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DEPLOYMENT OF ENVIRO SYSTEM FOR OBTAINING GEOSPATIAL DATA FOR FOREST MONITORING AND IMPROVING FOREST MANAGEMENT AND PROTECTION **12**

Materna, M., Novák A., Kandera, B., Badánik B.

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SUSTAINABLE AVIATION FUEL FROM THE PERSPECTIVE OF LONG-TERM SUSTAINABILITY AND DEVELOPMENT

Kristína Šajbanová
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
sajbanova@stud.uniza.sk

Michal Janovec
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
janovec@fpedas.uniza.sk

Jana Zachar Kuchtová
Department of Informatics and Management
Academy of the Police Force in Bratislava
Sklabinská 1,
83517 Bratislava
jana.kuchtova@akademiapz.sk

Abstract

The aim of the article is to create a SWOT analysis of the position of sustainable aviation fuels (SAF) as an innovative available product on the aviation fuel market and to evaluate its development and application in the coming years. The motivation for the analysis and subsequent creation of this work is the fact that the topic of sustainable aviation fuels is currently extremely actual and also relevant for the future of air transport, as well as the future of the ecosystem from the point of view of reducing the emission load caused by the emissions of aircraft engines, which have a non-negligible share of the ecological load our planet. Because the combustion process in aircraft engines is the main factor in the creation of emissions, alternative aviation fuels from sustainable sources have been developed in order to reduce them. Thanks to the analysis of the goals of the influential aviation manufacturers, we found that the attention paid to the implementation of sustainable fuel is currently and will be given increased attention in the future. Achieving this goal will be made possible through technological advances and governance adjustments in many companies affecting aviation, from aircraft and fuel manufacturers to institutions dealing with administrative matters affecting aviation.

Keywords

fuel, emissions, sustainability

1. Introduction

Fluctuations in climatic conditions are mainly caused by the release of emission elements from human activity, which cause changes in the natural balance of element ratios in the atmosphere. These changes are, of course, unnatural for the planet and result in negative phenomena, and therefore global warming causing climate change. There are changes in climate temperatures that negatively affect the entire ecosystem. The development of alternative aviation fuels is therefore a non-negligible part of reducing the negative impact of air transport emissions on the environment. The most influential manufacturers of aeronautical technology have set goals with which they want to direct aviation on a sustainable path. One of their main goals is also to achieve the transition to 100% use of sustainable fuel. Some technologies already allow the use of 100% sustainable fuel, and in the near future the development of these technologies will increase thanks to the mutual cooperation of aircraft manufacturers. The implementation of SAF in the future requires minimizing the price as well as improving availability as much as possible, as well as simplifying certification and adjusting rules in individual segments of aviation to quickly and efficiently achieve the decarbonization of air transport.

2. Methodology

In order to predict the future state of SAF in the aviation sector, the form of SWOT analysis is applied. The purpose of a SWOT analysis is to assess the current state and create alternatives for the future development of the examined object. In order to achieve the result of the SWOT analysis, it was necessary to perform the following steps. In the first step, a general analysis of strengths, weaknesses, opportunities and threats was performed, which led to the selection of the most relevant parameters. Based on a thorough study of verified sources and scientific articles of renowned databases, a categorization of the determined parameters was subsequently carried out, resulting in a table of categorization of SAF elements.

Table 1: Schematic representation of the strengths and weaknesses of SAF, as well as its opportunities and threats. Source: Authors.

Strengths ○ Use of renewable feedstocks sources for production ○ Reduction of NOx and CO emissions ○ Carbon neutrality ○ Same fuel properties compared to Jet-A ○ Aircraft certified for the current specification of jet fuel can use SAF	**Weaknesses** ○ Higher cost (2-5 times higher price) ○ More inaccessible in opposition to conventional fuel ○ Low volume of production
Opportunities ○ Enabling the use of 100% blend of SAF in the near future ○ Accelerating the development of new technologies for reduction of fuel consumption ○ Raise of new job opportunities ○ Strengthening of the agricultural sector	**Threats** ○ Land occupation ○ Increase in the cost of flying

2.1. Analysis of strengths

2.1.1. Use of renewable feedstocks sources for production

These resources include corn grain, oil seeds, algae, other fats, oils, and greases agricultural residues forestry residues wood waste, urban solid waste stream, wet wastes (manures, wastewater treatment sludge), special energy crops. This broad resource contains enough raw materials to meet the needs for aviation industry, provide additional quantities of low carbon fuels for other modes of transportation, and produce high-quality bio-products and renewable chemical compounds.

2.1.2. Reduction of NOx and CO emissions

The sustainable combustion of aviation fuel reduces NOx and CO production compared to fossil fuels. These compounds were measured in experiments using a mixture of fossil fuels and SAF in an engine under the same conditions. The results showed a 38% reduction in NOx and a 44% reduction in CO compared to Jet-A. SAF has the potential to achieve a CO_2-neutral life cycle, reducing CO_2 impacts by 80%.

2.1.3. Carbon neutrality

SAF's arguments are convincing. It reduces life-cycle CO_2 emissions by around 80%, and this number is expected to increase significantly over the next few years. It is possible to generate negative carbon SAF.

2.1.4. Same fuel properties compared to Jet-A - aircraft certified for the current specification of jet fuel can use SAF

SAF can be produced using a variety of techniques that use physical, biological and chemical reactions to break down biomass and waste resources and recombine them into energy-dense hydrocarbons. As with conventional jet fuel, the hydrocarbon mixture in the SAF must be tuned to achieve the key properties required for safe and reliable aircraft operation.

Working with biorefineries, aerospace companies and farmers, researchers are developing new ways to produce SAF from renewable and waste feedstocks that meet stringent fuel specifications used in existing aircraft and infrastructure. The laboratories works with industry partners to develop SAF pathways and fuel formulations for the testing and certification required to ensure these fuels are fully compatible with existing aircraft and infrastructure.

2.1.5. Reduction of CO2 during combustion process

CO_2 reduction during combustion process is minimal, but the problem of CO_2 emissions is solved by SAFs carbon life cycle ability.

As part of the established SWOT analysis methodology, a matrix of the importance of strengths was created, which formed the basis for the subsequent evaluation of the parameters.

Table 2: Matrix of strengths importance. Source: Authors.

		Effect (value)	
		High	**Low**
Importance	**High**	○ Use of renewable feedstocks sources for production ○ Carbon neutrality ○ Same fuel properties compared to Jet-A ○ Aircraft certified for the current specification of jet fuel can	○ Reduction of NOx and CO emissions ○ Reduction of CO2 during combustion process
	Low		

On the basis of the above-mentioned table, the identified strengths were assessed, while the values of the "value" and "scale" parameters were determined based on the number of scientific articles, the contents of which determined the strengths of SAF. The total number of reviewed scientific articles related to SAF was 68. The value of the parameter "scale" represents its importance and the value of the parameter "value" to what extent the parameter is currently valid and represents the real state of the problem.

Table 3: Assessment of identified strengths. Source: Authors.

	Value <1-5>	**Scale (0-1)**	**Calculated values**	**Maximal values**
Use of renewable feedstocks sources for production	4	0,3	1,2	1,5
Reduction of NOx and CO emissions	5	0,2	1	1
Reduction of CO2 emissions during combustions process	4	0,3	1,2	1,5
Carbon neutrality	3	0,05	0,05	0,25
Same fuel properties compared to Jet-A	3	0,05	0,15	0,25
Aircraft certified for the current specification of jet fuel can use SAF	4	0,1	0,4	0,5
OVERALL	**-**	**1,00**	**4,0**	**5**

2.2. Analysis of weaknesses

2.2.1. Higher cost (2-5 times higher price)

Current costs of sustainable aviation fuel are 2-5 times higher than conventional fossil fuel. Airlines used about 100 million litres of sustainable aviation fuel in 2021 which is a small amount compared to the total fuel required for the aviation industry. Airlines had ordered 14 billion litres of SAF. This happened despite the fact that the price of SAF was about two and a half times the price of fossil kerosene.

2.2.2. More inaccessible in opposition to conventional fuel

Currently, the availability of SAF is lower compared to conventional fuel, but this deficiency is one of the problems that aircraft manufacturers and institutions will eliminate in the near future.

2.2.3. Low volume of production

SAF is already offering a resources with 78 000 tonnes produced and used in 2021, with expected production capacity raising to 4 million tonnes by 2025 which means 100 times increase. Nevertheless, to obtain a net zero target for air transport by 2050 it is likely that a production capacity of the order of 500 million tonnes of SAF would be required in 2050, which is another 100 times increase opposite to 2025.

2.2.4. Land occupation of food crops

There are crops considered as source for feedstocks with ability to grow in water environment or in inhospitable places such as deserts.As in the case of positive aspects, also in the case of SAF weaknesses, an importance matrix was compiled, which served as a basis for the subsequent evaluation of the parameters.

Table 4: Matrix of weaknesses importance. Source: Authors.

		Effect (value)	
		High	**Low**
Importance	**High**	○ Higher cost ○ Low volume of production	
	Low	○ More inaccessible in opposition to conventional fuel	○ Land occupation of food corps

Subsequently, based on the above-mentioned matrix, an assessment of the identified weaknesses was created.

Table 5: Assessment of identified weaknesses. Source: Authors.

	Value <1-5>	Scale (0-1)	Calculated values	Maximal values
Higher cost (2-5 times higher price)	5	0,5	2,5	2,5
More inaccessible in opposition to conventional fuel	2,5	0,1	0,25	0,5
Low volume of production	4	0,2	0,8	1
Land occupation of food crops	0	0,2	0	1
OVERALL	-	**1,00**	**3,55**	**5**

2.3. Analysis of SAF opportunities

2.3.1. Enabling the use of 100% SAF in the near future

Most major aerospace companies agree that aviation agencies should allow 100% SAF blends, as only 50% SAF blends with fossil fuels are currently allowed. Allowing the use of 100% SAF could lead to increased use of SAF by airlines, which would lead to higher SAF consumption and demand for SAF. Higher consumption and demand will lead to more investment in the SAF sector, which can grow and improve faster.

2.3.2. Accelerating the development of new technologies for fuel consumption reduction

Higher price of sustainable aviation fuel can mean greater demand for the engines with lowest possible consumption, this fact can lead to effort of manufacturers to speed up the technological improvements of engines.

2.3.3. Raise of job opportunities

Expanding SAF domestic production may help sustain the interests of biofuel industry and create new economic benefits by creating and securing job opportunities. These include jobs in:

- Feedstocks production in agricultural communities
- Construction for building advanced biorefineries
- Manufacturing for operating SAF biorefineries and infrastructure
- Aviation, including pilots, aircrew members, maintenance personnel and other industry professionals.

2.3.4. Strengthening of agricultural sector

Growing, sourcing and producing SAF from renewable and waste sources can create new economic opportunities for farming communities and improve the environment. By growing biomass crops for SAF production, farmers can make more money by providing raw materials for this new market, while ensuring their farms benefit, such as reduced nutrient losses and improved soil quality.

The opportunities listed above are again placed in a matrix of importance.

Table 6: Success probability of SAF opportunities based on their attraction. Source: Authors.

		Effect (value)	
		High	Low
Importance	High	○ Enabling the use of 100% blend of SAF in the near future ○ Raise of new job opportunities ○ Strengthening of the agricultural sector	
	Low	○ Accelerating the development of new technologies for reduction of fuel consumption	

All mentioned opportunities of SAF application have been discussed in detail several times in scientific articles. The greatest importance was attributed to the possibility of using 100% SAF mixture as well as the possibility of developing new technologies. It is for this reason that they are assigned a value of 5 on a scale of 1-5 in the assessment table of the identified options. Many scientific articles have dealt with the impact of SAF development on the agricultural sector as well as in relation to the impact on employment in the agricultural sector. Since the direct impact of the introduction of SAF on employment in the agricultural sector has not been directly proven and is only marginally mentioned in the scientific literature, it is assigned a value of 3 in the calculations.

Table 7: Assessment of SAF opportunities. Source: Authors.

	Value <1-5>	Scale (0-1)	Calculated values	Maximal values
Enabling the use of 100% blend of SAF in the near future	5	0,3	1,5	1,5
Raise of new job opportunities	3	0,25	0,75	1,25
Low volume of production	4	0,3	1,2	1,5
Accelerating the development of new technologies for reduction of fuel consumption	5	0,15	0,75	0,75
OVERALL	-	**1,00**	**4,2**	**5**

The last step was the evaluation of possible threats and therefore external aspects of the development and application of SAF from the point of view of long-term sustainability.

2.4. Analysis of threats

2.4.1. Land occupation

The International Air Transport Association (IATA) claims that there are significant concerns in some quarters that increased SAF intake could lead to severe deforestation and lead to shortage of crops vital to food production. The head of the IATA believes it is crucial that the industry does not use raw materials that compete with land use or food production. Any regulation related to the long-term development of sustainable aviation fuels will ensure that this is not the case.

2.4.2. An increase in the cost of flying

Sustainable aviation fuel is 2-5 times more expensive than conventional fuel, but plenty of consumers are willing to pay, therefore orders for sustainable aviation fuel increases. This fact may result in more expensive flights overall, therefore mirrored on the higher prices of air tickets of airliners. However the more SAF is implemented to the aviation, the faster the development of this sector will be in future, resulting in normalization of SAF costs.

Table 8: Effects of SAF threats based on their importance. Source: Authors.

		Effect (value)	
		High	Low
Importance	High		○ Increase in the cost of flying
	Low		○ Land occupation

In the last step of the SWOT analysis, we identified only 2 threats to SAF. Since most of the scientific articles that served as a basis for the creation of the matrix were devoted to the impact of the SAF price on ticket prices or the total price of the flight, and indicated a favourable development of the price of flights using SAF, a value of 1 is assigned. Likewise, in the case of the land occupation aspect, most articles deal with alternative options production of SAF, such as the use of crops capable of growing in deserts, or the use of algae as a basic raw material, which in its essence does not need land for cultivation. Since a direct land occupation threat has not been proven the aspect has reached a value of 0.

Table 9: Assessment of SAF threats. Source: Authors.

	Value <1-5>	Scale (0-1)	Calculated values	Maximal values
Increase in the cost of flying	1	0,7	0,7	3,5
Land occupation	0	0,3	0	1,5
OVERALL	-	**1,00**	**0,7**	**5**

3. Results

The final balance of the observed parameter is obtained by subtracting the value of weaknesses from the final value of strengths. The same calculation method is applied for the parameters of opportunities and threats.

$$\Sigma S - \Sigma W = 4 - 3{,}55 = 0{,}45$$

$$\Sigma O - \Sigma T = 4{,}2 - 0{,}7 = 3{,}5$$

As we can see in the graphic representation of the SWOT analysis results, SAF tends to outweigh negative influences with its advantages. We can observe this fact by position of the resulting SWOT analysis value in the quarter of strengths. The result indicates a positive development of the SAF in aviation, since the negatives of the SAF are less significant factors compared to the positive influences.

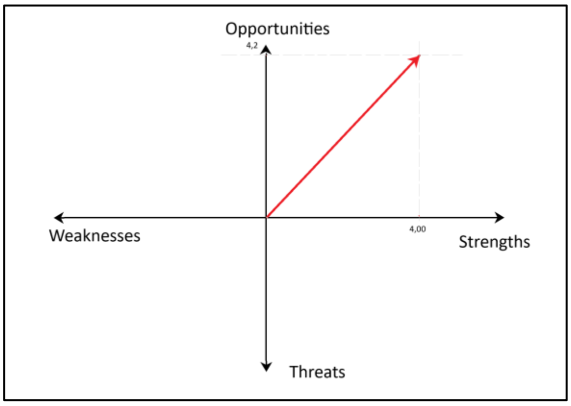

Figure 1: Final evaluation of SWOT analysis depicted in quartals.
Source: Authors

4. Discussion

For decades we have continuously dedicated ourselves to improving the efficiency of our engines, taking each working part and making it better, shaving fractions of a percent off the amount of fuel burnt. The effort to achieve lower consumption of fuel and efficiency of engines were one of the main goals for decades. While alternative technologies such as hydrogen and electric propulsion can be suitable for use in commercial aviation, when these technologies are mature enough to introduce passenger service, larger aircraft flying long-haul flights will be only able to use SAF for emission neutralization. Further research should allow SAFs to replace 100 % of fossil fuel-based kerosene in the coming years. SAF is already offering a resources with 40 kilotons produced in 2019 and with expected production capacity raising to 4 million tonnes by 2025 it means 100 times increase. Aerospace companies are working to assure that all new aircraft and power plants can run on 100 % SAF blends by 2030. Also airports are ensuring airport infrastructure is SAF prepared. Aviation airworthiness and safety organs are making more simple the licensing of higher mixtures percentages and certifying new kinds of SAF.

5. Conclusion

The development of alternative aviation fuels is an essential part of reducing the negative environmental impact of aviation emissions. Thanks to the SWOT analysis, we found that the attention paid to the implementation of sustainable fuel is currently and continuously given increased attention. Achieving this goal will be possible through technological progress and adjustments to governance rules in many corporations affecting aviation operations, from aircraft and fuel manufacturers to institutions dealing with administrative matters affecting aviation. By comparing and explaining the carbon life cycle of the alternative fuel, a justification of its sustainability was achieved on the basis of the same carbon dioxide consumption in production, distribution and the same amount of emission exclusion in the fuel consumption of aircraft engines. The most effective implementation of the SAF in the future also requires minimizing the price as much as possible, improving its availability worldwide, and simultaneously simplifying certification and regulatory adjustments in individual aviation segments to achieve decarbonisation of air transport quickly and efficiently.

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UNIVERSITY OF ŽILINA

AMSS IN EUROPE

Andrej Novák
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
andrej.novak@fpedas.uniza.sk

Kristína Kováčiková
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
kristina.kovacikova@stud.uniza.sk

Abstract

Nowadays, technology is developing rapidly, therefore satellite and aviation systems need to keep pace with modern trends and new technology. The paper is focused on satellite systems and aviation systems. Based on analysis of the issues it is possible to take measures against problems that may arise in the future. There is a need for satellite-based navigation system that can solve the problems of the existing systems and make the existing systems better and more efficient by providing great convenience to the airspace users for the safe, efficient, comfortable and economical realisation of flights in the future. The paper contains information about Air Communication and Navigation Systems and discusses the state of current aviation and satellite systems.

Keywords

Aeronautical mobile-satellite service, AMSS, Navigation

1. Introduction

Technology is developing rapidly today, and air transport has managed to become a sector that can adapt to developed technology. Estimates suggest that 4 billion passengers travel by air each year and that this number will more than triple in the next 20 years. Therefore, measures are needed to solve existing issues in order to be able to meet the forecast demand. Current plan is to provide air navigation and communication services via satellite in order to meet the increasing air traffic demand and to solve the problems that may arise due to congestion and delays (Bilen et al., 2022).

The use of satellites in air navigation and communications services was first proposed in mid 1980 by Brian O'Keeffe of the Australian Civil Aviation Authority. Brian O'Keeffe proposed the use of satellite communications, Controller/Pilot Data Link Communications, Global Positioning System, Inertial Reference System and Automatic Dependent Surveillance technologies for improved monitoring and control in Air Traffic Control Centres (Chen & Xiong, 1994).

After that with the study initiated by the International Civil Aviation Organisation (ICAO) in 1983, the inadequacies of the existing systems were revealed. According to the results of the committee reports prepared at the 10th Air Navigation Conference held in 1991 satellite-based technologies were approved to overcome these inadequacies (Chen & Xiong, 1994).

Nowadays, system analysis are ongoing in the USA and Europe within the framework of the forecasts created to increase the capacity of the airspace by using satellite systems and to ensure more efficient use of the airspace. At the same time, the cost/benefit analyses and economic development of satellite systems are being evaluated (Chen & Xiong, 1994).

There is a need for satellite-based navigation system that can solve problems of the existing systems and make the existing systems better and more efficient by providing great convenience to the airspace users for the safe, efficient, comfortable and economical realisation of flights. Satellite based navigation systems should be economical, effective, efficient, productive and safe. Studies focused Satellite Air Navigation Systems are developing rapidly under the auspices of ICAO with the contributions of the United States of America, European countries and other Civil Aviation Organisations.

It can be potentially difficult to adapt to new technology systems that are developing rapidly every day. The transition from existing systems to new technologies is certainly not an event that can be realised in a short time. In order for satellite systems to gain integrity all over the world, global planning must be made. Regional and national studies are necessary in order to determine the regional differences of each place in the world and the inadequacies of the existing system. These studies are carried out by regional planning groups within the air navigation regions established by ICAO (Abo-Zeed et al., 2019).

2. Characteristics of AMSS

Aeronautical mobile-satellite service (AMSS) is a type of satellite communication service that is specifically designed for use in the aviation industry. This service allows aircraft to communicate with ground stations and other aircraft through the use of satellites, providing a reliable and efficient means of communication for the aviation industry (Zhang, 2021).

In Europe, AMSS has become increasingly important as a means of communication for both commercial and military aircraft. The EU has recognized the importance of AMSS in the aviation industry and has taken steps to ensure that this service is widely available throughout the region. One of the main benefits of AMSS in Europe is that it allows for real-time communication between aircraft and ground stations. It is particularly important for commercial airlines, which rely on constant communication with ground stations in order to maintain safe and efficient operations. For example, with AMSS pilots can communicate with air traffic control to receive updated weather and flight information, which can help them to make more informed decisions about the best route to take (Abo-Zeed et al., 2019).

In addition to commercial airlines, military aircraft also benefit from AMSS in Europe. Military aircraft often operate in remote or hostile environments, where traditional forms of communication may not be reliable. With AMSS, military aircraft can communicate with ground stations and other aircraft in real-time, which is essential for maintaining operational readiness and carrying out effective missions (Morioka et al., 2020).

The EU has also recognized the importance of AMSS in terms of safety and has taken steps to ensure that this service is widely available throughout the region. The EU has established regulations and standards for AMSS, which are designed to ensure that the service is reliable, secure, and efficient. For example, the EU has established regulations for the use of AMSS frequencies, which ensure that there is no interference between different users of the service. In addition, the EU has also invested in the development of new technologies for AMSS, such as the use of satellite based navigation systems. These systems, such as the European Geostationary Navigation Overlay Service allow aircraft to determine their position and speed with a high degree of accuracy, which is essential for safe and efficient flight operations.

Despite the benefits of AMSS in Europe, there are also challenges that need to be addressed. One of the main challenges is that AMSS is a relatively expensive service, which can make it difficult for smaller airlines and aircraft operators to afford. Additionally, there is also a need to ensure that the service is secure and that communications are protected from unauthorized access or interference.

Aeronautical mobile-satellite service (AMSS) is a type of satellite communication service that is specifically designed for use in the aviation industry. This service allows aircraft to communicate with ground stations and other aircraft through the use of satellites, providing a reliable and efficient means of communication for the aviation industry. However, there are several problems associated with the propagation of satellite signals that can affect the performance of AMSS in Europe (Koga et al., 2014).

One of the main problems with the propagation of satellite signals is the effect of atmospheric conditions on the signal. The atmosphere can cause signal attenuation, which is the reduction of the signal strength as it travels through the atmosphere. This can be caused by various factors such as rain, snow, and atmospheric gases, which can all absorb or scatter the signal. This can result in a weaker signal reaching the aircraft, which can affect the quality of the communication and even cause it to be lost completely. Another problem with the propagation of satellite signals is the effect of the earth's surface on the signal. The earth's surface can cause signal reflections. This can cause signal interference, which can affect the quality of the communication. For example, if the signal is reflected off water or a large building, it can cause the signal to be delayed or distorted, resulting in poor communication quality. Additionally, the problem of signal blockage can also affect the performance of AMSS in Europe (Bilen et al., 2022).

Signal blockage occurs when a physical object such as a building, mountain or even a large aircraft blocks the line of sight between the satellite and the aircraft. This can cause the signal to be lost completely, resulting in a loss of communication. There are also problems associated with the use of frequency bands for AMSS. The frequency bands allocated for AMSS are shared with other communication services, such as mobile telecommunications and weather radar. This can lead to interference between the different services, which can affect the performance of AMSS. To mitigate this problem, the European Union (EU) has established regulations and standards for the use of AMSS frequencies, which aim to ensure that there is no interference between different users of the service (Koga et al., 2014).

AMSS is a type of satellite communication service that is specifically designed for use in the aviation industry. This service allows aircraft to communicate with ground stations and other aircraft through the use of satellites, providing a reliable and efficient means of communication for the aviation industry. However, one of the main problems with AMSS in Europe is the limited coverage area provided by the current satellite systems. One of the main challenges in providing AMSS coverage in Europe is the vast geographical area that needs to be covered. Another problem with the coverage area of AMSS in Europe is the limited number of satellites that are currently in operation (Kovacikova et al., 2022).

The current satellite systems used for AMSS in Europe are not able to provide coverage to the entire region, leaving some areas without access to the service. This can be particularly problematic for aircraft operating in remote or sparsely populated areas, where traditional forms of communication may not be available. The current generation of satellites used for AMSS are geostationary satellites, which means that they are positioned in a fixed location relative to the Earth's surface. The signal from these satellites can be blocked by the terrain, such as mountains or tall buildings. This can result in a weaker signal reaching the aircraft or even a complete loss of signal, which can affect the quality of the communication (Abo-Zeed et al., 2019).

In addition to the coverage area, the availability of the service is also a problem with AMSS in Europe. The service is dependent on the satellites being operational and in good working condition. If a satellite were to fail, it would result in a loss of service in the area covered by that satellite. This can be particularly problematic for aircraft operating in remote or hostile environments, where traditional forms of communication may not be available. The cost of providing AMSS coverage can be high, particularly in areas where the terrain and climate make it difficult to provide consistent and reliable coverage. Additionally, the cost of maintaining and upgrading the equipment and infrastructure required for AMSS can also be high. This can make it challenging for airlines and aircraft operators to keep their systems up-to-date and ensure that they are operating at optimal performance (Ilcev, 2019).

3. Analysis of AMSS

An analysis of AMSS in Europe can provide a comprehensive understanding of the strengths, weaknesses, opportunities, and threats associated with the service.

3.1. Strengths

AMSS allows aircraft to communicate with ground stations and other aircraft through the use of satellites, providing a reliable and efficient means of communication for the aviation industry. This is particularly important for aircraft operating in remote or hostile environments, where traditional forms of communication may not be reliable (Ilcev, 2019).

AMSS can provide coverage worldwide, which is crucial for the aviation industry that operates on a global scale. AMSS can improve safety by allowing pilots to communicate with ground control and other aircraft in real-time, which can help to prevent collisions and other accidents (Koga et al., 2014).

AMSS can be more cost-effective than other forms of communication, such as VHF radio, which can save airlines and aircraft operators money.

3.2. Weaknesses

The current satellite systems used for AMSS in Europe do not provide coverage to the entire region, leaving some areas without access to the service. This can be particularly problematic for aircraft operating in remote or sparsely populated areas. The service is dependent on the satellites being operational and in good working condition. If a satellite were to fail, it would result in a loss of service in the area covered by that satellite. This can be particularly problematic for aircraft operating in remote or hostile environments.

The cost of providing AMSS coverage can be high, particularly in areas where the terrain and climate make it difficult to provide consistent and reliable coverage (Sedláčková et al., 2020).

3.3. Opportunities

AMSS can increase efficiency and safety in the aviation industry by allowing pilots to communicate with ground control and other aircraft in real-time, which can help to prevent collisions and other accidents (Morioka et al., 2020).

The EU has been working on the development of new technologies to improve the coverage area of AMSS such as the use of Low Earth orbit satellite, which are positioned closer to the earth and can provide a more consistent and reliable coverage area (Morioka et al., 2020).

AMSS can provide a reliable means of communication for aircraft operating in remote or sparsely populated areas, where traditional forms of communication may not be available.

3.4. Threats

Other satellite systems, such as GPS and GLONASS, may provide similar services as AMSS and can be a threat to the adoption of AMSS. AMSS can be affected by interference from other communication systems, which can affect the performance of the service (Ilcev, 2019).

The implementation of AMSS in Europe is dependent on the support and funding from the EU and ESA and it represents political and regulatory challenges (Tropea et al., 2022).

4. Best practices for safety

One of the best practices for safety in AMSS in Europe is the use of satellite-based navigation systems. These systems, such as the European Geostationary Navigation Overlay Service (EGNOS), allow aircraft to determine their position and speed with a high degree of accuracy, which is essential for safe and efficient flight operations. Additionally, these systems can also provide information on weather conditions and other hazards, which can help pilots to make more informed decisions about the best route to take (Ilcev, 2019).

Another practice for safety in AMSS in Europe is the use of secure communication systems. The safety of AMSS depends on the ability to communicate reliably and securely. This is particularly important for military aircraft, which often operate in remote or hostile environments, where traditional forms of communication may not be reliable (Tropea et al., 2022).

By using secure communication systems, aircraft can communicate with ground stations and other aircraft in real-time, which is essential for maintaining operational readiness and carrying out effective missions (Nair & Kirthiga, 2022).

The use of redundant systems can increase the safety of AMSS in Europe. This means having multiple systems in place to ensure that communication can still take place even if one system fails. This is particularly important for aircraft operating in remote or hostile environments, where traditional forms of communication may not be available. By having redundant systems in place, aircraft can continue to communicate even if one system fails, which can help to ensure the safety of the aircraft and its passengers (Nair & Kirthiga, 2022).

Regular maintenance and inspections of the equipment and infrastructure used for AMSS ensures safety of these systems in Europe. This includes the satellites themselves, as well as the ground stations and other equipment used for communication. By regularly maintaining and inspecting the equipment and infrastructure, it is possible to detect and fix any problems before they can affect the performance of the service and cause safety hazards (Bilen et al., 2022).

Regular training of pilots and other personnel who use the service is crucial for safety. This includes training on the proper use of the equipment, how to troubleshoot problems, and how to respond to emergency situations. By providing regular training, it is possible to ensure that pilots and other personnel are prepared to use the service safely and effectively (Bilen et al., 2022).

Finally, the EU has established regulations and standards for AMSS in Europe, which are designed to ensure that the service is reliable, secure, and efficient. These regulations and standards cover areas such as the use of frequencies, equipment and infrastructure, and maintenance, which are crucial for ensuring the safety of the service. By adhering to these regulations and standards, it is possible to ensure that the service is being used safely and effectively (Novák et al., 2018).

5. Conclusion

In order to make flights safer, more efficient, comfortable and economical, it is understood that a satellite-based navigation system should be developed to solve the problems of the existing systems and make the existing systems better and more efficient by providing great convenience to the airspace users.

Aeronautical mobile-satellite service is a vital service in the aviation industry, providing real-time communication between aircraft and ground stations. The EU has recognized the importance of AMSS for the aviation industry and has taken steps to ensure that this service is widely available throughout the region. However, there are also challenges that need to be addressed, such as the cost of AMSS and the need to ensure that communications are secure.

In conclusion, the propagation of satellite signals is a critical aspect of the performance of AMSS in Europe. However, there are several problems associated with the propagation of satellite signals that can affect the performance of AMSS. These include the effect of atmospheric conditions, the effect of the earth's surface, signal blockage, frequency band interference, and the cost of the service. The EU has established regulations and standards for the use of AMSS frequencies to mitigate the problem of frequency band interference. However, more efforts are needed to address other issues such as signal blockage, cost and atmospheric condition to ensure the optimal performance of AMSS in Europe.

In conclusion, the coverage area is a critical aspect of the performance of AMSS in Europe. However, there are several problems associated with the coverage area of AMSS in Europe. These include the vast geographical area that needs to be covered, the limited number of satellites that are currently in operation, the limited availability of the service, and the high cost of providing coverage. The EU has been working on the development of new technologies to improve the coverage area of AMSS such as the use of Low Earth orbit satellite, which are positioned closer to the earth and can provide a more consistent and reliable coverage area. However, more efforts are needed to address other issues such as the high cost of providing coverage and the limited availability of the service to ensure that AMSS is widely available throughout the region.

In conclusion, the safety of Aeronautical mobile-satellite service in Europe is a crucial aspect that needs to be considered in the implementation of this service. By implementing best practices such as the use of satellite-based navigation systems, secure communication systems, redundant systems, regular maintenance and inspections, regular training and adherence to regulations and standards, it is possible to ensure that AMSS is being used safely and effectively. These best practices can help to ensure the safety of the aircraft and its passengers, as well as the overall performance of the service.

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DEPLOYMENT OF ENVIRO SYSTEM FOR OBTAINING GEOSPATIAL DATA FOR FOREST MONITORING AND IMPROVING FOREST MANAGEMENT AND PROTECTION

INFORMATIVE PAPER

Matúš Materna
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
materna1@uniza.sk

Andrej Novák
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
andrej.novak@fpedas.uniza.sk

Benedikt Badánik
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
benedikt.badanik@fpedas.uniza.sk

Branislav Kandera
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina
branislav.kandera@fpedas.uniza.sk

Abstract

Paper describes deployment of ENVIRO System used for obtaining geospatial data for forest monitoring and improving forest management. Two main parts of ENVIRO system – Aerial segment and ground segment are described based of their construction and installation. Paper also describes functionality of the system in terms of data collection, processing and evaluation using ENVIRO System solution in real life deployment.

Keywords

ENVIRO System, forest monitoring, forest management, air quality

1. Introduction

Research and development of contactless methods for obtaining geospatial data for forest monitoring to improve forest management and enhance forest protection is nowadays important topic due to ever growing pollution and deforestation. This paper describes ENIRO System as method of obtaining geospatial data from real-life operations.

2. ENVIRO System specifications

ENVIRO System consists of two main segments – Aerial segment and Ground segments. Aerial segment installed in Viper SD4 aircraft is used for obtaining geospatial data. Ground segment is used for data handling, processing, and evaluation.

Figure 1: Viper SD-4 equipped with ENVIRO System. Source: Authors.

2.1. Aerial segment – ENVIRO System

Aerial segment is based on combined sensors installed in SENSORS chasis and datalogger installed in ENVIRO System BOX. All datalogger components are packed in one plastic case (IP68 protection class) and sensors are installed on robust SENSORS chassis.

Figure 2: ENVIRO System BOX datalooger. Source: TECHNISERV (2022[b]).

2.1.1. System installation

Both ENVIRO System Box and SENSORS chassis are installed within storage department of Viper SD-4 aircraft.

System is designed for fast implementation in harsh environmental conditions, as customized version designed for aircraft air quality monitoring application.

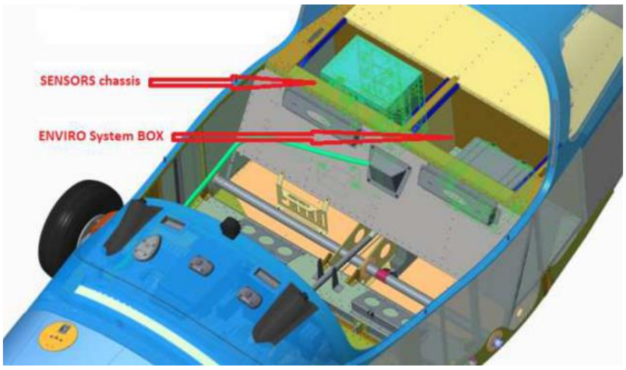

Figure 3: Placement diagram of ENVIRO System BOX and SENSOR chassis. Source: TECHNISERV (2022[b]).

Figure 4: Placement ENVIRO System Box datalogger inside Viper SD-4 aircraft. Source: Authors.

2.1.2. Sensor equipment

ENVIRO System is capable of monitoring and logging wide-range parameters using environmental sensors.

Table 1: Overview of ENVIRO System sensors and measured parameters. Source: Authors.

Sensor order	Parameter	UNIT
#(O1)	TA	deg Celsius
#(O2)	RH	%
#(O3)	PA	hPa
#(O4)	NO_2	ppb
#(O5)	NO	ppb
#(O6)	CO	ppb
#(O7)	CO_2	ppm
#(O8)	SO_2	ppm
#(O9)	H_2S	ppm
#(O10)	O_3	ppb
#(O11)	PM2.5	ug/m^3
#(O12)	PM10	ug/m^3
#(O13)	VOC	none (index)
#(O14)	UVA	W/m^2
#(O15)	UVB	W/m^2
#(O16)	UVC	W/m^2
#(O17)	FLOW	slm
#(O18)	LAT	deg
#(O19)	LON	deg
#(O20)	N_2O	ppm
#(O21)	V_{BATT}	V

Figure 5: Sensor's installation in air intake. Source: Authors

2.2. Ground segment - ENVIRO System GIS SW

ENVIRO System GIS SW is designed for fast processing as customized SW version designed for evaluation of aerial environmental quality monitoring application and data collected from the aerial segment of the system.

2.2.1. Hardware

ENVIRO System GIS SW works on customized workstation class computer WS HP-Z4-G4 combined with two LCD monitors U2720 and GIS SW for ENVIRO data (customized version, with optimization for working with CS files). All hardware components are installed in 19’’ RACK at the SHELTER module an GIS SW is preinstalled and configured for operational and easy import data from SD card. Additional hardware and software components for processing and SMART CAM are applied into this solution.

Ground segment is also equipped with local industrial-grade weather station Davis Instruments Vantage Pro2 equipped with wide range of sensors Weatherlink software. Weather station is capable of monitoring and logging following data:

- Outside temperature
- Outside humidity
- Dew point
- Wind speed and direction
- Wind chill and heat index
- Barometric pressure
- Rainfall and rain rate

Figure 6: Weather station Davis Instruments Vantage Pro2 instalment. Source: Authors.

2.2.2. System functions

System includes fully implemented software equipment for data evaluation (GIS SW for ENVIRO data – customized version, with optimization for working with CSV files), which serves as SW equipment for evaluation and interactive display of measured parameters on the map. At the same time, SW enables visualizations and various types of analysis and offers the following functionalities:

- Creating an interactive map and scene from files, databases and online resources *customizable version for working with CSV files.
- Visually model and analyse the process.
- Basic spatial analysis tools for overlap, proximity, and aggregation.
- Statistical tools for analysing spatial patterns, clusters, and relationships.
- Extensive tools for automated data management.
- Scripting, geoprocessing, and other operations using Python.
- Create maps at the GPS location level.
- View CAD data or satellite/aerial imagery.
- Charts to visualize categories, relationships, and changes in data.

2.2.3. SW Evaluation options

PC with two LCD displays and SW equipment for evaluating measured data from the ENVIRO system, ensures computerized data processing, whereby all measured parameters can be systematically sorted and graphically displayed on the map, with a link to the camera recording from the Smart camera on the second LCD monitors.

Spatial analysis tools such as the Raster Calculator and Minus tools can provide powerful insights on raster value differences between raster images that are geographically overlapping. In ArcGIS Desktop, these tools are located in the Spatial Analyst toolbox.

Alternatively, environments without the ArcGIS Spatial Analyst extension can use the difference function from the Image Analysis window.

3. Conclusion

Current deployment ENVIRO System offers powerful tool for obtaining geospatial data used for improving forest management and protection. System offers wide range of options for data collection, processing, and evaluation.

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