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CONCEPT OF AVIATION TECHNICAL SUPPORT AS A SERVICE

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The concept of Aviation Technical Support as a Service (ATSaaS) has emerged as a new and innovative approach in the aviation industry, aiming to provide comprehensive technical support services to small airlines. The paper explores the development and implementation of this model, combining state-of-the-art digitalization methods and advanced technologies to address the unique challenges faced by small airlines. The research focuses on the customization and scalability of the service model, considering the diverse needs and requirements of small airlines in terms of aircraft maintenance and technical operations. By leveraging advanced digitalization methods, such as artificial intelligence, machine learning, and data analytics, the model aims to optimize decision-making processes, enhance operational efficiency, and improve overall safety and reliability. The article highlights the research novelty in terms of integrating advanced digitalization methods, developing a customizable and scalable service model, and optimizing performance metrics. It explores the practical significance of the ATSaaS model by providing guidance for small airlines to access high-quality technical support services, make informed decisions, and achieve business growth and profitability. Through a comprehensive literature review, the article examines the existing models of aviation technical support services and identifies the gaps that the ATSaaS model aims to address. The study also emphasizes the importance of collaboration between the service provider and the airline, promoting a collaborative ecosystem that fosters effective communication, information sharing, and mutual benefits.

Keywords: Aviation Technical Support, Service Model, Small Airlines, Advanced Technologies, Maintenance Optimization

1. Introduction

The aviation industry has experienced significant growth and transformation in recent years, driven by technological advancements, increased demand for air travel, and the emergence of new market players. Among these developments, small airlines have been striving to establish themselves in a competitive landscape. However, these airlines often face unique challenges in maintaining their aircraft, primarily due to limited resources, technical expertise, and access to efficient support services. As a result, there is a growing need for innovative solutions that cater specifically to the needs of small airlines, ensuring their safe and efficient operation.

One promising avenue for addressing these challenges lies in leveraging advanced technologies, such as the Internet of Things, artificial intelligence, and predictive maintenance tools, to enhance the quality and efficiency of aviation technical support services. These technologies have the potential to revolutionize the way maintenance and technical support are provided to small airlines, ultimately improving their operational performance and reliability.

This article explores the potential benefits and challenges of integrating advanced technologies into aviation technical support services, with a specific focus on a start-up solution designed for small airlines. The primary objectives of this study are to examine the role of advanced technologies in improving aviation technical support services, discuss the implementation of these technologies in a start-up context, and assess their potential impact on small airlines and the aviation maintenance industry.

By providing a comprehensive analysis of advanced technologies in aviation technical support services and presenting a case study of a start-up solution tailored to the unique needs of small airlines, this article aims to contribute valuable insights and practical guidance for industry stakeholders and policymakers alike. Through this investigation, we hope to shed light on the opportunities and challenges associated with integrating advanced technologies into aviation technical support services and inspire further research and innovation in this important area of the aviation industry.

The structure of the article contains 5 sections: the present introduction, description of motivation for research (section 2), a review of publications on the topic (section 3), a description of the Aviation Technical Support as a Service (ATSaaS) concept (section 4), a description of the ATSaaS model (section 5) and conclusions (section 6).

2. Motivation of research

Small airlines face a unique set of challenges in maintaining their aircraft, which can significantly impact their operational efficiency, safety, and competitiveness in the aviation industry. There are several key challenges that small airlines commonly encounter in aviation maintenance:

Small airlines often operate with limited financial and human resources compared to their larger counterparts. This constraint can affect their ability to invest in state-of-the-art maintenance facilities, equipment, and skilled personnel. As a result, they may struggle to maintain their aircraft to the same standards as larger airlines, which could have implications for safety and reliability.

Small airlines may lack the in-house technical expertise required to effectively manage and perform all aspects of aircraft maintenance. This deficit can lead to a reliance on external maintenance providers, which may not always be available or may charge higher fees for their services. Moreover, it can also result in delays and inefficiencies in the maintenance process.

Small airlines may find it challenging to source spare parts and components promptly and cost-effectively. They often face longer lead times and higher costs, as suppliers prioritize larger airlines with more substantial purchasing power. Additionally, small airlines may have limited access to technical support services, including aircraft manufacturer support, maintenance training, and information systems, further complicating their maintenance efforts.

Small airlines must adhere to the same stringent regulatory requirements as larger airlines, ensuring their aircraft meet airworthiness and safety standards. However, they may face challenges in managing the complex documentation, tracking, and reporting processes associated with regulatory compliance, particularly if they lack the necessary resources and expertise.

The aviation maintenance industry is continually evolving, with the introduction of new technologies and methodologies to enhance efficiency and safety. Small airlines may struggle to adopt these innovations due to cost constraints, limited technical expertise, or resistance to change. This reluctance can hinder their ability to remain competitive in the industry and optimize their maintenance processes.

These challenges faced by small airlines in aviation maintenance are multifaceted, encompassing resource limitations, technical expertise deficits, difficulties in accessing spare parts and support services, regulatory compliance hurdles, and barriers to adopting new technologies.

These challenges call for innovative new solutions tailored to the unique needs of small airlines, enabling them to overcome these obstacles and operate their aircraft safely and efficiently. The article considers one of the solutions to this problem based on the concept of Aviation Technical Support as a Service.

3. Related works

The aviation maintenance industry has developed various models of technical support services to cater to the diverse needs of airlines. In the Table 1 There is a review of the literature reveals several common models that have been employed to provide maintenance and technical support services to airlines, including small airlines.

It's important to note that these models are not mutually exclusive, and many airlines may adopt a combination of these approaches based on their operational needs and strategic goals. The choice of the model depends on factors such as the size of the airline, fleet composition, geographical reach, cost considerations, and the desired level of control over technical support operations.

Existing models of aviation technical support services offer various advantages and disadvantages for small airlines. Some of them are described in the Table 2. While some models provide cost savings and flexibility, they may not fully address the unique challenges faced by small airlines, such as limited access to resources, technical expertise, and support services. Therefore, there is a need for innovative solutions that cater specifically to the needs of small airlines, enabling them to maintain their aircraft safely, efficiently, and cost-effectively.

Table 1. Models of aviation technical support services

Model	Description	References
In-house maintenance	Some airlines, particularly larger ones, choose to establish and maintain their own maintenance facilities, staffed with skilled personnel. This approach allows for greater control over the maintenance process, streamlined operations, and potentially lower costs. However, small airlines often struggle to implement this model due to the high capital investments required and difficulties in recruiting and retaining skilled maintenance staff.	Bazargan, 2016 Machado, 2016 IATA, 2018 Demirtas, 2013 Quinlan, 2013
Third-party maintenance, repair, and overhaul (MRO) providers	Many airlines, including small ones, outsource their maintenance activities to specialized MRO providers. These providers offer a wide range of services, from routine maintenance to major overhauls and component repairs. While this model can offer cost savings, flexibility, and access to specialized expertise, small airlines may face challenges in negotiating favorable contracts and ensuring timely access to maintenance services.	Vieira, 2016 Liangrokapart, 2023 Nam, 2023 Lee, 2008 Dombrowski, 2013
Joint ventures and partnerships	Airlines, particularly those with limited resources, may opt to collaborate with other airlines or maintenance providers to share maintenance facilities, staff, and expertise. This approach can offer cost savings and improved access to resources. However, such arrangements may be complex to manage, and small airlines may still face challenges in securing favorable terms and accessing support services on-demand.	Park, 2021 Woo, 2021 Florio, 2017 EC, 2016 Fioriti, 2018
Original Equipment Manufacturer (OEM) Support	OEMs, the manufacturers of aircraft and aircraft components, often offer technical support services to their customers. They have in-depth knowledge of their products and can provide specialized maintenance and repair services, spare parts supply, and technical documentation. OEM support models can be advantageous as they leverage the manufacturer's expertise and ensure compliance with their recommended maintenance practices. However, they may be limited to specific aircraft types and components, and their services may come at a premium cost.	Debnath, 2022 Hyvärinen, 2023 Mecheter, 2022 Vargas. 2018 Goncalves, 2017

This paper explores Aviation Technical Support as a Service as a novel concept from a research standpoint, delving into its origins, key features, benefits, and implications. By leveraging digitalization, advanced technologies, and a collaborative ecosystem, ATSaaS offers a comprehensive and tailored approach to addressing the technical support needs of small airlines and other industry players in driving efficiency, cost-effectiveness, and operational excellence in the aviation industry.

Table 2. Advantages and disadvantages of existing maintenance models for small airlines

Model	Advantages	Disadvantages
In-House Technical Support	• Direct control and oversight of maintenance operations. • Tailored solutions specific to the airline's needs. • Ability to leverage internal expertise and knowledge. • Flexibility in scheduling and resource allocation.	• High costs associated with establishing and maintaining an internal technical support department. • Challenges in recruiting and retaining skilled personnel. • Limited access to specialized expertise or resources. • Potential for limited scalability and flexibility.
OEM Support	• In-depth knowledge of the manufacturer's products and systems. • Access to specialized technical support and documentation. • Compliance with recommended maintenance practices. • Potential for enhanced warranty coverage and support.	• Reliance on a specific manufacturer's capabilities and limitations. • Potential for higher costs compared to other support options. • Limited flexibility in adopting alternative solutions or technologies. • Dependence on the manufacturer's availability and response times.
Third-Party Service Providers (MRO)	• Expertise in a wide range of aircraft types and components. • Cost-effective solutions through economies of scale. • Access to specialized equipment, tools, and facilities. • Ability to handle complex maintenance and repair tasks.	• Potential for increased lead times due to demand fluctuations. • Challenges in ensuring consistent quality across multiple service providers. • Limited control over the maintenance process. • Risk of service provider availability and capacity constraints.
	• Access to specialized expertise and resources. • Cost flexibility through outsourcing specific services. • Potential for improved efficiency and reduced operational burden. • Ability to focus on core competencies and strategic objectives.	• Potential concerns over service quality and reliability. • Coordination and communication difficulties between the airline and service provider. • Need for strong contractual agreements and service level agreements.
Joint ventures and partnerships	• Sharing of resources and knowledge among participating airlines. • Cost savings through resource pooling and shared facilities. • Improved operational efficiency and coordination. • Access to a broader range of technical support capabilities.	• Challenges in aligning goals, resources, and schedules among participating airlines. • Potential for conflicts or imbalances in resource sharing. • Complex decision-making processes due to multiple stakeholders. • Difficulties in maintaining long-term cooperative relationships.

4. Concept of Aviation Technical Support as a Service

The emergence of Aviation Technical Support as a Service stems from the increasing complexity of aircraft maintenance, the growing demands for cost optimization, and the need for more efficient and reliable technical support services. ATSaaS combines elements of digitalization, advanced technologies, and collaborative frameworks to deliver a wide range of services, including maintenance, repair, logistics, documentation management, training, and consultancy. Its key features include customization, scalability, real-time data analytics, and collaborative decision-making, all of which contribute to enhancing the overall efficiency and effectiveness of technical support operations.

ATSaaS is an innovative concept that is transforming the landscape of aircraft maintenance and operations. ATSaaS encompasses a range of interconnected elements that work together to deliver a holistic and efficient technical support service.

ATSaaS focuses on tailoring its services to meet the specific needs and requirements of each airline or industry player. By offering customized service offerings, ATSaaS ensures that technical support solutions are precisely aligned with the client's individual needs. This level of customization sets ATSaaS apart from traditional models of technical support services.

The Aviation Technical Support as a Service model aims to address several gaps and challenges present in the traditional models of aviation technical support services. Some of the key gaps it targets include:

Traditional models often pose significant barriers for small airlines to access high-quality technical support services. They may lack the resources, expertise, and infrastructure to establish in-house support departments or engage with specialized service providers. ATSaaS bridges this gap by offering tailored and scalable support services specifically designed for small airlines, ensuring they have access to the necessary technical expertise and resources.

Establishing and maintaining internal technical support departments or entering long-term contracts with service providers can be costly and inflexible for airlines, particularly those with fluctuating operational requirements. ATSaaS addresses this gap by offering a pay-as-you-go or subscription-based model, providing cost flexibility and scalability. Airlines can optimize their costs by accessing the required support services as needed, without being tied to long-term commitments.

Traditional models often lack a collaborative ecosystem that promotes efficient communication, collaboration, and information sharing among industry stakeholders. This can result in fragmented processes, redundancies, and difficulties in accessing and leveraging collective knowledge and resources. ATSaaS fills this gap by establishing a collaborative platform or digital portal that facilitates seamless communication, collaboration, and data exchange among the service provider, small airlines, suppliers, OEMs, and other stakeholders. This enables efficient sharing of best practices, expertise, and resources.

Many traditional models may not fully leverage the potential of digitalization and advanced technologies in optimizing technical support operations. This can result in suboptimal maintenance practices, limited access to real-time data, and missed opportunities for predictive maintenance and analytics-driven decision-making. ATSaaS addresses this gap by integrating digitalization, advanced analytics, IoT, and other technologies into its service delivery model. It harnesses the power of data to enable proactive maintenance planning, enhance operational efficiency, and optimize resource allocation.

Traditional models often provide standardized solutions that may not fully align with the specific needs and requirements of individual airlines or industry players. Each airline has unique operational contexts, fleet compositions, and regulatory considerations. ATSaaS aims to address this gap by offering customizable solutions that can be tailored to the specific needs of each customer. It takes into account factors such as fleet size, operational requirements, geographical location, and regulatory compliance, ensuring a more precise fit for the technical support services delivered.

By targeting these gaps, ATSaaS aims to provide a more accessible, cost-effective, collaborative, and technologically advanced approach to aviation technical support services. It strives to empower small airlines, suppliers, and other industry players with the necessary tools and resources to optimize their maintenance operations, improve efficiency, and enhance overall operational performance.

ATSaaS encompasses a range of interconnected elements that work together to deliver a holistic and efficient technical support service. The key elements of ATSaaS are shown in Table 3.

Table 3. Key Elements of ATSaaS

Elements of ATSaaS	Description
Customized Service Offerings	ATSaaS focuses on tailoring its services to meet the specific needs and requirements of each airline or industry player. It recognizes that different organizations may have unique operational contexts, fleet compositions, and regulatory obligations. By offering customized service offerings, ATSaaS ensures that technical support solutions are precisely aligned with the client's individual needs.
Digitalization and Advanced Technologies	ATSaaS harnesses the power of digitalization and advanced technologies to optimize maintenance operations. It incorporates state-of-the-art tools and systems such as data analytics, predictive maintenance, Internet of Things (IoT), and artificial intelligence (AI). These technologies enable proactive monitoring, real-time data analysis, and predictive insights, leading to more efficient maintenance planning, improved aircraft reliability, and reduced downtime.
Collaborative Ecosystem	ATSaaS operates within a collaborative ecosystem that connects various stakeholders, including the service provider, small airlines, suppliers, OEMs, and regulatory authorities. This ecosystem facilitates seamless communication, information sharing, and collaborative decision-making. By fostering collaboration, ATSaaS promotes the exchange of best practices, expertise, and resources, ultimately enhancing the overall efficiency and effectiveness of technical support operations.
Scalability and Flexibility	ATSaaS is designed to be scalable and flexible, allowing organizations to adapt their technical support services based on their evolving needs. This scalability ensures that the level of support can be adjusted to accommodate changes in fleet size, operational requirements, and business priorities. The flexibility of ATSaaS enables cost optimization, efficient resource allocation, and improved operational agility.

5. Ecosystem and Model of ATSaaS

5.1. ATSaaS model

Generally, ATSaaS model is represented by its key components and their relationships:

$$P = \{p_i\}, i = 1, \dots n, \tag{1}$$

$$A = \{a_j\}, j = 1, \dots m, \tag{2}$$

where P denote the provider of Aviation Technical Support as a Service and represents the set of components of the provider p_i, and A denote the airline receiving the technical support services and represents the set of components of the airline.

These sets can include personnel, equipment, resources, and processes involved in delivering technical support services.

The Aviation Technical Support as a Service model can be represented as a set of functions and relationships between P and A:

$TS(P, A) \rightarrow R$ – Technical Support Function, which represents the technical support provided by P to A, resulting in the output R. R represents the combined effort of P to deliver maintenance, repair, and other technical services to A.

$SLA(P, A) \rightarrow S_{aut}$ – Service Level Agreement, which establishes the Service Level Agreement between P and A, defining the scope of services, performance metrics, and expected service levels. S_{aut} represents the agreed-upon terms and conditions that govern the provision of technical support services.

$PE(R, S_{aut}) \rightarrow M$ – Performance Evaluation, which evaluates the performance of the technical support services provided by P to A based on the output R and the defined Service Level Agreement S_{aut}. M represents the measurement of key performance indicators (KPIs) to assess the quality, efficiency, and effectiveness of the technical support services.

$CI(M) \rightarrow D$ – Continuous Improvement, which drives continuous improvement in the Aviation Technical Support as a Service model based on the performance evaluation M. It identifies areas for enhancement and generates the updated set of components D that reflects the improvements made in the service delivery process.

By defining the model using these mathematical representations and functions, we can analyze and optimize the ATSaaS model, ensuring efficient delivery of technical support services to the airline while meeting the agreed-upon service levels and performance metrics.

5.2. ATSaaS model

Entrepreneurship in the aviation industry involves the development of collaborative ecosystems, bringing together stakeholders from various sectors to share resources, expertise, and innovative ideas. These collaborations can help small airlines access a broader range of support services, including technical expertise, training resources, and spare parts, thereby strengthening their maintenance capabilities.

The key stakeholders and structure of ATSaaS collaborative ecosystem are shown at the Figure 1.

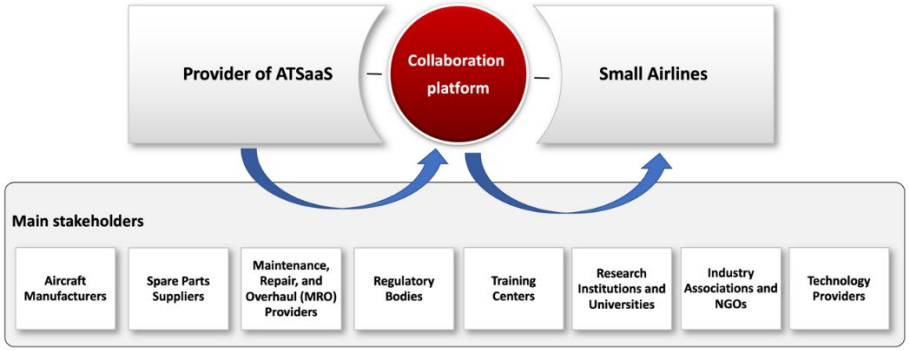


Figure 1. Collaborative ecosystem for Aviation Technical Support as a Service (developed by the authors)

A collaborative ecosystem for Aviation Technical Support as a Service brings together key stakeholders, such as the provider of the service and small airline companies, to create a synergistic relationship that benefits both parties. This ecosystem fosters the sharing of resources, expertise, and innovative ideas to streamline maintenance operations, enhance safety, and improve cost-effectiveness for small airlines.

Table 4. describes the roles, contributions, and potential benefits for both stakeholders in this collaborative ecosystem.

Table 4. Roles of main stakeholders in the collaborative ecosystem

Stakeholders	**Role and Contributions**	**Potential Benefits**
Provider of ATSaaS	• Develop and offer a comprehensive suite of maintenance and technical support services tailored to the unique needs of small airlines, including customized maintenance plans, access to advanced technologies, and regulatory compliance assistance. • Leverage digitalization, IoT, AI, and predictive analytics to optimize maintenance processes, improve decision-making, and proactively address potential issues before they escalate. • Create strategic partnerships with suppliers, manufacturers, training centers, and other industry stakeholders to ensure timely and cost-effective access to spare parts, technical expertise, and training resources. • Foster a culture of innovation and continuous improvement to stay ahead of industry trends and meet the evolving needs of small airline customers. • Engage in sustainability initiatives to minimize the environmental impact of maintenance operations and help small airlines meet regulatory requirements related to environmental responsibility.	• Access to a growing market of small airlines in need of specialized maintenance and technical support services. • Strengthened brand reputation and credibility within the aviation industry as a leading provider of innovative, customer-centric solutions. • Opportunities for revenue growth and expansion into new market segments by addressing the unique challenges faced by small airlines. • Collaboration with other industry stakeholders to share knowledge, resources, and expertise, driving further innovation and competitive advantage.
Small Airline Company	• Engage with the provider of "Aviation Technical Support as a Service" to communicate their specific needs, challenges, and requirements related to aircraft maintenance and technical support. • Invest in training and capacity building for maintenance staff, leveraging the resources and expertise provided by the service provider. • Embrace advanced technologies and innovative solutions offered by the service provider to optimize maintenance operations, enhance decision-making, and improve safety. • Collaborate with the service provider to develop and implement sustainable maintenance practices that minimize environmental impact and meet regulatory requirements. • Provide feedback and insights to the service provider to support continuous improvement and innovation in the delivery of maintenance and technical support services.	• Access to a comprehensive suite of maintenance and technical support services tailored to their unique needs and constraints, improving operational efficiency, safety, and cost-effectiveness. • Enhanced in-house expertise and capabilities in aircraft maintenance, reducing reliance on external providers and lowering maintenance costs. • Streamlined regulatory compliance and documentation processes, ensuring adherence to airworthiness and safety standards. • Improved environmental performance through the adoption of sustainable maintenance practices and technologies. • Strengthened competitiveness in the aviation industry by leveraging the innovative solutions and resources offered by the service provider.

The list of main other stakeholders of ATSaaS collaborative ecosystem and their functions are shown in the Table 5.

Table 5. Stakeholders of ATSaaS collaborative ecosystem and their functions

Stakeholders	Functions
Aircraft Manufacturers	Aircraft manufacturers play a crucial role in the ecosystem by providing technical expertise, OEM documentation, and updates on the latest design changes or modifications. They can also offer insights into best practices for maintaining their specific aircraft models, contributing to the overall safety and efficiency of maintenance operations.
Spare Parts Suppliers	Suppliers of spare parts and components are essential to the ecosystem, ensuring that small airlines have timely and cost-effective access to the necessary parts for maintenance and repair. They can also contribute by sharing information on parts availability, lead times, and alternative solutions, helping small airlines optimize their inventory management practices.
MRO Providers	MRO providers offer specialized maintenance services, such as engine repair or component overhaul, that may not be covered by the primary service provider. They can collaborate with the service provider and small airlines to ensure that the maintenance processes are streamlined and cost-effective.
Regulatory Bodies	Regulatory authorities, such as the Federal Aviation Administration (FAA) or the European Union Aviation Safety Agency (EASA), oversee compliance with airworthiness and safety standards. They can provide guidance on regulatory requirements, offer support in navigating the complex regulatory environment, and participate in the development of best practices for compliance and risk management.
Training Centers	Training centers contribute to the ecosystem by offering technical training programs, ongoing professional development opportunities, and access to knowledge resources and best practices for small airline maintenance staff. They help build in-house expertise and enhance maintenance capabilities for small airlines.
Research Institutions and Universities	Academic institutions and research organizations contribute to the ecosystem by conducting research on innovative maintenance technologies, materials, and processes. They can collaborate with industry stakeholders to develop and test new solutions, ultimately driving innovation and improvement in the aviation maintenance sector.
Industry Associations and NGOs	Industry associations and NGOs can play a supportive role in the ecosystem by facilitating networking opportunities, promoting industry standards and best practices, and advocating for the interests of small airlines and other stakeholders in the aviation maintenance sector.
Technology Providers	Companies specializing in advanced technologies, such as IoT, AI, and predictive analytics, can contribute to the ecosystem by offering innovative solutions that optimize maintenance processes, enhance decision-making, and improve safety. They can collaborate with the service provider and small airlines to integrate these technologies into the maintenance and technical support services.

The collaborative ecosystem for ATSaaS can create a mutually beneficial relationship between the service provider and small airline companies. By working together, sharing resources, and fostering innovation, both stakeholders can address the unique challenges faced by small airlines in aviation maintenance, ultimately enhancing operational efficiency, safety, and competitiveness within the industry.

5.3. The structure of Collaborative ecosystem for ATSaaS

The structure of a collaborative ecosystem for Aviation Technical Support as a Service consists of various interconnected elements that facilitate the sharing of resources, expertise, and innovative ideas among key stakeholders.

This ecosystem is designed to create a synergistic relationship between the service provider, small airline companies, and other industry stakeholders, driving improvements in maintenance operations, safety, and cost-effectiveness. The structure of collaborative ecosystem includes the next main components (Figure 2):

- At the heart of the ecosystem is a central platform that serves as a hub for communication, collaboration, and data exchange between the service provider, small airlines, and other stakeholders. This platform may include a cloud-based software solution or a digital portal that enables stakeholders to access and share information, resources, and expertise seamlessly.
- The service provider plays a crucial role in the ecosystem, offering a comprehensive suite of maintenance and technical support services tailored to the unique needs of small airlines. They are responsible for developing and maintaining the central platform, fostering strategic partnerships, and driving innovation in the delivery of support services.

- Small airlines are the primary beneficiaries of the ecosystem, engaging with the service provider to access customized maintenance plans, advanced technologies, and regulatory compliance assistance. They actively participate in the ecosystem by providing feedback, sharing insights, and collaborating on the development of innovative solutions.
- A key aspect of the ecosystem's structure is the strategic partnerships formed between the service provider and other industry stakeholders, such as aircraft manufacturers, spare parts suppliers, training centers, and regulatory bodies. These partnerships enable the sharing of resources, expertise, and best practices, ultimately enhancing the quality and effectiveness of maintenance and technical support services for small airlines.
- The collaborative ecosystem also includes a knowledge and innovation network that fosters the sharing of ideas, research, and best practices among stakeholders. This network can encompass online forums, workshops, conferences, and other channels for communication and collaboration, promoting a culture of continuous learning and improvement.
- Within the ecosystem, there is a focus on training and capacity building for small airline maintenance staff, facilitated by the service provider and their strategic partners. This component may include technical training programs, ongoing professional development opportunities, and access to knowledge resources and best practices.
- The ecosystem also emphasizes the importance of sustainability and environmental responsibility, encouraging stakeholders to develop and implement eco-friendly maintenance practices, materials, and technologies. This aspect of the ecosystem can involve sharing best practices, engaging in joint research initiatives, and promoting industry-wide adoption of sustainable solutions.



Figure 2. The structure of collaborative ecosystem for ATSaaS (developed by the authors)

The collaboration ecosystem E of ATSaaS can be described as follows:

$$E = \{P(S,T,C), A(H,F,N,W)\},$$

where

P – the provider of ATSaaS according to (1).

A – the airline according to (2).

$S = \{s_1, s_2, \dots s_n\}$ – the set of service modules offered by P, where each service module s_i is associated with a specific set of performance metrics $P_i = \{p_1, p_2, \dots p_m\}$.

$T = \{t_1, t_2, \dots t_m\}$ – the set of advanced technologies used by P, where each technology ti is associated with a specific set of data variables $T_i = \{d_1, d_2, \dots d_r\}$.

$H = \{h_1, h_2, \dots h_l\}$ – the set of historical performance data for A, where each data point h_j is associated with a specific set of variables $H_j = \{v_1, v_2, \dots v_n\}$.

$C = \{c_1, c_2, \dots c_p\}$ – the set of cost data for P, where each cost data point c_i is associated with a specific set of variables $C_i = \{r_1, r_2, \dots r_p\}$.

$F = \{f_1, f_2, \dots f_q\}$ – the set of flight data for A, where each flight data point f_j is associated with a specific set of variables $F_j = \{x_1, x_2, \dots x_q\}$.

$N = \{n_1, n_2, \dots n_r\}$ – the set of navigation data for A, where each navigation data point n_k is associated with a specific set of variables $N_k = \{y_1, y_2, \dots y_r\}$.

$W = \{w_1, w_2, \dots w_t\}$ – the set of weather data for A , where each weather data point w_m is associated with a specific set of variables $W_m = \{z_1, z_2, \dots z_t\}$.

The collaboration ecosystem can be represented as a set of interrelated functions:

$P(S, T, C) \rightarrow S_{opt}$ which define that provider P uses its set of service modules S , advanced technologies T, and cost data C to generate a set of optimized services S_{opt} that are tailored to the needs of A.

$A(H, F, N, W) \rightarrow M_{oe}$ which define that airline A uses its set of historical performance data H, flight data F, navigation data N, and weather data W to generate a set of performance metrics M_{oe} that reflect its operational efficiency, safety record, and customer satisfaction.

$S_{opt}(M) \rightarrow R$ which define that provider P uses the set of optimized services S_{opt} and the airline's performance metrics M to generate a set of performance reports R that provide insights into the airline's maintenance strategies, operational procedures, and resource allocation.

$A(R) \rightarrow C_R$ which define that airline A uses the performance reports R generated by P to adjust its maintenance strategies, operational procedures, and resource allocation to improve its overall performance. The set of cost data associated with these changes is denoted by C_R.

The collaboration ecosystem can be optimized by adjusting the inputs and outputs of these functions to achieve a balance between the needs of P and A. The optimal solution is a set of service modules, advanced technologies, performance metrics, and cost data that maximize the efficiency, safety, and profitability of the airline.

$$s_{opt} = argmin \{C_j(T_j, M_j) \in A(H, F, N, W)\}.$$

Subject to the following restrictions:

- constraints related to the specific needs and requirements of the airline company,
- constraints related to the available resources, expertise, and capabilities of the service provider,
- constraints related to the compatibility and integration of service modules and advanced technologies with the operational context of the airline,
- constraints related to the performance metrics and cost data that ensure the efficiency, safety, and profitability of the airline,
- constraints related to regulatory compliance, industry standards, and operational regulations.

5.4. Central platform of Collaborative ecosystem for ATSaaS

At the heart of the ecosystem is a central platform that serves as a hub for communication, collaboration, and data exchange between the service provider, small airlines, and other stakeholders. This platform may include a cloud-based software solution or a digital portal that enables stakeholders to access and share information, resources, and expertise seamlessly. The modules of the Central Platform provide the necessary functionalities to support communication, collaboration, data exchange, and knowledge management within the Aviation Technical Support as a Service ecosystem (Fig.3).

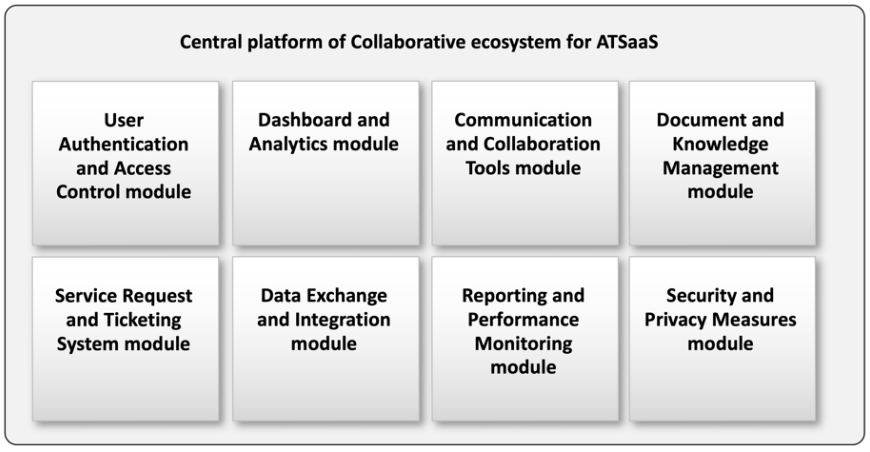


Figure 3. Structure of Central Platform (developed by the authors)

There are some key components and functionalities that can be included in the Central Platform (Figure 3):

- The Central Platform should have a robust user authentication system to ensure secure access to authorized stakeholders. Access control mechanisms can be implemented to manage different levels of permissions based on user roles and responsibilities.
- The Central Platform should provide a centralized dashboard that offers an overview of key metrics, performance indicators, and real-time analytics related to the technical support services. This allows stakeholders to monitor and assess the status and effectiveness of the services.
- The Central Platform should include features for seamless communication and collaboration among stakeholders. This can include messaging systems, discussion forums, and virtual meeting spaces to facilitate effective communication and knowledge sharing.
- The Central Platform should offer capabilities for storing, organizing, and accessing relevant documents, technical manuals, guidelines, and other knowledge resources. This ensures that stakeholders have access to the latest information and resources needed for efficient technical support operations.
- The Central Platform should provide a service request and ticketing system that enables small airlines to submit maintenance or repair requests, track the status of their requests, and communicate with the service provider. This helps streamline the workflow and ensures prompt resolution of issues.
- The Central Platform should support data exchange and integration with other systems, such as aircraft monitoring systems, maintenance databases, and inventory management systems. This allows for seamless sharing of data and information, enabling stakeholders to make informed decisions based on real-time and accurate data.
- The Central Platform should offer reporting capabilities to generate performance reports, maintenance histories, and other relevant insights. These reports help stakeholders assess the effectiveness of the technical support services, identify areas for improvement, and make data-driven decisions.
- The Central Platform should prioritize security and data privacy, implementing robust measures to protect sensitive information and ensure compliance with relevant regulations and standards.

The structure of the Central Platform should be designed in a user-friendly and intuitive manner, making it easy for stakeholders to navigate, access information, and interact with the various features and functionalities.

5.5. ATSaaS as a holistic approach to aviation technical support services

Considering the challenges faced by small airlines in aviation maintenance and the limitations of existing models of technical support services, a holistic approach is increasingly recognized as essential for addressing the unique needs of these airlines. It is importance of adopting a comprehensive, integrated, and customer-centric approach to aviation technical support services, which considers various interconnected aspects of maintenance and support.

A holistic approach to aviation technical support services emphasizes the need to incorporate digitalization and advanced technologies, such as IoT, AI, and predictive maintenance tools, to optimize maintenance processes, reduce costs, and improve safety. By leveraging these technologies, small airlines can enhance their decision-making capabilities, streamline maintenance operations, and proactively address potential issues before they escalate.

A comprehensive approach to aviation technical support services entails the development of customized solutions tailored to the specific needs, resources, and constraints of small airlines. This customization should extend to maintenance plans, pricing models, and service offerings, ensuring that support services are accessible, flexible, and cost-effective for small airlines.

A holistic approach to aviation technical support services recognizes the importance of investing in training and capacity building for small airlines. This investment can include technical training for maintenance staff, ongoing professional development, and access to knowledge resources and best practices, ultimately enabling small airlines to build their in-house expertise and enhance their maintenance capabilities.

A comprehensive approach to aviation technical support services encompasses the efficient management of supply chains and spare parts inventories, ensuring that small airlines have timely and cost-effective access to the components and resources needed for maintenance. This aspect of a holistic approach can involve the development of strategic partnerships with suppliers, optimization of inventory management practices, and leveraging advanced technologies to improve supply chain visibility and responsiveness.

A holistic approach to aviation technical support services also involves support in navigating the complex regulatory environment, ensuring that small airlines maintain compliance with airworthiness and safety standards. This support can encompass assistance with documentation, tracking, and reporting processes, as well as guidance on best practices for regulatory compliance and risk management.

The importance of a holistic approach in aviation technical support services lies in its ability to address the unique challenges faced by small airlines through the integration of digitalization and advanced technologies, customization and adaptability, training and capacity building, supply chain and spare parts management, and regulatory compliance and documentation support. By adopting such a comprehensive approach, small airlines can enhance their maintenance capabilities, improve operational efficiency and safety, and ultimately strengthen their competitiveness in the aviation industry.

5.6. Conclusion

Aviation Technical Support as a Service is an innovative concept that is transforming the landscape of aircraft maintenance and operations. ATSaaS encompasses a range of interconnected elements that work together to deliver a holistic and efficient technical support service.

ATSaaS focuses on tailoring its services to meet the specific needs and requirements of each airline or industry player. By offering customized service offerings, ATSaaS ensures that technical support solutions are precisely aligned with the client's individual needs. This level of customization sets ATSaaS apart from traditional models of technical support services.

ATSaaS leverages the power of digitalization and advanced technologies to optimize maintenance operations. Incorporating state-of-the-art tools and systems such as data analytics, predictive maintenance, IoT, and AI, ATSaaS enables proactive monitoring, real-time data analysis, and predictive insights. These technologies result in more efficient maintenance planning, improved aircraft reliability, and reduced downtime.

Collaboration is a key aspect of ATSaaS. It operates within a collaborative ecosystem that connects various stakeholders, including the service provider, small airlines, suppliers, OEMs, and regulatory authorities. This ecosystem facilitates seamless communication, information sharing, and collaborative decision-making. By fostering collaboration, ATSaaS promotes the exchange of best practices, expertise, and resources, ultimately enhancing the overall efficiency and effectiveness of technical support operations.

Scalability and flexibility are integral to the ATSaaS model. It is designed to be scalable and flexible, allowing organizations to adapt their technical support services based on their evolving needs. This scalability ensures that the level of support can be adjusted to accommodate changes in fleet size, operational requirements, and business priorities. The flexibility of ATSaaS enables cost optimization, efficient resource allocation, and improved operational agility.

ATSaaS offers several significant benefits to airlines and industry players. It provides access to specialized technical expertise and resources that may otherwise be challenging to acquire individually. The pay-as-you-go or subscription-based model ensures cost-effectiveness, enabling organizations to access support services without significant upfront investments or long-term commitments. Additionally, ATSaaS leverages digitalization and advanced technologies to drive operational efficiency, enhance collaboration, and promote knowledge sharing among industry stakeholders.

Aviation Technical Support as a Service represents a significant shift in the way technical support services are delivered in the aviation industry. By combining customization, digitalization, collaboration, scalability, and flexibility, ATSaaS offers a comprehensive and tailored approach to addressing the evolving needs of the aviation sector. It empowers organizations with the necessary tools and resources to optimize their maintenance operations, improve efficiency, and enhance overall operational performance. ATSaaS is poised to revolutionize the way technical support services are provided, setting a new standard for excellence in the aviation industry.

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