review**

This literature review is divided into two subsections. The first subsection includes some risk management methodologies applicable to commercial aviation. The second subsection presents definitions of *repurposing*, a roadmap, and barriers.

**2.1 Risk Management**

A risk is an uncertain event or condition that can, if it occurs, positively or negatively affect one or more proposed objectives (Project Management Institute 2021). Usually, risk management has focused mainly on negative threats and failures (Kaplan and Mikes 2012). Currently, the risk management approach is intended to decrease threats’ probability or impact or to increase opportunities’ increase probability or impact (Mulcahy 2018). Companies can use different risk management methodologies to manage risks. Table 1 summarizes the main risk management methodologies that can be applied to environmental risk.

Kaplan and Mikes (2012) suggested that companies face three risk categories that require different risk management approaches: (1) preventable risks, which arise within an organization and are monitored and controlled through a rules-based model (rules, values, and standard compliance tools); (2) strategy risks; and (3) external risks, which both require alternative approaches through which managers find cost-effective ways to reduce the likelihood of risky events or mitigate their consequences. These three categories entail four main steps: (1) defining risk mitigation objectives, (2) identifying a control model, (3) establishing the risk management staff’s function, and (4) defining a risk management function’s relationship to business units. This approach focuses primarily on risks facing companies (Yun 2023).

Kot and Dragon (2015) proposed a risk catalogue with three risk levels: strategic, financial, and operational. At every level, the risk type is defined and broken down. For example, natural risks belong to operational risks, and they are broken down in extreme climate and natural disasters. In the enterprise risk management (ERM) structure, they specify seven components: (1) risk identification, (2) risk owner identification, (3) the alignment of the responsibility for risks, (4) creating a central risk function, (5) creating a “storehouse of knowledge” concerning ERM, (6) the involvement of a company’s management board (Jia and Li 2022), and (7) the use of a standardized risk assessment process. This approach considers risk holistically in the context of a company’s strategy and objectives.

ISO 31000:2018 (International Organization for Standardization 2018) provides guidelines on managing risks that face organizations. They can be customized to any organization and its context. These guidelines are based on eight principles: (1) integration, (2) structure and comprehensibility, (3) customization, (4) inclusivity, (5) dynamism, (6) the best available information, (7) human and cultural factors, and (8) continual improvement. The framework focuses on integration, design, implementation, evaluation, improvement, and leadership and commitment. The risk of this approach is that it mainly considers top-management stakeholders, who sometimes do not fully participate in operations (Bucke et al. 2022).

Huo et al. (2021) considered disaster management analysis and operations to continually manage emergencies. The cycle they identified considers four main stages: (1) prevention and mitigation, (2) preparedness, (3) response, and (4) recovery. It also involves five steps: (1) risk evaluation and assessment, (2) risk management response, (3) risk management recovery, (4) risk management mitigation, and (5) risk management preparedness. This approach helps address the main issues related to disaster preparedness, economic rehabilitation, and disaster-affected businesses (Kumar and Mallipeddi 2022).

Table 1. Risk management methodologies.

|  |  |  |
| --- | --- | --- |
| **Methodologies** | **References** | **Framework or risk categories** |
| System risk management | Kaplan and Mikes (2012) | Three risk categories: *preventable*, *strategic*, and *external* risks |
| Enterprise risk management (ERM) | Kot and Dragon (2015) | Seven major components and three risk levels: *strategic*, *financial*, and *operational* |
| ISO 31000:2018 | ISO (International Organization for Standardization 2018) | Eight principles based on five components: *integration*, *design*, *implementation*, *evaluation,* and *improvement* |
| Risk performance analysis and disaster management framework | Huo et al. (2021) | Four main disaster management analysis and operations stages: *prevention and mitigation*, *preparedness*, *response,* and *recovery*;five disaster management steps: *risk evaluation and assessment*, *risk management response*, *risk management recovery*, *risk management mitigation*,and *risk management preparedness* |
| Risk management | Project Management Institute (2013, 2021) | Seven risk management processes: *plan risk management*, *identify risks*, *qualitative analysis*, *quantitative analysis*, *plan risk responses*, *implement risk responses*, and *control and monitor risks* |
| Failure mode and effective analysis (FMEA) and bow tie | Ambarwati et al. (2022) | Seven risk management steps: *data*, *process*,and *risk identification with FMEA*, *RPN score*, *determine priority for completion of work*, *determine priority based on RPN score*, and *root cause analysis* |
| Supply chain risk mitigation strategies (SCRMS) | Fan and Stevenson (2018) | *Identification*, *assessment*, *treatment*, *and monitoring of supply chain (SC) risks* |
| Strategic response map | Kim et al. (2022) | *Risk environment*, *various risks*, *response measures*,and *lessons learned for an effective response* |

The Project Management Institute’s (2013 2021) methodology involves seven steps: (1) planning risk management, (2) identifying risks, (3) performing qualitative analysis, (4) performing quantitative analysis, (5) planning risk responses, (6) implementing risk responses, and (7) controlling or monitoring risks. The advantages of this approach include the early identification of risk, the assignment of roles and responsibilities, timely communication, the incorporation of findings based on past events (lessons learned), and stakeholders’ involvement. Additionally, it allows organizations to determine the cost of risk response strategies, which helps with better decision-making. The activities carried out in each process are neither exhaustive nor fixed; they depend on the magnitude of the risk environment.

The Failure Mode and Effective Analysis (FMEA) or bow tie method (Ambarwati et al. 2022) comprises seven steps: (1) obtaining data for analysis, processing, and risk identification with FMEA; (2) assigning a risk priority number (RPN) score based on severity, occurrence, and detection; (3) determining the priority for works’ completion; (4) bow tie analysis (determining priority based on RPN scores); (5) analyzing causes; (6) applying corrective action; and (7) preventing action (steps 6 and 7 are abbreviated as CAPA). This method identifies a risk’s route cause (RC), preventive actions, recovery actions, and RPN scoring consequences. Although RCA can take too long, it helps clearly define risks and prescribe actions.

The Supply Chain Risk Mitigation Strategies (SCRMS) comprise the identification, assessment, treatment, and monitoring of supply chain (SC) risks (Fan and Stevenson 2018). The Strategic Response Map for cascading pandemics consists of a risk environment, various risks, response measures, and lessons learned for effective responses (Kim et al. 2022). Both proposals emphasize the importance of a systemic risk approach, the identification of risk types, and risk mitigation strategies.

The Strategic Response Map comprises anticipated risk, emerging risk, amplified risk, and lingering risk. The authors proposed a strategic response map to address cascading pandemics.

Therefore, this paper applies the risk management framework based on the PMI (2013 2021). It identifies opportunities for repurposing operations to avoid the huge costs and time involved in developing new infrastructure for commercial aviation operations. Furthermore, this framework’s application will help prevent risky environments during the early stages.

**2.2 Repurposing**

Repurposing has been practised since people began creating and acquiring products (Ali et al. 2020). However, as time goes by, and according to the needs of certain industries, the term has acquired different definitions. In 2009, *repurposing* was defined as “utilizing a product or its components in a role that it was not originally designed to perform” (BS 8887-2 2009). In 2010, *repurposing* was defined as “the activity to create a new or a second life for an existent product by making some transformations to it” (Aguirre 2010). These concepts were used to repurpose building materials (Assefa and Ambler 2017), metadata (Kurt et al. 2004), and innovations (Mars 2014).

COVID-19 led to a new approach to repurposing. A rapid response solution was needed to address the global shortage of critical products using idle manufacturing capacity (López-Gómez et al. 2020). With this framework, companies are intended to reduce their losses by repurposing their facilities and returning to normal production after exiting a risk environment. During the pandemic, repurposing was applied to many fields, such as medicine (Malik et al. 2022), circular economies (Schulz et al. 2020; Schulz-Mönninghoff et al. 2021), and air transit (Wu et al. 2022). The reasons for carrying out repurposing are diverse, and according to Ali et al. (2020), they can be summarized as necessity, creativity, financial, emotional, and environmental reasons.

**2.2.1 Repurposing roadmap**

During the pandemic, the growing demand for products on the market forced companies to look for options to generate revenue (Ho et al. 2022). However, changing operations is not always feasible; accordingly, López-Gómez et al. (2020) proposed a Rapid Repurposing Roadmap for COVID-19. The framework was based on five questions: Why repurpose? What should be repurposed? How should repurposing take place? When should the repurposing happen (the timeline according to the local context)? And who should coordinate this effort? All of these activities are based on NPI processes.

*Why repurpose?* The reason for repurposing is to estimate critical supply needs and shortages (Chervenkova and Ivanov 2023). Policymakers must ensure repurposing incentives. At this point, liaising with health sectors and public authorities is mandatory.

*What should be repurposed*? Industry representatives must be aware of which items could be repurposed. Moreover, such representatives and government officials must verify whether some products could be repurposed in local communities. In 2020, the WHO listed critical items; for example, clinical care equipment was manufactured in aerospace manufacturing plants.

*How should repurposing take place*? Governments must share specifications (safety specifications, standards, type approvals, quality information, and conformity details) about required products. When the pandemic started, some products were returned because they did not meet medical standards. The root cause was poor communication with the health sector (Butler 2020).

*Who should coordinate repurposing*? Authors have established that this point is crucial to hasten repurposing. In some countries, public centers of excellence or technology and innovation centers started to take the lead.

**2.2.2 Barriers**

Repurposing is not always achieved overnight. In some cases, complying with regulatory requirements specific to each sector is necessary. During the pandemic, several barriers to manufacturing and manufacturing repurposing were identified. In a study by Okorie et al. (2020), research several respondents indicated that they were unable to repurpose due to an increased demand for their product types, financial constraints due to increased repurposing costs, time constraints, safety and regulatory concerns, and a lack of skillsets to support repurposing.

On the other hand, Poduval et al. (2021) identified strategic, cultural, technological, and innovation barriers for which plant managers were responsible. These professionals are also responsible for modifying existing operations and planning changes accordingly. Therefore, the determination of not only where and which operations should be repurposed but also the barriers involved is necessary.

**3. Methodology**

This study’s research methodology comprised three steps: first, the identification of repurposing and risk management methodologies applicable to commercial aviation through a literature review; second, the adoption of a risk management framework for COVID-19; and third, the proposal of this risk management framework. Project management according to the PMI is usually performed when implementing any kind of project. The goal is to prevent problems and avoid dealing with them, which concerns how much time and money could be saved. Unlike other methodologies, the proposal by Kim et al. (2022) does not consider the cost of risks, and the Sendai Framework focuses on pandemics and epidemics, though it also addresses both natural and human hazards, as well as related environmental, technological, and biological risks.

Figure 1 depicts the risk management framework. It begins when a risk environment is identified. The sector where this scenario occurs should form a risk committee to manage this event. Then, this committee should identify whether the risk environment is local, national, or global before initiating risk management processes. The committee should also identify whether other sectors are involved in the risk environment (government, tourism, etc.). If more sectors are involved, they should be identified, and a high-level crisis committee should be established to coordinate all the involved sectors. This latter committee should coordinate high-level risk management and establish strategies to mitigate the risk event. The high-level committee should also keep stakeholders informed.

Once the risk environment has been resolved, the lessons learned from this event should be identified, and all documents, policies, and processes should be updated and communicated. This framework suggests that preventive activities be conducted periodically. When the COVID-19 pandemic began, many young people may have been unaware of the pandemic during the previous century (Spanish flu) and how it was managed. If simulation exercises had been carried out every five years (for example), awareness would likely be generated about the precautions that should be followed in similar situations. Such exercises would provide insight into plans and capabilities in a realistic environment, allowing for improvement through practice.

The proposed risk management processes and their corresponding activities are based on the works of the PMI and Mulcahy (2018), and they are shown in Figure 2. They comprise the following: *(1) planning risk management, (2) identifying risks, (3) qualitative and quantitative risk analysis, (4) planning risk responses, (5) implementing risk responses, and (6) monitoring risks*. Processes 1–5 are sequential, and Process 6 involves constant monitoring throughout an event (Mulcahy 2018). The activities carried out as part of each process are not exhaustive since their application depends on the magnitude of a risk environment.

The units of analysis used in this study were publicly available data from governments, organizations, and newspapers related to airlines and passengers during COVID-19.

**3.1 Data Collection**

Data are collected at different times throughout a risk environment. When the event starts, risk management processes and a crisis committee (at least the first approach, risk managers, operations managers, and plant managers) are put in place. Depending on the risk environment, the related crisis committee must identify the areas, industries, supply chains, and international institutions.

During the first process, *planning risk management*, the crisis committee defines the plan for managing risks, work approaches, roles, and responsibilities. It also assigns a single point of contact and defines authority levels for decision-making to avoid the duplication or omission of activities. Stakeholders, documents, and previous findings are also identified. This work considers lessons learned from experiences with SARS, Middle East Respiratory Syndrome (MERS), and respiratory viruses’ known routes of transmission.



Figure 1. Risk environment framework flow chart.

During the second process, *identifying risks*, the crisis committee identifies risks and involves the main stakeholders as soon as possible. For the COVID-19 emergency, stakeholders and expert judges were included from the WHO, the International Air Transport Association (IATA), airlines, governments, and researchers. However, literature reviews, research, communication, and non-stakeholder involvement can also be considered (Mulcahy 2018). Techniques such as brainstorming, interviewing, or root cause analysis are used to identify the risks associated with a risk environment and their associated categories (Cerniglia-Lowensen 2015). Documents, policies, and regulations related to an event should also be considered (Mulcahy 2018).

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Figure 2. Risk management processes.

Note: Figure 1 was adapted from the works of the Project Management Institute (2013) and Mulcahy (2018). \* *Lessons learned*: knowledge gained during past events used to improve future performance for a team or an organization (Mulcahy 2018). \*\* *Risk owner*: someone who helps lead the development of a risk response and enacts this risk response (Mulcahy 2018, p. 470).

We also considered secondary data from government organizations and private companies’ publications, books, records, articles, and websites published between 2019 and 2022. Expert judgment is key to identifying risks, and it should be considered. In this context, expert judgment comprises a set of opinions by professional experts on commercial aviation, COVID-19, or discipline in relation to the risk environment.

During the third process, *qualitative risk analysis*, every risk is assessed based on its probability and impact. A scale of 1–5 for probability (*1 = very low: almost impossible*; *2 = low: it could happen*; *3 = medium: it could happen any time*, *4 = high: it usually happens*;and *5 = very high: it is a fact that can happen*) is used. Similarly, impacts are scored from 1 to 5, depending on their positive or negative consequences (*1 = negligible: the impact is not a problem*; *2 = minor: the impact is low, and few people are affected*; *3 = moderate: the impact is medium, and some areas or countries are affected*; *4 = major: the impact is high, and many areas or countries are affected*; and *5 = catastrophic: the impact is very high, it can halt several countries’ economies, and it affects many people*).

The risk severity index is calculated by multiplying the probability and impact values. A risk is considered *very high* for outcome values of 20–25, versus *high* for 12–16, *medium* for 8–10, *low* for 3–6, and *very low* for 1–2. Figure 3 depicts a risk assessment map.



Figure 3. Risk assessment map.

Next, the risk attention priority—that is, the order in which a risk should be attended to—is assigned. These scores are assigned sequentially; *1* indicates the highest attention priority.

During the framework’s fourth process, *planning risk responses*, risk scores are listed from the highest priority to the lowest. Additionally, the crisis committee defines risk responses to eliminate threats and ensure opportunities. It also identifies whether repurposing operations could be applied. According to Harvey (2005) and Mulcahy (2018), risk response strategies are divided into three categories: threats (avoiding, mitigating, or transferring risk), opportunities (exploiting, improving, or sharing risks), and threats and opportunities (escalation and acceptance). Table 2 depicts the risk response options.

Table 2. Risk response options from Mulcahy (2018)

|  |  |  |
| --- | --- | --- |
| **Threats** | **Opportunities** | **Both threats and opportunities** |
| Avoid | Exploit | Escalate |
| Transfer | Improve | Accept |
| Mitigate | Share | — |

During the fifth process, *implementing risk responses*, all the response actions that are part of a strategy are carried out. At this point, repurposing operations applicable to commercial aviation are identified. The actions that a response team has agreed upon are performed by responsible parties, and any changes must be documented and communicated to the entire team (Mulcahy 2018). Documents, laws, or policies must be updated or generated. Moreover, team members must confirm whether a plan has succeeded, whether any changes are needed, or whether some suggestions should be included for future cases. Timely communication must be ensured throughout the event. Communicating with stakeholders is also important at this stage to avoid misunderstandings.

Finally, the sixth process, *controlling risks*, assesses whether risks have been resolved or whether new risks can be identified. A team could define workarounds and evaluate a plan’s effectiveness. In this process, the team defines whether new responses are needed, and it also communicates the risk status both internally (to a work team and a crisis committee) and externally (to the general population).

**3.2 Data Analysis**

The data collected are analyzed to determine whether the risk environment is local, national, or global, as well as the roles and responsibilities of each risk committee member and their corresponding authority. The lessons learned help determine whether a similar event has occurred, how it was handled, and what actions must be reinforced. Assigning a unique number to identified risks helps track them throughout the event until these risks have been resolved. Additionally, risk categories are used to group risks. Assigning probability and impact values helps determine risks’ priority and cost. Assigning priority helps plan risk response strategies. Finally, data also help in planning post-risk environment preventive actions. These teams, other stakeholders, and experts should select strategies to determine the most cost-effective and likely approaches for addressing risks (Mulcahy 2018).

**4. Assessing the risk environment: COVID-19**

Using this risk management framework, the authors reviewed information from December 2019 to December 2022 and identified some risks for airlines and passengers during the COVID-19 pandemic.

**4.1 Determining local, national, or global risk environments**

The COVID-19 emergency had a global scope. Thus, many sectors and countries were involved, and they all had to collaborate in order to formulate a robust action plan. Examples of relationships between commercial aviation and some sectors are shown in Figure 4. In practice, crisis committees and relevant authorities should apply the steps we propose in order to obtain more accurate information.

**4.2 Implementing Risk Management Processes**

The information obtained and used in risk management processes is described in the following subsections.

*4.2.1. Planning Risk Management*. The risk categories in the current work were adapted from a World Economic Forum (2021) report. They comprise economic, societal, geopolitical, technological, and environmental (Table 4, Column A, and Table 5, Column B) aspects. Table 3 shows the lessons learned from past and present pandemics that were considered in this work. As it indicates, several authors agree that health systems, communications, planning, and the protection of vulnerable groups must be strengthened.

*4.2.2. Identifying Risks.* We used brainstorming, documents, and news to identify risks facing commercial aviation according to each risk category (Table 4, columns b and c, and Table 5, columns b and c). New risks can be identified at any time, and already-identified risk levels can change if appropriate treatment is not provided. Thus, a low-priority risk could become a high-priority if it is not properly attended to.

Table 3. Lessons learned from past and present pandemics.

|  |  |  |
| --- | --- | --- |
| **Bennett and Camey (2015)** | **Da vid and Ozuluoha (2020)** | **Feitelson et al. (2022)** |
| Strengthening global public health laws | Health system strengthening  | Initial response |
| Strengthening regional and national preparedness | Early planning and proper responsive measures  | Legal context |
| Flexible and responsive guidance | Adherence to laid-down guidelines  | — |
| The importance of communication | Timely and accurate information to counter false information | Governance structures and networks |
| Protecting vulnerable populations | Consideration of vulnerable groups | Political turbulence |



Figure 4. Commercial aviation and its relationship with certain sectors.

Source: Updated from Air Transport Action Group (September 2020), *Aviation Benefit beyond Borders* (https://www.atag.org/our-publications/latest-publication).

*4.2.3. Performing Qualitative Risk Analysis.* Risks were analyzed to determine their probability and impact in a risk environment according to the information defined in Figure 3. Probability values are presented in Table 4 (column e) and Table 5 (column e). Impacts are shown in Table 4 (column f) and Table 5 (column f). Outcomes are depicted in Table 4 (column g) and Table 5 (column g). Finally, risk priorities are presented in Table 4 (column h) and Table 5 (column h). In Table 4, the highest priorities were assigned to a geopolitical risk related to new airport requirements (risk 14) and agreements between countries (risk 15); as a result of these threats, some countries closed their borders, while others did not. In Table 5, the highest priorities were assigned to an economic risk related to fewer passengers (risk 1) and a geopolitical risk related to onboard flight restrictions (risk 11). Risk 11 in Table 5 is related to risk 1 in Table 4; these risk response strategies should propose actions that involve both threats.

To perform a quantitative analysis, access to confidential information from the bodies involved would have been necessary; however, the information gathered from news reports indicated the number of modified aircraft and some related costs. In 2020, the regions where the largest conversions were performed were Asia-Pacific (62 aircraft), Europe (58 aircraft), the Middle East (12 aircraft), North America (nine aircraft), Latin America (eight aircraft), and Africa (six aircraft). At the beginning of January 2021, 60 aircraft (39% of the cabin cargo fleet) returned to passenger service (Communication and Media Group 2021). In most of these cases, the change only included seat removal. The cost of conversions depended on the aircraft type. A narrowbody conversion costs $4.2 million for a 737-800 and $6.1 million for an A321-200; meanwhile, a widebody conversion costs $14.7 million for a 767-300ER and $18.4 million for an A330-300 (Spells and Tan 2022).

*4.2.4. Planning Risk Responses.* Risk responses are presented in Table 4 (column i) and Table 5 (column i). For the high-priority risks shown in Table 4, the risk response strategy comprised escalating the threats to the international level in order to reach an agreement between the involved countries. The crisis committee analyzed whether some repurposing operations applied to each risk, and the response is depicted in Table 4 (column j) and Table 5 (column j). For example, consider risk 3 (Table 6). A repurposing operation was identified, and the risk response considered converting a passenger aircraft to a freighter. Such a conversion takes three to four months and costs a few million dollars; however, this investment may be worthwhile. Mexican domestic airlines, such as Volaris, increased their international freight activity by 352% (SALBO LOGISTICS 2021). To make such a decision, the committee considered the barriers that airlines could face (Okorie et al. 2020; Poduval et al. 2021). These barriers include the capital needed to switch from passenger to freighter aircraft, the time needed for this switch, the trained personnel needed to achieve this transition, and access to a sufficient number of customers.

*4.2.5. Implementing Risk Responses.* Table 6 shows six areas where repurposing occurred in the airline subgroup. Four of them took place in the societal category, one took place in the economic category, and one took place in the technological category. Table 7 shows three areas, two in the societal category and one area in the economic category. Response strategies for repurposing areas are shown in Table 6 (column k) and Table 7 (column k). Some measures taken for the airline subgroup are shown in Table 8. These measures are examples used to illustrate the proposed response strategy.

*4.2.6. Monitoring Risk.* In the risk monitoring process, risks are reevaluated, updated, and resolved. This step defines whether risk responses have been effective or whether new actions are needed. It also communicates the risk status internally (to work teams) and externally (to the general population). Vaccines have allowed for economies’ partial revival; however, government strategies remain active to stop the spread of new variants (World Health Organization 2022). From 2020 to September 2022, a cumulative total of 612 million COVID-19 cases—including 6.5 million deaths—were reported in all six WHO regions (Pan American Health Organization 2022).

The lessons learned should be documented and communicated from the beginning of a risk environment to its end. These lessons should indicate what was done right, what was done wrong, and what could be done differently if the risk environment recurred. Additionally, these lessons should indicate whether policies, regulations, or procedures (among other aspects) should be reviewed and updated. All changes should be communicated to stakeholders and, if required, to the population. Finally, the results of risk management should enable the proposition of preventive actions for future events.

Table 4. Risk detection for the airline subgroup.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk category (a)** | **Risk****number****(b)** | **Associated risk** **(c)** | **Description****(d)** | **Probability****(e)** | **Impact****(f)** | **Assessed risks****(e × f) = (g)** | **Priority****(h)** | **Risk response****(i)** | **Does repurposing apply?****Y or N****(j)** |
| Economic | 1 | Decrease in passengers | Reduction in the number of passengers who want to fly during the pandemic, leading to a reduction in airline revenue | 4 | 5 | 20 | 4 | Mitigate | N |
| 2 | Healthcare products | Increased costs due to the purchase of large quantities of cleaning products to reduce contagion | 4 | 4 | 16 | 15 | Accept | N |
| 3 | Flight cancellations  | Below-estimated numbers of scheduled flights due to a decrease in passengers or health decisions (border closures) | 4 | 5 | 20 | 5 | Mitigate | Y |
| 4 | Decrease in flights | Fewer sold seats, reducing airline revenue | 4 | 4 | 16 | 14 | Mitigate | N |
| 5 | Airline bankruptcy | Earnings below estimates and a lack of government support, leading to airline bankruptcy | 4 | 5 | 20 | 13 | Mitigate | N |
| 6 | Reduction in input purchases | Fewer supplies purchased than estimated due to canceled flights | 4 | 5 | 20 | 6 | Mitigate | N |
| Societal | 7 | Crew vaccination | Crew vaccination below expectations due to a lack of supplies or a lack of vaccines for a new virus | 3 | 4 | 12 | 21 | Mitigate | N |
| 8 | In-flight measures | Non-standard procedures: each airline generates its own procedures | 5 | 5 | 25 | 3 | Mitigate | N |
| 9 | Requirements for passenger flights | Inefficiently or inconsistently communicated travel needs | 4 | 5 | 20 | 7 | Escalate | N |
| 10 | Training | Crews inefficiently trained regarding the virus or emergency affecting the population | 4 | 4 | 16 | 16 | Mitigate | Y |
| 11 | Workplaces | Reduction in jobs due to border closures | 4 | 5 | 20 | 12 | Mitigate | Y |
| 12 | Culture | Insufficient hygiene habits among passengers and even the refusal to follow established hygiene measures to address the pandemic | 4 | 5 | 20 | 8 | Escalate | Y |
| Geopolitical | 13 | Flight requirements | Non-synchronized travel requirements between origins and destinations (each country establishes its own requirements) | 5 | 4 | 20 | 9 | Escalate | N |
| 14 | New airport requirements | Each country establishes its own provisions for receiving flights, and some countries decide to close their borders  | 5 | 5 | 25 | 1 | Escalate | N |
| 15 | Agreements between countries | A flight can receive different indications of where it should land | 5 | 5 | 25 | 2 | Escalate | N |
| Technological | 16 | Spread of diseases | A lack of devices to detect the presence of diseases during flights in order to reduce their spread | 3 | 5 | 15 | 19 | Mitigate | N |
| 17 | Physical contact | Reduced space inside aircraft to avoid contagion | 4 | 4 | 16 | 17 | Mitigate | N |
| 18 | Devices to detect infections | A lack of devices to detect people infected with COVID-19 or the poor use of such devices | 4 | 5 | 20 | 10 | Mitigate | Y |
| Environmental | 19 | Medical waste | Poorly treated medical waste | 4 | 4 | 16 | 18 | Mitigate | N |
| 20 | Personal cleaning articles during flights | Insufficient personal cleaning supplies during flights | 4 | 5 | 20 | 11 | Mitigate | N |
| 21 | Garbage generated | Excessive garbage generated during flights | 3 | 3 | 9 | 22 | Mitigate | N |
| 22 | Reduction in air pollution | Reduction in pollution generated by airplanes | 3 | 5 | 15 | 20 | Exploit | N |

Table 5. Risks detected for the passenger subgroup.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk category (a)** | **Risk number****(b)** | **Associated risk** **(c)** | **Description****(d)** | **Probability****(e)** | **Impact****(f)** | **Assessed risks****(e × f) = (g)** | **Priority****(h)** | **Risk response****(i)** | **Does repurposing apply?****(Y or N) (j)** |
| Economic | 1 | Decrease in passengers | Decrease in passengers due to the pandemic | 5 | 5 | 25 | 1 | Mitigate | N |
| 2 | Healthcare products | Greater demand for personal cleaning articles, such as face masks, antibacterial towels, and antibacterial gel | 4 | 4 | 16 | 6 | Escalate | N |
| 3 | Flight cancellations | Flights canceled due to the COVID-19 emergency | 5 | 2 | 10 | 15 | Accept | N |
| 4 | Exceeding budgets to cover extra expenses | Extra funds spent to cover surplus expenses due to quarantines outside the place of origin | 3 | 4 | 12 | 9 | Accept | N |
| 5 | Cheaper flights | Cheaper flights due to low demand | 4 | 3 | 12 | 10 | Exploit | N |
| 6 | Contracting COVID-19 | Payment for medical services if necessary | 2 | 5 | 10 | 14 | Accept | N |
| Societal | 7 | Contracting COVID-19 | Passengers infected with SARS-CoV-2 during a flight | 2 | 2 | 4 | 19 | Mitigate | Y |
| 8 | Flight restrictions | Passengers refuse to use face masks during a flight | 3 | 4 | 12 | 11 | Escalate | Y |
| 9 | Mental health | Mental problems due to quarantine | 4 | 4 | 16 | 7 | Mitigate | N |
| 10 | Social divisions | Discrimination against unvaccinated people | 4 | 3 | 12 | 12 | Escalate | N |
| Geopolitical | 11 | Restrictions to board a flight | Restrictions imposed by airlines | 5 | 5 | 25 | 2 | Accept | N |
| 12 | Restrictions at the destination | Requirements imposed at the destination | 4 | 5 | 20 | 3 | Accept | N |
| 13 | Vaccine requirements | Type of vaccine needed to travel to a certain country | 3 | 4 | 12 | 13 | Mitigate | N |
| Technological | 14 | Boarding control | Lack of an automatic control system to facilitate passenger boarding and reduce contact | 3 | 5 | 15 | 8 | Exploit | N |
| 15 | Lack of access to technology | Lack of access to technology for booking flights and obtaining tickets | 3 | 3 | 9 | 16 | Escalate | N |
| 16 | Insufficient bandwidth  | Insufficient bandwidth to cover data demands | 3 | 3 | 9 | 18 | Mitigate | N |
| Environmental | 17 | Medical waste | Large amounts of masks discarded during flights | 4 | 5 | 20 | 4 | Mitigate | N |
| 18 | Personal cleaning articles during flights | Large amounts of water, soap, and hand sanitizer needed for cleaning during flights | 4 | 5 | 20 | 5 | Accept | N |
| 19 | Trash | Minor amounts of trash generated by passengers | 3 | 3 | 9 | 17 | Exploit | N |

Table 6. Repurposing areas detected in the airline subgroup.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk category (a)** | **Risk number** **(b)** | **Associated risk (c)** | **Assessed risks (g)** | **Priority (h)** | **Risk response****(i)** | **Response strategy****(k)** | **References** |
| Economic | 3 | Flight cancellations | 20 | 5 | Mitigate | Determine whether some passenger aircraft can be modified and used as freight aircraft; satisfy product demand with maritime freighters | Kulisch (2020), Kim and Sohn (2021), and Herrera (2021)  |
| Societal | 8 | In-flight measures | 25 | 3 | Mitigate | Identify and use lessons learned about the present event | Dube et al. (2021) |
| Societal | 10 | Training | 16 | 16 | Mitigate | Train cabin crews on the emergency and then reassign them to assist with health services | British Broadcasting Corporation News (2020) |
| Societal | 11 | Workplaces | 20 | 12 | Mitigate | Train cabin crews on the emergency and then reassign them to assist with health services | British Broadcasting Corporation News (2020) |
| Societal | 12 | Culture | 20 | 8 | Escalate | Reinforce the advantages of using masks, hand washing, and a healthy distance to the population before, during, and after flights | Dube et al. (2021) |
| Technological | 18 | Devices to detect infections | 20 | 10 | Mitigate | Permanently use infrared thermometers before, during, and after flights | Dube et al. (2021) |

Table 7. Repurposing areas identified in the passenger subgroup.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk category (a)** | **Risk number****(b)** | **Associated risk (c)** | **Assessed risks (g)** | **Priority (h)** | **Risk response****(i)** | **Response strategy****(k)** | **References** |
| Societal | 7 | Contracting COVID-19 | 4 | 19 | Mitigate | Airport, air, and hotel authorities can achieve the following, depending on the number of sick people:1. Define which airports will receive flights with people who are infected with a certain virus.
2. Adapt some hotels as hospitals
 | Organización Panaméricana de la Salud (2020) |
| Societal | 8 | Flight restrictions | 12 | 11 | Escalate | Reinforce to the population the advantages of using masks, hand washing, and a healthy distance before, during, and after flights; periodically strengthen simulation exercises that test preparations for a global pandemic (as is done for earthquakes) to inform passengers of this emergency type | Organization Panamericaine de la Santé (2018) |
| Technological | 14 | Boarding control | 15 | 8 | Exploit | Standardize the use of electronic boarding passes | British Broadcasting Corporation News (2020b) |

Table 8. Planning risk responses.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Risk category (a)** | **Risk number****(b)** | **Associated risk (c)** | **Assessed risks (g)** | **Priority (h)** | **Risk response****(i)** | **Response strategy****(k)** | **References** |
| Societal | 7 | Contracting COVID-19 | 4 | 19 | Mitigate | Apply frequent, deeper cleaning and sanitization in airports and on aircraft; conduct health screening, including self-declarations and temperature screening | Dube et al. (2021) and Project Management Institute (2020) |
| Technological | 17 | Physical contact | 16 | 18 | Mitigate | Implement more contactless and self-service processes and physical distancing in airports and on aircraft when possible | Dube et al. (2021), BBC News (2020b), and A21mx (2020) |

**5. Discussion**

This paper’s objective was to propose a risk management framework based on the PMI risk management knowledge area in order to minimize risk environments and identify repurposing operations in commercial aviation. The following steps were taken to achieve this objective:

1. Repurposing and risk management methodologies that are applicable to commercial aviation were identified through a literature review to minimize risk environments’ impact.

The results of the first step suggest that our proposal not only allows for the identification of repurposing areas but also highlights weaker, overlooked areas in commercial aviation. Identifying and improving these areas would help decrease the impact of risk environments such as pandemics.

Moreover, this study’s proposal has shown that, during the early stages, identifying key stakeholders, defining the relationships between the affected sector and other sectors, identifying risks and lessons learned from past events, and categorizing risks are important. Risk assessment and prioritization allow for the development of strategies that minimize a disruptive event’s impact. This proposal, unlike that of Hong et al. (2022), emphasizes the importance of considering previous historical events or lessons learned when generating strategies for new risk situations.

1. The risk management framework was adapted for COVID-19 to identify repurposing operations.

The study’s risk analysis revealed a few areas where repurposing operations apply to commercial aviation. Strategic responses should consider the material and human resources, costs, barriers (increased demand, financial burdens, time, safety, and regulatory concerns), and constraints (strategical, cultural, technological, and innovation-related limitations) to quickly respond to market demands (Okorie et al. 2020; Poduval et al. 2021).

1. A risk management framework was proposed to identify strategies to apply during the different phases of future commercial aviation emergencies.

The recommendation of Belhaddi et al. (2021) to define joint actions for two sectors (airports and flights) reinforces the current work’s proposal to perform risk management jointly with all sectors related to commercial aviation. Additionally, collaboration and coordination with other subgroups and the wider industry are important. If commercial aviation authorities define sanitary protocols but other transit groups that access airport areas—such as cabs, buses, or subway authorities—lack established sanitary protocols, the safety of passengers, and transit users generally, will be affected since they could become infected when accessing transit (Nugraha and Amalia 2021).

Communication is imperative; disagreement with decisions adopted by each country and even each airline causes confusion among travelers (Bielecki et al. 2021; Sun et al. 2021). Moreover, actions that support the recovery of air mobility depend on the implementation of coordinated, standardized measures between countries (Herrera 2021).

Risks related to passenger sanitation habits require cultural changes to understand efforts that improve cleanliness, quarantines, mask use, vaccinations, case-tracking software, and maintaining a healthy distance. These practices have worked in cases such as Singapore’s SARS response (Sharratt 2020).

Importantly, the actions proposed to address risks focused on maintaining business continuity. The risk management framework also promotes cooperation among supply chain actors, which is necessary to overcome pandemic-related challenges. Sriyanto et al. (2021) concur, emphasizing supply chains’ continuity to minimize COVID-19 cases. Commercial aviation should adopt a more proactive and systemic risk management system.

The current study’s risk management proposal based on the PMI is open; the activities performed during each process can be scaled in relation to the size of the risk environment. This proposal can be complemented by the risk analysis proposed by Fan and Stevenson (2018) or the work of Kim et al. (2022), which are very detailed and can be applied to any company. The work of Kim et al. (2020), divides risks into four categories: anticipated, emerging, amplified, and lingering. The current work’s proposal divides risks into categories defined by a crisis committee. Additionally, this work’s proposed risk management framework seeks to define prevention actions that can be carried out periodically. These efforts will help inform the population about possible future impacts and how they should act.

**6. Conclusions**

The COVID-19 pandemic disrupted the globalized world. The transmission of new variants continues despite measures imposed across all sectors and at the local, national, and global levels. As the pandemic continues, companies must identify areas for repurposing operations so that they can quickly respond to the demand for essential and non-essential products.

This study’s literature review identified risk management methodologies applicable to commercial aviation and allowed for the identification of barriers and constraints to repurposing operations. The proposed risk management framework was based on the PMI (2013, 2021), and it will help identify whether a risk environment is local, national, or global. Additionally, it allows for a reflection on involved sectors—in this study’s case, commercial aviation. The framework recommends the creation of risk committees to jointly coordinate and follow up on risks (involving all sectors and levels). This measure will allow for the generation of global strategies and avoid contradictory actions. The proposal also allows for the identification of areas where repurposing operations can be applied. Such operations require sufficient space and financial capacity to meet demand and regulatory requirements (regulatory and safety concerns) while training individuals to support repurposing.

The information gathered in this study shows that the actions taken by governments and industries have focused more on one of the five risk criteria. Accordingly, in-depth assessments were suggested to achieve a better balance. For example, flight cancellations generated environmental benefits (a reduction in CO2 emissions) but negatively affected economic and social aspects (a loss of income and jobs).

This work also demonstrated that identifying and documenting lessons learned is a key element of improving the management of risk situations such as the COVID-19 pandemic. Concerningly, the lessons learned from previous pandemics (updating documents, policies, standards, strategies, etc.) show that the same points should be addressed, which could mean that the actions taken so far have been ineffective. Finally, the proposed framework covers actions to be taken before, during, and after a risk environment.

This research has highlighted the following insights:

* The proposed framework will help authorities, stakeholders, crisis committees, and experts involved in commercial aviation to identify, assess, and define preventive actions in a risk environment.
* Commercial aviation representatives could use the framework to improve communication, involve stakeholders, and balance response strategies in the defined risk categories.
* This framework will help commercial aviation representatives identify repurposing operation areas.
* This research has recommended actions to minimize risks to society and supply chains.

Moreover, the following theoretical contributions have been presented:

* This study contributes to risk management and decision-making in commercial aviation.
* Governments, industries, and researchers can use the proposed framework to assess the risks they face.
* This study has also proposed some activities for improving the risk management process before, during, and after a risk environment.

This study’s limitations and recommendations concern its methodology. This work was conceptual and generic, a product of our experiences in project management using the PMI methodology. Therefore, empirical validation through a case study involving all sectors related to commercial aviation during a risk environment is needed. Finally, this work did not include a quantitative risk analysis since this analysis would require access to classified information.

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