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Civil Aviation Approach to Safety Risk Management: A New Perspective on a Mature Process

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ABSTRACT

This literature review aims at reflecting on current issues about how Civil Aviation Industry manages the notion of Risk. In face of recent indisputable challenges, such as COVID-19 Pandemic, geopolitical and energy crisis as well as unpredictable markets, but also chronically experienced volatility, uncertainty, complexity and ambiguity, as the main characteristics of the aviation operational environment (VUCA World), Aviation industry has to accept that this is the norm and consequently, do more. We suggest the adoption of the *S*ustainability-*E*thics-*R*esilience, *SER*, aviation specific, overarching approach for managing Safety Risk, as an evolution of the generalized business model of *ESG*, and we provide reasons and solutions for that, based on evidence from the academic and the operational world. A systematic, five-step research method process for literature review has been used. We have taken into consideration article publication year 2017 onwards, and some classical ones from earlier on, using credible academic databases, complemented by statistical data, data on contemporary approach to safety risk management, as well as other aviation related data from aviation dedicated sites and official websites of multiple aviation key stakeholders.

1. Introduction

We face risk every day in our lives. From crossing the road, to open a new business, to launch a mission to the moon, either implicitly or explicitly, we count and assess the possibilities and consequences of adverse outcomes. This process is inherent to human nature and as individuals we are more or less risk averse (Rohrmann, 1998).

Safety critical industries, such as the aviation industry, health care, nuclear operations, food industry, to name a few, have managed to operate and be reliable in a great extent due to the fact that they have developed and implemented safety management systems, as standalone management systems or components of integrated management systems (IMS) with hazard identification and risk management as integral parts (Reason, 1998; Lee, 2006; Yilmaz, 2014; Flight Safety Foundation, 2022).

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With regards to Aviation industry, and especially civil aviation activities, it is rather uncontested that air transport is the safest mode of transportation in a global scale and this has not come easily (Flight Safety Foundation, 2022). Five-year moving average of fatal accidents has been trending steadily downward since early 1990s (Figure 1). Fatal accidents are a widely used and understood measure of aviation safety performance. But, because there are few fatal accidents relative to the number of flight operations per year, it is necessary to examine a broader array of data to get an accurate picture of risk, to identify emerging or extant risk areas, and to compare risk across different sectors (European Union Aviation Safety Agency, 2022).

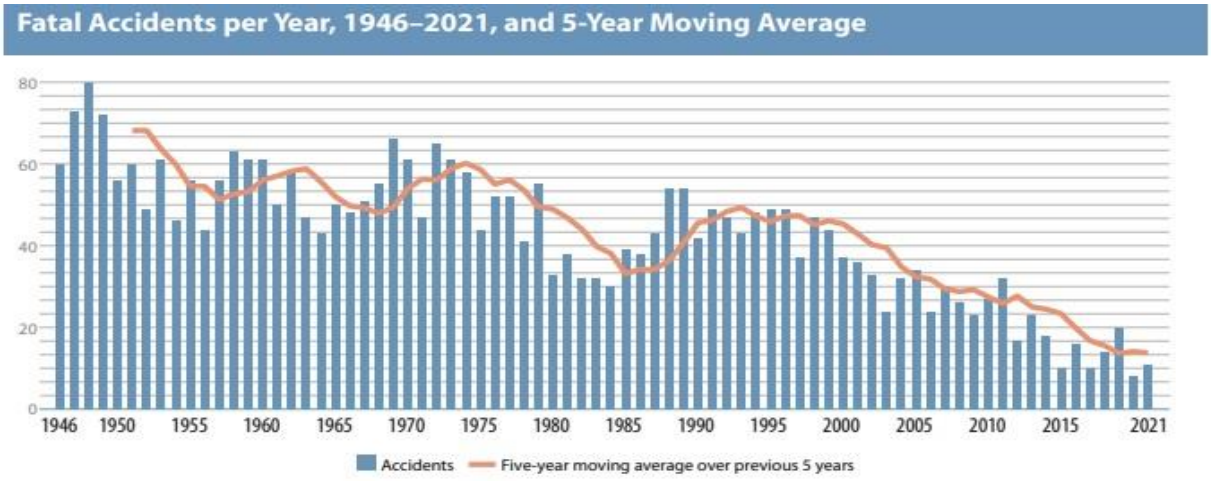

Figure 1. Useful Data Analytics on current state and trends in Civil Aviation Safety. FSF, 2022

Aviation industry, from aircraft manufacturers to providers of air traffic services, to airlines, to regulators, just to name a few of the involved stakeholders, operate more or less in a VUCA World, an environment of high volatility, uncertainty, complexity, and ambiguity (VUCA World Organization, 2022). Some of them, especially aircraft operators, experience the most of it, and recent situation with COVID-19 Pandemic and war in Ukraine has shown once more, after 9/11, that transport by air is extremely sensitive to external factors, other than purely technical, functional, or operational (European Union Aviation Safety Agency, 2022).

But how is it to operate in a VUCA World? According to VUCA World Organization, 2022, we experience volatility when the world is changing fast, becoming more and more unstable and unpredictable. Changes happen faster and faster and are more dramatic each time, causality being very difficult to be determined. As a result, it's becoming hard to predict or even anticipate events and historical data lose their relevance. Future is almost unknown, so planning for investment, development and growth is increasingly uncertain.

Complexity is present in current world due to technological advancements, plethora of interdependencies, interfaces and interactions between humans-machines-equipment-systems, and number of stakeholders involved. There are many and different layers that making it almost impossible to really understand how things are related. As a consequence, decisions are trapped in a futile cycle of reaction and counter-reaction, making hard not only to take the right one, but to be pro-active and acquire self-efficacy.

All of the above, compel ambiguity as an integral characteristic of the operational context and bring approaches such as 'one size fits all' and 'best practices' to an armlock. Grey is the new black & white, imposing demands on modern organizations and their management that are more contradictory and paradoxical than ever, provoking value systems, bringing 'why' and 'how' on the front seat, rendering decision making to be courageous, well informed,

challenging to status quo, willing to take responsibility and making mistakes (VUCA World Organization 2022).

On the other hand, the business model of *ESG* (Environmental, Social and corporate Governance) gained popularity in 2004 as a result of a long-standing discourse about the incorporation of environmental and social challenges into day-to-day business decision making. The doctrine of ESG is that the 'triple bottom line', referring to economic, environmental and social factors, must be included in the new calculation of a company's or equity's value.

The E represents the environmental criteria and incudes the energy balance of an organization, the resources in need, and the consequences on living beings. Not least, E encompasses carbon emissions and climate change. Every company uses energy and resources; every company affects, and is affected by, the environment (ESG Today, 2022; McKinsey & Company, 2022).

S, social criteria, addresses an organization's internal and external relationships as well as its reputation in the community. S includes labor relations, diversity and inclusion. Every company operates within a broader, diverse society and its footprint has to be clear and concise (ESG Today, 2022; McKinsey & Company, 2022).

G, for governance, is the internal system of practices, controls, and procedures an organization adopts in order to govern itself, make effective decisions, comply with the law, and meet the needs of external stakeholders. Every company, which is itself a legal creation, requires governance (ESG Today, 2022; McKinsey & Company, 2022).

Some critics of the *ESG* framework deal with the inclusion or not of intangible factors relating to sustainability and ethics into the equation, the movement of 'greenwashing' and the possibility that there will be no impact at all on the cost of capital for polluting enterprises. On the other hand, many scholars and industry people asserting that *ESG* is now more than ever essential and relevant, accounting for the cumulative geopolitical, economic and societal impact of recent tragedies such as Russia's invasion to Ukraine and the Pandemic (Cornell & Damodaran, 2020; ESG Today, 2022; McKinsey & Company 2022).

The objectives of the present review are:

- To reflect on current trends and future challenges with regards to notions of Safety and Risk within the aviation ecosystem,
- To propose the transposition of business *ESG* model into aviation specific *SER* Model, as a decision-making tool, for both strategic and tactical levels, for assisting relevant aviation stakeholders operate into a VUCA World,
- To evaluate the introduction and adoption, in an appropriate and integrated manner, of this new tool into the operational Aviation Safety Risk Management process in order to be used effectively by all relevant stakeholders.

2. Materials and Methods

We have followed a 5-Step procedure to review related articles from contemporary literature, year 2017 onwards, and some classical ones from earlier on, using credible academic databases, complemented by statistical data provided from aviation dedicated sites and data on contemporary approach to safety risk management (Table 1). We, also, have collected data and information on current civil aviation issues from official websites of aviation organizations such as ICAO, EASA, EUROCONTROL, FAA, and aviation businesses such as airlines, air traffic services providers, airport operators etc.

We have used this method in previous common projects and we have gain familiarity and trust in it.

Table 1.
A Five – Step Research Method Process for Literature Review. Adopted from Tornjanski, V., et al., EBT 2021

PROCESS STEPS	SYSTEMATIC LITERATURE REVIEW PROCESS	
	STEP DEFINITION	**STEP ELABORATION**
STEP 1	Research criteria clarification	Only relevant sources taken into consideration
STEP 2	Literature search	Scopus, Semantic Scholar, Research Gate, Google Scholar, Academia.edu data from official websites of credible civil aviation organizations
STEP 3	Literature filtering	Manual screening of relevant articles and content
STEP 4	Selected articles analysis	Content evaluation and selection
STEP 5	Illustration of key research results and implications	Data analytics and statistical representation

3. Results

Among the five Strategic Objectives of International Civil Aviation Organization, aka ICAO, Aviation Safety is the first and foremost. This is depicted in the Global Aviation Safety Plan (GASP) and the fact that all 193 participating states are currently working toward their agreed global safety target of zero fatalities by 2030. Alongside, they work on strengthening their regulatory capacities, while pursuing a range of programs and targets relevant to current core areas of global aviation safety planning, oversight, and risk mitigation (International Civil Aviation Organization-ICAO, 2022).

But what really is Safety and what is the role of Risk within the Safety concept?

According to ICAO's Annex 19, Safety Management, ICAO 2016, Safety is 'The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level'. It is evident that the notion of Risk is embedded in the definition of Safety. In ICAO's Document 9859, Safety Management Manual, ICAO 2018, we also find a definition of Risk Mitigation as 'The process of incorporating defenses, preventive controls or recovery measures to lower the severity and/or likelihood of a hazard's projected consequence'. Here comes into play the notion of Hazard which is defined in the same document as 'A condition or an object with the potential to cause or contribute to an aircraft incident or accident'. So, we can at once understand that the notions of Safety, Risk and Hazard are mutually reliant.

But then, how exactly we define Safety? Is zero accidents or serious incidents? Is error avoidance or minimization? Is plain regulatory compliance? Is freedom from hazards or risks? Is the condition where as little as possible go wrong? Or Is the condition where as much as possible go right?

The vast majority of aviation organizations approach safety in the classical way of minimizing risk As Low As Reasonably Practicable (ALARP), defining Risk as 'the predicted probability and severity of the consequences or outcomes of a hazard'. Contemporary approach to Safety Risk Management in Aviation Industry includes the stages of Hazard Identification, Safety Risk Assessment, Safety Risk Mitigation and Risk Acceptance (International Civil Aviation

Organization, 2018). This approach is a continuous one because of the VUCA World in which aviation organizations operate (Shyur, 2008) (Figure 2).

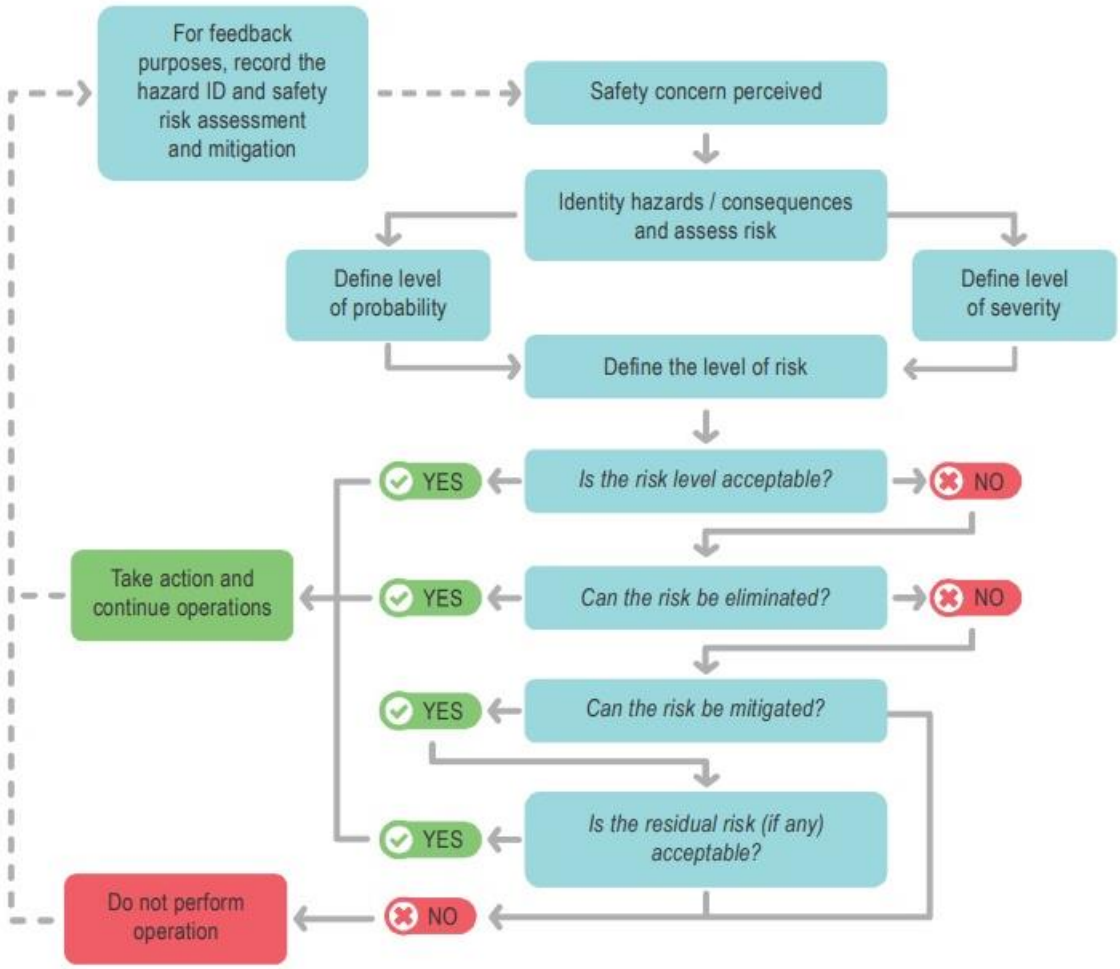

Figure 2. Safety Risk Management Decision Aid, ICAO, SMM, 2018

Let us take the example of COVID-19 pandemic which introduced a great risk in aviation ecosystem and has significantly reduced global air travel in the past two years, with the trend continuing up to now. Lacking statistics for the whole 2022 yet, data coming from the International Air Transport Association (IATA) indicate that total international scheduled passenger traffic through the first 11 months of 2021 was down about 60 % from the same period in pre-pandemic 2019. Cargo traffic during the same 2021 period, on the other hand, was up by more than 6.5 % from 2019. It is important to note that these traffic statistics are for scheduled airline operations only, and do not consider unscheduled commercial operations. Scheduled operations, however, do comprise the majority of commercial flights in a given year. Therefore, these statistics are a good barometer for traffic activity and demand. The International Civil Aviation Organization estimated, in mid-January, that the number of passengers carried worldwide in 2021 was 2.3 billion, which is 49 % below pre-pandemic 2019 levels, but an improvement compared to the 60 % decline seen in 2020 (Flight Safety Foundation, 2022). A consolidated view of the above-mentioned numbers is depicted schematically in the following figure, Figure 3, which shows the capacity in ICAO Regions, in terms of ASK, Available Seat-Kilometers.

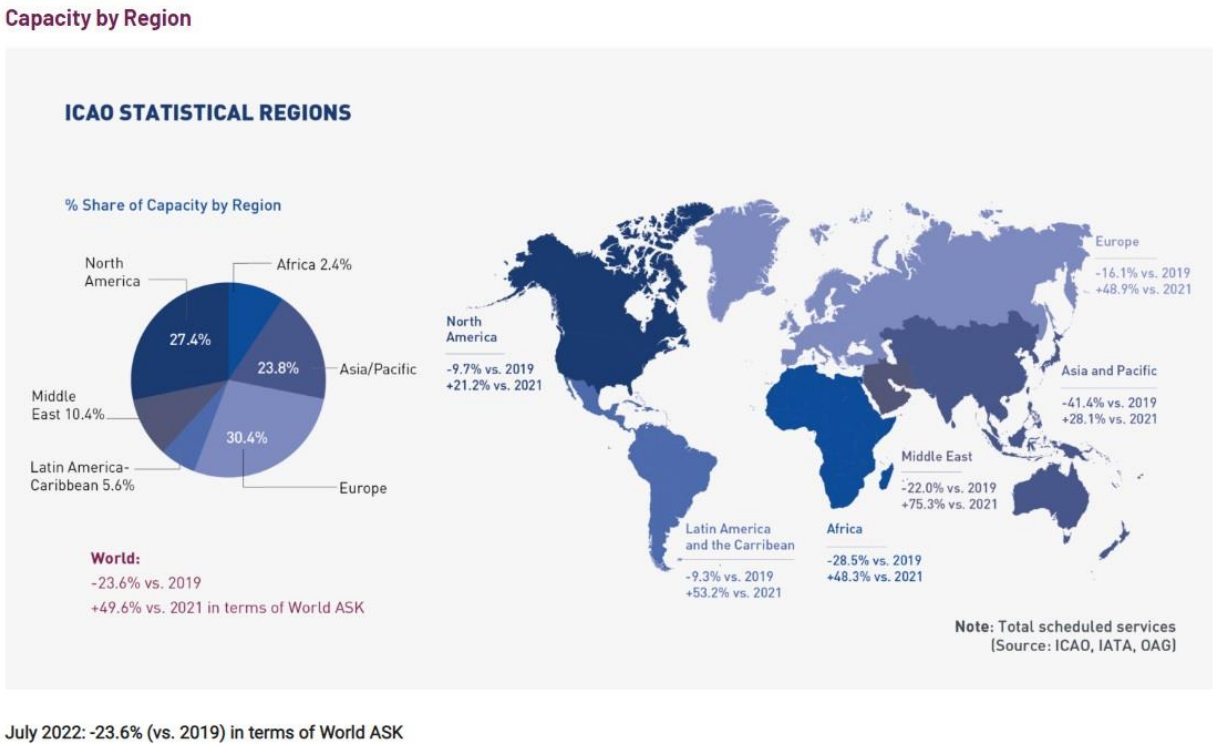

Figure 3. Capacity by ASK in ICAO's Regions. Source: unitingaviation.com, 2022

The antidote to operate in such a VUCA World demands Vision, Understanding, Clarity and Agility (VUCA World Organization, 2022). Aviation organizations need to take actions and induce changes that have clear orientation and objectives. Management of risk is one of these processes, along with occurrence reporting & analysis, that aims directly to improve safety but, nowadays, safety gains without organizational prosperity, including of a financial nature, and positive social impact, is of reduced importance.

Awareness and understanding not only on individual but also on organizational level, considering different stakeholders, views and perspectives and creating open communication channels can fight disorientation. Gaining clarity is essential for breaking down complexity and bring responsiveness, flexibility and creativity into the system. Last, but not least, the mainstream concept of agility is a real solution for managing projects and taking decisions within a rapid changing world, fostering innovation and a sense of confidence in abilities both at individual and organizational level (Stanford & Homan, 1999; Shyur, 2008; Hadjimichael, 2009; Ning et al., 2012; Suhir, 2014; Cioaca et al., 2015; Tulechki, 2015; Yousefi, 2022).

Let us first take the example of aviation organizations which use data for predictions, such as Eurocontrol. In order to make reliable forecasts for future traffic demands and exploit them to achieve better network performance, Eurocontrol provides low-medium & high impact scenarios, using AI techniques and better understanding of the air traffic dynamics key patterns. So far, accuracy of forecasts has made small, constant improvements (Eurocontrol, 2022). For the forecasts to be more pragmatic and to fight volatility and uncertainty, there is a need for wider prognostic period, considering robustness of used economic models and methods and considering, also, disrupting situations of long duration and their impact on aviation ecosystem (Eurocontrol, 2022).

An obvious example of complexity comprises the so called NextGen, Next Generation Air Transportation System, of the Federal Aviation Administration (FAA). It is an ongoing remodeling project of the United States National Airspace System (NAS) recognized as one of the most ambitious infrastructure projects in U.S history and it is about the modernization of

the busiest and most complex national airspace system. Within its scope are airport infrastructure improvements, new air traffic management technologies and procedures, and environmental, safety, and security-related enhancements. It is estimated to be completed in 2030 and when in operation it will enable more flexible, robust and resilient aerospace infrastructure, meeting projected demand and support the administration's goals. These goals include improvements in the safety of flight paths, ensuring safe introduction of new users into aviation, such as commercial space and advanced air mobility, reducing harmful emissions, improving aviation operational efficiency, accelerating the adoption of innovation and new technologies. In order to reduce complexity, NextGen is a series of interlinked programs, portfolios, systems, policies, and procedures which introduce clarity into the system. (Song, 2020; Federal Aviation Administration, 2022).

One last example of fighting inherent ambiguity is the implementation of the project of Functional Airspace Blocks, within Single European Sky overarching framework. The concept, which is a legal requirement, mandates that functional airspace blocks must be established, regardless of State boundaries, 'where the provision of air navigation services and related functions are performance-driven and optimized with a view to introducing, in each functional airspace block, enhanced cooperation among air navigation service providers or, where appropriate, an integrated provider' (Skybrary Aero, 2022). Nevertheless, the project is far behind schedule, facing real difficulties due to interoperability issues, as well as financial, operational and administrative discrepancies between different stakeholders, making the 'one size fits all' solution almost impossible (Pourdehnad & Smith, 2012; Paries, 2019).

4. Discussion

We propose a new overarching approach to aviation safety risk management, taking into consideration not only factors from inside the industry, but also factors emerging from real macro-analysis of the operational context of aviation organizations. Sustainability, with its social-economic-environmental constituents, substitutes for the Environmental, E, component of *ESG* model; Ethics substitutes for the Social, S, component of *ESG* model; and Resilience substitutes for the Governance, G, component of *ESG*. The overall purpose is to ensure that when things are normal, but even after major disruptions, civil aviation ecosystem, with its systems, sub-systems, and constituents, is able to recover safely, timely and efficiently, accounting for business continuity and economic viability, as well as for environmental awareness and protection, along with proven ethical conduct towards individuals and the community, increasing the added value of the industry (Figure 4).

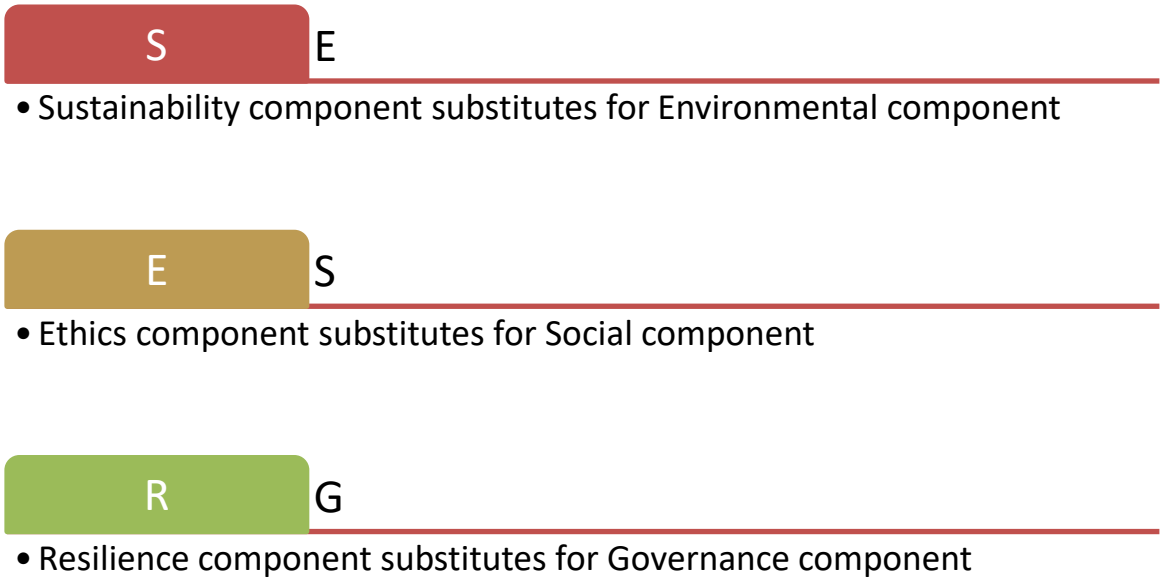

Figure 4. SER Concept in Civil Aviation after transposition of ESG business model

Let's take a closer look on each of the concepts of the proposed *SER* framework in Aviation as a robust approach to the aforementioned challenges.

When we talk about sustainability, we have to bear in mind that the concept is multidimensional. The environmental dimension has attracted focus and has also been used interchangeably but, there is also the economic and social dimension of the concept that are equal partners (Sharma & Singh 2017; McKinsey & Company, 2022).

When we bring the matter of sustainable aviation organizations, this has to take into consideration the full essence of the concept. Primary issues, along with their interdependencies, interactions, interfaces, solutions, must be put on the table. Such issues include, but not limited to: 1. On the side of Environmental Sustainability: climate change/crisis, environmental CO2 and non-CO2 pollution/emissions, local air quality, sustainable aviation fuel introduction and usage, noise reduction, new aircraft technologies, preservation of wildlife, mild environmental development, resources management, waste management, performance-based navigation, efficient operational procedures (CCO, CDO, Runway allocation, Free Route Airspace, use of optimum altitude/speed) 2. On the side of Social Sustainability: users/customers satisfaction and protection, users' consultation, stakeholder management, community interaction/impact, management of energy crisis, employee satisfaction/engagement/retention, talent acquisition and management, awareness of power of difference (inclusion), respect for diversity and human rights, labor relations and, 3. On the side of Economic Sustainability: profitability, revenue margin, cost efficiency, ROI, market/competitors analysis, liabilities (Karaman et al., 2018; Elhmoud & Kutty 2020; International Civil Aviation Organization, 2022) (Figure 5).

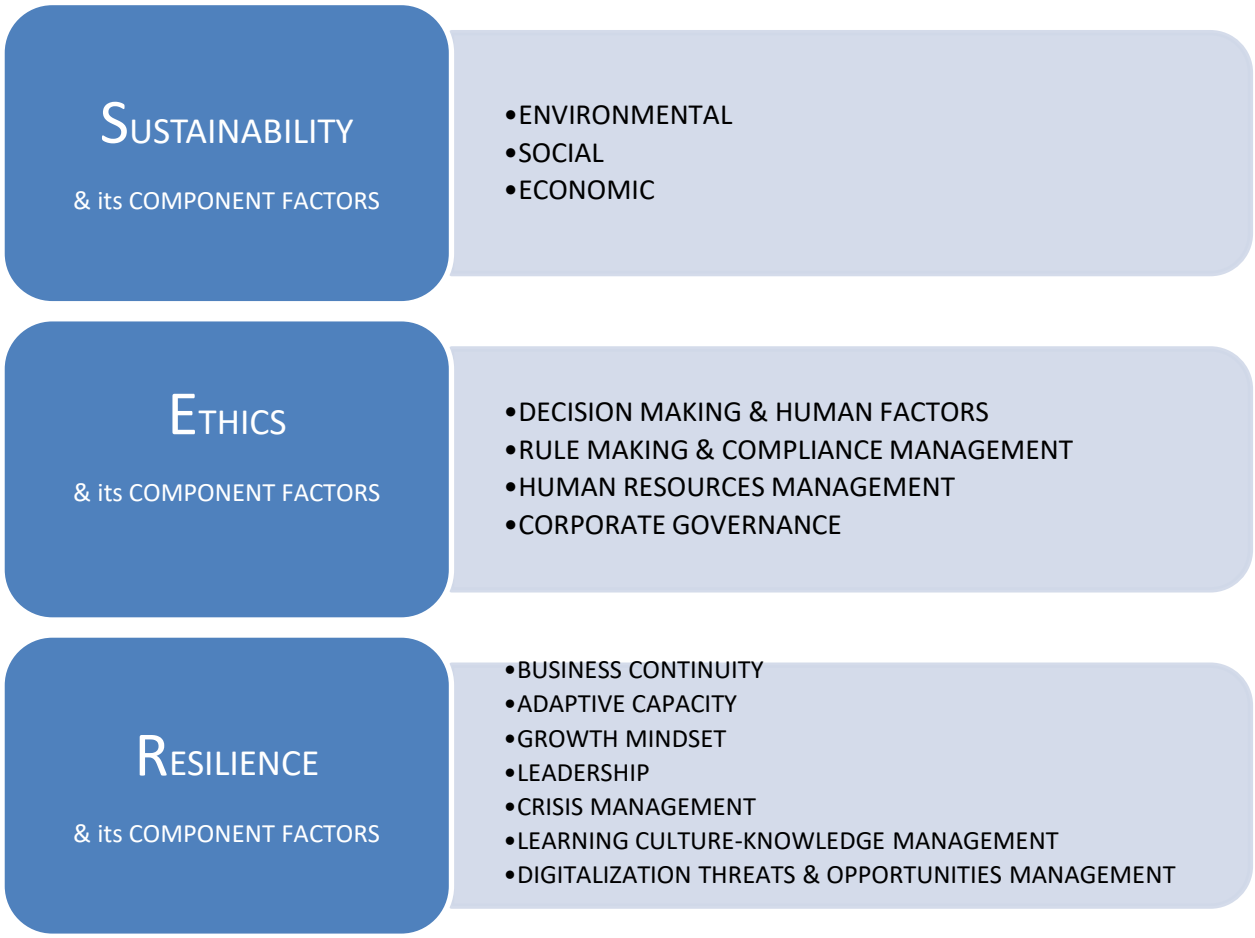

Figure 5. SER Concept and its components in Civil Aviation Air Transport Sector

It is more than evident that if aviation industry is to achieve the net zero targets by 2050, and also remain on the sustainable side of social and economic realms, sharing of knowledge is crucial as well as the strong belief that in order to be up to date on environmental and social issues is in the real interest of the whole industry (Elhmoud & Kutty, 2020). According to latest European Aviation Environmental Report, ‹‹The long-term future of the aviation sector will depend on the success of this effort…. as European citizens are becoming increasingly aware of the affect that aviation activities have on their quality of life through climate change, noise and air quality, and many are prepared to act on these concerns›› (European Union Aviation Safety Agency, 2022).

Aviation Ethics includes a broad area of issues such as ethics in decision making, compliance management, human resources management, corporate governance. Concepts of professionalism, responsibility, accountability, integrity, inclusion, trust, honesty, fairness, confidentiality, privacy, respect for others, psychological safety, freedom, health & safety issues, duty of care, and healthy organizational culture need to be defined accordingly within the specific aviation ecosystem (Benton, 1995; Oderman, 2003; Ravinder, 2006; Cahill et al., 2020b, Dekker, 2018; Molina & Campos, 2018; Schiff & Silva, 2021).

According to McKinsey & Company, Resilience should be seen as the ability to deal with adversity, withstand shocks, and constantly adapt and accelerate as disruptions and crises arise over time (McKinsey & Company, 2022). The notion of Resilience in aviation has been one of the mainstream concepts that have attracted the attention of academics and regulators. It’s not an easy one to grasp and its multifaceted. Business continuity during disruptions of increasing frequency and severity, such as terrorist attacks, wars, pandemics; digitalization with its

benefits, such as AI & big data utilization for operational improvements and its ramifications, such as cyber-security threats & tech-debt; the notion of innovation, creativity, adaptability and leadership as critical enablers for network performance and environmental gains; financial and operational robustness, crisis management, collaboration and co-creation among the plethora of different aviation stakeholders, both in private and public sectors, and the notion of flexibility and agility for complex projects such the European Single European Sky, are indispensable aspects of the concept of resilience (Cioaca & Boscoianu, 2011; Resilience Engineering Association, 2014; Akselsson et al., 2016; International Civil Aviation Organization, 2019; Gossling, 2020; Flight Safety Foundation, 2022).

Professor Hollnagel has recognized four capabilities, namely the Knowing What To Do, What to Work For, What To Expect and What Has Happened, as essential system capabilities in order to respond correctly, timely and efficiently to regular and irregular disruptions by adjustments to normal functioning; in order to be able to monitor operational performance and conditions escalating to threats in the short term; in order to anticipate future events and their implications, and in order to develop the ability to learn from experience, respectively (Hollnagel, 2018). What is important to understand is that truly resilient organizations bounce back better and even thrive (McKinsey & Company, 2022).

Much of COVID-19 Pandemic crisis consequences in aviation industry can be interpreted as an underestimation of risks. Risks not only within the operational context of organizations but also the financial one (International Federation of Air Traffic Controllers Association, 2022). Therefore, the incorporation of the *SER* Concept provides solid grounds on which aviation related stakeholders can build their safety risk management and fight a great deal of the discrepancies exist in a VUCA World. Risk in aviation industry need not be taken only as an *a priori* negative contributor; embracing a *SER* framework for safety risk management leverages challenging situations, giving opportunities to outperform even under disruptions, keeping Safety Performance Indicators untouchable. Today's arduous environment requires leadership in three critical areas: insights, commitment and execution and as the late Brazilian car-racing champion Ayrton Senna once said: ‹‹You cannot overtake 15 cars in sunny weather, but you can when it's raining››. (McKinsey & Company, 2022). On the pragmatic side, engine-makers aiming to power more than 30.000 new single-aisle airliners that the two major aircraft manufacturers forecast will be delivered over the next two decades; that's complicated or challenging? Maybe both (Aviation Week, 2022).

This approach is not to be taken as a hard, technocratic one; now is time to accept the fact that safety aviation risk must be maintained 'as low as reasonably practicable' and this term essentially means weighing the risk against both adverse consequences and benefits but also against time, money, people and other resources necessary to control it. This is endorsed by International Civil Aviation Organization, as Economic Development is among its five Key Strategic Objectives, and in the references of the Safety Management Manual is written that ‹‹The need to balance profitability and safety (or production and protection) has become a readily understood and accepted requirement from a service provider perspective››.

This balance is equally applicable to the State's management of safety, given the requirement ‹‹to balance resources required for State protective functions that include certification and surveillance›› (International Civil Aviation Organization, 2018; Insua et al., 2018). *SER* Model builds on previous suggested frameworks, with which can work synergistically, such as the Aviation Integrated Modelling project by Reynolds et al., 2017, which focuses on creating a policy evaluation capability for enabling comprehensive analysis of aviation, environment, and economic interactions at local and global levels. Aviation industry has to reinvent itself and its

available policies, strategies, processes, and tools can be used as enablers for sustainable, resilient, and ethical future worldwide aviation system growth.

5. Conclusions

To conclude with, what we understand is that relevant elements and aspects of aviation ecosystem, from outside and within, people-economics-environment-ethics-resilience, must be integrated to provide the assurance that aviation is, and will continue to be, an environmentally friendly, social conscious, financially robust, moral aware, safe and resilient industry in a world that is getting more and more disturbed and demanding (European Union Aviation Safety Agency, 2022; International Civil Aviation Organization, 2022).

Dealing with contemporary demands and challenges, Aviation Safety Risk Management has to incorporate all relevant stakeholders in the analysis, assessment and follow-up of Risk. Regardless of the nature of organization, and taking into consideration current applicable legislative requirements, not only dedicated teams that deal with each safety assessment *per se* but also recognized relevant stakeholders, from front line operators to all levels of management, to senior decision makers, to regulators, have to be aware of, well informed, collaborate with and contribute to the evaluation of risk, so as for results to depict, as much as possible, an accurate view of the situation in hand.

In order for that to be achieved in a complex socio-technical system, such as aviation industry, there is a need for a new structured approach to safety management, and especially safety risk management process, which is at the epicenter and an integral part of safety concept. This structured approach entails a strategic vision for the whole organization, with clear responsibilities and commitments towards its people, its financial prosperity, its operational excellence, the community, and the environment. We assume that *SER* Concept provides a solid framework for relevant stakeholders not only to support a robust risk evaluation but also to help aviation organizations circumnavigate the challenges in a VUCA World.

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