THE FUTURE OF DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

TREND REPORT 2023

THE FUTURE OF DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

AVIATAR

Lufthansa Technik

Kindly supported by Aviatar and Lufthansa Technik

Aviation is a catalyst for connecting cultures and driving economic advancement. At Lufthansa Technik, we're not only leading the market for maintenance, repair and overhaul services but we are on a mission to lead aviation towards a more sustainable future. Our philosophy centers on repairing and reusing, innovating fuel-efficient aircraft modifications and optimizing operations with digital solutions.

With our "digital corporate startup" AVIATAR, we develop engineering- and data-driven software solutions to streamline technical airline operations. We constantly strive to develop new applications and to test how software can make our industry more efficient, ultimately reducing the environmental impact.

Our partnership with CDTM during the 2023 Trend Seminar was one of AVIATAR's supported initiatives. We're excited to jointly introduce this format to Valencia for the first time, opening offices in the city as we grow together with its tech ecosystem.

CDTM

A project of the Center for Digital Technology and Management (CDTM)

The Center for Digital Technology and Management (CDTM) offers the interdisciplinary add-on study program "Technology Management". Students from various study backgrounds with creative ideas, great motivation and an entrepreneurial mindset are offered the tools to put their ideas into practice. As a research institution, CDTM closely cooperates with the industry, start-ups and public sector concentrating on topics at the intersection of technology, innovation, and entrepreneurship.

The Center for Digital Technology and Management (CDTM) is supported by Universitat de Valencia (UV) and Universitat Politècnica de Valencia (UPV).

The entire trend report was written by CDTM students under the close guidance of CDTM´s Management Team.

Visit www.cdtm.de for more information.

Trend   Scenario   Ideation

PREFACE OF THE EDITORS

As Herman Kahn, one of the founding fathers of modern scenario planning, nicely states, it is tremendously important for strategy and policymakers to get a deep understanding of possible future developments to be prepared for them.

The Center for Digital Technology and Management (CDTM) aims to connect, educate and empower the innovators of tomorrow. It is our mission to equip our students with the tools and knowledge they will need to become responsible leaders who actively shape their future environment rather than only react to changes.

This Trend Report is the result of the course Trend Seminar, which is part of the interdisciplinary add-on study program "Technology Management" at CDTM. About 16 selected students of various disciplines, such as Business Intelligence, Architecture, Computer Science, Electrical Engineering, Law, Biotechnology and others, work together on a relevant topic of our time. Over the course of six intense weeks of full-time work during their semester break, the participating students dive deeply into the topic of the Trend Seminar. Working in several interdisciplinary sub-teams, students apply the knowledge of their main studies and learn new perspectives from their team members. They conduct trend research, develop scenarios of the future, generate ideas for innovative products or services, and detail them out into concrete business concepts.

We would like to take the chance to thank everyone who contributed and made this CDTM Trend Report possible:

We want to thank Lufthansa Technik AVIATAR for supporting this Trend Seminar. Particularly, we want to thank Felix Adam for his collaboration, valuable insights, and feedback throughout the whole project. We hope our findings support

> **" Everybody can learn from the past. Today it is important to learn from the future! "**
>
> Herman Kahn

you in driving innovation in the context of digital solutions for a sustainable aviation industry!

In addition, we very much thank all our lecturers, who shared their knowledge and largely contributed to this project's success:

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Last but not least, we would like to thank the CDTM students of the class of Valencia 2023. They put great energy and enthusiasm into this project, which made it a pleasure for us to supervise the course and coach the individual teams.

Alicia Durán González, Carla Pregel Hoderlein and Ferran Pla Cardona

Center for Digital Technology and Management (CDTM)

PREFACE OF THE PROJECT PARTNER

> **We are on a mission to lead aviation towards a more sustainable future.**
>
> *Felix Adam*

Aviation is not just a mode of transportation; it's a cornerstone of connecting cultures and economic progress. Now we want to lead it into a sustainable future. At Lufthansa Technik, we understand aircraft like no other and have become one of the leading maintenance, repair & overhaul providers of the industry. We believe in repairing and reusing instead of replacing. We stick sharkskin foil to fuselages. We wash engines on-wing. We construct ceiling panels with renewable flax fibers. And we believe that the future of aviation must be deeply intertwined with digital solutions that not only enhance technical efficiency of aircraft but also champion sustainability.

In this pursuit, Lufthansa Technik has founded AVIATAR in 2017. As digital corporate startup, we develop data-driven sofware solutions that leverage decades of engineering know-how to streamline technical airline operations. With applications like predictive maintenance and fuel analytics, we are already making strides towards more resource-efficient industry.

So, how can software make air(line) operations more sustainable?

This study serves as compass, navigating us through the intricacies of this multifaceted challenge. Its focus is sharpened by centering on the B2B dimension, magnifying the 'E' in ESG (Environmental, Social, and Governance), and examining the operational phase of aviation – a pivotal stage often overlooked in favor of aircraft design.

As we believe that the bedrock of sustainability is anchored in unity, the study extends AVIATAR's home turf of technical operations into its neighboring sectors along the value chain: flight and ground operations. Thus, the trend report explores how we are entering an era where the industry, together with all of its stakeholders (airports, maintenance providers, flight planners, …) might grow closer together while data and software are building the bridges.

The trajectory we chart today will influence aviation's environmental footprint for the next decade, and intelligent, forward-thinking minds will be the architects of this transformation. Our gratitude extends to the participants who have illuminated this journey: To the goal-driven students whose creative ideas have invigorated the study. To the various interview partners, from pilots to ESG strategists and airport managers, whose insights have been invaluable.

And lastly, a heartfelt thanks to the dedicated management team at CDTM. We are especially thrilled to pioneer the migration of this impactful format to Valencia for the first time, while establishing offices in the city and together growing with its tech ecosystem.

Felix Adam

Lufthansa Technik, Hamburg & Valencia

TABLE OF CONTENTS

METHODOLOGY

For a given topic that is highly impacted by digital technologies, the Trend Seminar pursues three main goals:

To analyze the status quo and recent developments in order to identify important trends

To develop extreme but plausible scenarios of the future to be prepared for upcoming challenges

To develop future-proof product and service ideas and to detail them out into business concepts

These goals are represented by the three main phases of the trend seminar: The Trends Phase, the Scenario Phase, and the Ideation Phase. The Kick-off Phase and the Communication Phase support the introduction into the Trend Seminar journey and the communication of the results in a written and presentation format, respectively.

Sixteen students, supervised by two members of the CDTM Management Team, pursue the Trend Seminar in six weeks of intensive full-time work alongside their project partner. In each phase, interdisciplinary sub-teams are formed, including students from technology, business, and various other backgrounds, to combine versatile ways of thinking.

The **Trends Phase** yields a holistic overview of recent developments and trends in the environment of the overall topic. Based on the commonly used STEEP approach (Social-Technological- Economic-Ecological-Political), the status quo and trends in the fields of society & environment, technology, economics and business models, politics & legal are analyzed. Knowledge is gathered by literature research and expert interviews, preceded by a series of input presentations by experts on the topic. The class is split into four teams, each working on one of the thematic scopes. At the end of the Trends Phase, the teams present their key findings to each other for everyone to get a holistic view of the topic to build upon in the following phases.

The **Scenario Phase** builds upon the analyzed trends in order to create four scenarios of different futures in twenty years ahead. The driving forces behind the developments are identified and specified as drivers with bipolar outcomes. Once specified, all drivers are ranked according to their respective impact on the overall topic and the perceived degree of uncertainty regarding their outcome. Two key drivers that are independent of one another and have both a high impact and a high degree of uncertainty are chosen. Their bipolar outcomes are used to create a scenario matrix of four scenarios. A timeline for each of the scenarios is created, and the scenarios are sketched out using persona descriptions and visualizations. The Scenario Phase starts with a three-day workshop followed by group work in four teams. The teams are newly formed to include experts from each subtopic of the Trends Phase in each new Scenario Team.

In the third phase, the **Ideation Phase**, the goal is to develop innovative business concepts, which are then tested against the previously developed scenarios. Within a three-day workshop on structured ideation following the SIT approach (systematic inventive thinking) and unstructured ideation methodologies, a large number of business ideas are developed. Out of these, the most promising five ideas are selected and further developed into detailed business concepts. The sustainable business model canvas serves as the base structure. At the end of the seminar, the business model concepts are presented to the project partner and external guests.
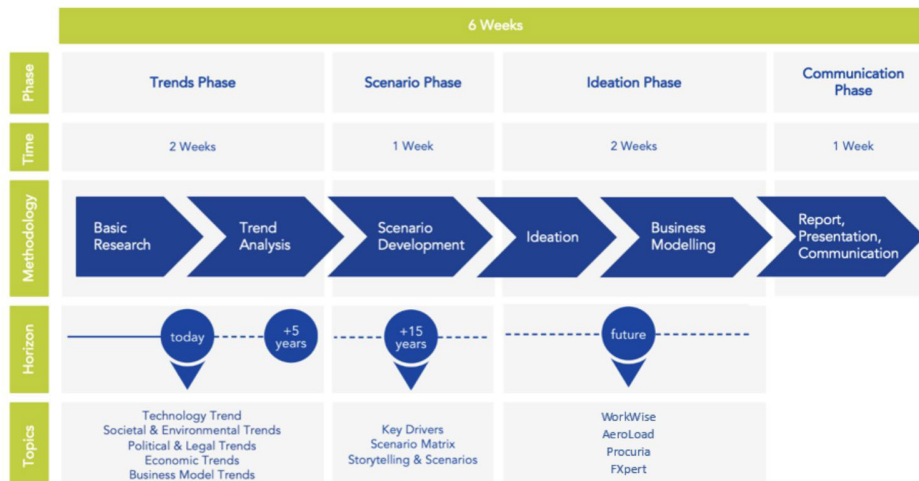
LIST OF ABBREVIATIONS

ACARS
Aircraft Addressing and Reporting Systems

ADS-B
Automatic Dependent Surveillance-Broadcast

AFRA
Aircraft Fleet Recycling Association

AI
Artificial intelligence

AM
Additive manufacturing

AMT
Aircraft Maintenance Technicians

B2B
Business-to-Business

BIPAD
Best Industry Practices for Aircraft Decommissioning

BMP
Best Management Practices

bn
Billion

BRICS
Brazil Russia India China South Africa

CAGR
Compound Annual Growth Rate

CDTM
Center for Digital Technology and Management

CO2
Carbon dioxide

Corsia
Carbon Offsetting and Reduction Scheme for International Aviation

COVID-19
Coronavirus Disease 2019

CRM
Customer relationship management

CSR
Corporate Social Resposibility

CSRD
Corporate Sustainability Reporting Directive

CTO
Chief Technology Officer

CVR
Cockpit Voice Recorder

EASA
European Union Aviation Safety Agency

ESG
Environmental, social, and governance

ETC
Emission Trading Credit

EU
European Union

EU-ETS
EU Emissions Trading System

FAA
Federal Aviation Administration

FAQ
Frequent Asked Questions

FATE
Future Affordable Turbine Engine

FDR
Flight Data Recorder

FLI
Future of Life Institute

GDP
Gross domestic product

GDPR
General Data Protection Regulation

GHG
Greenhouse gasses

GPS
Global Positioning System.

HS
Human Resources

IATA
International Air Transport Association

ICAO
International Civil Aviation Organization

ID
Identity

IEC
International Electrotechnical Commission

IoT
Internet Of Things

ISO
International Organization for Standardization

IT
Information Technology

ITU
International Telecommunication Union

MRO
Maintenance Repair and Overhaul

NGOs
Non Governmental Organizations

OECD
Organization for Economic Cooperation and Development

RAII
Responsible AI Institute

RE
Renewable energies

SAF
Sustainable aviation fuels

SEO
Search Engine Optimization

tn
Trillion

TSA
Transport Security Administration

UK
United Kingdom

UN
United Nations

UNESCO
United Nations Educational, Scientific and Cultural Organization

USA
United States of America

USD
United States Dollars

VC
Venture Capital

VR
Virtual Reality

WSC
World Standards Cooperation

TRENDS

The following chapter lists current trends that have a strong impact on digital solutions for sustainable aviation. In accordance with the Basic Phase methodology, trends and related driving forces are structured into five areas: technological trends, societal and environmental trends, legal and political trends, economic trends, and business model trends.

TECHNOLOGY TRENDS

DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

Data Analytics for Resource Allocation

Biometric Authentication

Blockchain for Aviation Security

Efficient Maintenance with Predictive AI

Flight Operation Optimization

3D Modelling in Aircraft Procedures

Cristal Campos

Joan Navarro

José David Poncelas

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TECHNOLOGY TRENDS
Digital Solutions for Sustainable Aviation

Artificial Intelligence (AI) related technologies are increasingly used to tackle climate change. Reflexively, the looming issue of climate change significantly impacts the development of AI technologies. As our global conscience shifts toward environmental sustainability, our technological developments are keeping pace, particularly in AI. The following chapter summarizes the five most significant AI-related technology trends affecting climate change.

First, academia and industry are focused on making AI applications more energy-efficient. Research and development follow two complementary approaches: developing new AI algorithms that need less computational operations and developing specialized hardware tailored to the algorithms requirements. Both methods aim to reduce the power consumed by AI applications during training and inference, thus making AI itself more sustainable. Reducing power consumption further enables AI applications on edge devices that currently struggle with their computation and energy requirements.

Second, AI can help us move from centrally controlled resource systems like energy, water, and waste to distributed ones. The greenhouse gasses (GHG) emissions that have been fueled by rising urbanization and population growth among other factors can be reduced by managing the mentioned systems, detecting errors early, and understanding the underlying dynamics. In short, more efficient smart grid systems, water management, and automated waste management can all be implemented with AI models and their fundamental driver technologies, such as 5G and the Internet of Things (IoT).

Third, there is a strong trend toward geospatial image processing. More precisely, aerial and satellite images are increasingly analyzed using various AI learning approaches (e.g., reinforcement learning) to estimate carbon stocks, monitor deforestation, and prevent ecosystem degradation. The trend has enormous potential to decrease emissions, enforce data-driven decision-making, and leverage carbon-binding prediction models in terms of these geospatial use cases.

Fourth, AI is revolutionizing the material discovery space, potentially providing sustainable alternatives to the most climate damaging materials of today, such as cement, steel, and oil. Leveraging AI opens new possibilities to combine research in physics and chemistry to support and accelerate discovery when human methods reach their limits.

Lastly, freight-carrying trucks account for a significant part of global GHG emissions. Making logistics autonomous offers ample opportunities to reduce emissions with AI. More efficient autonomous eco-driving, avoiding traffic congestion, and the efficiency improvements due to platooning are some technological breakthroughs. However, technological challenges and slow and inconsistent legislation across states and countries impede the implementation of autonomous trucks on public roads.

Altogether, these five AI-related technology trends strongly impact climate change and are central drivers in shaping the climate in the future.

Trend   Scenario   Ideation

DATA ANALYTICS FOR RESOURCE ALLOCATION

Improved Hardware and Software are Reducing the Carbon Footprint of AI Applications

As deep-learning models become increasingly complex, computational performance skyrockets – but at what cost? A recent study showed that the training of one of these large deep-learning networks on average produces the amount of CO equal to the lifetime emission of five cars [1]. As industry and academia become increasingly aware of AI's energy consumption, development and research about AI hardware and software are accelerating.

AI Hardware: The general-purpose CPUs currently used in modern computers lack the capabilities for the vast amount of parallel computation that current AI algorithms require. AI hardware combines new electromechanical elements such as graphics processing units (GPUs), field programmable gate arrays (FPGAs), and application-specific integrated circuits (ASIC) with specifically designed architectures, resulting in an efficiency improvement of up to a thousand times [2].

AI Software: So far, significant breakthroughs in algorithm and model efficiency have been made mainly as a side effect of research projects that target high-performance networks rather than computation efficiency itself. However, with increased awareness and rising costs, academia and industry are slowly shifting focus from pure accuracy toward emphasizing efficiency and collective learning approaches [3], [4].

Facts:

- Adoption of AI applications is expected to drive up the energy consumption of the data centers that consumed 200 TWh of electricity and emitted roughly 0.3% of all global CO2 emissions in 2020 [5], [6].
- Patents for AI hardware have been increasing exponentially over the last decade in the technologically leading countries China and USA [8].
- Computation time needed for neural net architectures halved roughly every 16 months from 2012 to 2019 [9].

Key Drivers:

- Disruptive technologies such as neuromorphic chips [10] or quantum computers enable completely new learning approaches with drastic reductions in computation and energy consumption.
- The focus of academia is shifting toward developing more efficient models and algorithms because of the enormous training costs for new AI models, which only companies can afford [11].
- Research in transfer learning shows promising results for reducing training time and, therefore, energy consumption by repurposing existing models [12].

Challenges:

- Reporting standards for quantifying the carbon emissions for machine learning (ML) models are currently missing but need to be established as a basis for comparison and awareness [13].
- Model growth and the subsequent demand for computing power are outpacing improvements in hardware efficiency [14].
- Fundamental electronic hardware components are approaching their upper physical boundaries, requiring new engineering approaches [15].

Impact on Climate Change in the AI Era:

The more energy-efficient an AI model is, the smaller the negative impact is on the climate. Depending on the algorithm, the hardware, and the training procedure, the carbon footprint of training ML models can be reduced by a factor of up to a thousand [16]. Making model architectures more compact and cherry-picking the most relevant data saves computation time and energy [14]. Additionally, AI chips' more efficient hardware design can impact carbon emissions massively. For example, Google has achieved an efficiency gain of up to 80 times by using tensor processing units (TPUs) instead of conventional chips [17], while NVIDIA has recently developed a chip that uses ten times less energy than a mobile GPU [14].

Trend	Scenario	Ideation

BIOMETRIC AU-THENTICATION

AI-enhanced Management Systems are Optimizing Waste, Energy, and Water Networks

Biometric authentication is a groundbreaking technology trend that leverages distinct physical or behavioral characteristics, such as fingerprints, facial recognition, iris scans, or voice recognition, to authenticate and verify the identities of passengers and airline personnel [16]. With the growing need for enhanced security measures and streamlined passenger processes, this technology has gained significant traction as a promising solution. Biometric authentication improves the passenger experience by reducing wait times and eliminating the requirement for multiple document checks. Moreover, it improves accuracy and acts as a deterrent against identity fraud [17], as biometric features are unique to individuals and highly resistant to falsification, ensuring that only authorized individuals gain access to secure areas.

Facts:

- Biometric authentication in aviation relies on unique physical or behavioral traits like fingerprints, facial features, or iris scans to verify the identity of passengers and airline personnel [16].
- The willingness of passengers to share their biometric data for airport process improvement significantly increased to 73% in 2021, compared to 46% in 2019 [18].
- By eliminating physical documents, biometric identification enhances airport efficiency, reducing wait times and improving the overall passenger experience [4].
- In 2022, United States of America (USA) consumers reported losses of nearly 8.8bn United States Dollars (USD) to fraud, representing a 30% increase from the previous year. Imposter scams and identity theft were the most reported types of fraud [19].

Key Drivers:

- With the rise in identity theft and related fraud, there is a pressing need for strong biometric authentication in aviation to ensure robust security and protect individuals' identities [4].
- The demand for seamless and contactless processes, particularly in the context of the Coronavirus Disease 2019 (COVID-19) pandemic and its aftermath, drives the adoption of biometric authentication solutions [18].
- Addressing passenger concerns, as 55% of travelers identify queuing at boarding as an area requiring improvement, biometric authentication plays a crucial role in reducing wait times and enhancing the overall boarding experience [18].

Challenges:

- The extensive collection and storage of biometric data raise significant privacy concerns among passengers [4].
- Achieving high accuracy and reliability in biometric authentication systems is crucial to minimize false positives and negatives, ensuring seamless and efficient passenger processes and experience [20].
- Ensuring interoperability among different biometric systems used by airports and airlines is a big challenge, as it requires standardization and compatibility to enable smooth authentication processes across various locations and access points [21].

Impact on sustainable aviation:

Biometrics plays a crucial role in shaping digital solutions for the sustainable aviation industry. By incorporating biometric authentication, airports, and airlines can streamline processes, enhance security, and reduce environmental impact [4]. Biometrics eliminates the need for physical documents, reducing paper waste and contributing to a paperless environment. The seamless authentication process enabled by biometrics improves operational efficiency, reducing energy consumption and carbon emissions. Moreover, by preventing identity fraud and unauthorized access, biometrics enhance overall safety and security [4]. The adoption of this technology aligns with the industry's goal of minimizing its environmental footprint while providing efficient and secure travel experiences for passengers.

BLOCKCHAIN FOR AVIATION SECURITY

Exploring the role of blockchain in securing the skies

Blockchain, often associated with cryptocurrencies, is a decentralized and immutable ledger that enables transparent and secure transactions. Its core characteristics are decentralization, cryptographic security, immutability, and transparency [22]. When applied to aviation security, blockchain brings unprecedented benefits. One of its key advantages is the ability to create an immutable record of transactions and data exchanges within the aviation ecosystem. This transparent and tamper-proof nature enhances the traceability of critical processes, such as aircraft maintenance, component sourcing, and supply chain management. It also can create a robust security framework that safeguards against cyber threats and enhances overall operational processes [23]. Recording aircraft data in blockchain will create a digital environment for participants, where unstructured and complex data will be transformed into structured data, which will facilitate the extraction of relevant and accurate information when needed [24].

Facts:

- Blockchain facilitates tracking of the status and location of assets such as passenger bags, cargo, and aircraft spare parts in a very reliable and immutable manner [23, 24].
- It reduces costs by decreasing the dependency on third-party intermediaries using smart contracts, which increases revenue among network members [25].
- Blockchain in airlines is projected to grow from 421M USD in 2019 to 1,394M USD by 2025 [26].
- PwC analysis has found that efficiency gains enabled by blockchain could increase industry revenue by as much as 4%, or 40bn USD while cutting maintenance, repair, and overhaul (MRO) costs by about 3.5bn USD [27].

Key Drivers:

- Security risks arising from the vulnerability of paper records, which account for about 90% of commercial aircraft maintenance records, highlight the necessity of implementing blockchain technology [28].
- The imperative to combat identity fraud calls for secure and unchangeable data and digital IDs [24].
- Streamlining the ticketing process is important, and blockchain's tokenization and smart contracts offer a solution by enabling seamless paperless tickets and eliminating the disruptions caused by system crashes [24].
- Ensuring traceability and verifying the authenticity of aircraft parts is a pressing requirement, and blockchain provides a reliable and immutable solution for establishing the legitimacy of spare parts [23].

Challenges:

- Existing blockchain platforms can handle only a few transactions per second compared to centralized systems like Visa, which can process many more per second [29].
- Aerospace is a global industry, therefore, the regulatory uncertainty affecting blockchain will be an important consideration [27].
- Decentralized blockchains can incur high transaction fees and suffer from price volatility, impeding mass adoption by aviation stakeholders [24].
- Blockchain's energy-intensive mining process raises concerns about sustainability and operational efficiency, leading to potential environmental impacts and resource consumption in aviation applications [24].

Impact on sustainable aviation:

Blockchain technology's transparency and traceability features promote the sustainable sourcing of materials in aviation while playing a vital role in improving waste management and recycling practices. It fosters a circular economy and reduces environmental pollution. Another crucial aspect is that it allows for accurate measurement and verification of carbon emissions throughout an aircraft's lifecycle facilitating effective carbon offset programs and contributing to global sustainability goals. Its immutable record-keeping enhances maintenance and repair processes, reducing downtime and optimizing resource utilization for more sustainable practices.

EFFICIENT MAINTENANCE WITH PREDIC- TIVE AI

AI-powered solutions for efficient and sustainable aircraft maintenance

Predictive maintenance has emerged as a transformative trend in the aviation industry, offering remarkable potential for reducing safety hazards [30], optimizing time management [7], and fostering sustainability. Predictive maintenance is reshaping traditional maintenance practices by transitioning from reactive and scheduled approaches to a proactive and predictive framework [31]. Moreover, by identifying and rectifying potential safety hazards early on [32], airlines can avoid costly delays and cancellations, reducing their environmental footprint by optimizing flight schedules and minimizing fuel consumption [33], aligning its use with the aviation industry's growing focus on sustainability. By harnessing the power of data-driven insights, airlines can minimize disruptions, maximize operational efficiency, and contribute to a greener and more sustainable future for aviation.

Facts:

- Around 9% of the total operational cost of airlines was spent on repairing and conducting maintenance [32].
- DOT data shows that airline-controlled factors, such as aircraft maintenance, were the main cause of flight cancellations in 2021 and April 2022 [34].
- Predictive maintenance is key to ensuring passenger safety. It allows airlines to avoid and identify potential maintenance issues before they are safety hazards [11, 32].
- Experts and industry forecasts indicate that the long-feared shortage of Aircraft Maintenance Technicians (AMTs) has materialized and is anticipated to persist without imminent improvement [35].

Key Drivers:

- The implementation of predictive maintenance in the aviation industry is bolstered by government bodies such as the Federal Aviation Administration (FAA) and European Union Aviation Safety Agency (EASA), which enforce maintenance regulations. These regulations encourage the adoption of predictive maintenance, ultimately enhancing safety and operational efficiency [36].
- The substantial impact of engine failures on aviation accidents and fatalities highlights the critical need for implementing predictive maintenance to avert catastrophic incidents [37].
- Airline delays in Europe are a pressing industry concern, leading to passenger dissatisfaction and high costs for airlines and customers [38].

Challenges:

- Ensuring seamless data integration and compatibility can be complex and time-consuming due to the complexity of the systems and the need to ensure that the new technology does not disrupt existing operations [32, 39].
- Deploying AI systems requires skilled personnel who are proficient in AI technologies and can effectively train, monitor, and maintain the optimization systems [40]
- The implementation of AI-powered optimization systems often demands significant organizational changes and the adaptation of cultural practices to ensure successful integration [40].

Impact on sustainable aviation:

The adoption of predictive maintenance in aviation is generating a profound impact. It enables proactive identification of maintenance needs, reducing safety risks [30] and optimizing time management. By minimizing unscheduled maintenance and improving operational efficiency, predictive maintenance reduces environmental impacts by optimizing flight schedules, reducing fuel consumption [33], and lowering emissions. Ultimately, predictive maintenance is pivotal in promoting sustainability within the aviation industry, aligning with its commitment to reducing its ecological footprint and ensuring long-term environmental viability.

FLIGHT OPERATION OPTIMIZATION

Improved Hardware and Software

Flight trajectory management systems enable precise and streamlined route planning while considering critical factors like weather conditions, airspace restrictions, and fuel efficiency [9]. These systems harness real-time data and sophisticated algorithms to optimize flight paths [41], reducing unnecessary fuel consumption and emissions [9]. Additionally, seamless integration with air traffic control systems ensures effective coordination and further enhances overall safety and efficiency in the aviation ecosystem.

Autopilot systems play a part in the trend of digital management of flight operations. They ensure precise course headings, altitudes, and speeds, minimizing deviations and optimizing fuel consumption [8]. Additionally, autopilot systems facilitate smoother takeoff and landing procedures, reducing noise pollution [42] and enhancing operational efficiency. By relieving pilots of routine tasks, autopilot systems allow them to focus on critical decision-making, improving overall flight safety.

Facts:

- Flight operation optimization solutions help airlines reduce operational costs by minimizing fuel consumption [42] and planning and optimizing routes to reduce flight time [43, 44].
- Fuel costs account for approximately 20 to 30% of an airline's overall expenses [45].
- Wind can potentially reduce the capacity of flight operations by up to 30%, leading to further flight delays and cancellations and millions in lost revenue for Lufthansa, as happens in Zurich Airport with Bise [46].
- The use of autopilots enhances the precision and dependability of flight operations while alleviating the workload on pilots [8].

Key Drivers:

- Route optimization enables airlines to minimize fuel consumption and emissions by identifying more direct flight paths [44], avoiding congested airspace, and optimizing altitude profiles, lowering the aviation industry's increasing pressure to reduce its environmental footprint.
- By optimizing routes, airlines can reduce fuel consumption and associated costs [45], which constitute a significant portion of the airline's operating expenses [45].
- Wind effects on flight schedules can be severe, such as forcing planes to change runways, which can create a chain reaction of flight delays and possible cancellations. Being able to predict this kind of wind well in advance lets you schedule flight operations optimally [46].

Challenges:

- Adopting and integrating route optimization or autopilot systems can involve complex technological integration, requiring compatibility with existing aircraft systems and infrastructure and complete adaptation [47].
- Acquiring the necessary skills and knowledge to operate and troubleshoot these systems effectively can require significant time for learning and resources for developing courses [47].
- Ensuring robustness, accuracy, and fail-safe mechanisms is a crucial activity to prevent potential system failures or malfunctions that could compromise flight safety.

Impact on sustainable aviation:

Flight management technologies have tangible impacts on sustainable aviation. By optimizing flight paths, reducing fuel consumption [44], and minimizing emissions, airlines contribute to overall environmental sustainability, aligning with their sustainable objectives. Additionally, these technologies result in time and cost savings, improving operational efficiency and aircraft on-time performance. They also help reduce noise pollution around airports [42] and enhance flight safety through precise control [48]. These combined impacts promote a more sustainable aviation industry by reducing environmental footprint, enhancing operational effectiveness, and improving the overall flight experience for passengers and communities.

3D MODELLING IN AIRCRAFT PROCEDURES

Improving aircraft production and maintenance quality of life

Additive Manufacturing (AM) is the general term for those technologies that successively join material to create physical objects as specified by 3D model data [49]. More specifically, AM is the process of joining materials to make parts from data, usually layer upon layer, as opposed to subtractive manufacturing, such as turning and cutting, and formative manufacturing methodologies, such as casting [49].AM processes can directly positively impact weight, costs, number of parts, and production speed, saving aircraft businesses a tremendous amount of money, we can expect to increase production as well as save a considerable amount of money, approximately between 2 to 3M EUR per plane [5].Over the next 20 years, around 38,000 new aircraft will be ordered and produced, forcing designers and suppliers to find cost-effective solutions such as AM processes, from design to production, to develop these aircraft as quickly and efficiently as possible, while maintaining the safety and quality required [6].   .

Facts:

- GE Aviation was able to merge 20 different parts of an engine into one, achieving a 25% weight reduction in the device [5].
- According to EOS, AM processes can lead to reducing weight in aircraft by up to 60% [6].
- In 2017, the Future Affordable Turbine Engine (FATE) model completed its prototype testing, achieving a 35% reduction in fuel consumption and cutting maintenance costs by 45% [5].
- Thor, an unmanned and almost entirely 3D-printed flying drone, was able to complete a 40km route without any issues [50]

Key Drivers:

- Concerns over the environment and rising carbon emissions push manufacturers to look for aircraft production efficiency and weight reduction via 3D printing parts and components [51, 52].
- Rising demand for aircrafts creates the need of having much quicker model prototyping and production processes [6].
- The industry's competitiveness is pushing companies to look for ways to stay ahead, thus looking into 3D printing parts and innovating materials used in models while also cutting costs.
- The need to optimize MRO operations lead to having on-site production of replacement parts and minimizing aircraft downtime.

Challenges:

- Assuring quality and safety in aircrafts. Robust certification processes, rigorous testing, and validation methods are essential to guarantee the integrity and reliability of components.
- Having powerful enough tools for part production, requiring access to high-capacity printers and leading to the rework of investments, logistics, and maintenance management.
- Acquiring a skilled workforce for the successful implementation of 3D printing. Several experts are required in every part of the process: modeling, printing, post-processing, and quality control.

Impact on sustainable aviation:

3D modeling in aviation enhances material efficiency and reduces waste. Lightweight components produced through 3D printing contribute to weight reduction, leading to improved fuel efficiency and reduced emissions. Moreover, 3D printing assists in repair and maintenance operations, enabling on-site production of replacement parts, reducing aircraft downtime, and minimizing waste associated with traditional supply chains. These advancements in 3D modeling also optimize fuel consumption by facilitating the design of more aerodynamic and fuel-efficient aircraft components. Overall, AM processes drive sustainability by promoting resource conservation and environmental responsibility in the aviation industry.

SOCIETAL & ENVIRONMENTAL TRENDS

DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

Travel's New Wave

Rising Pollution And Emissions

Consumer Sustainability Value-Action Gap

Increasing Airlines Commitment To Sustainability

Waste Management and Resource Scarcity

Elena Agudo

Mattia Di Luca

Fernando Pintado

Alejandra Reig

SOCIETAL & ENVIRONMENTAL TRENDS

Digital Solutions for Sustainable Aviation

Society and environmental factors are deeply interconnected, and this relationship becomes increasingly apparent as we delve into the future of sustainable aviation. As the aviation industry navigates the post-pandemic landscape with increased travel demand and a growing environmental consciousness, it is crucial to prioritize sustainability.

In the wake of the COVID-19 pandemic, as global restrictions are lifted, there has been a significant surge in both business and leisure travel. People are eager to embark on new adventures, reunite with loved ones, and explore different cultures. The desire for unique experiences has become a driving force behind the increased demand for flights.

However, this rise in travel comes with a significant environmental cost. Air travel is a major contributor to GHG emissions, leading to climate change and other environmental challenges. The aviation industry's reliance on fossil fuels, such as jet fuel, has resulted in a considerable carbon footprint that needs to be addressed urgently.

While there is a growing awareness of the environmental impact of air travel, there remains to be a significant gap between people's consciousness and their actions. Many individuals express concern for the environment and acknowledge the need for sustainable practices. However, when it comes to actually taking steps to mitigate their carbon footprints, such as offsetting emissions or opting for sustainable travel options, the uptake still needs to be improved. Despite this gap, it is encouraging to see that with each passing day, more people are becoming conscious of the need for sustainable choices and are actively seeking ways to reduce their impact.

Another critical environmental challenge the aviation industry faces is the proper disposal of end-of-life aircraft. As a sizable segment of the global commercial aircraft fleet nears retirement, the industry must find environmentally responsible methods for retiring and disposing of these aircraft. The improper disposal of aircraft can lead to the leakage and contamination of hazardous materials, posing significant environmental risks. Developing effective waste management strategies and implementing strict regulations for aircraft disposal is es-

sential to address these concerns and ensure environmentally responsible practices.

In conclusion, as the aviation industry navigates the post-pandemic landscape, it is evident that sustainable practices and environmental responsibility must be at the forefront of its evolution. The rising demand for flights after COVID-19 presents opportunities and challenges for the industry. The aviation industry can work towards a more sustainable future by investing in digital technologies, reducing emissions, and promoting waste management. Furthermore, efforts to bridge the gap between awareness and action should be intensified through education and incentives for travelers to make sustainable choices. By addressing the challenges of pollution and waste management, the aviation industry can move towards a more sustainable future where growth and environmental responsibility go hand in hand.

Trend	Scenario	Ideation

TRAVEL'S NEW WAVE

The travel industry is experiencing a remarkable post-pandemic resurgence

The travel industry is witnessing a remarkable surge in leisure and business travel, largely due to the relaxation of COVID-19 restrictions worldwide. This resurgence, led predominantly by the leisure sector, is being fueled by the evolution of personal mobility, a significant shift towards experiential travel, and the rise of remote work, which is now facilitated by the introduction of digital nomad visas in several countries. The changing lifestyles, increased global connectivity, and a rapidly growing middle class with higher disposable income are all driving this new wave of travel. These transformative changes are reshaping the travel industry, offering innovative opportunities for travelers and businesses, and paving the way for a more flexible, personalized, and sustainable future of travel.

Facts:

- Leisure travel remains robust, with a significant increase of approximately 31% in March 2023 compared to the same period in 2019 [53].
- The demand for passenger traffic is projected to grow annually by 3.6% over the next 20 years [54].
- Global spending by travelers combining business with leisure is expected to more than double from 150bn USD in 2021 to approximately 360bn USD by 2027 [55].
- The company's business travel expenses have already rebounded to pre-pandemic levels and are poised to continue growing [56].

Key Drivers:

- Advances in technology and globalization have facilitated an interconnected world, making travel more accessible and fueling a desire for exploration.
- The growing global middle-class population has contributed to an increase in the demand for travel experiences.
- Individuals increasingly prioritize experiences over posses-

sions, leading to a rise in leisure travel and demand for personalized and unique travel experiences.
- The COVID-19 pandemic has triggered a shift in work culture, with remote work and digital nomad visas becoming more prevalent [57]. These combined factors have significantly reshaped the travel industry, catering to the evolving preferences of modern travelers.

Challenges:

- Airports and travel infrastructure face significant challenges in adapting and scaling up to handle the projected increase in passenger traffic efficiently. The need for these adaptations is critical, as experts estimate that there will be more than 150% growth in passenger and cargo volumes by 2040 [58].
- Efficiency management is crucial to addressing rising passenger volumes without causing congestion in airport operations. One key area is optimizing the flow of passengers throughout the airport, from check-in to boarding and baggage claim. As the number of travelers grows, optimizing maintenance and operations to maintain smooth and timely transit while avoiding congestion and delays becomes increasingly important.

Impact on Sustainable Aviation:

The growth of demand for traveling presents significant challenges in terms of environmental impact. The increase in passenger traffic needs a focus on sustainable aviation practices. As the travel demand continues to rise, it is crucial to address the environmental consequences of increased emissions and energy consumption. The aviation industry must prioritize developing and adopting eco-friendly technologies, alternative fuels, and carbon offset initiatives. Sustainable aviation practices can help mitigate the environmental impact while ensuring that future generations can continue to enjoy the benefits of travel and personal mobility. The development of digital solutions has the potential to reduce emissions while scaling up management and operations.

RISING POLLUTION AND EMISSIONS

Emissions are increasing in the aviation sector

The surge in air travel, driven by technological advancements and the globalization of commerce, has significantly increased the sector's emissions, particularly those stemming from carbon-dense traditional aviation fuels. In response to the rising pollution and emissions, the aviation sector is adopting measures, aiming for a sustainable future. The industry is wholeheartedly embracing emission reduction strategies to combat climate change and minimize its carbon footprint. With the projected growth in air travel, addressing this issue is an absolute necessity for the industry's sustainability. This commitment to sustainability is also a response to growing public awareness and demand for environmentally responsible practices in all sectors, including aviation.

Facts:

- Aviation emissions are estimated to contribute up to 5% to anthropogenic emissions. They contribute about 12% towards transport emissions [59].
- The flights scheduled for very short distances are less fuel-efficient, resulting in higher emissions per distance traveled [60].
- Transportation is the only sector in which Greenhouse Gas (GHG) emissions have increased over the last three decades, with an increase of 33.5% between 1990 and 2019 [61].
- Although individual aircraft have become 75% less noisy over the last 30 years, the growing air traffic means many European Union (EU) citizens are still exposed to high noise levels [62].

Key Drivers:

- The growing demand for air travel has resulted in more flights and increased emissions; therefore, emissions reductions have slowed down in recent years. The improvement in accessibility and affordability of flights are two factors that explain the increasing demand [61].
- The rapid growth of the air cargo market, with a projected value of 130.19bn USD by 2030 and a Compound Annual Growth Rate (CAGR) of 4.9% between 2020 and 2030 [63].
- There are limited viable alternatives to traditional jet fuel for powering aircraft, which predominantly forces the aviation industry to use kerosene.

Challenges:

- Developing a Sustainable Alternative Fuel (SAF) or hydrogen to replace kerosene in the aviation industry.
- Implementing measures to prevent price increases that discourage people from using transportation options.
- Competition between countries when planning optimized routes and paying air taxes.
- Seeking an eco-friendly alternative for heating and reducing airport cars emission.
- Addressing the need for paths in environmental strategies and enhancing sustainable operations.
- The International Energy Agency estimates that net-zero emissions might require investments of almost 5tn USD annually by 2030 and 4.5tn USD annually by 2050 [64].

Impact on Sustainable Aviation:

The rising pollution and emissions in the aviation sector significantly impact sustainable aviation. The sector produces atmospheric aerosol particles contributing to cloud formation and potential warming effects [65]. Furthermore, the urgency to curb aviation emissions annually to prevent the exacerbation of global warming is emphasized [66]. With initiatives like Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and increasing pilot awareness, the industry is actively working towards reducing its environmental footprint. Moreover, the growing demand for sustainable travel options and the importance of corporate social responsibility are driving the adoption of emission reduction measures. However, challenges such as developing SAF and preventing price increases that discourage transportation usage must be addressed.

CONSUMER SUSTAINABILITY VALUE-ACTION GAP

Turning intentions into tangible actions for responsible global travelers

The aviation industry is witnessing a shift towards eco-consciousness among travelers due to COVID-19, with a focus on nature, air quality, and sustainable travel. However, a value-action gap exists, with 70% of travelers seeking sustainable options, but less than 1% compensating for their carbon emissions. Factors like economic instability, convenience, and household savings affect this gap. The industry must prioritize sustainable solutions to bridge this gap and promote greener travel.

Facts:

- Travelers continue to prioritize price and connections over sustainability in booking decisions. This might be because most airlines' marketing centers around low-cost or superior service [68].
- 34% of travelers consider CO2 emissions their top concern about aviation [68].
- 51% of those opting to help offset their emissions were based in the United Kingdom (UK), Germany, or the USA [69].
- While consumer brands are firmly demanding sustainability, the truth is that 48% of consumers admit to embracing sustainable initiatives only and exclusively [70].
- Younger customers are more conscious about flying and willing to pay for carbon-neutral flights [71].

Key Drivers:

- The pandemic has accelerated the shift into sustainability awareness, demonstrating the scale of change needed to mitigate the detrimental effects of climate change [69, 72].
- Economic uncertainty, the increase in the cost of living, or the energy crisis are key factors for the consumer when deciding to purchase flying tickets, leaving offsetting the carbon footprint as a less favorite or viable alternative.
- Imitation plays an important role in sustainable consumption decisions. People tend to imitate what others do for the environment to learn faster. Studies have found that factors such as education, family size, lifestyle, unemployment, and income influence these choices [71].

Challenges:

- The main challenge for airlines is to gain a deeper understanding of changes across heterogeneous customer segments and geographies. With that in mind, they could build awareness among each passenger segment and better connect with customers. The level of awareness and commitment to the environmental impact of aviation on passengers depends on several factors, such as age, social class, and culture.
- A huge challenge is reducing the gap between travelers who believe climate change is a major problem and those willing to pay to solve this crisis. The fact that it is costly to compensate for flying discriminates against people with lower purchasing power.

Impact on Sustainable Aviation:

On the one hand, travelers are interested in more sustainable traveling options, creating potential demand for airlines offering eco-friendly solutions. On the other hand, traveler preferences are still largely influenced by economic and convenience factors. In this regard, solutions that address equity and accessibility are required to ensure that sustainable options are not out of reach for certain groups of travelers.

If travelers do not take sustainable actions and pressure airlines to adopt more environmentally friendly practices, the aviation industry could face a diminished reputation and a loss of consumer confidence. This could have a negative impact on demand and future growth of sustainable aviation.

INCREASING AIRLINES COMMITMENT TO SUSTAINABILITY

Companies take responsibility and embrace carbon offsetting for sustainable aviation

The aviation industry, a significant contributor to GHG emissions, is under pressure to reduce its environmental impact. Many companies have adopted sustainable practices, including carbon offsetting through investments in climate projects and the use of Sustainable Aviation Fuel (SAF). The industry is also exploring innovative technologies such as advanced air traffic management systems, fuel-efficient aircraft designs, and electric propulsion systems to improve fuel efficiency and reduce emissions. However, the reliance on conventional jet fuels and high R&D costs pose challenges to achieving complete decarbonization.

Facts:

- The International Air Transport Association (IATA) has committed to achieving net-zero carbon emissions by 2050 [73].
- The projected global demand for voluntary carbon credits is expected to increase 15-fold by 2030 and 100-fold by 2050, signifying a substantial growth trend [74].
- The aviation industry would need to spend up to 1tn USD in carbon offsets by 2050 to achieve net-zero emissions, considering various scenarios and the demand for air travel [75].
- An overwhelming majority of 73% of global consumers believe that it is crucial for companies to take environmentally responsible actions for a sustainable future [76].

Key Drivers:

- Regulatory bodies and industry associations, such as IATA, are setting ambitious sustainability targets, exerting pressure on companies to embrace carbon compensation measures as part of their environmental responsibilities [73].
- The escalating global recognition among individuals regarding the multifaceted advantages of preserving and safeguarding a more intact natural environment is evident, reflecting the growing importance of environmental consciousness and sustainability efforts [76].
- The challenges in attaining carbon neutrality in aviation, mainly due to the current limitations in the availability and viability of sustainable technologies, have resulted in a notable trend toward adopting carbon offset schemes as a viable short-term solution [77].

Challenges:

- The journey toward carbon-neutral aviation demands a substantial investment in research, development, and implementation of innovative technologies while modernizing infrastructure to support sustainable practices [78].
- Effectively measuring and accounting for Scope 3 emissions and emission reduction across the entire value chain presents a complex challenge, demanding comprehensive data collection, analysis, and extensive collaboration among various stakeholders [79].
- The overarching objective is to establish a large, transparent, verifiable, and robust voluntary carbon market, effectively serving as a catalyst to accelerate global decarbonization efforts and promote environmentally responsible practices [80].

Impact on Sustainable Aviation:

The progressive acceptance of carbon offsetting in sustainable aviation marks a significant step forward in addressing environmental consequences caused by the industry. However, without noteworthy technological advancements, the expense associated with carbon offsetting remains excessively high, offering only a partial solution. Companies' dedication to counterbalancing their carbon emissions, investing in sustainable aviation fuels, and embracing innovative technologies is evident, primarily focusing on reducing GHG and generating additional benefits for improved social and environmental outcomes [80]. Nevertheless, decarbonizing a fossil fuel-dependent industry poses formidable obstacles.

WASTE MANAGEMENT AND RESOURCE SCARCITY

Dealing with dismantled aircraft to recycle components and reduce waste generation

The aviation industry grapples with waste management as 20% of the 27,000 global commercial aircraft aged over 20 years face decommissioning. These end-of-life aircraft pose environmental risks, but 92% of an aircraft's weight can be recycled or reused. Industry associations Aircraft Fleet Recycling Association (AFRA) and IATA have outlined best practices for aircraft decommissioning and recycling, conserving resources and reducing waste. Challenges include high transportation and storage costs, especially for materials like carbon fiber. With a goal to modernize 95% of the air fleet by 2041, embracing responsible recycling practices and technological advancements like 3D printing is crucial.

Facts:

- Of the more than 27,000 commercial aircraft in service globally, over 20% are older than 20 years and likely to be decommissioned in the coming decade. More than 20,000 commercial flights are estimated to be retired over the next 20 years [81].
- End-of-life aircraft abandoned on the edges of airfields present a risk of hazardous material leakage and the contamination of surrounding soils and water [81].
- An average of 92% of an aircraft's weight could be reused or recycled [82].
- The amount of emissions from waste depends on how the waste is treated [83].

Key Drivers:

- By 2041 more than 95% of the air fleet will be changed and modernized, which implies that many aircraft will be dismantled and considered waste [84].
- 3D printing could reduce raw material by up to 95% [82].
- Two global industry associations have produced documents describing best practices in aircraft decommissioning and recycling: The Best Management Practices (BMP) by the AFRA and The Best Industry Practices for Aircraft Decommissioning (BIPAD) manual by IATA [81, 84],[85].
- Airlines have also got on board with the notion of upcycling by giving a second life to plane components, uniforms, or seats and turning them into different furniture pieces or bags [86].

Challenges:

- The financial and environmental cost of getting the aircraft to the requisite sites for beaks-up is too great to justify the transportation and the cost of the big storage infrastructures where the components would be placed [82].
- Some materials are harder to recycle, e.g., carbon fiber, which is far less energy intensive and hence less expensive, but the facilities able to recycle commercially are few and far between [81].
- The end of use depends on aircraft utilization and mostly on the maintenance done during its life. A lack of maintenance would have a negative impact on the plane's lifespan [82].

Impact on Climate Change in the AI Era:

By reusing materials, natural resources such as aluminum, steel, and titanium that are commonly used in aircraft construction are conserved. Recycling these materials reduces the need for new resource extraction, often involving environmentally damaging processes such as mining and refining.

Furthermore, recycling planes reduces waste and landfill usage. Aircraft retirement and dismantling can generate significant amounts of waste, including non-recyclable materials and hazardous substances. It also alleviates the strain on landfills, which can become overwhelmed with discarded aircraft components. Proper recycling processes ensure that these materials are handled and disposed of responsibly, minimizing the environmental impact.

LEGAL & POLITICAL TRENDS

DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

Impact of Instability on Aviation

Increasing Regulations within Communications

Standardizing Responsible AI

Regulating Carbon Emissions

Sandra Buenache

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LEGAL & POLITICAL TRENDS

Digital Solutions for Sustainable Aviation

Riots and social crises can significantly impact the aviation sector, posing unique challenges for airlines and airport authorities. Safety and security measures must be intensified during such incidents to protect passengers, workers, and aircraft. Airlines must work closely with relevant authorities and law enforcement agencies to implement contingency plans that address potential disruptions caused by civil unrest or other social crises. One crucial element in managing such situations is establishing effective crisis communication channels.

Due to the extensive collection and processing of passenger data, robust measures are necessary to safeguard privacy and security. Regulations such as the General Data Protection Regulation (GDPR) are in place to protect individuals' data. Airlines and aircraft manufacturers must implement privacy protocols, including encryption, access controls, and secure storage. Prompt reporting of data breaches and notifying affected individuals is essential. Striking a balance between data-driven innovation and passenger privacy protection is critical when establishing legal and policy frameworks.

Aircraft emissions are a significant contributor to environmental pollution and climate change, making it imperative for the aviation industry to take active steps to reduce its ecological footprint. Governments and international bodies have implemented legal and political measures to address this issue and promote sustainable practices within the industry. One of the key strategies to mitigate aircraft emissions is the adoption of cleaner fuels. Researchers and companies have been exploring alternative fuels, such as biofuels and SAF, which have the potential to significantly reduce GHG emissions compared to traditional jet fuels derived from fossil sources. Encouraging cleaner fuels through incentives and regulations helps the aviation sector achieve a more sustainable future.

AI enhances safety, navigation, and efficiency in modern aviation. However, its implementation raises important legal and policy questions. Regulations must address the transparency, accountability, and liability of AI systems in aircraft operations. Ensuring AI algorithms are explainable and auditable is vital to build trust and prevent potential biases. Additionally, policies must prioritize AI technologies' ethical and responsible deployment, considering passenger rights, pilot training, and the human-machine interface.

The subsequent sections of this report will delve into two main topics: sustainability's impact on aviation and digitalization's influence on aviation. Furthermore, the challenges these trends pose for the near future will be discussed.

IMPACT OF INSTABILITY ON AVIATION

Challenges when traveling to areas with conflicts or crises

When instability occurs in a country or city, airlines face the challenge of operating as safely as possible. As crises arise, it is necessary to have action plans to face them. To ensure safe operations during tumultuous times in a nation or urban center, airlines must strategize and be equipped with contingency measures such as fuel reserves and secure accommodations for their personnel. These events often result in the closure of airports due to damage or unsafe conditions, disrupting flight schedules, making the routes take extra hours to accomplish, and causing economic losses. Moreover, social crisis leads to a decreased demand for fly travel, and airlines may face reputational challenges during social crises, especially if they operate in regions experiencing political or societal turmoil airlines must closely monitor and comply with government regulations and advisories to maintain compliance and mitigate potential legal and operational risks. In light of the ever-increasing occurrence of global crises, it is imperative to establish comprehensive action blueprints to tackle these challenges and provide safe travels effectively.

Facts:

- Aircraft take special measures when traveling to politically unstable countries [87].
- In tense situations, some countries lend each other planes to help each other face them [88].
- When there are instabilities, the price of necessary items for an airplane to function increases, and fuel increases a 30% after the war between Russia and Ukraine [89].
- The COVID-19 pandemic lead to a significant reduction in flight operations and air travel worldwide, as numerous countries implemented stringent and ever-changing traveling restrictions to curb the spread of the virus and mitigate its devastating effects on public health [90].

Key Drivers:

- Economic crises can have a significant impact on the aviation industry. Reduced consumer spending, decreased business travel, and financial difficulties airlines face can result in route cancellations, bankruptcies, and overall instability in the industry [91].
- The September 11, 2001 attacks in the USA led to significant political instability and a global shift in aviation security measures, including creating the Transportation Security Administration (TSA) and implementing stricter airport security protocols worldwide [92].
- The conflict between Russia and Ukraine in 2014 resulted in airspace closure over eastern Ukraine. This increased political tensions, airspace restrictions, and changes in flight routes [93].

Challenges:

- Creating comprehensive action plans and fostering international cooperation ensures seamless crisis management that leads to seamless and effective crisis management, effectively resolving and mitigating potential challenges and complexities that could emerge from the variations in legislation and regulations across different countries.
- A robust and well-organized system to secure the necessary resources during crises is crucial for maintaining the proper functioning of airplanes and ensuring operational continuity. This goes from fuel reserves to accommodations for airline personnel, all of which play an integral role in enabling the smooth operation of airplanes.

Impact on Sustainable Aviation:

Political instability has far-reaching effects on airlines, forcing them to alter routes, consume more fuel, and increase pollution. Effective crisis management, communication, and adaptation are essential to ensure passenger and employee safety and the continued operation of the aviation industry. Airlines must remain resilient and proactive, working closely with governments and regulatory bodies to navigate uncertain times. By fostering collaboration and innovation, the aviation sector can continue to play a vital role in connecting people and promoting economic growth, even in geopolitical and social challenges.

INCREASING REGULATIONS WITHIN COMMUNICATIONS

Enhanced legislative strength against data security breaches

Aircraft are complex systems that rely heavily on surveillance and real-time communication with ground control for safe and efficient operations. During flight, a wealth of data is gathered from various sources, including the Cockpit Voice Recorder (CVR), Flight Data Recorder (FDR), logbook, passenger information, and passenger manifest. This data is crucial for understanding the aircraft's performance, ensuring passenger safety, and facilitating incident investigations [94]. The lack of encryption in the communications between aircraft pilots and air traffic controllers intensifies this vulnerability. These communications, primarily audio files, are stored openly in data centers at ground stations, making them easily accessible to unauthorized individuals. This lack of security measures leads to a significant risk to the individual's privacy and the safety of the flight operations. It could potentially lead to data breaches, where sensitive information is exposed, or even more severe incidents if the data is manipulated.

Facts:

- The GDPR mandates businesses to be transparent about any personal data processing activities and to establish suitable mechanisms to adhere to the specified data protection principles [95].
- Aircraft Addressing and Reporting System (ACARS) is a vital tool utilized globally by commercial airlines for their daily operations. ACARS messages are still mostly sent in the clear over a wireless channel, any sensitive information sent with ACARS can potentially lead to a privacy breach for users [96].

- Identifying potential targets and gathering basic information about aircraft through Automatic Dependent Surveillance-Broadcast (ADS-B) is straightforward because there are many websites where ADS-B data is shared, such as on flightradar24.com [97].

Key Drivers:

- Recent security breaches increased public awareness and demand for enhanced data regulation, reflecting a strong call for increased protection and privacy [94].
- Numerous security weaknesses have been identified in air traffic communication, primarily due to unsecured channels between an aircraft and ground control systems [96].
- The digital age has seen a surge in users turning to apps for flight identification. This emerging trend signifies a shift towards more tech-savvy travelers seeking real-time aviation information [97].

Challenges:

- The rules surrounding data management differ greatly among various countries and sectors. With the emergence of new regulations, international companies must remain updated with the respective local data laws in the markets they operate [98].
- Many users may not be fully aware that the communication transmitted via ACARS is effectively public and should be treated as such. Effectively spreading this information and fostering a culture of awareness presents a challenge that needs to be overcome [99].
- Implementing robust data security to safeguard aircraft data is challenging due to the rising data breaches. Enhanced legislative measures are necessary to protect sensitive information [97].

Impact on Sustainable Aviation:

The aviation industry will adopt more robust security measures and encryption to protect sensitive information during flights. These steps are part of the industry's move towards digitalization, where data protection is a priority. People are becoming more aware of the importance of data security, and the industry is responding to meet their expectations. Implementing strict security measures will ensure that data is kept private, accurate, and available when needed. This builds trust among aviation passengers, operators, and others, making the industry safer and more secure in the digital age.

STANDARDIZ-ING RESPONSI-BLE AI

Unifying principles and procedures for responsible global AI deployment

Standardizing responsible AI is driven by the aspiration to establish unified and globally accepted practices guiding the ethical and accountable integration of AI technologies across nations. Its primary goal is to confront and alleviate issues such as algorithmic bias, lack of transparency, and legal compliance complications, all of which hinder the advancement of AI. Nevertheless, the rapidly evolving AI landscape presents challenges in maintaining relevant standards, as technological evolution threatens to render newly formed guidelines obsolete. Additionally, diverse industries leveraging AI demand tailored standards considering their unique attributes and situational contexts. Beyond these technical challenges, the inherently socio-technical nature of AI systems necessitates the inclusion of ethical, legal, and societal aspects for a holistic approach to standardization. Standardization aims to overcome these challenges in the worldwide evolution and implementation of AI technologies by instilling trust, fairness, and accountability.

Facts:

- The European Union Aviation Safety Agency (EASA) provided AI Roadmaps in 2020 and 2023, detailing AI's safety and ethics in aviation [100, 101].
- The EU Commission introduced the "AI Act" in April 2021, suggesting unified AI rules [102].
- United Nations Educational, Scientific and Cultural Organization (UNESCO) global standard on AI ethics was accepted by all 193 Member States in November 2021 [103].
- Responsible AI Institute (RAII) Framework records 200+ AI principles, supports implementation, and assesses AI systems [104].
- NIST launched the AI RMF 1.0 on January 26, 2023, and then the Responsible AI Resource Center on March 30, 2023 [105].

Key Drivers:

- RAII drives responsible AI adoption by collaborating with experts across fields, applying its framework to AI systems and real-world scenarios, and promoting the global ethical use of AI through diverse perspectives [104].
- World Standards Cooperation (WSC) alliance members International Electrotechnical Commission (IEC), International Organization for Standardization (ISO), and International Telecommunication Union (ITU) addressed Future of Life Institute FLI) concerns on advanced AI risks, emphasizing international standards and conformity assessments. They leverage expertise to establish comprehensive, universally accepted AI safety guidelines [106].

Challenges:

- The speed of AI advancement creates a tough race for timely standardization, often risking technology becoming obsolete.
- The broad application of AI across diverse industries calls for standards adaptable to different contexts, meeting unique requirements.
- The performance of AI, heavily reliant on input data, presents challenges in establishing universally verifiable criteria, making consistent evaluation difficult.
- Persistent unresolved issues in AI, such as avoiding bias, ensuring transparency, and dealing with ethical and legal concerns, warrant further investigation and resolution.

Impact on Sustainable Aviation:

Promoting responsible AI standardization could significantly influence sustainable practices. Clear, transparent guidelines, alongside addressing ethical concerns, can help integrate AI smoothly, boosting safety, efficiency, and environmental performance. AI can also foster the creation of optimized solutions such as enhanced air traffic management systems, efficient maintenance procedures, and methods for reducing emissions. It can improve passenger experience too. Thus, such AI incorporation supports the industry's sustainability goals while ensuring safer and more efficient travel for passengers. In short, standardized AI could be key to achieving a greener, more efficient aviation industry.

REGULATING CARBON EMISSIONS

Increasing governmental interest in decarbonizing the aviation industry

Governments worldwide are increasingly focusing on legislating carbon emissions in the transportation sector, particularly in the aviation industry. With the growing concern about climate change and its environmental impact, governments recognize the need to address the carbon footprint of air travel.

International organizations like International Civil Aviation Organization (ICAO) also enforce stricter emission standards for aircraft. However, decarbonizing aviation is difficult and will sharply increase costs and depress air traffic [107]. Without major scientific breakthroughs, getting to net-zero emissions will require trade-offs, particularly if air traffic continues to grow as expected. Nevertheless, governments encourage collaboration among stakeholders, including airlines, airports, and industry experts, to develop and implement sustainable aviation strategies. Worldwide, governments are taking legislative actions to address carbon emissions in the transportation sector, focusing on the aviation industry.

Facts:

- In 2017, the aviation industry emissions represented 3.8% of the total global CO_2 emissions and 13.9% of the CO_2 emissions in the transport industry [108].
- In 2019, The European Commission made public the Green Deal, which aims to make Europe the first climate-neutral continent by 2050 [109]. Also, in 2023, the European Parliament and Council reached a political agreement on the "ReFuelEU Aviation" proposition, intending to reduce by two-thirds the carbon emissions in the aviation industry by 2050 [110].
- European aviation emissions increased by an average of

5% year-on-year between 2013 and 2019. Although there was a drastic decrease during the pandemic, these emissions are projected to continue to increase [110].

Key Drivers:

- International agreements and regulations like the CORSIA, EU-ETS, and Fit for 55. These agreements create a legal framework that requires airlines to comply with certain requirements and commit to reducing their emissions.
- Aviation fuel suppliers will be obliged to supply a minimum share of SAF at EU airports, starting at 2% of overall fuel supplied by 2025 and reaching 70% by 2050 [110].
- The aviation sector's growth rate will be a key factor in determining whether it can reach net-zero emissions by 2050, as many governments have set as a goal [111].

Challenges:

- Technological development: the aviation industry will need to overcome the challenge of developing and adopting new technologies to meet the requirements of the regulations that, for now, have outpaced this development [112].
- Infrastructure and supply chain: a new infrastructure will be required to support the production, storage, and distribution of SAF. Also, airports may require upgrades to accommodate electric aircraft and charging infrastructure [112].
- Economic viability: the aviation industry will face the following years problem of the economic viability of the application of the new environmental regulations, with the additional cost of producing SAF, and creating the infrastructure for the new electric and hydrogen aircraft that are estimated to be operational by the 2030 decade [112].

Impact on Sustainable Aviation:

The decarbonization of the aviation industry can profoundly impact achieving sustainable aviation. By reducing carbon emissions through adopting cleaner technologies, alternative fuels, and improved operational practices, the industry can contribute to mitigating climate change. The government's policies and incentives to promote the decarbonization of aviation, such as incentives for reducing emissions from airports, sustainable aviation fuels, and improving air traffic and airport efficiency, have encouraged the aviation industry to adopt sustainable practices [111]. Furthermore, the aviation industry can play a vital role in shaping the future of air travel and fostering a greener and more environmentally conscious global transportation system.

ECONOMY AND BUSSINES MODEL TRENDS

DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

Circular Economy

Emerging Low-carbon Economy

Rise of Developing Economies

Improvement of Supply Chains

Business Model Diversification

Mario Albelda

Natalia Alonso

Alejandro Atienza

Sahira Janeir

ECONOMY AND BUSSINESS MODEL TRENDS

Digital Solutions for Sustainable Aviation

Aviation has been traditionally driven by maximizing profits and attracting a more significant market share of customers. However, nowadays, there is a strong need for developing sustainable aviation business models that will consider the damages that pollution has on the environment. Our economic system has to reflect these concerns, as they are valuable for consumers. In the following section, it will be explored the main changes that will be happening in the next few years at the heart of the economy. Furthermore, it is important also to explore the main ways in which aviation models are trying to adapt their business model strategies in these challenging times. In brief, it can be said that there are emerging economic trends, traditional economic sectors that are being remodeled, and a process of adaptation to this new economic environment.

The economy is now changing and adapting to society's concerns in two main ways. First, a circular economy is developing around the residues of aviation. The circular economy takes into account recycling and reusing both mechanical

parts and expendables inside the plane, effectively reducing costs and reducing the manufacturing environmental impact. By reusing parts, aviation can cope with fleet modernization better. On the other hand, aviation companies are looking to reduce and recycle expendables, such as plastics. This circular economy is going hand to hand with a new uprising carbon economy, where polluting less increases the companies' profits. The carbon economy is becoming stronger thanks to an increasing awareness of sustainability. Stronger legal regulations and higher awareness will make sustainable businesses more profitable. There is a third factor of crucial importance that will mark the future of economics, an unprecedented expansion due to the rise of developing economies. The expansion of the global economy will necessarily need to follow the circular and low carbon economies presented before, presenting a real test for them but also a great opportunity for the previous to grow stronger and consolidated.

On the other hand, some traditional economic sectors, such as the supply chain, are being remodeled to better fit in a sus-

tainable future. Supply chain economics, traditionally based on finding the best production prices, is being optimized to obtain a more robust and trustworthy supply without losing many profits; this usually means closer and more diverse raw material suppliers, lowering both waiting times and liability to external threats. It may also mean having a more diverse supply net depending on local communities to production areas. Above all, these changes mean a more sustainable, trustable, and eco-friendly supply chain.

With all these changes in the economic sector, aviation companies are diversifying their business models in two main approaches: low-cost companies and more traditional and complete carriers. Both models focus on different market shares and offer different sustainability solutions. Competition between these two models will also drive how aviation will be shaped in years to come.

Trend	Scenario	Ideation

CIRCULAR ECONOMY

Transitioning Towards Sustainability

Circular Economy drives society beyond the conventional approach of extracting, producing, consuming, and disposing. Instead, it finds a more efficient and sustainable path forward. This new economic concept embraces practices such as sharing, leasing, reusing, repairing, refurbishing, and recycling. By extending the lifetime of products, it can minimize waste generation and promote a sustainable approach to production and consumption. This new model has gained significant traction, as it offers economic growth while ensuring that the production level does not increase the consumption of raw materials. It has the potential to create opportunities for new products with a higher price while relieving society from the burden of waste management at the end of its life cycle. Instead, the cost of recycling or recovery is already included in the product price. In the last decades, there has been an increased focus on extracting value from end-of-life aircraft, primarily due to the growing number of aircraft reaching their retirement age. A small percentage of aircraft is currently reused and remanufactured, and remanufacturing generally takes place only when the aircraft reaches its retirement stage. Additionally, economic factors may lead to the retirement of an aircraft even before its operational lifespan is fully utilized [113, 114].

Facts:

- In 2022, humans depleted and consumed resources at a rate 75% higher than the Earth's capacity for regeneration [114].
- The European Parliament reports show that implementing circular economy practices has the potential to yield annual savings of 600bn EUR for companies in the EU and create 580,000 job opportunities [114].
- The adoption of the circular economy could lead to significant annual net material cost savings for EU companies, estimated to be between 250 and 465bn USD. These savings would represent 12% to 23% of their total material costs [115].
- It is estimated that over the next 20 years, around 10,000 aircraft will retire [116].

Key Drivers:

- With the recent implementation of the EU Corporate Sustainability Reporting Directive (CSRD) by the European Parliament, over the next 1 to 5 years, more than 50,000 companies based in the EU will be required to report on their sustainability performance [117].
- The need to reduce waste, be more sustainable, and reuse non-renewable products [118].
- Need for long-term cost saving and innovative product availability without bearing the economic and environmental costs [118].
- A circular economy enhances a spirit of economic growth, increasing competitiveness, and fostering innovation, all sustainably and profitably [118].

Challenges:

- Insufficient strategic guidance and lack of standardization [119].
- Difficulty in aligning circularity with competitive business models. Facing barriers such as the transition costs and virgin materials being more affordable, businesses chose them instead of opting for recovered or recycled materials [120].
- Many stakeholders have yet to grasp the potential magnitude of aviation-related waste [121].
- Certain materials have limitations in terms of their recyclability as they cannot be recycled indefinitely [115].

Impact on sustainable aviation:

Although the concept of circular economy in the aviation sector has yet to be prevalent, its application could provide opportunities for the future. The aviation industry is projected to experience a significant expansion, with global air traffic anticipated to double by 2035. These projections suggest that resource consumption, waste generation, and emissions in the aviation industry could rise. Another aspect to consider in the current recycling situation is that a significant portion of recycled and recovered aerospace materials is redirected to other industries. However, if aerospace companies could establish direct recycling processes within the industry, it would enhance the value of these materials and reduce the need for new raw materials [121].

EMERGING LOW-CARBON ECONOMY

When polluting comes with a cost

Carbon's effect on climate change is now more than ever evident. Several systems have tried to account for the damage that carbon emissions generate [122]. After the Kyoto Agreement, the carbon market was born under an Emission Trading Credit (ETC) system [122]. The ETC system allows for cap and trade schemes, where an authority sets a specific overall emission limit and then divides them into different industrial sectors; if one sector has surplus credits, these allowances can be re-sold to more contaminant industries [123, 124]. Besides ETCs, the carbon market includes offsetting strategies to recover liberated CO_2 by investing money in projects that will fix determined amounts of CO_2 [125]. For example, planting trees or researching new technologies. A growing interest in brand image, more aware customers, and especially political regulation will affect the price of carbon emissions [126]. With new green taxes [127], a decreasing number of carbon emission allowances for every sector, and the social urge to curb climate change, the price of these taxes is expected to keep growing. The threat of new costs makes companies from all sectors develop sustainable solutions, especially in aviation, where emissions should be non-existent by 2050.

Facts:

- Swisher and Masters (1989) argued that we should use an "international market mechanism that assigns value to climate protection," meaning that the idea of the economy helping to curb climate change is coming a long way [122].
- International carbon markets have proliferated in recent years [122, 126].
- New technologies are emerging to make aviation more sustainable (hydrogen fuel, e-planes, zeppelins [128], drones, especially for short distances), meaning that it is attractive and viable for companies to go green [129, 130].

- Carbon offsetting methods are increasingly used in aviation, evidencing the rise of an environmentally centered economy [131].

Key Drivers:

- Legal and regulatory systems will drive the carbon market economy in the next few years, assigning prizes to green taxes, allowances to different sectors, and regulating the market legislation overall [127, 123, 131].
- The will to make a more sustainable world environmental impact of a growing industry is based on the idea that pollution should be compensated thanks to a more aware population [122, 131].
- Companies intend to expand market share and attract talent and customers [132].
- Renewable energies and offsetting strategies are decreasing prizes, making it feasible for a low-carbon economy to develop [129].

Challenges:

- Carbon markets have also suffered from severe growing pains. They have been criticized for not generating real emissions reductions [131], over allowances of a sector not so contaminant, and allowing other sectors to keep polluting longer [122].
- Classic offsetting methods are liable to disasters, such as wildfires. Often offsetting comes in the form of forest maintenance, even if most times that maintenance was already taking place, making it false [131].
- Lack of essential safeguards against fraud and institutional failures [122] and still working out the basic rules of the global economy make the appearance of the carbon market harder [131, 133].

Impact on sustainable aviation:

The low-carbon economy, once well implemented, could provide both the perfect framework for a competitive economy focused on sustainability and the motivation needed to start changing towards a more sustainable future [122, 127, 131] as the alternative is a future of increasingly expensive allowances. However, carbon markets will make aviation more environmentally responsible and help decarbonize other sectors [127, 125, 131], as traditional offsetting methods are already being questioned in efficiency.

RISE OF DEVELOPING ECONOMIES

An emerging reinforced middle class

In recent years, the rise of developing economies has begun to be observed. Specifically in Brazil, Russia, China, India, and South Africa (BRICS) which have experienced very significant and fast growth. A whole new sector of clients that did not exist before has appeared. An increasing proportion of China's population is now considered middle class, and vacation travel and commerce are now easier than ever before. The ending of the pandemic and the Asiatic regions' economic opening are promising to reshape the global economy, impacting consumer goods and market expansion. The rise of new markets will expand the existing ones, flooding as we see work positions and tourism locations with new talent and travelers, respectively; this will revolutionize all types of industrial and economic activities. In addition, globalization and personalized care will be the main players in this social, cultural, and economic expansion. Most of the expansion has been observed in early 2023 due to the reopening of borders in the Asia Pacific region. Still, they are expected to spread globally in other low-income countries [134, 135, 136, 137, 138].

Facts:

- Demand for air travel is expected to double by 2040, growing at an average annual rate of 3.4%. Origin destination passengers would increase from around 4 bn in 2019 to just over 8bn [139, 140].
- By 2030, another 700M people are expected to join the global middle class, making it more than half of the world's population. Most come from BRICS countries representing important emerging markets with substantial consumption potential [141, 142].
- A 200% growth in China's middle class is projected in the coming years. It currently represents half of the global middle class, which consists of around 400M people [143]

Key Drivers:

- The increase in the degree of globalization positively impacts the growth rate of gross domestic product per capita, which increases by 0.33% points when the globalization index rises by one point [144].
- BRICS countries have an increased average per capita income allowing citizens to allocate excess money to other countries, impacting their economies [144].
- Overall, countries are experiencing rapid economic growth, specifically BRICS. These countries represent almost 42% of the world's population and contribute about 24% of the world's GDP and 16% of world trade [145, 146].
- Massive expansion and reform of global education. Training of future professionals [147].

Challenges:

- Increasement of air traffic is counterproductive for sustainability and decarbonization policies. In addition, likely, the costs derived from the impacts of climate change and the net zero transition will increase [148, 149].
- The supply of aircraft parts suffers delays, which negatively affects the delivery of new aircraft and the ability of airlines to respond to market needs [134, 150].
- The reopening of China's borders could lead to an increase in inflation. With more people traveling and increased trade activities, there is an expected surge in product demand, which can exert pressure on prices [151].

Impact on sustainable aviation:

Middle-class growth, particularly in the BRICS, drives the aviation market's recovery. Reopening of borders in the Asian Pacific region will increase connectivity between countries. This will impact the tourism and trade economy. This increase in the market will challenge all sustainability strategies, but also the opportunity to test and lay the foundations for sustainable aviation. Additionally, emerging professionals from these regions will reshape the aviation industry. To meet the needs of passengers, personalized experiences, new routes, and trained flight crews will be essential for the next 20 years. However, the surge in air traffic leads to increased carbon emissions and poses challenges in developing sustainable solutions [134, 144, 148, 152].

IMPROVEMENT OF SUPPLY CHAINS

Upgrading links to strengthen the whole

Efficient management of the supply chain is crucial for businesses to reduce costs, improve customer value, and stay ahead of the competition. However, the recent global pandemic has shown how vulnerable supply chains can be, putting companies to the test on a large scale. COVID-19 has worsened existing supply chain challenges as the economic situation becomes more complicated and sustainability becomes more important [153]. Furthermore, factors as rising labor costs, global problems, and environmental concerns have shown that chasing the cheapest prices is not always the best strategy. That is why companies must review their supply chain plans, emphasizing resilience, sustainable practices, and creating long-term customer value [154]. Adapting to these challenges is crucial for success in today's changing global market. Businesses must navigate uncertainties and take advantage of opportunities in the post-pandemic era. Nowadays, companies can position themselves for success in today's uncertain business world, by reassessing their supply chain strategies and embracing resilience, sustainability, and customer value.

Facts:

- Companies have been realigning global supply chains in response to shifting manufacturing cost structures, improvements in advanced manufacturing technologies, tariff wars, and rising protectionism. Many global enterprises have been moving toward regional manufacturing and sourcing footprints to be closer to end markets [155].
- The adoption of digital tools and solutions, such as AI, blockchain, cloud computing, and the IoT has enabled the acceleration of supply chain technology. This has enhanced supply chain visibility, collaboration and innovation [156].
- The pressure from stakeholders has increased to measure and improve supply chain activities' environmental and social impact [157].

Key Drivers:

- The geopolitical tensions have prompted some governments and businesses to seek self-sufficiency or diversify their sources and markets [158].
- The manufacturing footprint reshaping and unstable provision (due to events such as pandemics), which has involved the relocation of suppliers to be closer or reconfiguration of production facilities to optimize costs, quality, speed, and sustainability [154] [159].
- The supply chain technology acceleration has enabled the adoption of digital tools and solutions, such as artificial intelligence, blockchain, cloud computing, and the IOT, to enhance visibility, collaboration, efficiency, and innovation in supply chains [156].
- The Environmental, Social, and Governance (ESG) scrutiny has produced pressure from stakeholders such as investors, regulators, customers, and employees [157].

Challenges:

- Inflation has severely affected the cost of living. This makes it difficult for supply chain planners to accurately estimate in advance the amounts and types of goods likely to be needed by consumers [158].
- Geopolitical tensions have increased the uncertainty and risk of trade conflicts and prompted some governments and businesses to seek self-sufficiency or diversify their sources and markets [158].
- Energy shortages and extreme weather have disrupted global supply chains, causing delays in the shipment of certain goods [158].
- Cybercriminals have become more sophisticated when it comes to infiltrating supply chains to damage or steal from businesses, particularly via their supplier network [160].

Impact on sustainable aviation

Supply chain improvement will create a notable impact by reducing costs, maximizing customer value, and strengthening competitive advantage in aviation. Aviation companies will source the necessary supplies from nearby suppliers, allowing problems to be resolved quickly during disruptions. This not only boosts shareholder confidence but also significantly reduces the environmental impact associated with transporting goods over long distances.

Trend | Scenario | Ideation
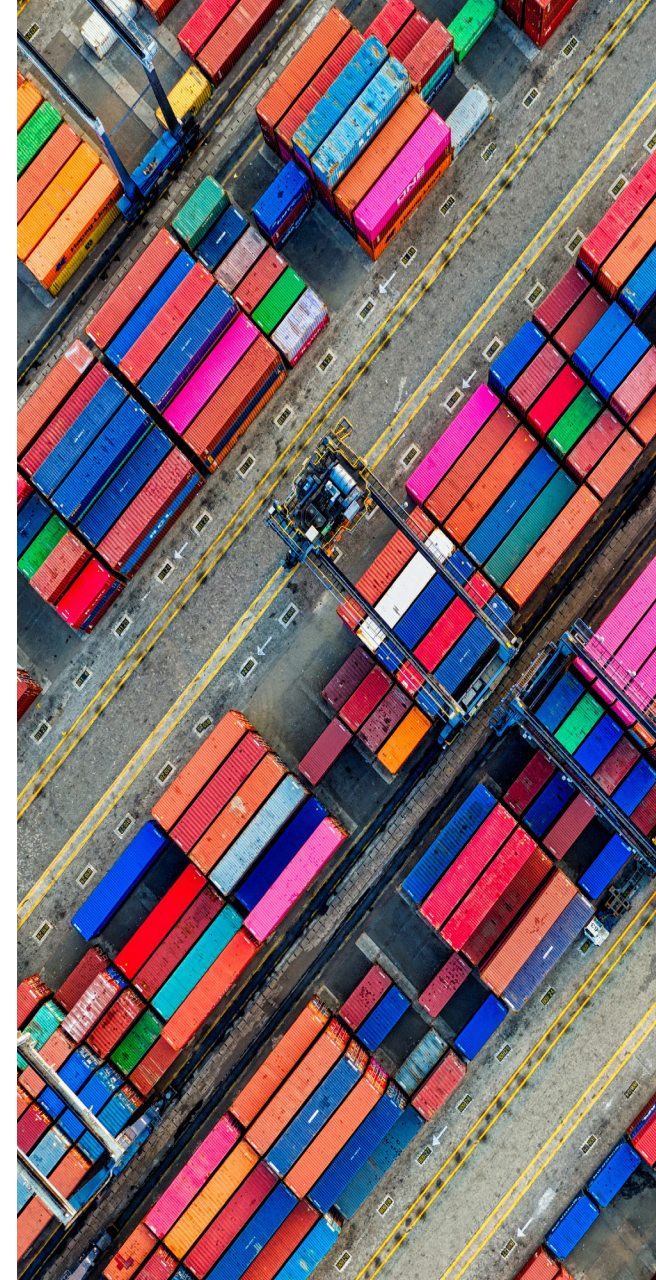
BUSINESS MODEL DIVERSIFICATION

In differentiating a highly competitive sector

The aviation industry is changing how it does business. Some airlines now focus on offering low prices, while others focus on giving customers more personalized, comfortable, and convenient experiences [161, 162]. Low-cost airlines are trying to attract travelers who are looking for affordable prices and do not mind sacrificing some extra benefits. They have found ways to operate more efficiently and make higher profits. However, larger, traditional airlines have needed help to copy this success when creating their own low-cost airlines. At the same time, traditional airlines are trying to appeal to customers who are willing to pay more for a better travel experience [163]. They are investing in things like personalized services and added comforts to attract these higher-paying customers [164]. Today the aviation industry has two different types of airlines: the low-cost ones and those that focus on personalization, comfort, and commodities [163]. Each one is targeting different types of customers. Low-cost airlines are profitable, whereas major airlines are struggling to replicate their success. As the aviation industry changes, finding the right balance between pricing, customer preferences, and profitability will be significant for airlines to succeed in this competitive market [165].

Facts:

- Companies are now focusing on providing either a more cost-effective strategy (low-cost) or a more personalized, comfortable, and customer-centered strategy [161, 164, 166].
- Budget airlines are expanding to secondary airports while traditional airlines remain in their classic hubs [162].
- In the next five years, a step-change is expected in the degree of personalization and customer centricity offered by airlines [162, 166].

- Variety in the business models makes it possible for different travelers to choose the price and commodities they need, which may vary depending on the reasons for traveling [161].

Key Drivers:

- The people emerging from the lower class and entering the middle class from developing economies will demand lower prices to afford the flights [162].
- Social inclusion and traveling democratization. This diversification of business models represents the ideal of everyone being able to fly wherever they want [167].
- COVID-19 pandemic recovery will likely push tourists toward low-cost operators, while work-related travelers will probably remain in traditional airlines [168].
- Customer-centered aviation n will be used as a differentiating factor between airlines [162, 165, 169].

Challenges:

- Although both business models are working for different shares of the market, they will always be competitors from one another. Effective online management technologies may favor one at the expense of the other [163].
- Placing sustainability as a central value on business plans could result in over costs for budget airlines, making their business model less effective, at least in the short term [170].
- Finding which expenses are removable and which should be maintained [171].
- An increasing market will challenge hub-dependent companies to manage very high affluence while challenging low-cost carriers' capacity, as their fleets are composed of identical planes [163, 172].

Impact on sustainable aviation:

The different business models present in the aviation sector right now increase competitiveness, decreasing costs overall, and favoring an even more significant increase in the aviation market [172, 173] which means even higher emissions [170]. The companies with these models will need to depend on decarbonization with cost-effective solutions such as software, meaning that low-cost companies could become solid allies to battle carbon emissions in the short term. Traditional airlines, with higher benefit margins, support technology development to battle climate change on a bigger scale, but also with longer times to develop [165, 170].

SCENARIOS

The following chapter describes four scenarios of different futures. The scenarios are plausible, relevant, challenging, consistent, and recognizable from the present and near future signals. All of the scenarios are equally plausible and derived from two identified key drivers. They present far-reaching visions of what the future of digital solutions in sustainable aviation could look like in 2043. Personal narratives tell stories of ordinary days in 2043 to allow an in-depth look into the future. Finally, identified signposts indicate the progress towards each scenario. They emphasize possible paths from the present to each of the four scenarios.

DRIVER MATRIX

The scenario phase employs a systematic approach to envisioning the potential landscape of 2043. Following the research developed during the Trends Phase, key ongoing influencing factors, both of high impact and high uncertainty, have been identified regarding the future of digital solutions for sustainable aviation. The results were presented in a matrix that visually represents each driver's level of impact and uncertainty. GHG emissions and data sharing were the predominant drivers. Both were modeled using binary results to create four extreme but plausible future scenarios. Additional drivers were chosen from the matrix and incorporated into the scenarios to enhance and sharpen these narratives. The subsequent pages depict the fully developed narratives along with their corresponding illustrations.

Impact (high)

Compliance Greenhouse Gas Emissions Existence of pollution Waste Management/ Data Security

Data Privacy

Social Awareness

Dominance of Developing Economies Data Sharing

Unexpected Events

Uncertainty (high)
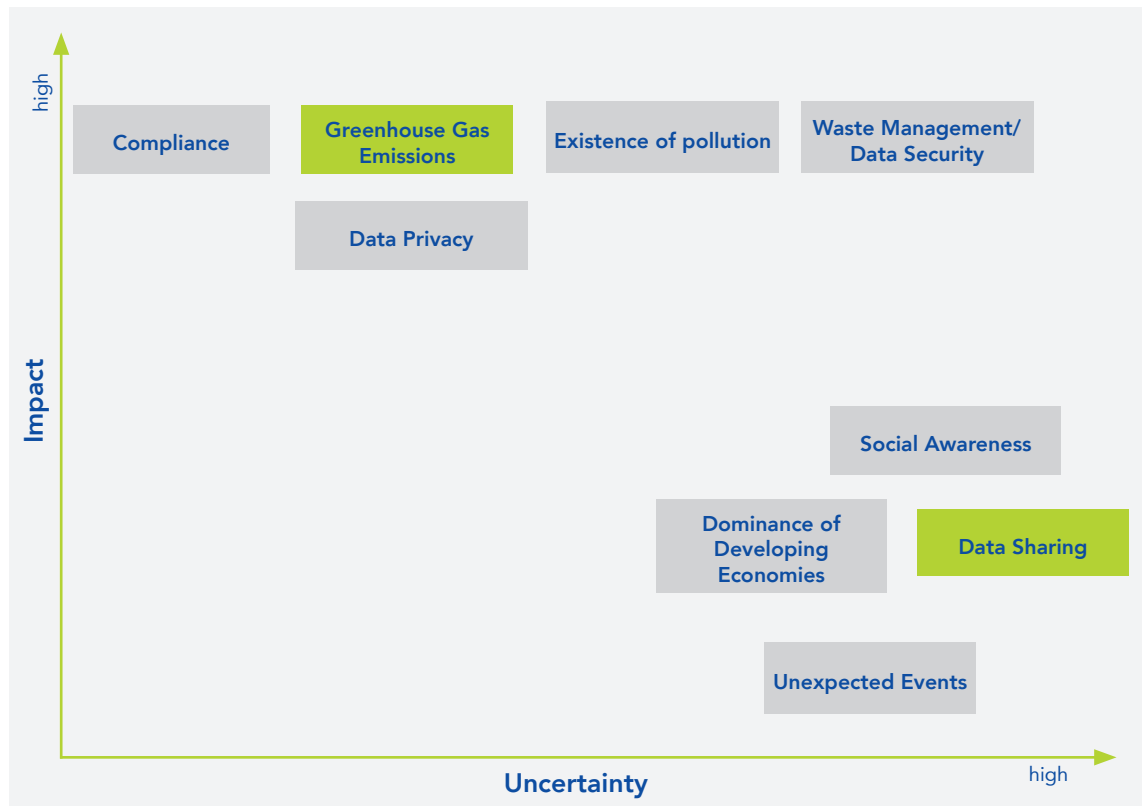
KEY DRIVERS

Low Emissions

By 2043, society will make significant strides in reducing GHG emissions to unprecedented low levels. This achievement will result from a concerted global effort marked by groundbreaking technological advancements, rigorous emission standards, and a shift toward sustainable practices. The industry will see the widespread adoption of electric aircraft and biofuels, significantly reducing the carbon footprint of air travel. Innovative flight path optimization techniques, facilitated by advanced AI and machine learning algorithms, will minimize fuel consumption and emissions during flights. Furthermore, proactive maintenance schedules, informed by real-time data analysis, will ensure optimal aircraft performance and efficiency. This outcome represents a future where the aviation industry acknowledges its role in climate change and takes decisive action to mitigate its impact.

← Greenhouse Gas Emissions →

GHG emissions are a critical factor in the context of sustainable aviation. They represent the industry's and society's environmental impact and contribution to global climate change. The level of these emissions is influenced by many factors, including the type of fuel used, the efficiency of flight routes, the technology incorporated in aircraft, and the overall operational practices of the industry. The management and reduction of these emissions are a matter of environmental responsibility and a determinant of the industry's future trajectory. The industry's ability to innovate, adapt, and commit to sustainable practices will be instrumental in navigating the challenges ahead.
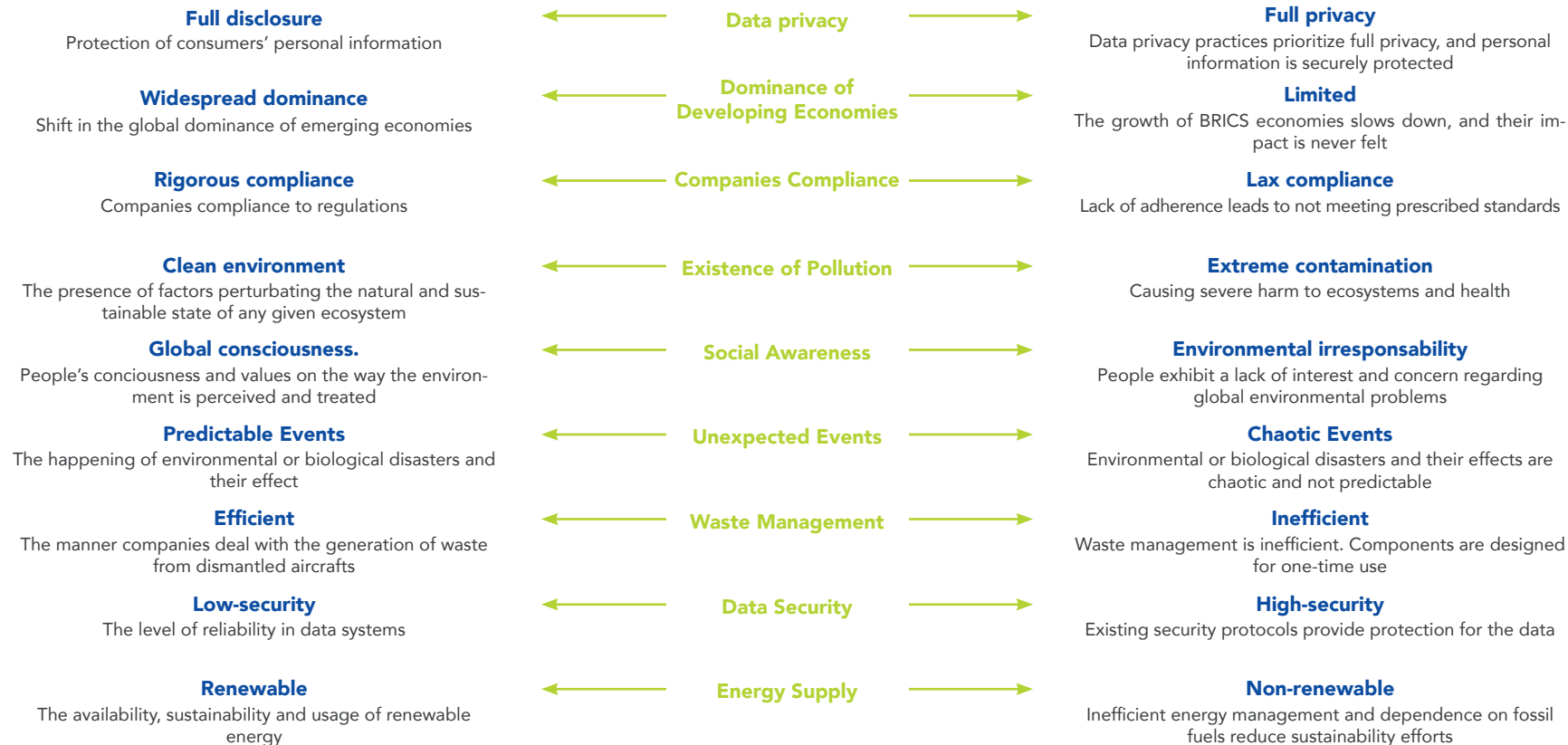
High Emissions

Despite the availability of technology and knowledge to reduce emissions, the industry will need help implementing sustainable practices. Factors such as economic constraints, lack of regulatory support, and resistance to change hinder the transition toward cleaner energy sources. The air industry continues to rely heavily on fossil fuels, and inefficient flight paths contribute to excessive fuel consumption. Despite society's growing environmental awareness, the inability to effectively reduce emissions has further exacerbated the problem. This outcome underscores the potential consequences of inaction and the pressing need for the industry to prioritize sustainability.

Low Data sharing

Society would witness a decline in connectivity and collaboration, leading to limited knowledge exchange and innovation. Critical sectors like research, health care, and education would need more access to valuable information, hampering advancements in these fields. Industries need help making informed decisions, impeding productivity and stifling growth. The lack of data sharing could result in limited transparency, ineffective policy-making, and reduced citizen engagement in political environments. The environment may face challenges as sustainability initiatives lose data-driven optimization, potentially leading to inefficiencies in resource allocation and environmental degradation. This outcome would underscore the importance of responsible data sharing for society's overall progress and well-being.

← Data sharing →

Data sharing refers to exchanging relevant information, insights, or resources between companies for collaborative purposes. It involves deliberately sharing structured or unstructured data with trusted partners or stakeholders, such as customer data, market trends, sales, supply chain and research, operational metrics, or research findings. Data sharing enables businesses to enhance decision-making, facilitate cooperation, and potentially achieve mutual benefits. It is crucial in fostering knowledge exchange, optimizing processes, and identifying potential growth opportunities. Additionally, data sharing allows society to grow more sensible and informed, being key for awareness and responsibility.

High Data sharing

In the event of data sharing consolidation, society will experience a shift towards hyper-connectivity, with individuals and communities interconnected like never before. This will lead to healthcare, education, and quality of life advancements. Economically, industries will revolutionize through data-driven insights, creating new business models, improving productivity, and driving innovation. Political landscapes might witness governance, policy-making, and citizen engagement changes, as data empowers informed decision-making. The environment will benefit from data-driven sustainability initiatives, optimizing resource allocation and mitigating ecological challenges. However, this outcome will also raise concerns regarding privacy, security, and ethical use of data, needing robust regulations and safeguards to protect individuals and society affecting mental health. An increase in data management will also require storage and processing facilities, which is costly in energy use.

OTHER IMPORTANT DRIVERS

Full disclosure
Protection of consumers' personal information

Data privacy

Full privacy
Data privacy practices prioritize full privacy, and personal information is securely protected

Widespread dominance
Shift in the global dominance of emerging economies

Dominance of Developing Economies

Limited
The growth of BRICS economies slows down, and their impact is never felt

Rigorous compliance
Companies compliance to regulations

Companies Compliance

Lax compliance
Lack of adherence leads to not meeting prescribed standards

Clean environment
The presence of factors perturbating the natural and sustainable state of any given ecosystem

Existence of Pollution

Extreme contamination
Causing severe harm to ecosystems and health

Global consciousness.
People's conciousness and values on the way the environment is perceived and treated

Social Awareness

Environmental irresponsability
People exhibit a lack of interest and concern regarding global environmental problems

Predictable Events
The happening of environmental or biological disasters and their effect

Unexpected Events

Chaotic Events
Environmental or biological disasters and their effects are chaotic and not predictable

Efficient
The manner companies deal with the generation of waste from dismantled aircrafts

Waste Management

Inefficient
Waste management is inefficient. Components are designed for one-time use

Low-security
The level of reliability in data systems

Data Security

High-security
Existing security protocols provide protection for the data

Renewable
The availability, sustainability and usage of renewable energy

Energy Supply

Non-renewable
Inefficient energy management and dependence on fossil fuels reduce sustainability efforts
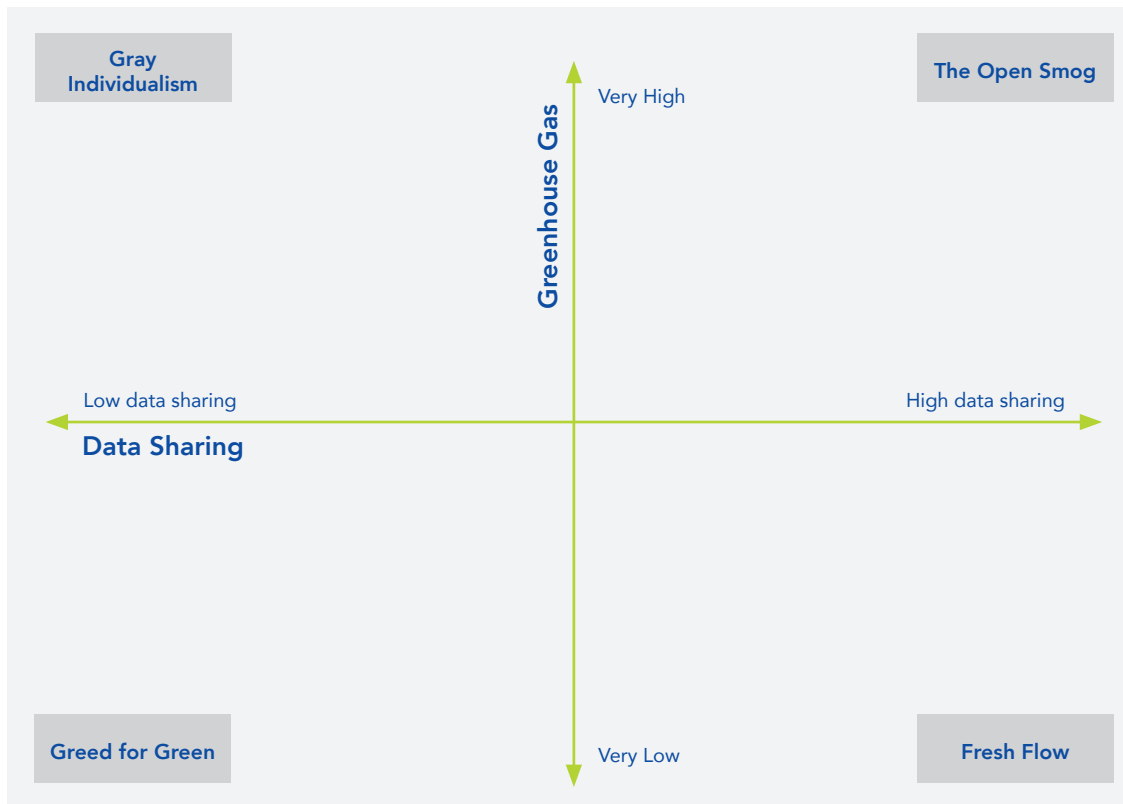
SCENARIO MATRIX

The scenario matrix is built on identifying two key drivers and their potential outcomes, represented on each axis. These outcomes span from one extreme to another, creating a bipolar scale. By combining the extreme outcomes of both drivers, four distinct scenarios emerge. Other significant factors and drivers are also considered, and their outcomes are carefully determined within each scenario to ensure feasibility and congruence. This comprehensive approach allows for exploring various potential futures, providing valuable insights for decision-making and strategic planning.

"**The Open Smog**" combines high emissions and significant data sharing in "The Open Smog" scenario. Unregulated industrial practices produce more GHG emissions, increasing climate change's effects. In the meantime, the culture of unlimited data sharing raises privacy and security concerns, emphasizing the need for ethical data practices and responsible environmental management.

"**Gray Individualism**": In the "Gray Individualism" scenario, there are many emissions and little data exchange. Knowledge sharing and innovation suffer from a lack of connectivity and collaboration. Lack of data sharing restricts access to important information, limiting development in key industries. The value of responsible data sharing for social well-being is shown by poor decision-making, decreased public engagement, and potential environmental deterioration.

"**Greed for Green**": The scenario "Greed for Green" depicts a world with reduced emissions but little data exchange. Reduced connectivity blocks innovation and knowledge flow despite lower GHG levels. Initiatives for sustainability are hindered by the absence of data-driven optimization, which presents problems with resource allocation and environmental preservation.

"**Fresh Flow**": Progress is driven by high data sharing and low emissions in the "Fresh Flow" scenario. Broad connectivity encourages innovation and cooperation, which speeds up sustainable practices. Data-driven insights enable well-

informed choices. A clear, environmentally conscious future is made possible through efficient sustainability programs and optimal resource utilization.

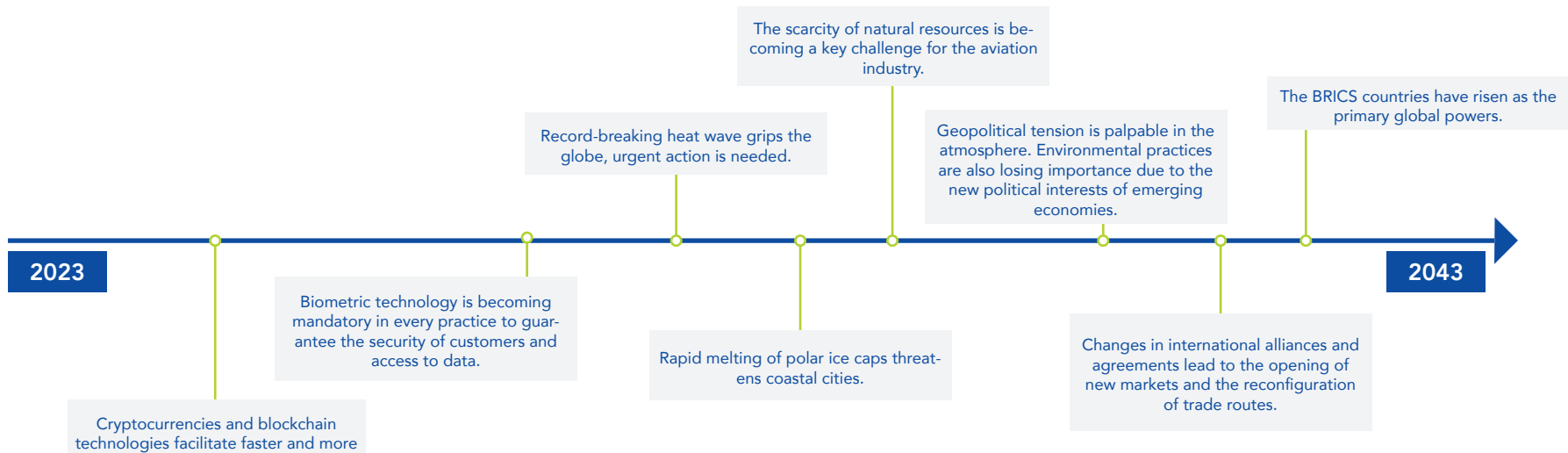| Gray Individualism		The Open Smog
	Greenhouse Gas — Very High	
Low data sharing	**Data Sharing**	High data sharing
	Very Low	
Greed for Green		Fresh Flow

Elena Agudo

Natalia Alonso

Cristal Campos

Javier Mateos

THE OPEN SMOG

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between 2022 and 2042. Therefore, they describe the development

The scarcity of natural resources is becoming a key challenge for the aviation industry.

The BRICS countries have risen as the primary global powers.

Record-breaking heat wave grips the globe, urgent action is needed.

Geopolitical tension is palpable in the atmosphere. Environmental practices are also losing importance due to the new political interests of emerging economies.

2023

2043

Biometric technology is becoming mandatory in every practice to guarantee the security of customers and access to data.

Rapid melting of polar ice caps threatens coastal cities.

Changes in international alliances and agreements lead to the opening of new markets and the reconfiguration of trade routes.

Cryptocurrencies and blockchain technologies facilitate faster and more

A Day in 2043

As the scorching sun rises over the ancient Malvarrosa beach, Lara's day begins in her tiny and energy-efficient apartment on the 30th floor of a building in the heart of the bustling smart city of Valencia. However, in this climate-crisis-stricken world, Lara experiences two contrasting realities.

For some time now, the BRICS countries have rapidly grown in power, emerging as the primary global players, surpassing both the EU and the USA. However, despite their increasing influence, these nations have struggled to cope with the challenges posed by climate change and embrace ecological sustainability. This lack of action has had devastating impacts, especially on cities like Valencia, which have embraced a more sustainable approach to face the future.

Valencia shines as a beacon of hope on the global stage. Its advanced technological and ecological measures, such as solar energy usage, smart transportation systems, and a progressive mindset in combating carbon emissions, have made it an exemplary city in effectively addressing climate challenges. This dual reality is overwhelming for Lara, leading to a growing awareness of the urgency for global action. As she navigates through Valencia's sustainable streets to her job at a tech company focusing on sustainable aviation solutions, she feels the weight of responsibility in confronting the climate crisis. Geopolitical tensions arising from the rise of the BRICS and their struggle to tackle climate change directly impact her work and conscience.

This situation not only affects Lara and Valencia but also has far-reaching consequences for the entire global ecosystem. Climate change knows no borders and requires a collective effort from humanity to find sustainable solutions and address the crisis in its entirety. Lara is driven to contribute wholeheartedly to finding sustainable solutions for her city and the world. Her work becomes a personal mission, and each day, she feels the need to make a positive impact to protect the planet we all share. As she goes about her day, Lara's determination grows, and her hope that humanity can unite to face this common challenge never wavers.

When Lara entered her office by using a biometric scan, she met her boss and told him: "Good morning, Mr. Johnson. Did you hear about what happened in Brazil yesterday? An airplane had an oxygen tank leak, and all passengers suffocated to death due to air contamination." The boss snorted, showing enormous frustration, and said, "Oh no, that's disheartening to hear. It's unfortunate when some countries prioritize the massive demand of passengers before taking real solutions to deal with the environmental and air pollution problems."

Despite the challenges and geopolitical complexities, Lara's office remained a shining example of environmental and local consciousness. The office was not just a workspace but a living ecosystem that promoted sustainability and employee well-being. Equipped with state-of-the-art cooling systems, air filtration units, and abundant green spaces, the office provided a comfortable and eco-friendly environment. The green areas were strategically placed throughout the building, not only to enhance the aesthetics but also to regulate temperature, improve air quality, and create a sense of tranquility for the employees.

Drinking water fountains were conveniently scattered throughout the office, encouraging hydration while minimizing the use of plastic bottles. The office actively promoted waste reduction and recycling programs, ensuring that every employee understood the importance of their actions in preserving the environment. Additionally, the company orga-

nized regular workshops and training sessions on sustainable practices, encouraging employees to adopt eco-friendly habits both at work and in their personal lives.

In her role as an environmental analyst, Lara's decision-making process heavily relied on extensive data analytics, covering every aspect of the aviation sector. Her company revolutionized supply chain management, constantly optimizing processes and enhancing efficiency at every stage. Armed with advanced data tools, Lara monitored carbon footprints, tracked emission reductions, and identified areas for improvement. However, throughout the day, the significant impact of geopolitical situations on her work and personal life was impossible to escape. As the BRICS nations rose to prominence, there were shifts in international trade policies and agreements, influencing the aviation industry. Lara witnessed firsthand how these changes affected her company's operations, requiring them to adapt swiftly to evolving market conditions. Data-driven decisions became crucial in navigating the complexities of international trade and identifying new opportunities for system-wide advancements.

After an intense morning and an ultra-processed meal served by a robot at the cafeteria, Lara participated in a meeting centered around the stringent regulations imposed by local organizations to combat carbon emissions. The legal framework demanded that airlines comply with strict guidelines, compelling them to prioritize sustainable practices. As the workday drew to a close, Lara attended a conference focused on the shifting customer demands in the travel industry. The demand for flying had reached unprecedented levels, with nearly everyone embracing the freedom to explore the world. However, airlines and transportation systems faced the daunting task of meeting this high demand while minimizing their carbon footprint. Lara marveled at the advancements in technology that enabled more precise and extensive data analysis, empowering the industry to identify inefficiencies, optimize routes, improve fuel efficiency, and reduce emissions.

Seeking a momentary escape from the demands of her job, Lara decided to visit a nearby Virtual Reality (VR) experience center to escape from the polluted world. Lara indulged in a breathtaking adventure tailored to her preferences, and every desire was addressed. Returning to her tiny home, Lara couldn't help but notice Carmen, the owner of a gourmet store located in the shopping center. Carmen specialized in offering products cultivated in a pollution-isolated greenhouse, a pursuit that Lara's mother and Carmen had both engaged in during their time as students at the Center for Digital Technology and Management (CDTM). Witnessing Carmen stumble, and the airtight boxes containing her products scatter on the floor, Lara rushed to her aid. "Carmen! Are you okay?!" Lara shouted, approaching Carmen as she desperately tried to salvage the scattered produce. "Nooooo." Carmen sobbed, helplessly watching the fruits of her labor crumble in her hands upon exposure to the over-polluted atmosphere." The harvests are becoming less abundant due to pollution. This is the worst thing that could happen to us." Deeply affected by Carmen's distress, Lara sympathized with the adverse effects of pollution on local agriculture. The incident reaffirmed her commitment to making a positive impact on the environment.

While walking home, Lara sought solace in a nearby man-made park designed to mitigate the effects of climate change. The park had ample shaded areas provided by deciduous trees and pay-as-you-go water fountains that cooled the environment. Lara enjoyed a stroll, savoring the fresh air she missed so much and watching people engaging in outdoor activities amidst the artificial urban nature. When she entered her apartment, Lara conscientiously prepared a fresh and healthy dinner using locally sourced and seasonal produce. By supporting sustainable agriculture and reducing the carbon footprint associated with long-distance food transportation, she actively contributed to a more environmental-

ly friendly lifestyle. Lara was part of a community-supported agriculture program, which connected her directly with local farmers and ensured that she received fresh, organic produce while supporting the local economy. After dinner, she retreated to her apartment balcony, covered with vines and plants that provided shade and an additional sense of freshness. Lara found solace in her small oasis, surrounded by greenery and the calming sound of leaves rustling in the wind. The plants not only added beauty to her living space but also helped filter the air and create a healthier indoor environment.

Before retiring for the night, Lara checked the weather forecast for the next day. Fully aware of the challenges posed by climate change, she remained committed to reducing greenhouse gas emissions and adapting to the changing environment. She followed sustainability news and engaged in local initiatives to stay informed and actively participate in efforts to combat climate change. Filled with hope and determination, Lara fell asleep, ready to face another day in Valencia, where sustainability and resilience were fundamental pillars of her daily routine. With every decision she made, Lara understood that her efforts, combined with those of individuals, companies, and governments worldwide, would shape a future where technological advancements and environmental consciousness went hand in hand. She held onto the vision of harmonious coexistence between humans and the planet, ensuring a sustainable and fulfilling life for generations to come.
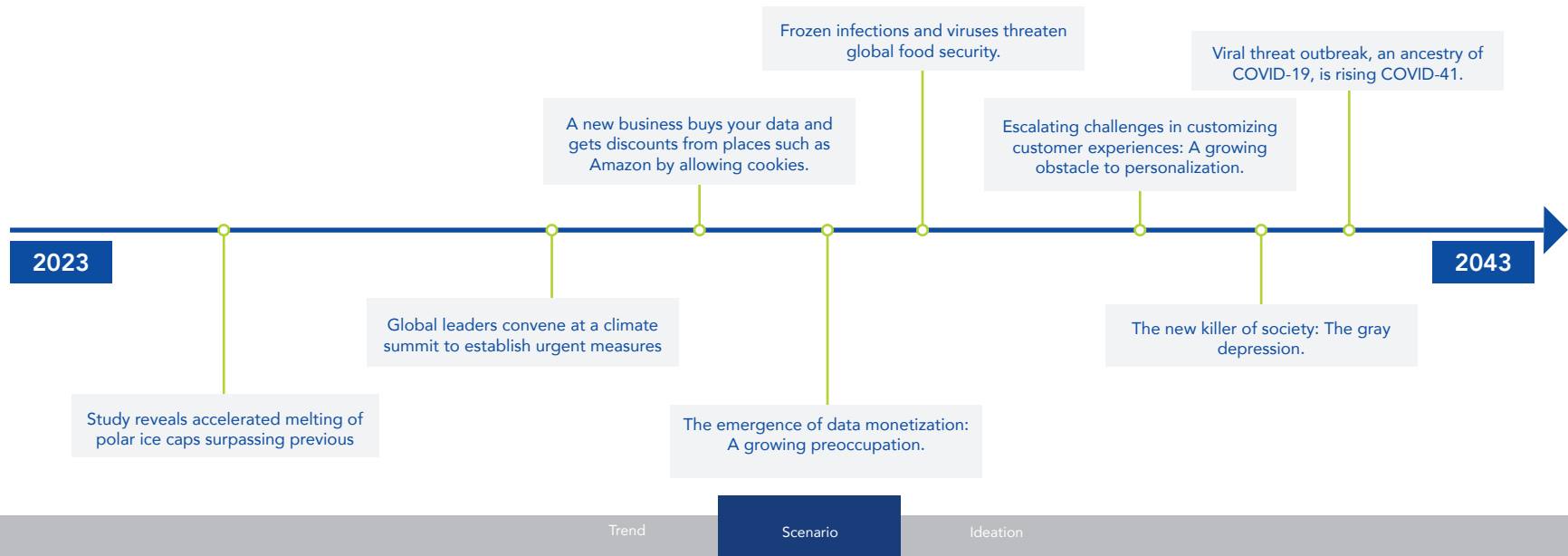
Alejandro Atienza

Berkay Suleyman Dik

Sara Power

Alejandra Reig

GRAY INDIVIDUALISM

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between 2022 and 2042. Therefore, they describe the development

Frozen infections and viruses threaten global food security.

Viral threat outbreak, an ancestry of COVID-19, is rising COVID-41.

A new business buys your data and gets discounts from places such as Amazon by allowing cookies.

Escalating challenges in customizing customer experiences: A growing obstacle to personalization.

2023

2043

Global leaders convene at a climate summit to establish urgent measures

The new killer of society: The gray depression.

Study reveals accelerated melting of polar ice caps surpassing previous

The emergence of data monetization: A growing preoccupation.

Trend

Scenario

Ideation

A Day in 2043

The morning dawned dark, like every day of the past week. Pollution has taken hold of the streets of the big city. James wakes up early, lamenting not remembering the last time the sun shone through the blue sky. Now, the streets are dark and gray, reflecting the pessimism and despair of those who inhabit them. All the measures implemented by world leaders after the devastating floods of 2030 in search of a greener and more sustainable future seemed insufficient and useless.

When he was younger, he dreamed of becoming a pilot, soaring through the blue sky. But times have changed, and now the sky does not seem as blue anymore. Airlines stopped hiring long ago when they decided to ban all flights by 2050. His mind wanders as he stands in the shower, just like every morning for the past few years. Sometimes he thinks about his family living abroad, and other times he reminisces about the scent of fresh air. Unconsciously, he reaches for his virtual headset, aware of its addictive nature. But as the synesthetic emulators kick in, the feeling of regret fades away. Today, he is feeling down, so he dives into his favorite simulation, being a pilot flying an orange crop duster over natural fields. The virtual sensors in his helmet even give him the sensation of rain and a gentle breeze, which syncs perfectly with his real shower experience.

He can visit his parents' house in this virtual world since personal travel has become too expensive. People now connect with their loved ones through the metaverse, where AI avatars step in when real connections are unavailable. The metaverse ensures data privacy using AI trained on random data, making it hard to distinguish between reality and artificial behavior, even for the company. Although he believes he can still tell the difference between humans and AI, there is a lingering fear that he might lose that ability

someday. After parking his virtual plane, he bumps into Charles, another plane enthusiast, who excitedly talks about a device that can disrupt plane weight controls, offering privacy during travel when weight monitoring is mandatory.

Leaving the simulation, he steps out of the shower and checks if the package he ordered days ago had arrived. Due to fewer flights caused by airlines' CO2 offset costs, he had been eagerly waiting for weeks. Like the rest of society, James fears revealing personal information, as the government might use it against him, accusing him of contributing to the world's contamination; even walking around the street may be risky. Thus, he decides to use a neutral address, directing his drone to the designated pickup point to avoid him being seen. There, his order of masks awaits him.

Masks have become highly coveted commodities in the past year. As a nurse in the general hospital, James knew it better than anyone. There, the number of patients with respiratory diseases has surged. Just as during the previous wave of COVID-19, the use of masks connected to oxygen tanks has become indispensable. The hallways are overflowing with patients admitted for asthma attacks, the medical staff is overwhelmed and overburdened. The hospitals are completely saturated, and the need for more data and communication between hospitals and local authorities makes it impossible to know the true magnitude of the problem and its tremendous scale. Since disclosing data has become synonymous with sowing panic, it has become impossible to base the government's plans on actual figures and statistics.

Exhausted from his morning, nurse James Harris makes his way to the cafeteria, where he meets some of his friends. The air quality seems to have improved throughout the morning, and James removes his mask to clear his head a bit. An agi

tated Charles, a lawyer somewhat distressed about the stock market and his invested money, awaits him at the bar. He has heard rumors that the prestigious Loraine Group is on the verge of fragmentation, potentially putting at risk its shares. On the other hand, Claudie, an optimistic artist, is very cheerful because she has read that the Loraine Group is merging with another important company prognosticating growth in the imminent days. Contradictory information has unfortunately become their bread and butter, with uncertainty now an unwelcome companion in their lives.

Gray Individualism

James orders a glass of water to mix his food powder made from insects, which he will complement with the five daily vitamins and supplements he must take. Among them is vitamin D, which compensates for the lack of sunlight. Since water scarcity and pollution have ravaged crop fields, and animal protein cannot be consumed due to the numerous viruses and diseases transmitted, powdered food has emerged as an enduring solution. Initially, James was horrified by the idea, but he is starting to find it more flavorful. Perhaps he might even enjoy what he eats again in a few years.

On his way back home after lunch, he is overcome by nostalgia. He has found an old postcard from the town where he grew up. In the distance, a small tower surrounded by hydrangeas can be seen, very typical of the north. Those, like many other flowers, are no longer seen. When he gets nostalgic, reminiscing about the good years, painting helps him a lot. Upon arriving home, it is decided that James will disconnect from the technology surrounding him and return to the manual labor of the past. He will pick up the brush and relax by painting those pink hydrangeas that bring back many fond memories. As James picks up his paintbrush and starts to bring the pink hydrangeas to life on the canvas, he finds solace in the act of creation.

As he is about to silence his phone, he receives a message from Stephanie, the girl the matchmaking agency has found for him. At least with them, the confidentiality of his data is assured. James has gone too long without a romantic date because fear has invaded him. He is overwhelmed by the idea of telling a stranger personal information. He does not want to tell any woman about the frequency of his work-related travels or any of his minor infractions that promoted pollution and, therefore, an increase in emissions. The fear of being reported and paying substantial fines for transgressing governmental regulations looms in his mind. It is a constant battle between his desire for a romantic connection and his fear of the potential repercussions.

The date is scheduled for a week later, so James still has time to review the list of data he could share and what should be left unmentioned as a precaution. The fact that he has to hide information fills him with immense sadness. Looking out the window as he observes how the stone on the facades of the surrounding buildings darkens and turns gray, he becomes depressed, reminiscing about his twenties when there was no information to hide and everything was clearer.

Amid this gloomy environment, James remembers a recent conversation with an acquaintance from the hospital. He told him about a small group of privileged individuals who had managed to travel to the new space stations being built, where they could enjoy clean air and live without environmental concerns. But James no longer knows what to believe because society's lack of data and prevailing uncertainty perplexes him. He can not help but wonder about people leaving the planet. Are they genuinely free from the environmental concerns that plagued the Earth? Or are they simply experiencing a different set of challenges and uncertainties? He realizes that the grass is not always greener on the other side and that actual change and progress require collective action and a commitment to transparency and sustainability. As an old reflex, he looks at the stars trying to find evidence of the existence of these new stations, but of course, the stars are nowhere to be seen, their light consumed after decades of pollution.

James decides to focus on what he can control: his actions and choices. He will strive to lead a more environmentally conscious life, making sustainable decisions wherever possible. He will advocate for transparency and accurate information sharing, believing that knowledge is essential in driving meaningful change. But regardless of his goodwill, it seems like a distant dream.
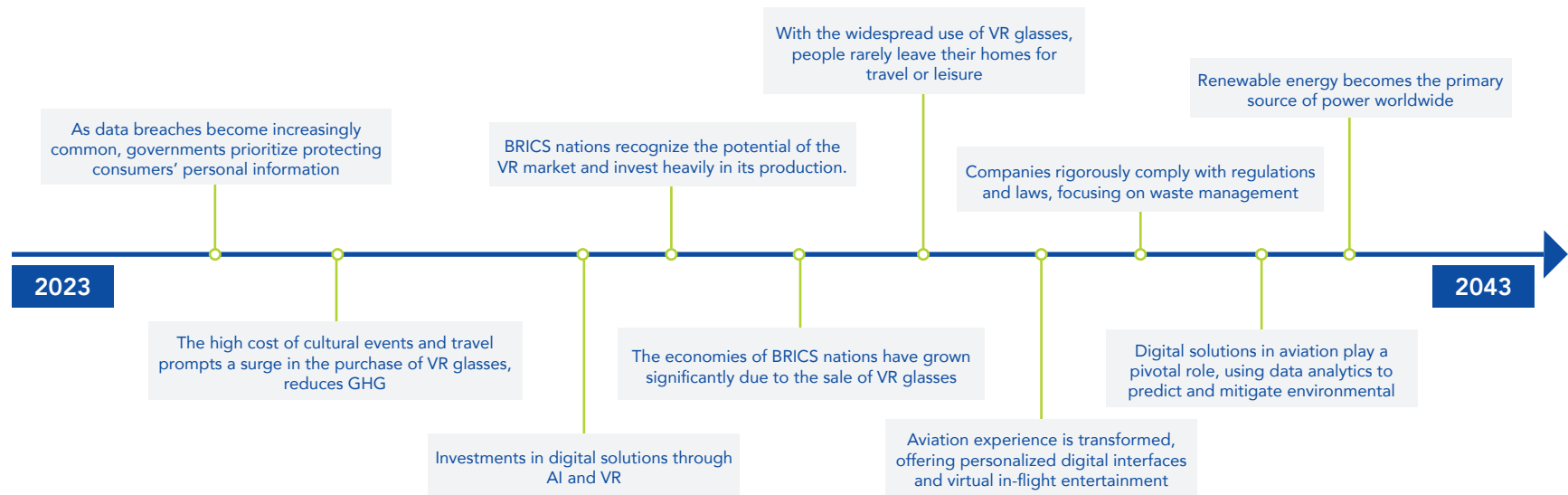
Mario Albelda

Alicia Nuria Correcher

Mattia Di Luca

Joan Navarro

GREED FOR GREEN

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between

With the widespread use of VR glasses, people rarely leave their homes for travel or leisure

Renewable energy becomes the primary source of power worldwide

As data breaches become increasingly common, governments prioritize protecting consumers' personal information

BRICS nations recognize the potential of the VR market and invest heavily in its production.

Companies rigorously comply with regulations and laws, focusing on waste management

2023

2043

The high cost of cultural events and travel prompts a surge in the purchase of VR glasses, reduces GHG

The economies of BRICS nations have grown significantly due to the sale of VR glasses

Digital solutions in aviation play a pivotal role, using data analytics to predict and mitigate environmental

Investments in digital solutions through AI and VR

Aviation experience is transformed, offering personalized digital interfaces and virtual in-flight entertainment

Trend | Scenario | Ideation

A Day in 2043

Marlon wakes up with a sense of purpose on this crisp Monday morning in 2043. Sunlight filters through the curtains, casting a warm glow on his face. Now 46 years old, Marlon holds the position of Chief Technology Officer (CTO) in a prestigious company. As he rises from his bed, he contemplates the day ahead, knowing his actions could have a significant impact on the world. Stepping into his sleek, minimalist kitchen, Marlon activates the smart appliances with a wave. The aroma of freshly brewed coffee fills the air as he glances at his wearable device, confirming that his body has received the necessary rest. Simultaneously, the device projects a hologram, presenting the day's news.

"Today's headlines highlight the immense progress we've made in protecting consumers' personal information," the hologram announces. "Data privacy practices now prioritize complete confidentiality and security." Marlon nods, recognizing the significance of such practices in a world where trust and privacy are paramount. He believes empowering individuals to safeguard their personal data is a cornerstone of progress in the digital age. As he sips his coffee, another headline catches Marlon's attention. "Emerging economies from BRICS have become major global players, shifting the dynamics of economic dominance," the hologram continues. The rise of BRICS is transforming the global economic landscape, fostering cooperation and healthy competition. After breakfast, Marlon makes his way to his home office. His computer, equipped with quantum encryption, serves as the gateway to his professional domain. With advanced biometric identification, he unlocks the device, accessing a world of interconnected possibilities.

A virtual meeting reminder blinks on his screen, prompting Marlon to wear his VR glasses. In the Metaverse, he joins a conference room populated by his colleagues' avatars. The shift to virtual meetings has become the norm, as air travel has drastically reduced due to heightened sustainability concerns and policies. Physical presence is now a rarity, especially since the world leans more into connectivity technologies, avoiding flights for business and even leisure. Conversation flows, and Marlon's mind drifts to the state of the environment, an ever-present concern. The meeting touches upon the stringent regulations companies adhere to, ensuring compliance with laws and standards. These measures are crucial in preserving the delicate balance between progress and responsibility.

Suddenly, an urgent notification disrupts the discussion. Wolfgang, Marlon's favorite coworker, shares heartbreaking news. "Sorry, team, I must leave," Wolfgang's voice trembles. "My brother, living in another country, has fallen ill due to a new strain, and I can't even visit him." A heavy silence settles over the virtual room, a poignant reminder of the challenges of reduced physical interactions and the complexities of the sanitary supply chain in a world with limited flights, given the low-data sharing, detection, and treatment of illness remains a significant challenge. Hannelore, another colleague, seeks to comfort everyone, ensuring the meeting carries on. As lunchtime approaches, Marlon logs off briefly from work, anticipating a small adventure he has planned. He savors the freedom of working remotely, grateful for the balance it brings to his life. In the dining room, he once again puts on his VR glasses, immersing himself in a virtual experience. Transported to a bustling restaurant in Palermo, Sicily, Marlon delights in the sights and sounds of a bygone era. The virtual table before him transforms into a rustic Sicilian setting, evoking a sense of homesickness, a longing for the days when one could travel just for the joy of it. It's a momentary escape, a reminder of the world's beauty and diversity. While savoring his pizza, Marlon's thoughts turn to the responsible management of resources. He reflects on the efficient disposal and reuse of components from dismantled aircraft. Waste management has become integral to sustainable practices,
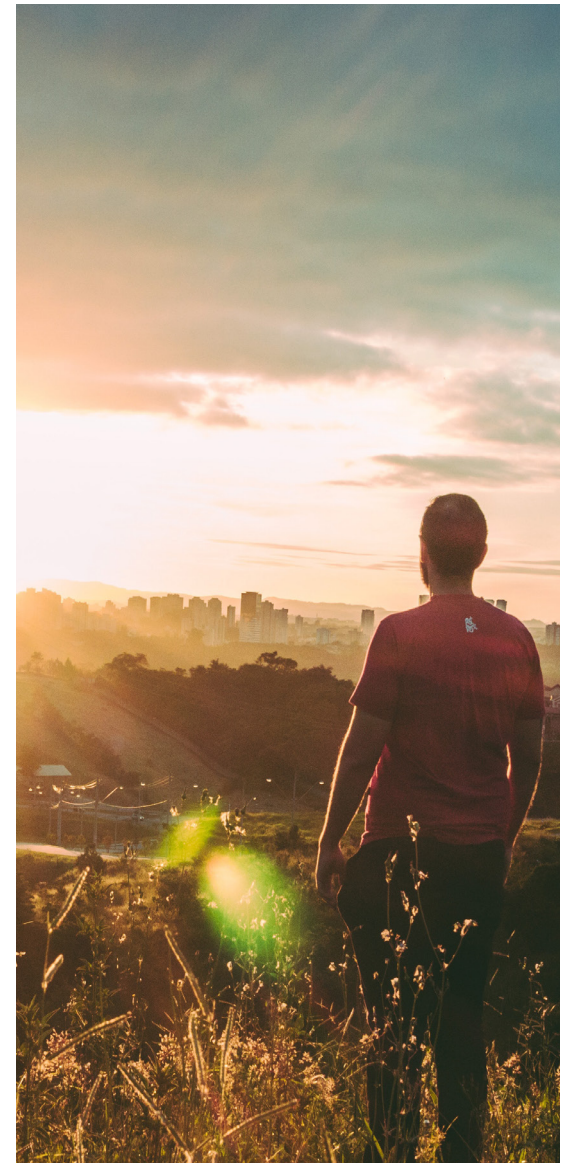
Trend   Scenario   Ideation

ensuring a cleaner and more responsible future. Having enjoyed his virtual dining experience, Marlon switches gears, realizing it's time for his therapy session. The virtual therapy room offers a safe space for reflection and growth, facilitated by an expert thousands of miles away. Marlon openly shares his thoughts and concerns, trusting in the reliability of data systems.

Emerging from the therapy session, Marlon's wearable device reminds him of a virtual reunion with his grandparents, who live overseas. The inability to visit them physically due to the decline in leisure travel has made these virtual meetings even more precious. Marlon cherishes these moments, knowing that their unchanging and familiar avatars represent their enduring bond. As he immerses himself in conversation with his grandparents' avatars, Marlon's grandfather reminisces about the advancements in biomedicine curtailed by past tragedies. Despite the setbacks, Marlon's grandfather believes responsible progress can still be achieved.

Time flies, and Marlon bids his virtual grandparents farewell. With a flicker of excitement, he prepares for an evening date facilitated by the latest dating app, Botbae. Intrigued by the app's stringent data policies, Marlon's curiosity is piqued as he speculates about his mysterious match. Dressed in his best attire, Marlon ponders the topic of data leasing, a potential avenue for additional income. However, the ethical implications weigh on him. He questions whether it is an option reserved solely for the financially disadvantaged. His wearable device chimes as he ponders, reminding him of the time. He quickly finishes dressing and exits his apartment.

Summoning a premium autonomous car share, Marlon embarks on the journey to meet his date. The sleek vehicle, powered entirely by renewable energy, hums softly as it navigates the city's clean, well-maintained streets. The vehicle doubles as a mobile hair salon, ensuring he arrives impeccably groomed. As he watches the cityscape pass by, he marvels at humanity's progress. The air is clean, the energy is

renewable, and the city is vibrant with life. It starkly contrasts the polluted cities of the past, a testament to the power of collective action and responsible governance.

With aspirations of starting a family, Marlon can't help but consider the prevailing baby boom and its impact on societal dynamics. The population is growing, but so too is the consciousness and values of the people. The environment is no longer an afterthought but a priority. People understand the importance of maintaining a sustainable ecosystem and are willing to make the necessary sacrifices to ensure its preservation.

On the way home from the date, Marlon passes a statue commemorating the Fighting BATS, a group that had tirelessly advocated for caution in biomedical technologies. Although their message clashes with Marlon's beliefs, he acknowledges their role in shaping the cautious approach adopted in the

present. Their efforts led to the implementation of stringent regulations and standards, ensuring that companies operate in a manner that is both ethical and sustainable.

Finally settling into bed, Marlon immerses himself in an eBook that chronicles the unmasking of governmental and corporate misinformation campaigns in 2026. The novel serves as a reminder of the strides toward a more secure and informed society. It's a testament to the power of truth and transparency and the importance of holding those in power accountable.

As he reads, Marlon can't help but feel a sense of pride. He's part of a society that values privacy, prioritizes the environment, and holds companies accountable.
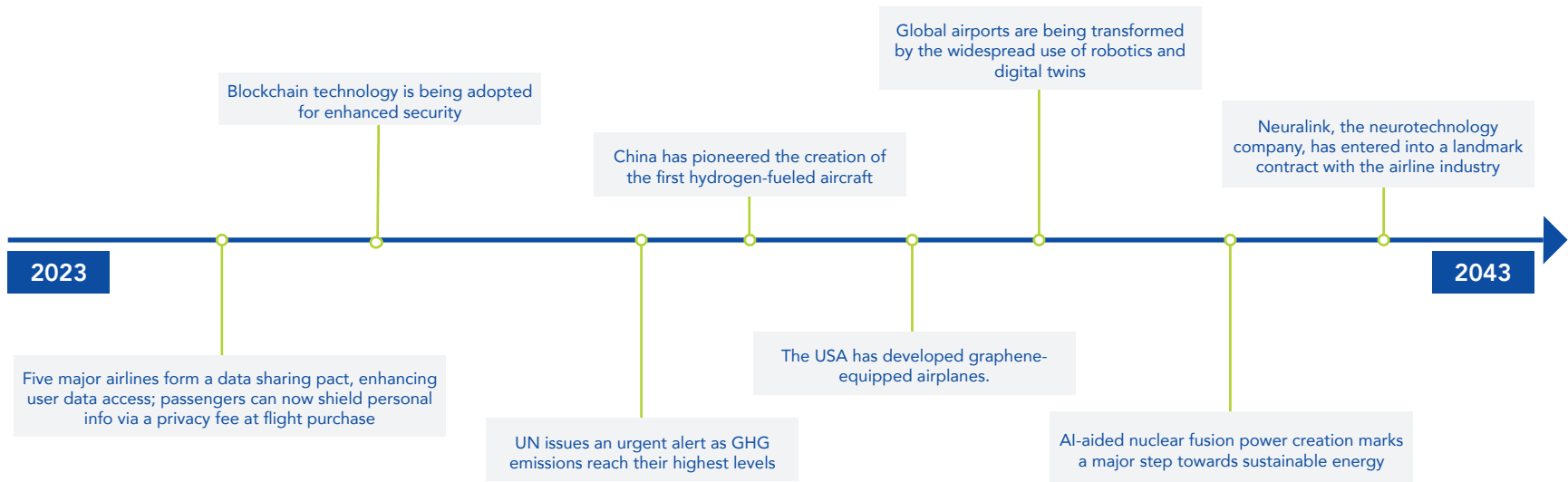
Fernando Pintado

Sandra Buenache

Sahira Janeir

José David Poncelas

FRESH FLOW

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between

Global airports are being transformed by the widespread use of robotics and digital twins

Blockchain technology is being adopted for enhanced security

Neuralink, the neurotechnology company, has entered into a landmark contract with the airline industry

China has pioneered the creation of the first hydrogen-fueled aircraft

2023

2043

Five major airlines form a data sharing pact, enhancing user data access; passengers can now shield personal info via a privacy fee at flight purchase

The USA has developed graphene-equipped airplanes.

UN issues an urgent alert as GHG emissions reach their highest levels

AI-aided nuclear fusion power creation marks a major step towards sustainable energy

Trend   Scenario   Ideation

A Day in 2043

It is a sunny day in April 2043 in Valencia, Spain. Marina, an 11-year-old girl, excitedly prepares to go to the airport accompanied by her grandfather. Technological advancements have transformed people's daily lives in this era, and flying with drones is as common as walking.

"Come on, Marina, the drone will arrive in 5 minutes. Hurry up, or we will miss the flight to London to see grandma, we have to get to the airport on time," her grandfather reminds her as they wait on the rooftop helipad adapted for drones. Despite the age difference, there is a special connection between them, and Marina always enjoys listening to her grandfather's fascinating stories from the past. Grandpa remembers working as a pilot for Lufthansa when he used to leave home almost three hours in advance to avoid any issues getting to airports. In modern times, drones have revolutionized short-distance mobility in cities, while planes continue to be the go-to option for efficient long-distance travel.

The drone, an engineering masterpiece, gracefully lands on the helipad, floating almost silently. Its wings shine with bright flashes of graphene out of recycled plastic, reflecting the sunlight in a mesmerizing way. With a capacity for twelve passengers, it showcases the advancement in automation. Without a need for a pilot on board, the aircraft is entirely autonomous. One minute after both characters jump in it, with a barely noticeable hum, it gently lifts off from the helipad, leaving the city of Valencia behind. From her position, Marina observes the ever-changing landscape, a world that has embraced innovation and environmental responsibility.

Marina prepares to put on her VR glasses, eager to enjoy all the content that awaits her despite the short journey. Her grandfather interrupts her, saying: "Look out my window, Marina. Do you see all those airplanes flying harmoniously without colliding? A few years ago, this would have been unthinkable. But thanks to the collaboration of airlines and

the agreements they reached years ago to share all the data they managed, we have achieved seamless coordination of all flights at different altitudes, thus reducing the risk of accidents and increasing flight efficiency." He knows it is something ordinary for her and that she does not give it much importance.

Before returning to her seat, Marina notices a difference on the content screen in front of her grandfather. A list of beverages and food specifically suggested for him is displayed, based on his tastes and personal preferences, provided by Neuralink, the famous neurotechnology company. "Look, Grandpa!" Marina exclaims excitedly, pointing at the screen. "Neuralink is recommending you my favorite soda. Why does it not work for me?" Her grandfather smiles and nods, gently stroking Marina's head. "That is right, my dear. When you turn 18, you will be able to decide whether to sign your contract with Neuralink. Until then, you must convince me or ask if your parents allow you."

"Please, Grandpa, just for today, I promise. Besides, it is 100% natural content," she replies. After a gesture from her grandfather to the air, a small sliding tray extends from a compartment in the seat, delivering the exact beverage that her granddaughter had selected. As the exchange for the drink takes place, the grandfather's eyes twinkle with warmth as he realizes the perfect opportunity to share a story with his granddaughter, even though he senses that she may not be initially interested in hearing it. "In the past, fossil fuel-based energy was expensive and harmful to the environment, but advancements in various renewable technologies such as nuclear fusion or hydrogen, along with AI and high taxes on GHG, have given us this beautiful panorama. Look, you can clearly see Ibiza in the distance! In my time, breathing clean and fresh air was not as common as it is for you. The struggle for RE was arduous, but we finally managed to achieve a balance in sustainability thanks to technological advancements," he comments, recalling the

challenges they faced in the past and thinking about all the progress that was made to be able to travel with nuclear aircraft prototypes for almost two years, after that California's laboratory managed to fuse two atoms stably. He knows this process would only have accelerated this much because of the pollution alert from the United Nations (UN) in 2029.

"Attention, passengers, fasten your seatbelts as we are going to catch the air current to optimize energy," comments the drone's virtual assistant.

After an exciting flight, the drone arrives at Valencia Airport. As they descend, both of them are amazed by the speed and efficiency with which they have traveled. But the most surprising part is yet to come. They head to the passenger control area, where a sophisticated biometric technology device facilitates the registration and boarding process through facial recognition. The line is incredibly short, and their identities are verified and authorized for the flight within seconds. "The use of biometric technology has made procedures much faster and safer, thanks to people and airlines sharing all their data. There is no longer a need to show any physical documents," explains the grandfather as they continue advancing toward the next stage of the journey.

In the peaceful resting area, Marina is captivated by a mesmerizing spectacle on the bustling runway before her. Automated robots, moving with elegant precision, handle luggage and packages seamlessly. The cargo is swiftly prepared and stored, ready for departure. As an aircraft taxis to the gate, the robots spring into action like well-rehearsed performers. With remarkable speed and accuracy, they unload each suitcase with finesse, placing them on conveyor belts for passengers to easily reclaim.

But the true marvel is the scene on the runway. The aircraft boasts a sleek design with streamlined curves and advanced materials. Its surface shimmers subtly, reflecting the colored lights that illuminate the runway. These lights mark parking zones at different altitudes, creating a visually stunning ef-

fect. The landing area is flat, but the taxi lanes rise like gently sloping ramps, forming parking zones that accommodate multiple planes simultaneously.

Grandpa, remembering his pilot days, is genuinely amazed by the flawless harmony of technology and efficiency he witnesses. The seamless integration of automation and innovative aircraft design fills him with wonder, while the mesmerizing runway lighting signals a new era of unmatched effectiveness in aviation. Passengers now enjoy shorter wait times, and flights consistently depart on schedule, thanks to this exceptional advancement in the world of aviation. The industry soars to new heights of efficiency and elegance, leaving Grandpa in awe of the progress made in his beloved field. While they wait, Grandpa takes the opportunity to explain to Marina about the use of digital twins in the aviation world. "Did you know each airplane has its exact digital replica?" the grandfather asks her. "These digital twins allow us to monitor and optimize the aircraft's performance, ensuring everything is in perfect condition before and during the flight." Digital twins are all connected and analyzed together today.

As Marina and her grandfather make their way to the gate, they encounter a stunning holographic display showcasing the history of aviation. From the Wright brothers' first flight to the supersonic jet age, the exhibition tells the captivating story of humanity's conquest of the skies. Marina listens intently as her grandfather shares his experiences as a pilot when airports were bustling with people and the challenges of air travel were far different. Marina is amazed to see how seamlessly data sharing between airlines has transformed the aviation industry. The display explains how airlines now collaborate and share real-time data on weather conditions, air traffic, and airport operations, significantly reducing flight delays and increasing passenger safety.

On another screen nearby, Marina learns that in this new era, limited resources have led to innovative approaches to sustainability. The aircraft she is about to board, for example, is

made entirely out of recycled plastic, showcasing the industry's commitment to environmental responsibility. The world has embraced a circular economy, with recycling and reusing materials becoming the norm in almost every aspect of life.

The flight takes off smoothly, and Marina looks out the window, marveling at the beauty of the world below. She reflects on how far humanity has come in embracing sustainability and technology, leading to this remarkable transformation in aviation. Flying has become the number one choice for efficient, eco-friendly transportation, and the seamless integration of cutting-edge technology has made it a seamless and enjoyable experience for everyone. Marina realizes that the journey they just had is not just a physical one, it represents the journey of humanity, the collective effort to create a better world through technology and sustainability. The future is bright, and Marina is excited about the possibilities that lie ahead. She knows that with continued determination, creativity, and cooperation, humanity can overcome any challenge and continue to soar to new heights of progress and prosperity. And in this new age of aviation, the skies are not only filled with planes but with hope, inspiration, and a shared vision for a better world.

IDEATION

The following chapter describes five novel business models in the field of digital solutions for sustainable aviation. Each of the business models is described using the Osterwalder Business Model Canvas.

Natalia Alonso

Alicia Nuria Correcher

José David Poncelas

Alejandra Reig

WORK WISE

WORKWISE

Innovative real-time technology to drive efficiency and motivation in ground operations

WorkWise aims to revolutionize ground operations by harnessing the power of smartphones and smartwatches to drive efficiency and motivation among workers while offering invaluable advantages to airports.

The company takes a proactive stance in improving work conditions for ground operations staff. The technology ensures a more organized and efficient workflow by streamlining tasks and schedules through smartphones and smartwatches. Real-time tracking and data-driven feedback inspire workers to excel, fostering a sense of motivation and dedication to their roles. Complemented by timely reminders, health monitoring features cater to employee well-being, creating a healthier and happier workforce. As a result, the frequency of medical absences due to sickness is significantly reduced, enabling workers to remain productive and committed.

WorkWise improves work conditions for ground operations staff with efficient technology, promoting motivation and dedication. Real-time tracking and health monitoring reduce medical absences, leading to a healthier and more productive workforce. The technology also empowers airports with real-time insights, enhancing service quality and operational efficiency, resulting in significant cost savings and a positive corporate image. In a nutshell, WorkWise heralds a new ground-operational era, forging a more productive, motivated, and health-conscious workforce. By elevating service quality, streamlining processes, and generating economic savings for airports, the technology fulfills its promise of efficiency and cost-effectiveness. WorkWise's holistic approach catalyzes transformative change in the aviation industry, cementing its status as a game-changer for ground operations and a driving force behind enhanced productivity and success in airports worldwide.

Business Model

Key Partners

- Smartwatch manufacturers.
- Connectivity providers.
- Partnership with airlines and airport authorities for pilot testing and feedback.

Key Activities

- Continuous improvement of the mobile application and its smartwatch counterpart.
- Implementation and adaptation at the airports.
- Maintenance of the software.

Key Resources

- Software development team for the mobile application and smartwatch.
- Designers and user experience professionals.
- Strong relations with smartwatch manufacturers and technology suppliers.

Value Proposition

For workers:
- Improvement of work conditions.
- Greater motivation and commitment.
- Health monitoring.
- Treat medical absences for sickness.

For airports:
- Real-time information.
- Upgrade service quality.
- Efficiency and coordination.
- Economic savings.
- Corporate image.

Customer Relationships

- Assistance in problem-solving.
- Continuous feedback.
- Technical support for the implementation and training in using the application and smartwatches.
- One-on-one relationship.

Channels

- Direct sales to airports and authorities.
- Events of the industry (to promote the product).
- Alliances with airports and services companies.
- Online platforms (to promote the product).

Customer Segments

Customers:
- Airports

Users:
- Ground operators

Cost Structure

Fixed cost:
- Platform development.
- Software maintenance.
- Office space and equipment.

Variable cost:
- Employees' salary.
- Cloud storage.
- Marketing and promotion.

Revenue Streams

- Annual license (depending on airport size, number of employees, and demanded characteristics).

Eco-Social Costs

- Exclusion of non-connected workers.
- Excessive competition leads to a negative work environment.
- The pressure of self-comparison in work performance.

Eco-Social Benefits

- Increase workers' well-being.
- Optimization of logistic processes.
- Fewer errors.
- Greater operational efficiency.
- Carbon footprint.

🖐 Value Proposition

For workers:

Improvement of employers' work conditions: flexible and employee-friendly schedule, shift rotations to provide sufficient rest periods and regular reminders and notifications to encourage healthy habits, taking short breaks to stretch and relax, and promoting healthy eating options at the workplace.

Greater motivation and commitment: workers feel a greater sense of value and recognition from the company, demonstrating a genuine effort to improve their working conditions. Allowing them to set achievable targets and receive rewards that they can customize. The possibility of viewing their performance and comparing it to previous months fosters a desire for self-improvement.

Track health: incorporating health monitoring features into the workplace, such as wearable devices or smartwatches, to track vital health metrics like heart rate and stress levels. It would further promote the overall well-being of the workers, helping them cope with the physical demands of their job and reducing health-related issues. It also helps to know when a worker needs a health absence for a sickness or operation.

For airports:

Real-time information: by accessing real-time data on the performance of their workers and their health-related matters, airports can make informed decisions to optimize operations and enhance the well-being of their employees.

Upgrade the quality of services: by fostering a highly motivated workforce and providing incentives, such as monetary rewards or redeemable services based on their performance,

airports can significantly elevate the quality of services offered.

Efficiency and coordination: by leveraging real-time data, airports can achieve improved efficiency and seamless coordination among their teams. Allowing for more precise scheduling, ensuring tighter and better-optimized timetables for workers.

👥 Customer Segments

Customers

Airports' efficiency and productivity: airports seek a groundworker monitoring platform to enhance operational efficiency, reduce delays, and optimize groundworker activities. The platform must provide real-time data, analytics, and insights to airport management, allowing them to make informed decisions and allocate resources effectively. Airports vary in size, complexity, and operational demands so the monitoring platform should be customizable to adapt to each airport's unique requirements.

Users

Ground operators' user-friendly interface: groundworkers need a user-friendly and intuitive mobile application and smartwatch interface to access information and perform tasks efficiently. Simple navigation and clear instructions are essential to promote quick adoption and utilization of the technology. Groundworkers rely on timely information regarding flight schedules, gate changes, and task assignments. The platform should provide instant notifications and updates to ensure smooth coordination and seamless execution of duties.

💚 Customer Relationships

Assistance in problem-solving: the service provider places a strong emphasis on providing extensive assistance and support to airport staff, particularly in the realm of problem-solving concerning the utilization of mobile applications and smartwatches.

Continuous feedback: to improve the service and address evolving needs, the service provider actively seeks and encourages continuous feedback from airport management and ground workers to gain insights into user experiences, challenges, and suggestions for enhancement.

Technical support for the implementation and training: training in using the application and smartwatches: as part of the service, the provider offers comprehensive technical support during the implementation phase. This includes assisting with the software's initial setup and configuration on mobile devices and smartwatches.

One-on-one relationship: this type of relationship ensures a direct and personal connection between the two entities, facilitating clear communication, tailored interactions, and focused attention on each other's needs or objectives.

🚚 Channels

Direct sales to airports and authorities: involve the service provider actively approaching airports and aviation authorities to offer their groundworker monitoring service. The sales team engages in personalized communication with airport decision-makers, showcasing the benefits and features of the service.

Events of the industry: participating in industry events and exhibitions effectively promotes the groundworker monitoring service to a broader audience. The service provider can showcase their product's capabilities, conduct live demonstrations, and interact with potential clients face-to-face.

Alliances with airports and services companies: forming alliances with airports and other service companies in the aviation industry can be mutually beneficial. Collaborating with airports allows the service provider to understand their needs better and tailor the solution accordingly.

Online platforms: leveraging online platforms, such as a dedicated website, social media channels, and online advertisements, enables the service provider to reach a global audience. The online presence serves as a digital storefront, providing detailed information about the service, testimonials, and customer success stories.

Sales representatives: A dedicated sales representative team drives business growth. Sales representatives engage in direct outreach, follow up on leads, conduct product demonstrations, and negotiate contracts with potential clients.

Key Activities

The training focused on properly utilizing the software: provide comprehensive training sessions to airport staff, instructing them on how to use the application.

Continuous improvement of the mobile application and its smartwatch: counterpart to incorporate new features, improve user experience, and address any identified issues.

Implementation and adaptation of the airports: work closely with each airport to implement and adapt the software according to their specific requirements and workflows.

Maintenance of the software: provide ongoing maintenance and support to ensure its smooth and uninterrupted operation.

Customer Relationship Management (CRM): maintain strong relationships with airport management and staff to address concerns, gather feedback, and understand their evolving needs. The service provider can continuously enhance the software by maintaining an active CRM approach and ensuring it aligns with the airports' changing requirements.

Dashboard development: design and develop a comprehensive and user-friendly dashboard that offers real-time insights into the activities and status of ground workers. **Global position system (GPS) to locate workers:** the system is designed to provide real-time location data of workers, enabling efficient coordination and task management.

Key Resources

The software development team for the mobile application and smartwatch: as part of the service, a dedicated software development team is responsible for creating and maintaining the mobile application and its smartwatch counterpart. This team is essential for ensuring the seamless functionality and integration of the software across both platforms. They work on designing, coding, testing, and updating the applications to meet the specific needs of airport groundworkers and provide a user-friendly experience.

Designers and user experience professionals: users they play a crucial role in crafting an intuitive and visually appealing interface for both mobile and smartwatch apps. They focus on creating a user-friendly design that streamlines the workflow of airport staff and ensures easy navigation and access to essential features. Their expertise enhances user satisfaction and productivity, as well as the overall success of the service. User experience experts ensure that the user interactions with the mobile and smartwatch applications are seamless and enjoyable.

Strong relations with smartwatch manufacturers and technology suppliers: maintaining strong relationships with smartwatch manufacturers and technology suppliers is vital for accessing the latest advancements and ensuring compatibility with the smartwatches used by airport ground workers.

🤝 Key Partners

Smartwatches manufacturers: smartwatch manufacturers can provide customized solutions for airport workers, catering to their specific needs and responsibilities. For instance, airport staff, such as security personnel, maintenance workers, or ground operations staff, can benefit from robust and specialized smartwatches designed to withstand the demands of their work environments.

Connectivity providers: reliable connectivity is crucial for airport workers who rely on smartwatches to communicate and access essential information. Connectivity providers can ensure that the airport premises have excellent network coverage, both indoors and outdoors, enabling seamless data transmission between smartwatches and backend systems. Airport workers might need to access databases, communicate with colleagues, or receive live updates on various operational aspects. A robust data connection allows them to do their jobs efficiently and respond promptly to changes or emergencies.

Partnership with airlines and airport authorities: for pilot testing and feedback: partnerships between smartwatch manufacturers and airlines can benefit airport workers. Pilot testing of smartwatch applications and functionalities can help evaluate their effectiveness in improving the productivity and efficiency of airport staff.

💰 Revenue Streams

The annual license for the dashboard-smartwatch application is a pivotal component of the groundworker monitoring service offered to airports. The pricing of the annual license is dynamic, tailored to suit the individual requirements of each airport. Several factors, such as the airport size, the number of employees to be monitored, and specific demanded characteristics, influence the license cost.

By choosing an annual license, airports gain the advantage of continuous updates and improvements to the dashboard smartwatch application. The service provider's software development team diligently enhances the application's features, user interface, and overall performance, keeping it up-to-date with the latest technological advancements and industry best practices.

With the annual license, airports receive unparalleled technical support and regular maintenance services. A dedicated team of experts is readily available to address any issues, troubleshoot technical glitches, and provide guidance during the implementation and training phases.

Moreover, the smartwatch application's annual license guarantees compliance with privacy regulations and data security standards. The service provider remains committed to safeguarding the confidentiality and integrity of sensitive information collected and transmitted through the application, providing peace of mind to airports and their stakeholders.

Trend   Scenario   Ideation

▦ Cost Structure

Since Pericule has a license-based model, the cost structure mainly consists of salaries, computational costs, and back-up connectivity costs. As the software is either deployed on remote devices or devices of emergency response teams, Pericule does not bear any hardware or production costs. Further, fixed costs pose the most significant part of overall yearly costs, as variable costs marginally decline when scaling the product.

Salaries: In the early stages of initial product development and first customers, the number of employees is expected to be at most 20. These include engineers, account managers, and management. On average, salary costs amount to approximately 1M EUR per year for the first years. In this stage, management and account managers also work on customer acquisition, which consists of activating lobbyists to enforce a political need for the service. Once more customers are acquired, the team is expected to grow to about 100 employees since particularly the need for more testing, maintenance, and customer support arises. Outsourcing customer support is not sensible, as the application must always be completely reliable.

Computational Costs: The computational costs of Pericule mainly consist of cloud bills. These are needed for data ingestion, data storage, and computation. However, this can at least partly be outsourced to the infrastructure of the respective customer, which would, in turn, reduce the computational costs significantly.

Backup Connectivity Costs: As the functioning of Pericule is highly dependent on a fast internet connection, a backup connection is necessary. This backup connectivity yields additional recurring costs that have to be paid to the connectivity provider for, e.g., satellite internet.

$ Eco-Social Costs

Exclusion of non-connected workers: the implementation of smartwatches and mobile applications to monitor ground-workers may inadvertently lead to the exclusion of non-connected workers, such as those who do not have access to smartphones or smartwatches. It is crucial to consider and address this issue to ensure that all groundworkers can be integrated. The service provider can collaborate with airport management to implement inclusivity measures and ensure that non-connected workers are not excluded from important updates, training, or opportunities for career growth.

Carbon footprint: using smartwatches and mobile applications in the airport monitoring service introduces electronic devices that consume energy and contribute to the carbon footprint. To address this concern, the service provider should optimize the software and hardware energy efficiency. Additionally, exploring eco-friendly alternatives and offsetting carbon emissions through sustainable practices can help reduce the environmental impact of the technology.

The pressure of self-comparison in work performance: individuals with high self-expectations may experience pressure and nervousness when comparing their monthly or weekly performance to others. Constantly measuring achievements against past performance and peers can create competition and fear of falling short of personal standards.

⊕ Eco-Social Benefits

Increase in worker's well-being: implementing a monitoring service using smartwatches and mobile applications can increase workers' well-being. By providing real-time information and task updates directly to their wrists, groundworkers experience reduced stress and improved time management. The convenience and ease of accessing essential data empower them to carry out their duties efficiently, leading to greater job satisfaction and a sense of accomplishment.

Optimization of logistic processes: the monitoring service streamlines logistic processes at the airport. Groundworkers can receive instant notifications about changes in flight schedules, gate assignments, or baggage handling instructions, allowing them to respond promptly and coordinate activities more efficiently. This optimization of logistic processes leads to smoother operations, fewer delays, and improved overall airport performance.
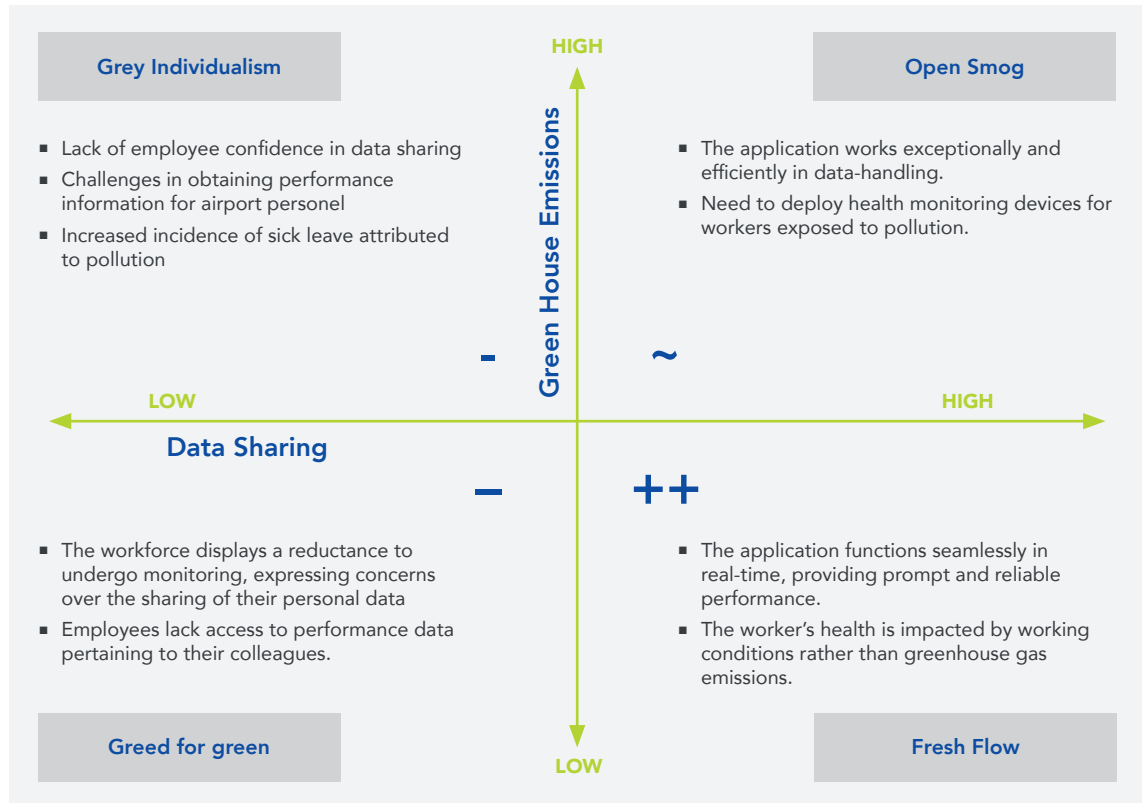
Fewer errors: the real-time access to information and clear task instructions provided by the monitoring system minimizes the occurrence of errors in ground operations. Groundworkers are less likely to overlook critical tasks or miss important updates, reducing the risk of operational mistakes.

Greater operational efficiency: the monitoring service enhances overall operational efficiency by enabling groundworkers to access information and manage tasks efficiently. Communication among different airport departments is streamlined, leading to better coordination and smoother workflows. The centralized dashboard allows airport management to gain real-time insights into groundworker activities, enabling them to allocate resources more effectively and make informed decisions. This proactive approach enhances airport efficiency, reduces downtime, and optimizes resource utilization.

Scenario Fit:

The Open Smog: in this scenario, WorkWise could have access to a vast amount of real-time information. However, the high emissions could negatively impact its reputation and ability to promote sustainability. Workers would experience rigorous working conditions exacerbated by exposure to a climate with elevated GHG emissions, leading to an increased likelihood of work absences or sick leaves. By proactively addressing these issues, WorkWise aims to create a healthier and more supportive work environment, safeguarding its workforce's physical and mental health.

Gray individualism: in this scenario, with low data sharing and high GHG emissions, WorkWise could face challenges in obtaining real-time information about worker performance and working conditions. The lack of accurate data could limit its ability to provide feedback and improve employee efficiency and motivation. Additionally, the workers would have harsh working conditions compounded by the effects of being exposed to a climate with high GHG emissions, leading to an increase in the number of sick leaves. To adapt to this scenario, the company could encourage airports and other businesses to adopt more sustainable practices and share relevant data for informed decision-making.

Grey Individualism
- Lack of employee confidence in data sharing
- Challenges in obtaining performance information for airport personel
- Increased incidence of sick leave attributed to pollution

Open Smog
- The application works exceptionally and efficiently in data-handling.
- Need to deploy health monitoring devices for workers exposed to pollution.

Green House Emissions — HIGH / LOW

Data Sharing — LOW / HIGH

- (−)
- (~)
- (−)
- (++)

- The workforce displays a reductance to undergo monitoring, expressing concerns over the sharing of their personal data
- Employees lack access to performance data pertaining to their colleagues.

- The application functions seamlessly in real-time, providing prompt and reliable performance.
- The worker's health is impacted by working conditions rather than greenhouse gas emissions.

Greed for green

Fresh Flow

Greed for green: in this scenario, with low data sharing and minimal greenhouse emissions, WorkWise could face challenges in obtaining detailed information about worker performance and working conditions. The lack of data could hinder informed decision-making and the implementation of specific improvements. To address this scenario, the company could incorporate new methods of gathering employee information, enhancing the company's data insights.

Fresh Flow: in this scenario, with high data sharing and low GHG emissions, WorkWise could leverage the abundance of real-time information to implement highly efficient and sustainable solutions. Access to accurate data could enable better optimization of operations and continuous improvement of working conditions. WorkWise could use shared data to identify improvement opportunities and design strategies that promote sustainability and efficiency in airports and other businesses. This situation would allow WorkWise to focus on other areas of improvement and optimization to provide an even more efficient and satisfactory usually disclose their data. This also complicates accessing important

service to its clients.

Challenges

- One of the critical objectives of WorkWise is to integrate diverse data sources efficiently and present them clearly and coherently to aid decision-making and enhance operational insights.
- WorkWise needs to make the process of capturing the user's information as seamless as possible to gather all relevant information.
- Provide comprehensive explanations and guidance on using its technologies for individuals with limited technological knowledge, ensuring inclusivity and accessibility for all users.
- To keep the platform up-to-date and relevant, WorkWise also focuses on implementing updates efficiently, ensuring minimal disruption and maximizing the benefits of new features and enhancements..

Outlook

In the future, WorkWise achieves remarkable scalability, becoming integral in airports worldwide, improving efficiency, and elevating worker satisfaction. Its potential expands beyond aviation, fitting services, and construction sectors. Businesses recognize its value in streamlining processes, optimizing employee allocation, and empowering workers. WorkWise's evolving dedication to sustainability is steadfast, focusing on reducing waste, optimizing energy use, and minimizing environmental impact. Airlines and industries using it can proudly promote eco-friendly practices, contributing to a greener world. WorkWise leads the way, illuminating the skies with a brilliance that leaves a lasting legacy on the aviation landscape.

Trend   Scenario   Ideation

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AeroLoad

AEROLOAD

A Smart Solution for Equal Loading in the Air

AeroLoad, an innovative software solution set to revolutionize the airline industry on a global scale. During the check-in process, passengers will be presented with the option to voluntarily register the weight and dimensions of their hand luggage, as well as provide non-intrusive personal details such as body weight and height. We want to emphasize that we hold passenger privacy in the highest regard, and all personal data will be handled with the utmost confidentiality, ensuring their comfort and peace of mind.

This registration process serves two vital and interconnected objectives. Firstly, by collecting these data points, we can allocate seats while considering both the passenger and their backpack or hand luggage as one combined unit. This approach allows us to achieve a balanced distribution of weight in the cabin, resulting in an optimal seating arrangement for each flight. However, passengers need to know that the ultimate goal of gathering these data is to enhance flight safety and optimize critical resources such as fuel consumption, ultimately leading to a more sustainable and eco-friendly aviation industry.

The second pivotal goal of AeroLoad is to leverage the power of aggregated data to generate accurate future predictions. By thoroughly analyzing the gathered information, we can make well-informed decisions that further enhance flight efficiency, reduce environmental impact, and optimize resources more effectively. To encourage voluntary participation and ensure the accuracy of the data, AeroLoad implements a robust reward system based on passenger loyalty.

Additionally, we conduct periodic random checks to verify the authenticity of the provided data, guaranteeing the precision and reliability of the final model. By fostering a culture of trust, transparency, and collaboration with our valued passengers, we firmly believe that more and more individuals will willingly contribute their data. This, in turn, will lead to safer, more fuel-efficient, and sustainable flights, benefiting not only the passengers but also the environment and the aviation industry as a whole.

We are committed to reshaping the future of air travel, prioritizing passenger safety, comfort, and environmental responsibility at every step. By harnessing the power of data and passenger engagement, we aim to create a brighter and more sustainable future for aviation.

Trend   Scenario   Ideation

Business Model

Key Partners

- Audit partner
- Airlines
- Aviation consultants
- IT Infrastructure

Key Activities

- Software development
- Investigation & innovation
- Testing the quality
- Continuous updating
- Data analysis and estimations
- Infrastructure

Key Resources

- Intellectual property
- Tech platform
- Human resources (HR)
- Brand
- Venture capital

Value Proposition

- Innovation
- Optimization of space
- Better use of resources (fuel, time, space)
- Augmented revenues
- Regulatory compliance and safety
- Technical support and updates
- Passenger loyalty

Customer Relationships

- Technical support
- Feedback platform to improve customer service
- Data management services

Channels

- Official website
- Personal selling

Customer Segments

- Worldwide airlines

Cost Structure

Initial Investments
- Web software developments

Fixed Costs
- Software development
- Maintenance activities
- Intellectual property
- Salaries

Variable Costs
- Marketing campaigns and publicity
- Sales expenses
- Technical support
- Updates and upgrades

Revenue Streams

- Subscription-based model: Annual subscription calculated on companies savings
- Sponsors

Eco-Social Costs

- Use of energy
- Sharing personal data
- Privacy and security
- Dividing passengers could lead to social inequity

Eco-Social Benefits

- Less CO_2 emissions
- Optimization of space
- Load balance of weight
- Reduction of in-flight risks
- Ensuring accomplishment of regulations

Trend   Scenario   Ideation

Value Proposition

Innovation: AeroLoad introduces cutting-edge technology that revolutionizes the way airlines manage passenger weight distribution. By offering passengers the option to voluntarily register their hand luggage data, along with non-intrusive personal details, AeroLoad optimizes flight operations through data-driven decision-making.

Optimization of Space: With precise passenger and hand luggage weight data, AeroLoad enables airlines to allocate seats more efficiently. This optimized space distribution ensures a balanced and safe flight, enhancing passenger comfort and overall flight experience.

Better Use of Resources: AeroLoad's data-driven approach enables airlines to optimize critical resources such as fuel, time, and space. By accurately estimating weight distribution and fuel requirements, airlines can reduce fuel consumption, resulting in cost savings and reduced environmental impact.

Augmented Revenues: By offering passengers the option to voluntarily register their hand luggage data, airlines can allocate seats strategically. This opens up opportunities for additional ancillary revenue streams, such as seat upgrades and additional services, enhancing profitability.

Regulatory Compliance and Safety: AeroLoad's data analysis ensures that airlines remain compliant with regulatory weight and safety guidelines.

Technical Support and Updates: AeroLoad provides continuous technical support and updates to its partner airlines. This commitment ensures a seamless user experience and fosters long-term partnerships.

Passenger Loyalty: Passengers appreciate the value of AeroLoad's focus on safety, comfort, and efficiency. By offering a data-driven approach to seating allocation, airlines can enhance passenger satisfaction, leading to increased loyalty and repeat business.

Customer Segments

Worldwide airlines: AeroLoad's customer segment consists of airlines operating on a global scale. These are companies that are continually seeking innovative solutions to improve flight safety, fuel efficiency, and overall sustainability of their operations. With the aviation industry witnessing increasing pressures to minimize their environmental impact, these airlines are progressively prioritizing the adoption of technology to achieve these objectives. As such, they are the perfect candidates for AeroLoad's value proposition.

Airlines worldwide deal with diverse passenger demographics, including business and leisure travelers, solo and group travelers, and passengers with different luggage weight and size preferences. All these passengers, regardless of their purpose of travel or their luggage specifics, can contribute vital data points to AeroLoad, helping optimize flight load and, in turn, enhancing safety and efficiency. AeroLoad's solution is a natural fit for airlines with varying fleet sizes and route networks. From large, international carriers operating long-haul flights to regional and budget airlines focusing on short-haul routes, all can benefit from AeroLoad's capabilities. This broad market reach not only provides AeroLoad with a wide customer base but also allows for the collection of diverse data, further enhancing the effectiveness of the predictive models. The software presents an opportunity for airlines to foster deeper engagement with passengers by allowing them to participate voluntarily in the data sharing process, in return for rewards. This engagement strategy, in turn, boosts airlines' brand image and passenger loyalty, a key factor in maintaining a competitive edge in the industry. Moreover, for those airlines already committed to the principles of CSR, AeroLoad's eco-friendly and resource-saving promise resonates with their environmental goals, making the solution even more attractive.

Customer Relationships

Technical Support: It is critical in preserving a seamless user experience for AeroLoad's passengers. The company acknowledges that the introduction of new technology could bring certain challenges. To address this, AeroLoad's technical support team is resolutely committed to assisting passengers on their journey. This personalized assistance not only enhances the user experience, but it also builds trust and assures users of AeroLoad's unwavering dedication to their needs.

Feedback Platform for Improving Customer Service: AeroLoad values passenger input and views it as a vital tool for continuous service improvement. The company strives to establish a two-way communication channel, making passengers feel appreciated and heard. Feedback, whether positive or constructive, enables AeroLoad to gain a deeper understanding of user needs and expectations, helping them to fine-tune and optimize their services accordingly.

Data Management Services: Data management is a top priority for AeroLoad. Since their model revolves around the voluntary disclosure of sensitive information, they strictly adhere to the highest standards of data security and confidentiality. They assure users that their data is solely used to enhance flight safety and efficiency, always treating it with the utmost respect for privacy and confidentiality.

Channels

Official website: The official AeroLoad website serves as a central hub for information, marketing, and customer engagement. Through this digital platform, airlines and potential clients can access detailed product information, explore the benefits of AeroLoad's innovative software, and learn about the company's value proposition. The website showcases AeroLoad's features, case studies, and success stories,

building credibility and trust with visitors. It also offers a user-friendly interface for airlines to request demos, get in touch with sales representatives, and access customer support. The website serves as a key resource for driving inbound leads and converting interested prospects into satisfied customers.

Personal selling: AeroLoad's personal selling strategy targets airline partnerships. A team of skilled sales representatives, equipped with in-depth knowledge about the AeroLoad system and its benefits, pitches the solution to airline companies. They compellingly articulate how AeroLoad can transform the aviation landscape with a more efficient and sustainable approach to passenger seating and weight management. The team actively negotiates strategic collaborations, offering thorough integration support and promising sustained partnerships to ease the transition toward the new system. To meet each airline's unique requirements and quell any concerns, AeroLoad tailors its solution and delivery, demonstrating a level of adaptability that assures partners of their commitment to a successful partnership.

Key Activities

Software Development: Skilled teams of developers work to create and enhance the AeroLoad software platform. By leveraging cutting-edge technology, they will ensure a user-friendly, efficient, and secure system. Continuous improvement and innovation are prioritized to meet the evolving needs of airlines and passengers.

Investigation & Innovation: Extensive research and analysis are conducted to stay informed about industry trends, regulatory requirements, and passenger preferences. This ongoing investigation allows AeroLoad to remain at the forefront of innovation, providing airlines with advanced solutions to optimize flight operations.

Testing the Quality: Rigorous testing processes are implemented throughout the software development lifecycle. Comprehensive testing procedures, including functional, performance, security, and user acceptance testing, ensure the software's reliability and seamless functionality.

Continuous Updating: The aviation industry is dynamic, with regulations and technologies constantly evolving. AeroLoad stays adaptable by regularly updating its software to align with these changes. This ensures compliance with industry standards and delivers accurate data analysis and estimations to airlines for optimal decision-making.

Data Analysis and Estimations: AeroLoad's data analysis capabilities are central to its value proposition. Airlines can make informed decisions based on weight distribution, fuel consumption estimations, and resource optimization, leading to safer and more efficient flights.

Key Resources

Intellectual Property: The core of AeroLoad's competitive advantage lies in its intellectual property, encompassing patents, trademarks, and proprietary algorithms. This protection safeguards the innovative technologies and solutions developed by the company, ensuring its uniqueness in the market and preventing unauthorized use.

Tech Platform: The heart of AeroLoad's operations is its sophisticated technology platform. This robust platform serves as the backbone of the software, enabling seamless integration with airlines' check-in processes and efficient collection and analysis of passenger data. It ensures a smooth and user-friendly experience for both airlines and passengers.

HR: AeroLoad's talented and dedicated HR form a vital asset. Skilled software developers, data analysts, aviation experts, and a proficient management team drive the company's progress. Their collective expertise and experience enable continuous software improvement and adaptability to the dynamic aviation industry.

Brand: AeroLoad's brand reputation and recognition are essential resources. Establishing a strong brand identity
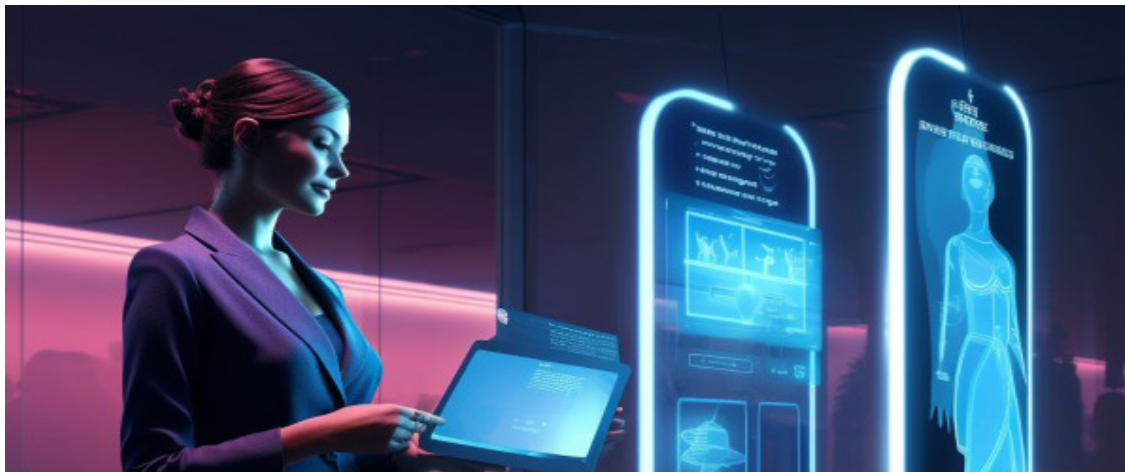
associated with safety, efficiency, and reliability fosters trust among airlines and passengers alike. A positive brand perception also attracts potential partners and investors.

Venture Capital (VC): Securing VC or other forms of funding is critical for AeroLoad's growth and expansion. The financial resources provided by investors allow the company to invest in research and development, marketing, and infrastructure. This capital infusion supports scaling operations and helps AeroLoad reach a broader market.

🤝 Key Partners

Audit Partner: An audit partner is essential for ensuring compliance with industry regulations, data security, and privacy standards. They will conduct thorough audits to validate the accuracy and integrity of the data collected through the AeroLoad software. Their expertise will instill trust among passengers, airlines, and regulatory authorities, reinforcing

the credibility of the entire operation.

Airlines: Collaborating with airlines is fundamental, as they are the primary users of the AeroLoad software. Airlines will integrate the platform into their check-in process, allowing passengers to register their hand luggage data voluntarily. This partnership will enable a seamless implementation of the software across various airlines, leading to a standardized and efficient approach.

Aviation Consultants: Partnering with aviation consultants brings specialized industry knowledge and insights. These experts can offer valuable guidance on optimizing resources, fuel efficiency, weight distribution, and flight safety. Their input will help refine the software's algorithms and enhance its predictive capabilities, ultimately leading to better decision-making and performance optimization.

IT Infrastructure Providers: A strong IT infrastructure is the backbone of the AeroLoad software. Collaborating with reliable IT infrastructure providers ensures a robust and secure platform that can handle the volume of data generated by

multiple airlines and passengers. These partners will be responsible for maintaining system stability, scalability, and cybersecurity.

💰 Revenue Streams

Subscription Fees from Airlines: AeroLoad offers its innovative software solution as a valuable service to airlines and aviation companies. By subscribing to AeroLoad's platform, airlines gain access to sophisticated data analytics and predictive modeling tools, optimizing flight efficiency and safety. The subscription fees follow a tiered pricing structure, enabling airlines to choose plans that align with their needs and scale of operations. Larger airlines with more flights and passenger data analysis requirements pay higher subscription fees, while smaller regional airlines can benefit from a more cost-effective option.

Sponsors: AeroLoad actively explores opportunities to participate in research and development projects funded by European organizations or institutions focused on aviation, data analytics, and sustainable transportation. By aligning its software platform's objectives with the project's sustainability and innovation goals, AeroLoad becomes an attractive candidate for grants and funding. European project funding serves as an additional revenue stream, providing vital financial support to invest in research, technology development, and talent acquisition. Collaborating with other organizations and institutions within these projects also grants AeroLoad access to diverse expertise, specialized knowledge, and valuable networking opportunities.

⬚ Cost Structure

Initial Investments: The primary financial outlay comes in the form of initial investments, with significant resources being allocated toward web software development. The capital is intended to cover aspects such as software engineering, system testing, bug fixes, and quality assurance protocols.

Fixed costs: Fixed costs form the backbone of AeroLoad's financial plan, which involves ongoing expenses such as software development and maintenance activities. Given the technology-driven nature of the product, the company allocates a considerable portion of its budget to continuous software updates and improvements. Additionally, a significant part of fixed costs involves expenses related to intellectual property protection, including patent filings and trademark registration. Staff salaries, which include compensation for developers, data analysts, customer service representatives, and management.

Variable costs: Variable costs for AeroLoad include marketing campaigns and publicity, which will likely fluctuate based on the stage of the product's lifecycle, market competition, and promotional activities. Sales expenses also form part of the variable costs, as these are expected to vary with the amount of software sold or licensed. Moreover, there is the cost of providing technical support to end-users. Another variable cost is related to updates and upgrades.

⑂ Eco-Social Costs

Use of Energy: The adoption of new technologies, including AeroLoad's software, may lead to increased energy consumption in data processing and system maintenance. To address this, AeroLoad must prioritize energy-efficient prac-

tices and utilize renewable energy sources where possible to minimize its carbon footprint and contribute to a greener aviation industry.

Sharing Personal Data: While AeroLoad's voluntary data registration enhances flight optimization, it raises concerns about passenger data privacy. Safeguarding personal information, and ensuring compliance with data protection regulations are paramount to establishing trust with passengers. Transparent data usage policies and robust security measures should be in place to protect passenger privacy and prevent any misuse of sensitive information.

Privacy and Security: As airlines collect and share passenger data through AeroLoad, the risk of data breaches and cyberattacks increases. Investing in robust cybersecurity measures and conducting regular audits will be vital to safeguarding passenger data and maintaining the integrity of the system.

Dividing Passengers and Social Inequity: The division of passengers based on their voluntarily provided data could potentially lead to social inequity and perceived discrimination. It is crucial for AeroLoad to ensure that the process of seat allocation remains fair and unbiased.

⑂ Eco-Social Benefits

Less CO2 Emissions: By optimizing passenger and hand luggage weight distribution, AeroLoad helps airlines reduce fuel consumption. This results in lower CO2 emissions, contributing to environmental conservation and efforts to combat climate change.

Optimization of Space: AeroLoad's data-driven approach to seat allocation ensures efficient space utilization in the aircraft cabin. This optimization not only enhances passenger comfort but also reduces the need for additional flights due to space constraints, leading to a more resource-efficient aviation system.

Load Balance of Weight: AeroLoad's software ensures a balanced distribution of weight in the aircraft, enhancing flight stability and safety. Proper weight distribution minimizes the risk of incidents caused by uneven loading, resulting in safer and smoother flights for passengers and crew.

Reduction of In-flight Risks: With accurate weight data and optimized seat allocation, AeroLoad contributes to reducing the risk of in-flight incidents, such as turbulence-related injuries and equipment damage. Passengers can feel more secure, and airlines can maintain a high standard of safety.

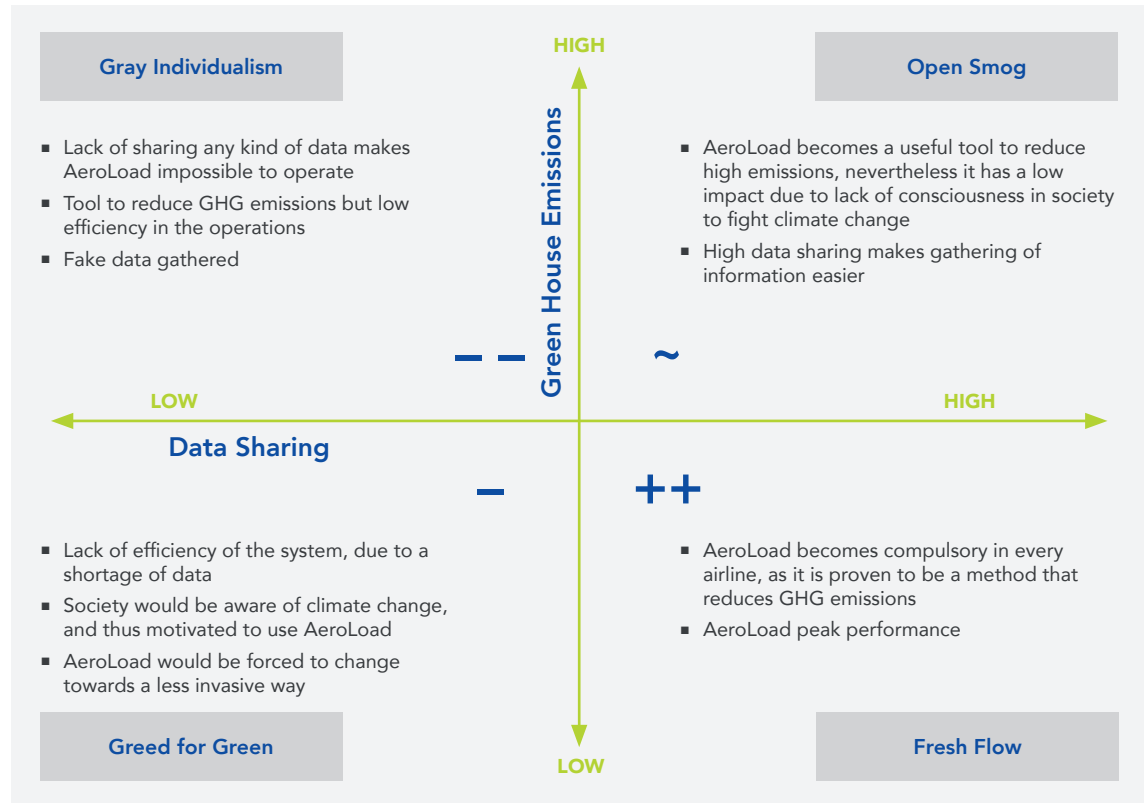**Ensuring Accomplishment of Regulations:** AeroLoad's data

analysis capabilities help airlines comply with weight and safety regulations set by aviation authorities. By adhering to these guidelines, airlines can demonstrate their commitment to safety and regulatory compliance, instilling confidence among passengers and regulatory bodies.

Scenario Fit:

The Open Smog: In "The Open Smog" scenario, AeroLoad plays a critical role in addressing the environmental challenges caused by high emissions and significant data sharing. The software's optimization capabilities help airlines reduce fuel consumption and emissions, contributing to climate change mitigation. Simultaneously, AeroLoad prioritizes data privacy and security, implementing ethical data practices to protect passenger information amidst the culture of data sharing.

Gray Individualism: In the "Gray Individualism" scenario, society isn't environmentally responsible, always trying to keep doing things as they have been doing for years. At the same time data privacy and possession of information has become an obsession, if not a fear. With high levels of pollution and a decrease in air traveling, AeroLoad would not efficiently make a change, as it would be impossible to obtain data from customers. However, variants of the system could have a place in the market, as compulsory data for those interested in flying.

Greed for Green: In the "Greed for Green" scenario, AeroLoad bridges the gap between reduced emissions and limited data exchange. The software empowers airlines to optimize their resources efficiently, despite the absence of broad connectivity. By utilizing AeroLoad's insights, sustainability initiatives gain traction, ensuring better resource allocation and preserving the environment effectively.

Gray Individualism

- Lack of sharing any kind of data makes AeroLoad impossible to operate
- Tool to reduce GHG emissions but low efficiency in the operations
- Fake data gathered

Open Smog

- AeroLoad becomes a useful tool to reduce high emissions, nevertheless it has a low impact due to lack of consciousness in society to fight climate change
- High data sharing makes gathering of information easier

Green House Emissions — HIGH / LOW

Data Sharing — LOW / HIGH

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Greed for Green

- Lack of efficiency of the system, due to a shortage of data
- Society would be aware of climate change, and thus motivated to use AeroLoad
- AeroLoad would be forced to change towards a less invasive way

Fresh Flow

- AeroLoad becomes compulsory in every airline, as it is proven to be a method that reduces GHG emissions
- AeroLoad peak performance

FreshFlow: AeroLoad finds the perfect gap to proceed in the "FreshFlow" scenario. High data sharing and low emissions drive innovation and cooperation, leading to the swift adoption of sustainable practices. AeroLoad's data-driven approach enhances airlines' environmental consciousness, resulting in optimal resource utilization and a clear path toward a greener future. At the same time, low emissions mean that society is highly responsible with the environment. All factors build the optimal scenario for AeroLoad to operate at full strength.

Challenges

- Industry competition: standing out in the market requires a strong value proposition, superior performance, and effective marketing strategies.
- Technical Complexity: overcoming technical challenges and ensuring a seamless user experience demands continuous improvement and innovation.
- Environmental Advocacy: advocating for environmental responsibility and showcasing the benefits of sustainable operations will be essential in overcoming these challenges.

- Data Quality and Voluntary Participation: The accuracy and reliability of the voluntarily provided passenger data are critical for AeroLoad's success. Encouraging passengers to participate willingly and provide precise data can be challenging, as some may have concerns about privacy or sharing personal information.
- Adoption and Integration: Convincing airlines to adopt a new software solution and integrate it into their existing systems can be a challenge. AeroLoad needs to showcase the tangible benefits and return on investment to gain traction and widespread adoption across the aviation industry.

Outlook

AeroLoad will emerge as a company that has as a core value sustainability, safety, and revenue generation. Aerolad will gain traction and engage with customers from the very beginning, offering an easy-to-implement system that could potentially save up to 5% of fuel. Introducing AeroLoad as a B2B in particular airlines will empower companies to better prepare for the future, and to optimize flight operations by knowing and distributing the weights on the plane more efficiently. By minimizing the eco-social costs such as energy, and assuring data sharing privacy, AeroLoad will maximize the impact that making a smart use of resources has.

AeroLoad's solution will flourish in a scenario with raise of awareness and with high data sharing. However, this solution could be adapted to other scenarios, as not only is AeroLoad good for the environment, but also for investors as it produces significant economical benefits in terms of fuel savings. It would become more risky only if data sharing becomes difficult.

The Initial solution will gather data in a simple way, but a spirit of continuous updating and training of new predictive models with self-generated databases will help AeroLoad never stop growing.

Mario Albelda

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PROCURIA

Digital Platform Allowing Airlines to Connect with Sustainable Suppliers

The aviation industry stands at a critical crossroads in a world increasingly aware of its environmental impact. With the pressing need to address emissions and embrace eco-conscious practices, sustainability has become more urgent than ever before. Procuria is a pioneering platform at the front line of sustainable procurement, connecting airlines with verified eco-friendly suppliers to drive positive environmental change.

For airlines, Procuria offers a gateway to adopt sustainable practices that align with their CSR goals, reduce environmental impact, and cater to the increasing demand for eco-conscious services from environmentally aware travelers.

Suppliers in the aviation industry also benefit significantly from Procuria's platform. Different aviation-related businesses recognize the importance of sustainability in maintaining competitiveness and attracting environmentally conscious customers. Using Procuria allows suppliers to showcase their sustainable practices, certifications, and eco-friendly products, positioning themselves as preferred partners for airlines seeking sustainable procurement decisions.

The platform collaborates with accredited organizations to validate sustainability certifications presented by suppliers. These certificates prove eco-friendly practices and ethical standards, adding credibility to the sustainability rankings.

Additionally, Procuria bases its judgment on tailored questionnaires that delve into crucial aspects of environmental practices. This data-driven evaluation process ensures a comprehensive and accurate assessment of each company's sustainability performance.

Procuria redefines sustainable procurement, bridging the gap between airlines and eco-friendly suppliers through data-driven insights and encouraging an interconnected community committed to environmental preservation. With its steady commitment to sustainability, Procuria directs a transformative shift toward a greener and more responsible aviation industry.

Business Model

Key Partners

- Accreditation organization.
- Environmental Non-Governmental Organisations (NGOs)
- Research institutions (to enable innovative sustainability research and data)
- Government sustainability agencies

Key Activities

- Company evaluation
- Platform management, data management, and data analysis
- Providing sustainable solutions to suppliers.

Key Resources

- Supplier insights, certifications, and data for evaluation
- Cloud servers and platform infrastructure
- Cybersecurity measures to protect supplier data and maintain privacy

Value Proposition

Airlines
- Transparency and accountability
- Access to a pool of sustainable suppliers for airlines
- Enhanced brand reputation by using the platform
- Positive environmental impact and contribution to the fight against climate change

Suppliers
- Assistance in increasing ethicality and sustainability in their practices.
- Transparency and accountability

Customer Relationships

- Personalized customer support for airlines to assist in their sustainable procurement
- Data transparency for a fair judgment
- Facilitating networking opportunities

Channels

- Digital platform
- Dedicated sales and customer support personnel
- Utilizing various marketing channels to reach potential suppliers and airlines
- Sustainability experts to promote the platform

Customer Segments

- Airlines
- Suppliers

Cost Structure

Fixed costs
- Investment in servers and IT infrastructure
- Salaries for the team managing the platform, including data analysts and engineers

Variable Costs
- Cost for external consultants for auditing and advising on sustainable practices

Revenue Streams

- Subscription for platform use for airlines
- Subscription fees from suppliers for showcasing their sustainable products and services
- Consulting services
- Payment for insights and reports

Eco-Social Costs

- Energy consumption
- Personnel transport
- Incorrect certifications
- Possibility of fostering bad products

Eco-Social Benefits

- Giving value to more sustainable companies
- Emission reduction and reduction of carbon footprint
- Supporting eco-social projects and initiatives through a percentage of platform revenue
- Fostering a culture of sustainability and responsible business

Procuria

Value Proposition

Access to a pool of sustainable airline suppliers: By offering airlines easy access to environmentally and ethically responsible products and services, the platform integrates the sourcing process for eco-conscious airlines. This strategic advantage aligns with the increasing consumer demand for eco-friendly options, positioning airlines at the front of sustainable practices and differentiating them from competitors that may not prioritize sustainability rigorously.

Enhanced brand reputation for airlines and suppliers: Being associated with a credible sustainability platform allows airlines to ensure their sustainability practices and suppliers to showcase their eco-friendly practices, attracting environmentally conscious customers and stakeholders. This branding advantage sets them apart in a competitive market where sustainability considerations are becoming increasingly influential in consumer choices.

Positive environmental impact and contribution to the fight against climate change: By enabling airlines and suppliers to make more eco-conscious choices, the platform actively contributes to the fight against climate change by promoting sustainable procurement practices

Assistance in increasing sustainability for suppliers: The platform fosters a culture of continuous improvement and learning by connecting suppliers with a community of sustainable stakeholders. This support differentiates the platform from others that merely provide a listing of suppliers without actively encouraging sustainability growth and development.

Transparency and accountability: transparency is a key platform pillar, providing airlines with clear and reliable information about suppliers' sustainability practices. This emphasis on accountability ensures that suppliers' claims are substantiated with verified data and certifications, fostering trust and credibility with airlines.

Customer Segments

Airlines: Procuria's platform is designed to cater to airlines of all sizes, ranging from major commercial carriers to private and corporate jet operators. In an era where corporate social responsibility has gained significant importance, these airlines actively seek to adopt sustainable procurement practices that align with their environmental and ethical goals.

Procuria plays a pivotal role in facilitating this transformation by providing airlines access to diverse, sustainable suppliers. By collaborating with these environmentally responsible suppliers, airlines gain a competitive edge in the market. Embracing sustainability enhances their reputation as socially responsible aviation providers and allows them to meet the evolving expectations of travelers who prioritize eco-friendly travel options.

Suppliers: Procuria's platform aims to cater to a wide spectrum of suppliers within the aviation industry. These suppliers encompass catering services, water suppliers, manufacturers of aircraft components, fuel providers, ground handling companies, and other aviation-related businesses. Recognizing the significance of sustainability in the modern business landscape, these suppliers understand that it is vital to maintain their competitiveness and appeal to environmentally conscious customers.

By actively participating in Procuria's platform, suppliers can showcase their sustainable practices, certifications, and eco-friendly products. Through this exposure, they can position themselves as preferred partners for airlines dedicated to making ethical and sustainable procurement decisions.

Customer Relationships

Personalized customer support for airlines: the platform recognizes that each airline may have unique sustainability goals and challenges. By providing personalized customer support, Procuria's team can understand individual airlines' requirements and offer tailored guidance throughout their sustainable procurement journey.

Data transparency for a fair evaluation: transparency is a fundamental principle that supports Procuria's relationships with its customers. By openly sharing supplier data and grading methodologies, the platform ensures that airlines can access reliable and comprehensive sustainability information. This transparency allows airlines to make fair judgments when choosing suppliers, promoting an open and fair platform for sustainable procurement. Such openness builds trust and confidence, further solidifying the platform's position as a credible and reliable source of sustainability insights.

Facilitating networking opportunities: connecting airlines with sustainable suppliers is at the core of the platform's mission. Procuria creates a dynamic platform for sustainable procurement by facilitating networking opportunities between these stakeholders. Through direct access to a diverse network of eco-friendly suppliers, airlines can establish valuable partnerships, ensuring a steady flow of sustainable products and services.

Channels

Digital platform: Procuria's user-friendly and intuitive digital platform is its core channel. This web-based interface is the primary hub for suppliers and airlines to interact, providing access to sustainability grading, certifications, and other relevant data. By giving valuable information to airlines on different suppliers and providing data on how and why each supplier has different grading, the digital platform offers a

seamless experience for users to navigate and engage with sustainability insights.

Dedicated sales and customer support personnel: to ensure personalized assistance and seamless onboarding for suppliers and airlines, Procuria employs a team of dedicated sales and customer support personnel. These experts offer one-on-one guidance, address user queries, and facilitate smooth stakeholder interactions. This approach fosters trust and strengthens customer relationships.

Utilizing various marketing channels: to reach potential suppliers and airlines, Procuria employs a comprehensive marketing strategy. This includes utilizing Digital Marketing channels such as social media platforms, e-mail campaigns, and Search Engine Optimization (SEO) to drive organic traffic to the platform.

Sustainability experts for promoting the platform: utilizing the power of social influence Procuria partners with sustainability experts and industry thought leaders. The platform uses this influence from relevant experts and companies to enhance sustainability practices in the industry further.

Key Activities

Company evaluation: Procuria's core activity revolves around continuously evaluating suppliers to assess their sustainability practices. This fundamental process forms the basis of the platform's value. Sustainability certificates are meticulously verified to reflect the supplier's sustainability level while undergoing verification to ensure authenticity. Questionnaires provide valuable insights into environmental practices, social responsibility, and ethical sourcing that may not be reflected in determined certifications, allowing further analysis.

Platform management, data management, and analysis: efficient data management and analysis are critical in creating a user-friendly and valuable experience for all stakeholders. The platform generates valuable insights that empower airlines to make informed choices by performing rigorous data analysis, further enhancing its reputation as a reliable and data-driven resource.

Providing sustainable solutions to suppliers: Procuria actively supports suppliers in improving their sustainability practices. Through thorough risk assessments, Procuria identifies and helps suppliers mitigate environmental and social risks, helping their operations and reputation. Expert consulting services connect suppliers with sustainability specialists to implement best practices. By analyzing given certificates, Procuria offers targeted prompts for improvement, empowering suppliers to embrace renewable energy and responsible sourcing. Comparing with industry standards helps suppliers see how well they are doing and set bigger sustainability goals

Key Resources

Supplier insights, certifications, and data for evaluation: supplier data and insights provided through questionnaires and certificates give the necessary information to evaluate suppliers' sustainability practices and credentials accurately. Sustainability certifications and accreditations validate the eco-friendly practices of suppliers and demonstrate their commitment to responsible sourcing. The platform can ensure that suppliers meet industry-leading sustainability standards by having access to various certification resources.

Robust servers and platform infrastructure: reliable servers and a robust platform infrastructure ensure a smooth and efficient user experience. The platform needs to handle vast data from suppliers and airlines, perform real-time evaluations, and display sustainability rankings efficiently. With a robust infrastructure, the platform could avoid downtime, slow response times, and compromised user satisfaction, ultimately hindering its growth and success. A reliable infrastructure would result in more positive customer responses to the platform.
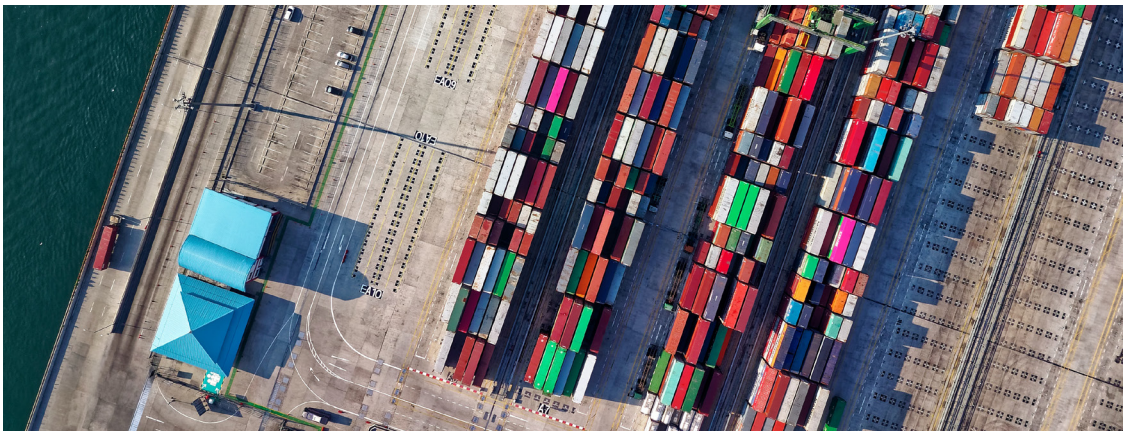
Cybersecurity measures: cybersecurity measures are a vital resource for the platform's development, ensuring trust among stakeholders by protecting supplier data and guaranteeing data privacy. Robust practices prevent breaches and comply with data protection regulations, assisting in the platform's integrity and reputation. As the aviation industry embraces digitalization, cybersecurity becomes crucial for advancing innovation and secure collaboration. The platform gains a competitive advantage by prioritizing data security, attracting more suppliers, and driving positive sustainability outcomes.

Key Partners

Accreditation organizations: accreditation organizations are essential in certifying and validating suppliers' sustainability credentials showcased on the platform. By partnering with reputable accreditation bodies, the platform gains credibility and ensures that the sustainability rankings and certifications are trustworthy and recognized by industry stakeholders.

NGOs: environmental NGOs contribute their expertise in environmental issues and data support to shape the platform's criteria and standards. They promote adopting sustainable practices among airlines and suppliers through advocacy and stakeholder engagement. NGOs also monitor and verify suppliers' environmental claims, ensuring transparency and credibility. They can also offer training to improve sustainability performance. Their collaboration drives positive change, making the platform effective in promoting sustainability.

Research institutions: collaborating with research institutions allows the platform to utilize advanced sustainability research and data. The platform can continuously improve its evaluation criteria, ranking methodologies, and reporting mechanisms by staying on top of sustainability advancements. Additionally, the insights gained from these collaborations can be shared with airlines and suppliers, fostering a culture of continuous learning and improvement across the industry.

Government sustainability agencies: partnering with government sustainability agencies creates synergies and fosters alignment with national and international sustainability initiatives. Government agencies can provide valuable data, regulations, and policy insights that inform the platform's evaluation process.

Revenue Streams

Subscription for platform use for airlines: Procuria will offer subscription packages to airlines, providing them with access to its comprehensive database of sustainable suppliers, data-driven sustainability grading, and personalized support. Airlines will pay a recurring fee for utilizing the platform's resources to make informed procurement decisions.

Subscription fees from suppliers: suppliers can showcase their eco-friendly products and services on the platform by paying a monthly subscription. Suppliers will pay subscription fees to be featured on the platform, gaining increased exposure to airlines seeking sustainable options. This revenue stream encourages suppliers to engage with the platform actively, add more information, and benefit from its growing network of eco-conscious airlines.

Consulting services: as part of its commitment to sustainability, the platform can offer additional consulting and auditing services to suppliers. Sustainability experts within the platform's team can conduct thorough audits of suppliers' practices, validate their sustainability claims, and provide guidance on improvement areas.

Payment for insights and reports: the platform can create detailed sustainability reports based on the data collected and evaluated from suppliers. Airlines and other interested parties can pay for access to these insightful reports, allowing them to gain a deeper understanding of the market and make strategic decisions based on data-driven analysis.

Trend   Scenario   Ideation

🏢 Cost Structure

Fixed Costs: Investment in servers and IT infrastructure: a robust and reliable digital platform is the foundation of the company's operations. Investment in servers and IT infrastructure is essential to ensure the platform can efficiently handle large volumes of data from suppliers and airlines. This includes data storage, real-time evaluations, sustainability rankings, and seamless user experiences. The platform can attract and retain customers by providing a smooth and reliable user experience, further bolstering its competitive position in the market. Salaries for the team managing the platform: the platform's success heavily relies on a skilled and dedicated team managing its day-to-day operations. Data analysts, engineers, and other personnel play critical roles in maintaining the platform, managing data, and generating valuable customer insights. Skilled professionals well-versed in sustainability practices are essential to handle complex data analysis and maintain the platform's credibility.

Variable Costs: Cost for external consultants for auditing and advising on sustainable practices: Hiring sustainability experts as external consultants enables the platform to validate supplier data, verify sustainability claims, and ensure adherence to industry-leading standards. These consultants contribute to the platform's credibility, ensuring it remains a trusted and authoritative source of sustainability information. While variable, these costs are essential to ensure the accuracy and integrity of the platform's sustainability insights.

💲 Eco-Social Costs

Energy consumption: the operation of Procuria's digital platform and data management infrastructure entails energy consumption, which contributes to the platform's carbon footprint. While efforts can be made to optimize energy us-

age through efficient server management and eco-friendly technologies, the environmental impact requires continuous monitoring and mitigation.

Personnel transport: Procuria's business activities may involve travel for meetings, conferences, or on-site evaluations with suppliers and airlines. Personnel transport generates GHG emissions, adding to the platform's eco-social costs. .

Incorrect certifications: in the pursuit of providing accurate sustainability grading, Procuria acknowledges the risk of suppliers misrepresenting or inaccurately reporting their certifications. To address this concern, Procuria has established robust verification processes.

Possibility of fostering bad products: Procuria understands the responsibility of promoting genuinely sustainable products and services. To avoid supporting suppliers who engage in greenwashing or present misleading sustainability claims, Procuria employs stringent vetting procedures. The platform continuously monitors supplier performance and actively seeks user feedback to ensure the products showcased align with high sustainability standards.

🌱 Eco-Social Benefits

Giving value to more sustainable companies: Procuria's platform acts as a catalyst for recognizing and rewarding businesses that prioritize sustainable practices. By showcasing suppliers' sustainability grading and certifications, Procuria encourages companies to prioritize eco-friendly approaches, leading to a positive shift in consumer preferences and increased market value for sustainable enterprises.

Emission reduction/reduction of carbon footprint: By carefully selecting sustainable suppliers and eco-friendly procurement practices, Procuria aids airlines in making environmentally conscious decisions. By promoting suppliers with lower
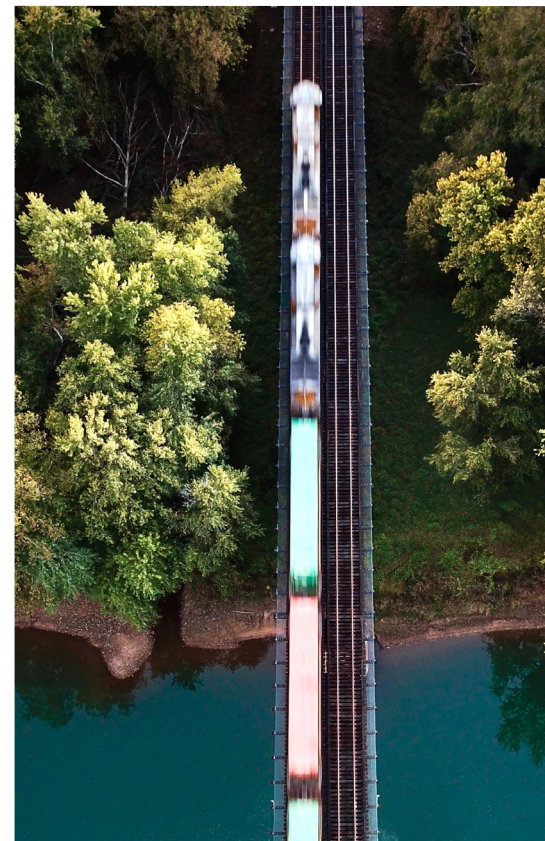
carbon footprints and encouraging airlines to choose greener options, the platform contributes to substantial emissions reductions in the aviation industry. This collective effort helps combat climate change and promotes responsible environmental stewardship.

Supporting eco-social projects and initiatives through a percentage of platform revenue: Procuria demonstrates its commitment to eco-social responsibility by dedicating a portion of its revenue to support impactful environmental and social projects. By investing in these projects, Procuria offsets its
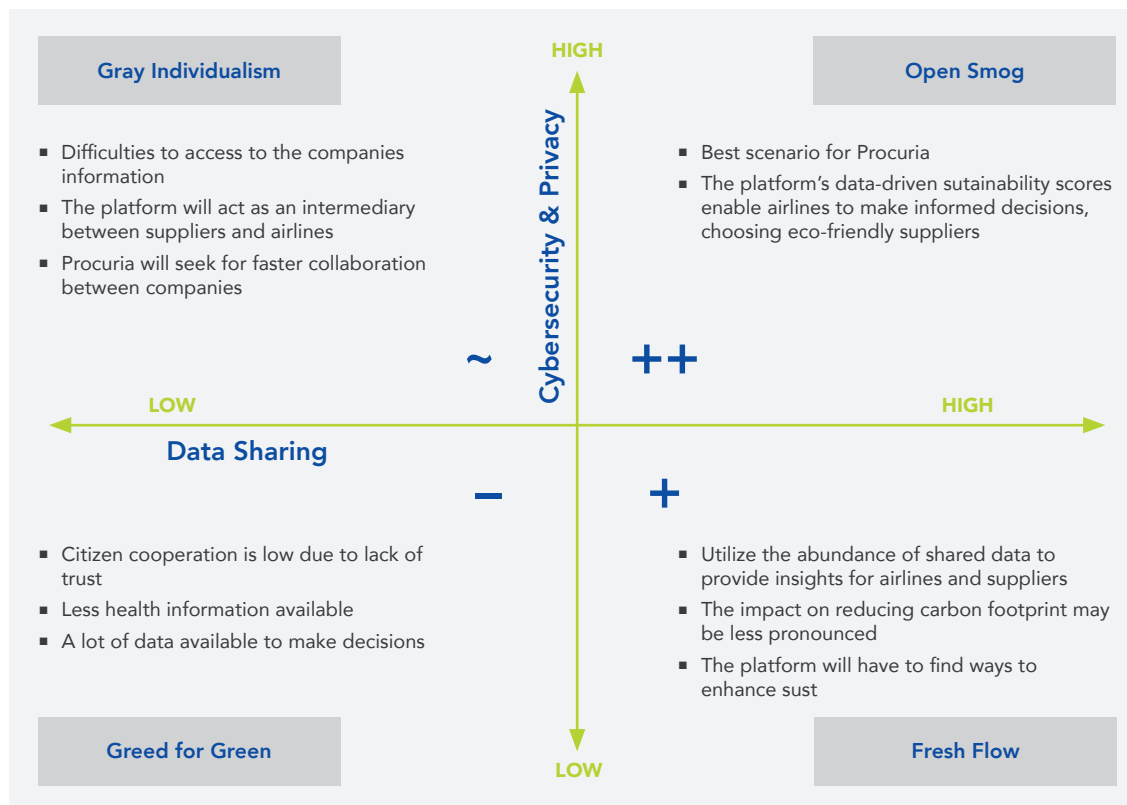
eco-social costs and actively contributes to improving communities and the environment.

Fostering a culture of sustainability and responsible business: by promoting sustainable procurement practices and providing airlines and suppliers with transparent data on sustainability performance, Procuria helps cultivate a broader culture of sustainability in the aviation industry. The platform inspires stakeholders to adopt environmentally and socially responsible approaches, influencing business decisions beyond procurement to encompass broader corporate social responsibility strategies.

Scenario Fit:

The Open Smog: in this scenario, Procuria will play a pivotal role in addressing the pressing challenges. The platform's data-driven sustainability scores enable airlines to make informed decisions, choosing eco-friendly suppliers to reduce their carbon footprint. By connecting airlines with verified sustainable suppliers, Procuria will actively contribute to combating climate change and promoting responsible environmental management. As emissions intensify and privacy concerns rise, Procuria's focus on sustainability and data transparency positions it as a vital solution, facilitating a greener and more sustainable future in the face of these challenges.

Gray Individualism: in a future scenario characterized by high emissions and limited data exchange, Procuria will emerge as a critical solution, addressing sustainability while tackling connectivity and collaboration challenges. Actively promoting sustainable procurement practices, Procuria will try to connect airlines with verified eco-friendly suppliers, contributing to environmental preservation amidst increasing emissions. However, in such a setting, a major challenge would be gaining access to essential supplier data, which forms an essential part of the functioning of Procuria, from reliable

Gray Individualism
- Difficulties to access to the companies information
- The platform will act as an intermediary between suppliers and airlines
- Procuria will seek for faster collaboration between companies

Open Smog
- Best scenario for Procuria
- The platform's data-driven sutainability scores enable airlines to make informed decisions, choosing eco-friendly suppliers

Greed for Green
- Citizen cooperation is low due to lack of trust
- Less health information available
- A lot of data available to make decisions

Fresh Flow
- Utilize the abundance of shared data to provide insights for airlines and suppliers
- The impact on reducing carbon footprint may be less pronounced
- The platform will have to find ways to enhance sust

Cybersecurity & Privacy — HIGH / LOW
Data Sharing — LOW / HIGH
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sources, ensuring that the data is accurate and trustworthy. Overcoming this situation would be crucial for Procuria's success in facilitating sustainable practices and fostering environmental responsibility in the aviation industry.

Greed for Green: in this scenario, Procuria will face challenges amidst reduced greenhouse emissions but a scarcity of data exchange. Acquiring comprehensive sustainability data from suppliers will become a formidable task, affecting the platform's ability to provide robust sustainability scores and establish optimal supplier connections for airlines. The

unreliability of limited data availability further complicates matters. Moreover, as low-emission objectives are successfully achieved, a new reality emerges where sustainability becomes ingrained in businesses, potentially leading to Procuria being less relevant. The scenario's data exchange and connectivity limitations pose significant obstacles to the platform's optimal functioning and its potential to drive significant change in environmental preservation.

FreshFlow: in the scenario of high data sharing and low emissions, Procuria will efficiently utilize the abundance of shared

data to provide valuable insights for airlines and suppliers, further strengthening sustainable practices and driving positive environmental outcomes. Procuria's impact on reducing carbon footprint may be less pronounced in a scenario already marked by low emissions, as its main goal is to foster a more sustainable society. The platform will have to find innovative ways to enhance sustainable practices beyond emissions reduction further. By fostering cooperation, empowering informed decisions, and optimizing resource utilization, the platform contributes significantly to maintaining an environmentally conscious future in this scenario and achieving a sustainable world.

Challenges

- Credibility and legitimacy of sustainable suppliers featured on the platform. While the platform diligently verifies sustainability certificates, ensuring authenticity, there might be instances where suppliers misrepresent or lack genuine eco-friendly practices. Maintaining supplier credibility becomes crucial to uphold the platform's reputation as a reliable source for sustainable procurement.
- Standardizing the metrics for measuring environmental and ethical credentials. As sustainability practices vary across industries and regions, establishing uniform metrics becomes complex. Procuria must navigate this challenge by collaborating with industry experts and sustainability organizations to develop comprehensive and adaptable evaluation criteria. Striving for standardized metrics ensures consistency and enhances the platform's effectiveness in providing airlines with relevant and meaningful sustainability scores.

Outlook

Procuria's data-driven approach and emphasis on data trans-

parency will build trust among stakeholders, solidifying its position as a reliable source for sustainable practices. Procuria's platform will play an increasingly pivotal role in connecting airlines with verified eco-friendly suppliers as the aviation industry continues to prioritize environmental impact reduction.

Collaboration with accredited organizations, industry experts, and sustainability institutions will further enhance Procuria's evaluation processes and standardized metrics. This collaborative approach ensures that Procuria stays at the front of sustainability advancements, continually refining its methodology to deliver, as mentioned above, the most comprehensive and meaningful sustainability scores to airlines.

As Procuria works to overcome determined challenges, it will cement its position as a key player driving positive environmental change. By fostering innovation, knowledge sharing, and resource optimization, Procuria is well-positioned to become the go-to platform for airlines seeking verified eco-friendly suppliers, ultimately contributing to a more sustainable and responsible aviation industry. As the platform grows and adapts, its profound impact on sustainable procurement in the aviation sector will shape a sustainable and more connected outcome for the industry.

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FUELXPERT

An AI-Powered Tool for In-Depth Fuel Market Analysis and Insights

Today, the aviation industry is concerned with implementing more sustainable measures and cutting costs. Reducing fuel use and economizing fuel procurement are objectives to be met. However, airlines and companies lack accurate, real-time information on the fuel market, which hinders sustainable decision-making and cost optimization.

This is where FuelXpert comes into play. FuelXpert is a fuel market analysis and forecasting platform, which predicts price rises and falls. In addition, the platform takes into account SAF and generates a ranking of values according to cost and/or sustainability. It is powered by AI that provides

real-time data, predictive analytics, and actionable intelligence to aviation companies, enabling them to make informed and sustainable decisions on choice, the timing of purchase, and quantity of fuel liters, discerning between SAF and conventional fuel, allowing them to carry out suggested purchase orders. This is possible thanks to the platform's data input such as: carbon offset, the price per tank of fuel in general and that offered by each supplier company, location data, the storage stock of each company, and the fuel usage data of each customer, making it a customized platform.

Airlines can select from an array of subscription options that

cater to their needs and preferences. These options encompass basic subscriptions that facilitate market analysis and predictions, as well as premium subscriptions that elevate the analytical prowess by incorporating and harnessing the unique customer data more personalized.

FuelXpert is resolutely poised to ascend to the pinnacle of excellence as a trusted B2B platform, establishing an unwavering commitment to facilitating fuel cost optimization, fostering strategic tankering practices, and nurturing data-driven decision-making paradigms that unequivocally champion and promote sustainable aviation practices. By catalyzing this

Business Model

Key Partners

- Aviation fuel suppliers and providers
- AVIATAR for data provision
- Aviation industry associations and environmental organizations for outreach and credibility
- Oil market experts for knowledge on market dynamics and prediction accuracy
- Carbon offset platform to retrieve data for SAF

Key Activities

- Training AI models on the fuel market and data analysis
- Developing, maintaining, and improving the platform
- Tracking and prediction of fuel prices
- Develop a proprietary sustainability rating system

Key Resources

- Knowledge in aviation fuel management
- Datasets from various fuel market sources
- Technical infrastructure
- Data scientists and developers

Value Proposition

- Providing accurate, real-time, and predictive fuel market information to airlines
- Enhancing airlines' decision-making to reduce emissions with actionable SAF data insights
- Optimizing fuel storage and tankering costs
- Delivering customized fuel procurement strategies for increased operational efficiency

Customer Relationships

- Dedicated account managers for larger airlines and fuel suppliers
- Customized insights and recommendations

Channels

- Online
- AVIATAR's online platform
- Digital Marketing
- Offline
- Direct sales to airlines, airports, and fuel buyers
- Through our key partners
- Conferences, workshops, and networking events

Customer Segments

- B2B
- Commercial and cargo airlines and aviation companies
- Aviation fuel suppliers

Cost Structure

Initial Investment
- Software and development of the model and "FuelXpert"
- Cloud infrastructure
- Consultancy fee for fuel experts
- Initial licensing fees, permits, or certifications

Fixed Costs
- Maintenance of the FuelXpert platform
- Salaries for data scientists, software developers, and support staff

Variable Costs
- Data acquisition
- Training costs for staff
- Marketing and sales expenditures

Revenue Streams

- Platform access subscription fees, along with additional charges for premium features
- Pay-per-use fees for on-demand in-depth market analysis

Eco-Social Costs

- High energy usage of cloud infrastructure
- Risk of wrong predictions and waste of fuel

Eco-Social Benefits

- Reducing carbon emissions by optimizing fuel use
- Increase sustainable awareness
- Increase the usage of SAF
- Minimizing fuel orders to reduce operational movement and environmental impact

Trend   Scenario   Ideation

FuelXpert

Value Proposition

The foundation of FuelXpert lies in providing precise, re-al-time, and predictive fuel market data to airlines. The availability of accurate data at the right time is not just a convenience; it is a critical factor that can drastically impact operational efficiency and bottom-line results. With advanced analytics and AI technologies, FuelXpert ensures airlines have the insights they need to make well-informed decisions.

An integral part of the value proposition is enhancing airlines' decision-making capabilities to reduce emissions through ac-tionable SAF data insights. Sustainability is more than just a buzzword in today's business world. It's a necessity, particu-larly in the aviation industry, where emissions reduction is a critical concern. FuelXpert empowers airlines to make strides towards sustainability by providing key insights into SAF data, aiding in strategic decision-making for a greener future, and connecting them with a carbon offset platform directly. Another aspect of the value proposition is optimizing fuel storage and tankering costs. Inefficient fuel management can lead to elevated costs and unnecessary complexities. By delivering these insights, pricing, and optimal fuel storage strategies, FuelXpert helps airlines minimize waste and make significant cost savings.

Recognizing that every airline has unique operational needs, FuelXpert offers customized strategies based on detailed market analyses and an in-depth understanding of individual needs. This results in optimized fuel procurement processes, contributing to improved overall efficiency and profitability. Through this comprehensive and holistic approach, FuelX-pert is redefining fuel management in the aviation industry

Customer Segments

B2B: FuelXpert targets selling services for aviation compa-nies in a B2B model. Its two main segments are commercial and cargo airlines and aviation fuel suppliers and distributors.

Commercial and cargo airlines and aviation companies: this segment is made up of commercial airlines, cargo airlines, and other aviation companies. FuelXpert caters to these airlines by offering real-time market insights, predictive an-alytics, strategic tankering solutions, and sustainability data related to SAF. With these tools, airlines can make informed, strategic decisions to optimize their fuel procurement and consumption. Notably, this leads to significant cost savings and contributes to sustainability goals.

Aviation fuel suppliers and distributors: these entities are navigating the dynamics of global fuel markets, an incredibly complex task. Thus, accurate, real-time market data and pre-dictive analytics are indispensable to their operations. FuelX-pert steps provides these suppliers with the necessary tools to understand market trends, predict future dynamics, and plan their operations more effectively. Consequently, they can not only optimize their supply strategies, but also cater more effectively to their client's needs. This enables them to stay a step ahead in this competitive landscape, ensuring they are positioned to respond to market shifts promptly and accuratel

Customer Relationships

Personal account management forms an important part of the customer relationship approach. FuelXpert takes pride in its commitment to personalized customer service by assign-ing dedicated account managers to major airlines and fuel providers. With their efficient coordination, account manag-

ers swiftly address any issues and facilitate timely delivery. The presence of these dedicated account managers exem-plifies FuelXpert's dedication to exceeding customer expec-tations and solidifying its position as a trusted partner in the aviation industry.

Continuous improvement is another critical component of this approach. At FuelXpert, there is a constant drive to im-prove the predictive accuracy of models and develop new features by continuously updating the platform. Designed to address emerging needs and trends in the industry, these innovations provide customers with state-of-the-art tools and information. This proactive stance helps clients remain com-petitive in a rapidly changing market landscape.

In addition, FuelXpert offers personalized information and recommendations, setting itself apart from providers that only present generic market data. Recognizing the unique-ness of each client's operating context, personalized da-ta-driven insights are provided to inform strategic decisions specific to each client's business needs.

Channels

Online: FuelXpert utilizes a digital platform to offer its ser-vices to customers. Its online portal provides a user-friendly interface where clients can access real-time market insights, predictive analytics, and strategic tankering solutions reduc-ing operational costs.

AVIATAR online platform: through a strategic partnership with AVIATAR, FuelXpert is able to leverage AVIATAR's well-established online platform to access its data and use it as inputs to the platform. In this way, you will be able to

extend your reach to a larger user base within the aviation industry and offer more personalized services.

Digital marketing: FuelXpert employs various digital marketing strategies, such as social media marketing, content marketing, SEO, and e-mail marketing. These tactics boost online presence, drive website traffic, and facilitate customer engagement.

Offline: beyond the digital sphere, FuelXpert actively engages with the aviation industry through offline channels.
Direct sales to airlines, airports, and fuel buyers: FuelXpert will contact these entities to increase sales of the platform. Personal interactions can foster strong relationships and business opportunities.

Key Activities

Training AI models for fuel market analysis: A core activity for FuelXpert involves consistently training sophisticated AI models. These models meticulously analyze fuel market data, predict price trends, and generate insightful findings. The ongoing refinement of these models assures the accuracy of market predictions, assisting airlines in their decision-making processes.

Platform development and enhancement: The FuelXpert team is dedicated to the constant development and improvement of the platform, with an emphasis on enhancing user experience and guaranteeing data security.

Real-time fuel price monitoring and forecasting: FuelXpert provides an indispensable service of real-time tracking and forecasting of global fuel prices. Harnessing a wide array of data points, along with the utilization of advanced predictive models, the platform is capable of foreseeing potential fuel

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Creation of an exclusive sustainability rating system: FuelXpert is also engaged in developing a unique sustainability rating system. This proprietary system assesses and rates the cost-effectiveness and environmental impact of various fuel options. By simplifying the complex decision-making process, it provides airlines with an easy-to-understand overview of the sustainability implications of their fuel choices, thus promoting a greener approach in the industry.

Key Resources

Knowledge of aviation fuel management: this refers to a deep understanding and proficiency in managing and coordinating all activities related to the procurement, storage, distribution, and consumption of aviation fuel. This knowledge is critical in shaping fuel procurement strategies, ensuring regulatory compliance, and improving overall efficiency and sustainability in fuel usage.

r Datasets from various fuel market sources: FuelXpert leverages extensive datasets procured from multiple fuel market sources across the globe.

This information, gathered from a wide range of diverse and reliable sources, offers a holistic picture of the fuel market landscape. The real-time and comprehensive data view empowers FuelXpert to provide accurate and strategic predictive analytics to its clients.

Technical infrastructure: this involves the advanced hardware and software systems that FuelXpert uses to collect, store, process, and analyze massive amounts of fuel market data. It includes servers, databases, cloud services, and cybersecurity measures to ensure the secure and efficient operation of the platform.

Data scientists and developers: these play a critical role in the company's success. Data scientists apply their expertise in statistics, machine learning, and predictive modeling to analyze the data and generate insights. Developers are responsible for building and maintaining the FuelXpert platform, ensuring its smooth operation, user-friendly interface, and integration with other systems.
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FuelXpert

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🤝 Key Partners

FuelXpert's partnerships are integral to its operations, with each partner bringing unique value to the table. As key players in the ecosystem, they offer unparalleled insights into fuel supply trends, market dynamics, and associated challenges. Their collaboration enriches the data on the FuelXpert platform, making it more comprehensive and relevant to users. The input from these stakeholders is vital, as it allows FuelX-

pert to maintain a finger on the pulse of the ever-evolving aviation fuel market.

Another indispensable collaboration is with AVIATAR, a provider of reliable data that significantly enhances FuelXpert's analytical and predictive capabilities. The data furnished by AVIATAR is aviation-specific, and thus, its incorporation into the FuelXpert platform helps to improve the accuracy and efficiency of market analysis and forecasting. This partnership guarantees that FuelXpert's assessments and projections are rooted in quality data, ensuring reliable outputs for its users.

In understanding the complexities of fuel market dynamics, collaboration with oil market experts is invaluable. These experts' insights augment FuelXpert's knowledge base, leading to an improved understanding of global oil market trends. Consequently, this enhances the accuracy of the predictive analytics offered by the platform.

A partnership with a carbon offset platform plays a pivotal

role in enabling FuelXpert to retrieve data for SAF. This information empowers airlines to make more informed, environmentally friendly decisions. By establishing a direct connection with real-time offsetting data, FuelXpert can prioritize SAF, leading to a more sustainable aviation industry.

💰 Revenue Streams

FuelXpert's revenue streams are primarily divided into three main categories: customer subscriptions, pay-per-use fees, and consulting services.

Customer subscriptions: these subscriptions can be billed monthly or annually. The basic subscription package provides customers access to critical market analyses, forecasts, fuel prices, and sustainability rankings. For customers seeking a more personalized service, we offer a premium subscription package. This includes additional features such as recommendations on fuel type, quantity, optimal purchasing times, and the capacity to place purchase orders.

Pay-per-use fees offer another revenue stream: understanding that some customers may need in-depth market analysis on a less frequent or ad-hoc basis, we have implemented a pay-per-use service.

Finally, we offer consulting services, leveraging our expertise in the aviation fuel market to provide customers with personalized fuel procurement strategies and in-depth market insights.

📊 Cost Structure

Our initial investment includes creating the "FuelXpert" model and software. The platform's foundation is an intelligent blend of data science and advanced computing, also extending to cloud infrastructure and playing a crucial role in handling and storing extensive data efficiently and securely.

Fixed costs are routine expenses that FuelXpert has to cover. Among these is the cost of maintaining the FuelXpert platform, ensuring it remains functional, updated, and secure against threats. Another key fixed cost is salaries for our teamconsisting of data scientists, software developers, and support staff. These recurring costs are vital for maintaining the high standard of service we offer and for fueling constant innovation.

Our variable costs can fluctuate depending on the scope of FuelXpert's activities. Training costs for staff also fall into this category, as these can increase when new team members are onboarded or when existing staff need to upskill. Additionally, marketing and sales expenditures, which can vary based on the extent and frequency of promotional activities, are included in our variable costs.

Eco-Social Costs

High energy usage of cloud infrastructure: cloud data centers consume substantial electricity, primarily sourced from fossil fuels, resulting in increased carbon emissions and contributing to climate change. This can lead to severe weather events, rising sea levels, and environmental disruptions.
Moreover, the platform's energy consumption places additional strain on existing energy resources and may perpetuate socio-economic disparities. The platform's reliance on energy-intensive infrastructure could divert resources away from investing in renewable energy and sustainable technologies.
To mitigate these eco-social costs, the platform can prioritize energy efficiency. Hosting operations on data centers powered by renewable energy sources can further reduce the platform's indirect contribution to carbon emissions.
Risk of wrong predictions and waste of fuel: the fact that a large amount of data is used and that it is analyzed according to the criteria assigned, makes it possible for other variable data not to be taken into account and for errors in the recommendations. This could lead to increased fuel costs and lead to waste.

Eco-Social Benefits

Reducing carbon emissions by optimizing fuel use: FuelXpert has a unique opportunity to significantly reduce carbon emissions and promote environmental sustainability. By driving optimization of purchasing, fuel usage and data-driven decisions based on FuelXpert recommendations, the goal is to help airlines identify efficiencies opportunities throughout the supply chain.

Increase sustainable awareness: As FuelXpert consists of a data and AI-driven platform that analyzes and predicts the fuel market, our company can play a vital role in increasing sustainable awareness within the aviation industry. By partnering with airlines, fuel providers, and other stakeholders in the aviation sector, we can increase awareness and share information about sustainable fuel alternatives. Through data-driven insights, we can highlight the environmental benefits of adopting these practices and show the long-term cost savings and operational efficiencies they can generate. Additionally, by incorporating sustainability metrics and reporting into our platform, we can incentivize airlines and other aviation companies to continuously track and monitor their environmental impact. This would create transparency and accountability, fostering a culture of sustainability within the industry.

Increasing the usage of SAF: FuelXpert actively promotes the use of SAF in the industry. By providing data on SAF and incorporating it into our fuel management solutions and recommendations, it guides airlines toward making greener choices, thus helping reduce their carbon footprint.
Minimizing fuel orders to reduce operational movement and environmental impact: Through optimized fuel procurement strategies, FuelXpert enables airlines to minimize their fuel orders. This leads to a reduction in operational movement associated with fuel supply logistics, resulting in both economic and environmental benefits, as fewer movements mean less

Scenario Fit:

The Open Smog: in a world of high carbon emissions and data sharing, FuelXpert would be offered to airlines that wish to play a role in sustainable aviation by allowing them to save money on fuel costs and contribute to the reduction of environmental impact by selecting more sustainable fuel sources (SAF) and reducing green emissions. The fact of high data availability and sharing would allow for much tighter predictions with greater confidence. However, this would also result in the presence of many competitors developing similar platforms. As such, it would be very difficult for FuelXpert to differentiate itself from the competition.

Gray Individualism: although gas emissions are high and data sharing is rare, this would be a positive context for the development of FuelXpert, which would be used as an extension of Aviatar. Since data sharing in this world is scarce, the platform would ensure that its analysis and predictions are reliable and transparent. The fact that data is so difficult to access makes FuelXpert likely to offer an almost unique business that is difficult to replicate. In addition, FuelXpert would not focus on increasing sustainability, but rather on reducing airlines' fuel costs and facilitating purchases.

Greed for Green: in this scenario, the environment is sustainable with low emissions of GHG, but there is little data exchange, caused by the decrease in gasoline demand due to the widespread use of VR glasses and the adoption of renewable fuels. In this case, FuelXpert would only be useful in assisting airlines to reduce costs and make better decisions when purchasing gasoline.

FreshFlow: In a world where GHG emissions are close to zero and progress is driven by high data sharing, innovation, and cooperation are fostered, accelerating sustainable practices to maintain those zero emission levels. Airlines would be
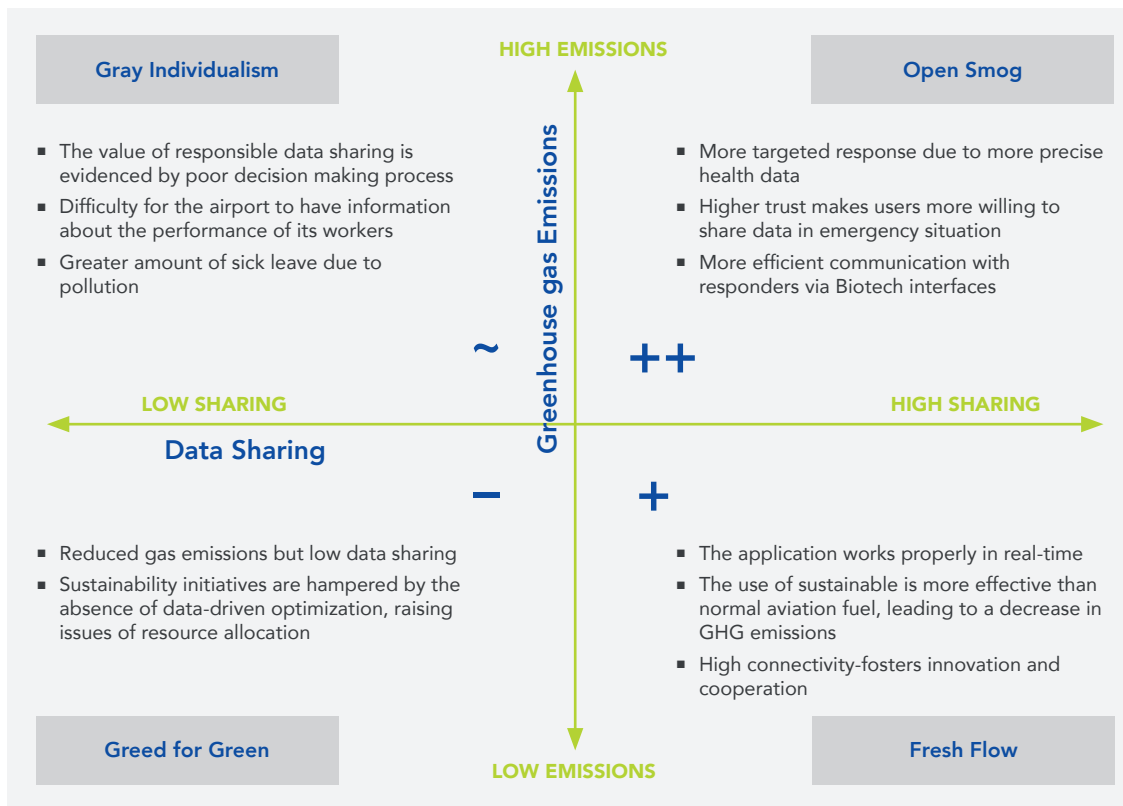
much more committed to gathering information to make all their decisions data-driven, and for this reason, the emergence of tools for the proper use of resources in the aviation industry would be very common. In this scenario, a platform solely focused on analyzing and forecasting gasoline costs might not be as relevant.

Challenges

- AI models predicting fuel market trends require extensive data and time to train.
- Convincing airlines to share confidential data is challenging. Proving reliability, data security, and accurate forecasting ability is crucial to earning customer trust.
- The aviation industry is competitive, with other companies likely offering similar fuel optimization services. It is important to differentiate services, offering unique, customized value to stand out.
- Seamless integration with established fuel handling systems, like Carbon Offset and AVIATAR, is necessary for efficient platform adoption and use.

FuelXpert

- As Pericule relies on highly confidential data such as health information and location, Pericule must ensure that this data is only accessed in emergency situations and compliance with data privacy regulations. Especially in non-emergency situations, cyber security, and data privacy pose a significant challenge.

- Catastrophes of larger extents can affect significant parts of communication infrastructure, including internet connection. Since Pericule strongly relies on connectivity, a backup connection must be provided to ensure functioning in any emergency, regardless of infrastructure damage.

Outlook

FuelXpert aims to become the leading fuel market analysis platform above its competitors. The goal is to recommend and drive airlines to make more informed decisions about what type of fuels to purchase, in what quantities, and when, to save money and enhance their sustainability. This is achievable through the analysis of emissions generated by each airline and estimating how much SAF the company needs to obtain.

In the future, FuelXpert aspires not only to optimize airlines' costs and sustainability but also to assist them in engaging with the realm of sustainable aviation, obtaining certifications, and improving their references. Also, FuelXpert generates reliable and personalized solutions for each airline. Moreover, it will contribute to reducing carbon emissions, thus improving the environment and air quality.

FuelXpert is determined to be part of the sustainable change and enhance the future of aviation.
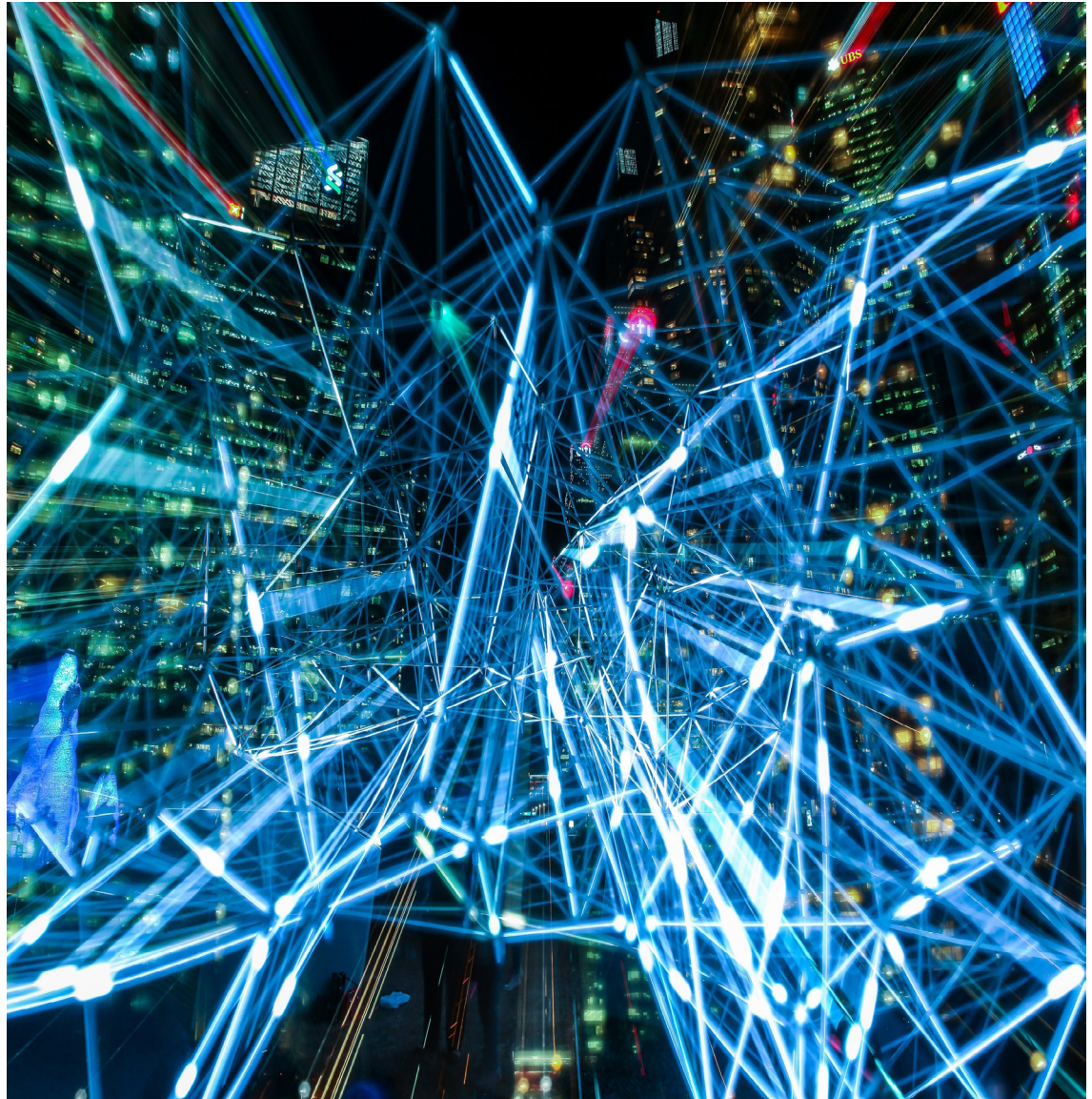
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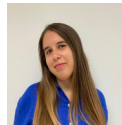
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THE FUTURE OF DIGITAL SOLUTIONS FOR SUSTAINABLE AVIATION

Aviation plays a crucial role in global transportation, but its environmental impact has raised concerns about its long-term sustainability. Amidst the backdrop of global political and economic turmoil, as well as rapid technological advancements, we delve into what lies ahead for the sector of digital solutions in sustainable aviation. Will these advancements fundamentally change how aviation companies operate? Can sustainable aviation businesses thrive in the future? And how do environmental challenges and societal inclusivity factor into this equation?

This report looks into these questions and provides an understanding of the future of digital solutions for the sustainable aviation sector in the next 20 years. It describes trends (political and legal, economic and business models, social and environmental, technological) that explain the current and upcoming challenges of this important sector, identifies potential future scenarios, and innovates new business models, ensuring a balance between sustainability, digital technology, and future prosperity. The generated business concepts include an approach to motivate and raise the performance of ground workers, a service revolutionizing weight management in planes, a program that connects Airlines with suppliers in a more sustainable way, and a smart platform for fuel management.

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