Dedicated to innovation in aerospace

NLR-CR-2020-297 | January 2021

AVISTRAT-CH strategic concept

A sustainable and robust aviation system for 2035

CUSTOMER: Federal Office of Civil Aviation

NLR – Royal Netherlands Aerospace Centre

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A sustainable and robust aviation system for 2035

Problem area

The current Swiss aviation system is described in the Vision document of AVISTRAT (FOCA, 2020) as functional, but rigid and at maximum capacity. Maintaining the current system results in a high workload, non-standardised practices and a low adaptability to new airspace users. There is a strong feeling among all stakeholders that the Swiss system would benefit from a new, clean-sheet approach to shape the future of aviation in Switzerland.

Description of work

This document presents the strategy concept of the Royal Netherlands Aerospace Centre (NLR) and PvL Partners (PvL) for the development of a clean-sheet strategy for Switzerland's airspace and aviation infrastructure for the year 2035 consisting of 14 'Strategic Orientations' that span the topics of 'Quality of Life', 'Climate Challenge', 'Safety and Security', and 'Fair Airspace Access'.

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NLR-CR-2020-297

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Results and conclusions

Each Strategic Orientation consists of concreate measures in the areas of 'Infrastructure', 'Regulation' and 'Management'. Based on a mapping of the impact of the orientations on the System Requirements as determined by FOCA and an assessment of feasibility, implementation considerations are presented.

Applicability

This report presents a strategy that presents FOCA with building blocks to achieve the vision set out in the AVISTRAT Vision document. The Strategic Orientations are input for the upcoming consolidation phase which selects the best input for actual implementation starting Q3 2022.

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Contents

Abbreviations

Table 1: AVISTRAT abbreviations

ACRONYM	DESCRIPTION
AA	Action Area
AoA	Area of Action
SO	Strategic Orientation
SR	System Requirement
TA	Target Area

Table 2: General abbreviations

ACRONYM	DESCRIPTION
ACI(-E)	Airport Council International (Europe)
AMC	Airspace Management Cell
ANSP	Air Navigation Service Provider
APU	Auxiliary Power Unit
ATAG	Air Transport Action Group
ATM	Air Traffic Management
BPPR	Booking Principles and Priority Rules
CNS	Communication Navigation Surveillance
CO_2	Carbon dioxide
COVID(-19)	Corona Virus Disease 2019, the respiratory disease caused by the SARS-CoV-2 virus
DMAN	ATM Departure Management
EASA	European (Union) Aviation Safety Agency
EREA	The association of European Research Establishments in Aeronautics
FDF	Federal Department of Finance (CH)
FEGP	Fixed Energy Ground Power
FOCA	Federal Office of Civil Aviation, also known as BAZL (DE), OFAC (FR) and UFAC (IT)
FSO	Federal Statistical Office (CH)
GDP	Gross Domestic Product
GPU	Ground Power Unit
H_2	Hydrogen
I2V / V2I	Infrastructure to Vehicle / Vehicle to Infrastructure
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LAQ	Local Air Quality
MaaS	Mobility as a Service

ACRONYM	DESCRIPTION
MTOW	Maximum Take-Off Weight
NDC	Nationally Determined Contributions (i.r.t. Paris agreement)
NLR	Royal Netherlands Aerospace Centre
NO_X	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
PCA	Pre-Conditioned Air
PvL	PvL Partners
QoL	Quality of Life
SAF	Sustainable Aviation Fuels
SESAR	Single European Sky ATM Research programme
UAM	Urban Air Mobility
UAV	Unmanned Aerial Vehicles or ‘drones’
UFP	Ultra-Fine Particles
UTM	Unmanned Traffic Management

1 Introduction

1.1 Assignment

The Swiss aviation system has been growing ‘organically’ over the past decades, always making incremental modifications. Over the years, these minor modifications resulted in a highly complex system. In addition to that, new entrants to the aviation system are moving much quicker compared to the conventional aviation industry. The current Swiss aviation system is described in the Vision document of AVISTRAT (FOCA, 2020) as functional, but rigid and at maximum capacity. There is a strong feeling among all stakeholders that the Swiss system would benefit from a new, clean-sheet approach to shape the future of aviation in Switzerland.

This document presents the strategy concept of the Royal Netherlands Aerospace Centre (NLR) and PvL Partners (PvL) for the development of a strategy for Switzerland’s airspace and aviation infrastructure for the year 2035; a consistent strategy that strikes a satisfactory balance between sustainability, safety and security and efficiency for all stakeholders through smart development of infrastructure, land-use, policy and regulation. The strategy in this report can help FOCA achieve the vision set out in the ‘AVISTRAT Vision’ document. The resulting Strategic *Orientations* (or SO’s) are input for the upcoming consolidation phase which selects the best input for actual implementation starting Q3 2022.

1.2 Reader’s guide

The document is structured as follows:

- Section 2 provides an understanding of the general trends, the impact of COVID-19 and the main challenges for the Swiss Aviation system.
- Section 3 discusses the strategic approach and sketches the future outlook in which the strategy is set.
- Section 4 contains the main building blocks of the strategy, a complete overview of all SO’s grouped into four themes that together fulfil the system requirements of the AVISTRAT Vision.
- Section 5 reflects on the interdependencies of the SO’s providing insights in the broader impact and implementation considerations.
- Section 6 concludes with the key takeaways.

2 Trends and challenges

2.1 General trends

2.1.1 Society and politics

According to projections of the Federal Statistics Office the population of Switzerland will grow from 8.5 million to nearly 10 million inhabitants in 2035 and 25% of the population will be 65 and over (FSO, 2020). According to an evaluation of the Economic Co-operation and Development () of the Swiss economy (OECD, 2019), the aging population increases the need to address barriers to new technologies including new forms of mobility (as a service).

Switzerland has one of the highest R&D intensities[1] in Europe, world class research institutes and repeatedly gets top listings in global competitiveness rankings (FDFA, 2020). Among others this earned the country a leading position in the implementation of drone services. Economic growth has slowed however over the last years. The high barriers of entry for foreign highly-skilled workers might hurt future innovation (OECD, 2019).

Sustainable performance is also high. Swiss carbon intensity of GDP[2] is very low, almost all energy is from carbon-free (although not necessarily renewable) sources, and environmental awareness is high. 40% of all emissions is from transportation. Local air quality is a challenge, as emissions from personal vehicles are higher than the European average. Switzerland has committed to reduce greenhouse gas emissions by 50% by 2030 compared to 1990 (OECD, 2019) in line with the Nationally Determined Contributions (NDC's) as part of the Paris agreement.

2.1.2 Aviation in Switzerland

Switzerland has 3 (inter)national airports and 11 regional airports. According to the most recent FSO-report (FSO, 2020), the country is home to 3211 aircraft. Only 8% of these are fixed wing aircraft above 5.700 kg[3] maximum take-off weight (MTOW) typically used for scheduled commercial aviation or as a business jet. 41% are smaller fixed wing aircraft < 2.250 MTOW (excl. gliders) such as the Cessna 172. Other notable categories are gliders (26%), helicopters (11%) and hot air balloons (10%). Off all scheduled or chartered traffic, the majority of aircraft movements (465.030 in 2019) operate from the three major airports: Zurich (243.115), Geneva (145.527) and Basel-Mulhouse (76.388 incl. French traffic). The figure on the next page from the FSO report gives an overview of the traffic distribution. Including other commercial flights and non-commercial flights the total number of movements at the three major airports is 560.638 or 40% of the total number of aircraft movements in Switzerland in 2019. Of course, these are pre-COVID numbers; the 2020 traffic will be drastically different. Please refer to section 2.2 for an assessment of the impact of COVID on aviation.

[1] Spending on R&D as percentage to Gross Domestic Product (GDP)
[2] Carbon emissions as a percentage to GDP
[3] 5.700 kg MTOW is the threshold for large, commercial aircraft subject to EASA CS25

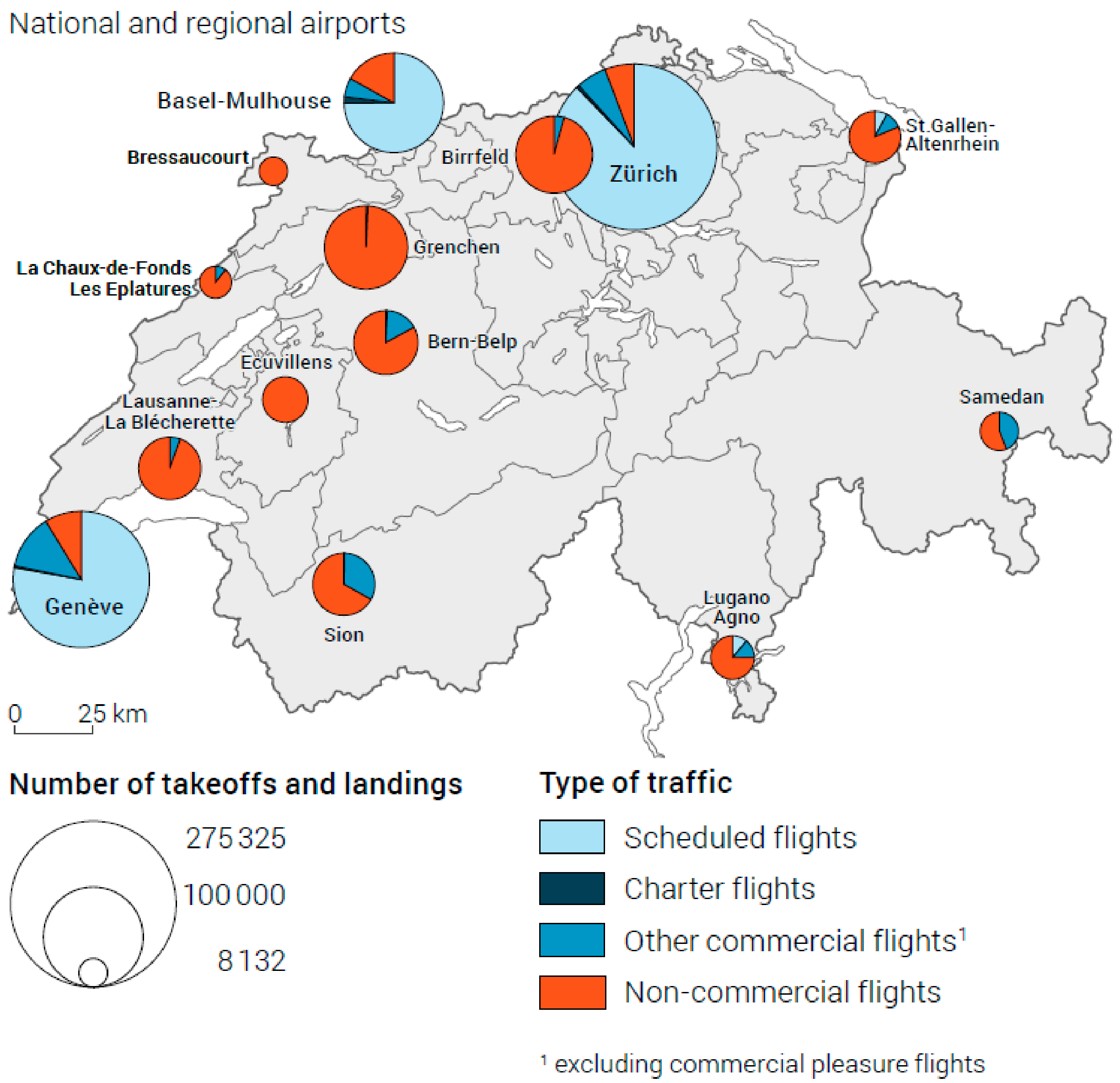


Figure 1: Aircraft movements in civil aviation, 2019 (FSO, 2020)

Predictions for traffic numbers in 2035 are uncertain, now more so than ever. In a 2020-publication just before COVID, the European Aviation Safety Agency (EASA) estimates a growth of 40% from 2017 to 2040 which equates to an annual growth rate of ~1.5% (EASA, 2020c). This growth rate matches the 'Low growth' forecast made by the Air Transport Action Group (ATAG) dating from after COVID nearly halted aviation (ATAG, 2020). Assuming this scenario applies to Switzerland, the three major airports can expect approximately 600.000 movements in 2035.

On top of the historical players, a new group of users emerges that also want to use the Swiss airspace. The most significant members of this group are the unmanned aerial vehicles (UAVs), or also more commonly referred to as 'drones. These drones exist in all shapes and sizes and potentially have a vast array of applications. In contrast to the classical manned aviation, drones have seen rapid developments since their introduction in the 90's. Early applications were primarily military. Since then, the application area has broadened significantly and is now a promising platform for example surveillance, logistics, first responders, media, recreational use and even passenger transport. Other emerging players include for example high altitude pseudo satellites, or the manned space transport missions that are increasingly being commercialised. The Swiss aviation system is making significant effort to facilitate these new entrants. For example, the Swiss Air Navigation Service Provider (ANSP) Skyguide has launched an app that helps drone operators with their flight planning (skyguide, 2020).

2.1.3 Technology

This section provides a short overview of relevant technological developments for 2035. The content is sourced from a recent NLR publication for the Dutch Ministry of Infrastructure and Water management (Derei, Hogenhuis, Hoolhorst, Veerbeek, & Speijker, 2019) unless stated otherwise.

Incremental improvements to conventional aircraft

Technological developments for (large) conventional passenger and cargo aircraft are mostly incremental. Since the Boeing 707 of the late 1950's little has changed to the base configuration of a cylindrical fuselage with two swept wings and two to four (turbo-fan) jet engines. Incremental improvements to engines, aerodynamics and materials mean each following generation is 15 to 25% more fuel efficient than before. The incremental improvements also mean each new generation is quieter than before. For example, the latest generation of aircraft that meet current 'chapter 14' noise requirements is almost 20 dB quieter than their counterparts from the 1970's and 1980's. This trend is expected to continue towards 2035 (EASA, 2018).

The speed at which technological improvements reach the market depend on fleet renewal by airlines. Aircraft are costly and well-maintained; therefore, they can be used for a long time; service life can run up to 20-25 years. New aircraft with a lower operational cost, changes in market demand or more stringent regulation can all stimulate fleet renewal.

Sustainable aviation fuels

In the last couple of years, strides have been made in the development of sustainable aviation fuels (SAF) as drop-in alternatives to conventional kerosene. These include bio-fuels and synthetically produced fuels, including hydrogen. These SAF's are developed to reduce the carbon footprint of aviation, other emissions highly depend on the production process.

- Biofuels are made from plant-based materials that capture CO_2 during production. First generation biofuels where made from food crops and thus competed with food production but this is no longer the case. However, biofuels are still scarce and expensive.
- Another SAF is hydrogen. Hydrogen can both be used in conventional jet engines and with electric motors via hydrogen fuel cells. The latter is not expected for 2035. Burning hydrogen produces no carbons, but does produce water vapor. Hydrogen also requires 4/3 times more volume per unit of energy than conventional kerosene. And production of hydrogen requires large amounts of (sustainable) energy.
- The last group of SAF's are synthetic fuels also involving hydrogen. In the production process, hydrogen is produced from of variety of energy sources using electrolysis and then combined with CO_2 to form hydrocarbons. These hydrocarbons then form the basis of the synthetic fuels. Many different production techniques are being developed with differences in cost and emissions.

New propulsion systems

Electric propulsion is currently only available for gliders and small, general aviation aircraft such as the Pipistrel Alpha Electro. The main bottleneck being the required mass of batteries per unit of energy which is approximately 40 times[4] higher than kerosene. In the upcoming decades it is expected that electric powertrain technology, e.g. from the automotive industry, will be introduced in smaller commercial aircraft (up to 50 passengers) first, although with limited range. For larger aircraft full electric propulsion is very difficult due to weight. Concepts such as the Wright 1 by Wright Electric together with easyJet are promising, but up till now no test flights have been made. Wright aims to have a planned test flight in 2023 and a market introduction in 2030 (Wright Electric, 2021). This seems to be a very challenging ambition. In the meantime, improvements can be made using hybrid systems or electrification of aircraft sub-systems that are currently still hydraulic or pneumatic through the main engines.

Operational improvements

The international community continues to push operational improvements for airspace design, flow management, approach and departure procedures and airport processes.

Through the Single European Skies ATM Research programme (SESAR), new operational concepts that improve capacity, efficiency, sustainability and safety are being researched and validated. These concepts include solutions for navigation (e.g. Performance Based Navigation), approach and departure procedures (e.g. Continuous Climb- and Continuous Descent Operations), and surveillance (e.g. Airborne Separation Assistance Systems).

At the airport, more and more ground equipment is being electrified. These include electrified tow tractors or on-board electric motors that power the aircraft towards the runway reducing the need to fire up the aircraft's main engines. Currently only one diesel-electric tractor is available with a second system in the final stage of certification. These are only suited for smaller, narrow-body aircraft such as the Airbus A320 and Boeing 737 but more powerful tractors fit for wide-bodies are expected for 2035.

New entrants

Among the new entrants of the aviation industry, technology evolves at a much faster pace. For example, drones are already capable of flying autonomously for long endurance missions. It is the expectation that the number of drones will continue to increase significantly, as well as their number of movements and applications.

Another group of new entrants closely linked to drones concern Urban Air Mobility (UAM). Ever since the publication of the Uber Elevate white paper (Uber, 2016), UAM gained traction. While UAM lacks a fixed definition, it concerns the commercial use of the low-level civil airspace above urban regions. This includes the transportation of people and goods and urban surveillance missions, but for example excludes rural surveillance of crops. Depending on the context, UAM can thus involve drones but not necessarily. Despite great promise UAM still has little commercial applications yet. Pilot projects for example by SwissPost show potential, but there are still key challenges that need to be solved, most notably: a viable business case, automation, airspace integration, infrastructure and public acceptance.

Many countries have a specific drone roadmap available, on a European level there is a roadmap for the design and implementation of an Unmanned Traffic Management system called 'U-space'. The U-space roadmap is part of the larger SESAR programme. The main goals of the roadmap are to solve operational challenges and the interoperability between drones versus manned operations, and drones versus drones. UAM is also supposed to operate under the U-

[4] Or 10-20 times after considering that electric motors are more efficient than combustion engines (85-90% efficiency vs. 30-40%)

space umbrella. The Swiss U-space environment seems to be ready for large amounts of operations. Skyguide recently opened the Swiss U-space for all Swiss unmanned vehicle operators.

By 2035 drones and UAM vehicles will be a common sight in both urban and rural area’s offering a wide range of logistic and surveillance services. Passenger transport with unmanned drones will be a relatively small niche market. Emergency services could use UAM vehicles in addition to conventional helicopters (Roosien & Bussink, 2018).

2.2 COVID-19

The ongoing COVID-19 outbreak was declared a Public Health Emergency of International Concern in January 2020, and a pandemic in March 2020. Once the medical severity of the pandemic became clear, most countries started imposing drastic measures to protect public health. These measures included unprecedented travel limitations to contain the virus. These restrictions almost completely halted air travel by the end of March 2020: less than 1% of last year’s airport passenger traffic remained, as shown in the figure below (ACI Europe, 2020). Since June 2020, European air travel has slowly recovered to about 30% of 2019 levels, however as the pandemic is far from under control, it is unclear how air travel will develop from here.

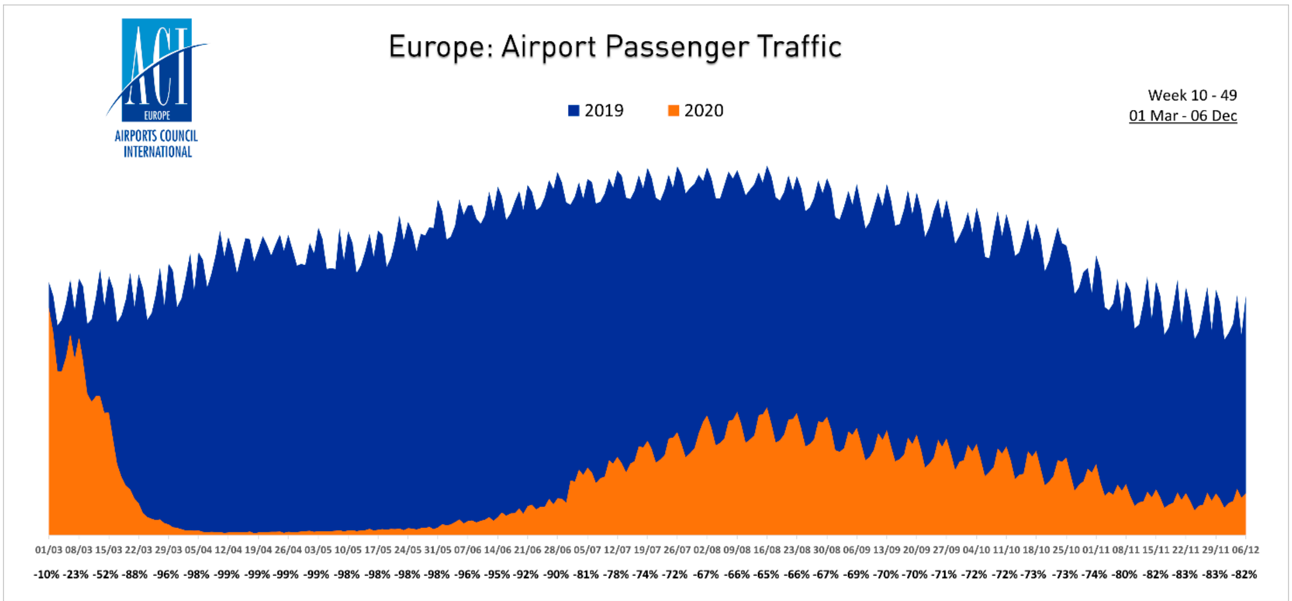


Figure 2: Airport passenger traffic March-December 2019 vs 2020 (ACI Europe, 2020)

COVID-19 put the aviation sector into survival mode as airlines and airports alike tried to protect passengers and employees from this new threat while struggling to make ends meet. A 20% increase in cargo activity cannot prevent that airlines are burning through their cash reserves at a high rate (IATA, 2020). Similarly, Airport Council International Europe (ACI Europe) estimates that 193 airports face financial insolvency (ACI Europe, 2020).

Airlines and airports face major uncertainties on the cost of health-related protection measures and the air traffic demand as a result of travel restrictions. The crisis also triggered a strong policy response from national governments, mostly directed at airlines. The OECD estimates that as of August 2020, 160 billion USD has been spent in supporting airlines (OECD, 2020). On April 29th, the Federal Council announced it will provide nearly CHF 1.9 billion to support the aviation sector: CHF 1.275 billion to secure the loans to Swiss airlines and CHF 600 million to support aviation-related businesses at the national airports (FDF, 2020).

In a study on COVID-19's impact on aerospace published in April 2020, Roland Berger developed three scenarios for the impact and development of the sector (Hader, Thomson, & Lipowsky, 2020). The study estimates both the time to reach a new equilibrium and the level of that "new normal" compared to 2019-levels (short-term impact) and the annual growth after this recovery (long-term impact). As the events unfold, the first, optimistic scenario is already considered unrealistic. And by now even the worst-case scenario is not a given.

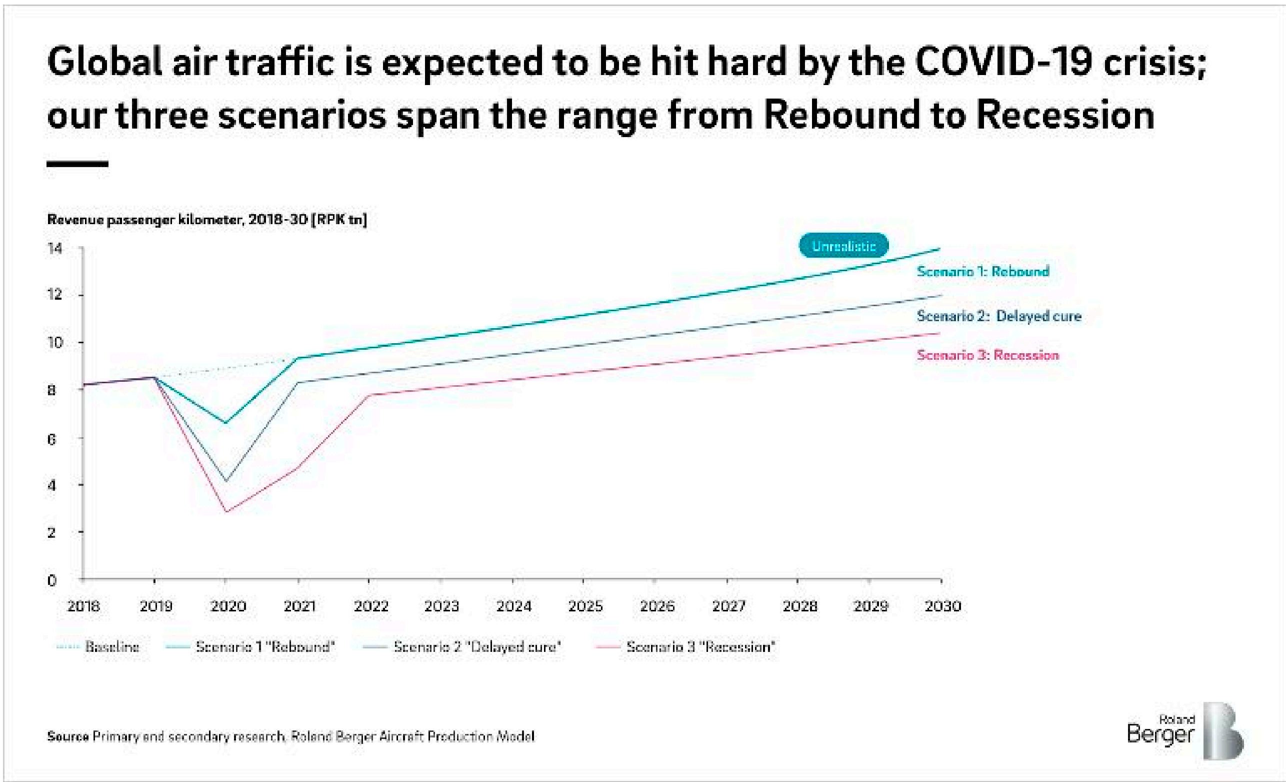


Figure 3: Aviation recovery in 3 scenarios (Hader, Thomson, & Lipowsky, 2020)

According to Roland Berger, the level of the "new normal" depends on a mix of traditional economic factors and factors directly related to or amplified by COVID, e.g. ticket price, consumer spending, remote business practices, consumer health concerns and government-imposed travel restrictions. However, the traffic development rate after the crisis depends on more long-term factors already existing or only amplified by COVID, such as: economic growth, globalisation and sustainability and environmental concerns.

This strengthens our conviction that although COVID completely dominates aviation in the short-term, in the medium-term to 2035 the Target Areas as defined in the AVISTRAT Vision will remain as relevant as they were before COVID.

2.3 Challenges

The current Swiss aviation system is described in the Vision document of AVISTRAT (FOCA, 2020) as functional, but rigid and at maximum capacity. Maintaining the current system results in a high workload, non-standardised practices and a low adaptability to new airspace users. There is a strong feeling among all stakeholders that the Swiss system would benefit from a new, clean-sheet approach to shape the future of aviation in Switzerland.

2.3.1 Challenges in Target Area 'Environment'

Climate change

Currently, aviation is responsible for 2-3% of global carbon emissions. However, due to projected growth and sustainability improvements in other sectors, this share will increase without counter action. Moreover, the long-term impacts of pollutants other than CO_2 (e.g. water vapour, H_2 and NO_X) might prove to be more severe than previously thought (EASA, 2020b). Finally, the segment with the highest CO2-emissions (long-haul air transport) is also the most difficult one to reduce the CO2-footprint and the most difficult one to replace by other modes of transportation.

Based on the amount of fuel filled-up at Swiss airports, Swiss aviation emitted 5,8 Mton CO_2 in 2019 (FSO, 2020). The vast majority of which can be accounted to international flights. This number has been steadily rising as is shown in the figure below and is still far from the 2030 target of a 50% reduction compared to 1990-levels.

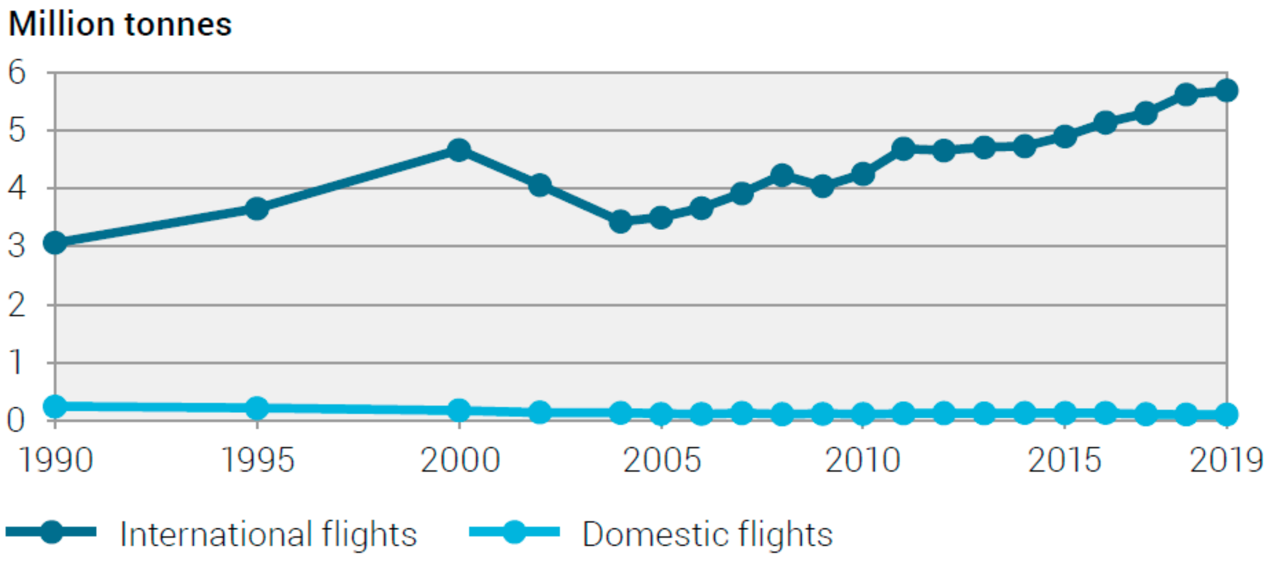


Figure 4: CO_2 emissions of civil aviation (FSO, 2020)

The key challenge is to reduce the overall environmental impact of aviation with light-weight solutions for long-range, high-capacity aircraft in a growing market (before COVID) for air transport at acceptable costs.

Public support for aviation

Quality of Life (QoL) is the combination of factors that determine the overall satisfaction with life. Aviation can have a significant impact on people's quality of life, through annoyance about noise or worries about safety, but also through the ability to visit friends, family, go on business trips, or provide regional economic development and employment. More than just noise and economic impact, the impact of aviation on quality of life is about aviation in relation to the public and its contribution to peoples living environment. However, the concept of QoL is still relatively new to aviation and in many cases not part of a coherent community strategy. In the UK, an increasing number of people are willing to accept higher cost or fly less due to public concerns about noise, health and climate impact (Ipsos, 2020). The worldwide impact of this trend is debated however, as aviation interest group ATAG estimates only 43% currently are willing to fly less to reduce their carbon footprint and that the majority of future growth will come from developing regions where “flight shame” is less of a topic (ATAG, 2020).

The key challenge is to move beyond stagnant debates on aviation noise to a fairer distribution of the benefits and burdens of aviation.

2.3.2 Challenges in Target Area ‘Safety and Security’

Aviation is built on public trust that it is safe to board an aircraft and that the aircraft overhead will not come crashing down. As is stated in the AVISTRAT-CH Vision, the concept of safety is divided into the safety and security, related to the sociological terms ‘physical safety’ and ‘social safety’. Under safety (apart from security), the aim is to avoid incidents and accidents, under security, to avoid damage caused by unlawful interference by third parties (and persons). Maintaining the current high levels of safety is therefore a top priority, especially when large numbers of new airspace users are entering the airspace. Aviation can also be a vital instrument in nation’s security allowing high-speed, flexible mobility for government agents and surveillance opportunities. The value and prestige of aviation also makes it a high-profile target for unlawful interference.

Safety is being maintained by a mechanism of initial approval and subsequent surveillance and oversight: whenever a change is introduced in the system (a new aircraft type, a change in airspace infrastructure, a new runway, a new service, etcetera) the responsible service provider must present evidence that the change meets safety requirements, and the authority must verify and approve. The service provider must then demonstrate that safety is sufficiently managed through all levels of the service provision, and the authority must verify the safety management capabilities and safety management processes of the service providers.

This mechanism has worked well in the past two decades, as evidenced by the current exemplary safety record of aviation, but faces a number of significant challenges:
1) The increased complexity of aviation systems and processes makes it more difficult for the service provider to present evidence that safety requirements are met. Personnel that are sufficiently qualified to develop evidence are becoming scarcer.
2) Similarly, the increased complexity makes is more difficult for the authority to verify and approved the evidence presented by the service provider. Also, at the authority, personnel that are sufficiently qualified to asses and verify the evidence are becoming scarcer.
3) New technologies and new products (drones, electric or hybrid propulsion etc) result in new companies entering the aviation world. These companies may have a background in other sectors, e.g. automotive, where safety requirements and the safety approval processes are different than in aviation. Getting them to fit in the aviation mould is not easy.
4) Safety management of interfaces between service providers is becoming more important as the aviation system is becoming more complex. This requires an orchestrated effort of the service providers at all levels of the organisation, including senior management. Coordination of safety management across service providers (including new services such as U-space) has proven to be notoriously difficult.
5) Surveillance and supervision of integrated safety management requires additional skills to what is currently needed, including the capability and skills to oversee integrated management systems and the skills to assess the governance of safety management.

The key challenge is to set acceptable levels of risk and monitor current risk levels while allowing new groups of airspace users to enter the airspace.

2.3.3 Challenges in Target Area ‘Performance’

The current Swiss airspace is limited in volume due to the relatively small size of the country (+/- 41.000km^2). At the same time the airspace is very busy with a high number of commercial operations, mixed with many military and general aviation operations. Relative to the size of the country there is also a sizable number of domestic flights. As highlighted in the introduction, there are many national and international airports, both for civil (commercial and non-commercial) and military usage. The mountains and complex operation make Air Traffic Management (ATM) an intensive task, with a lot of vertical guidance. It is in the ambition of FOCA to keep the airspace available for the highest number of users, as highlighted in the AVISTRAT vision, in order to maximize the benefits of the airspace.

The key challenge will be to keep the airspace dynamically (both in time and in geographic location) accessible for a variety of different users, while ensuring a low complexity of the airspace, a minimal environmental impact and (as always in aviation) a highly safe and secure airspace.

3 Strategic framework and focus

3.1 Approach and methodology

To develop a sound strategic draft for the Swiss aviation system in 2035, a holistic and aspiration-led methodology is applied based on a proven strategy development process perfected by PvL Partners. The approach consists of three steps: 'Understand', 'Shape' and 'Validate'.

The purpose and approach elements are outlined in the details and depicted in the figure 3 below and ultimately lead to a coherent set of 'Strategic Orientations' (SO's).

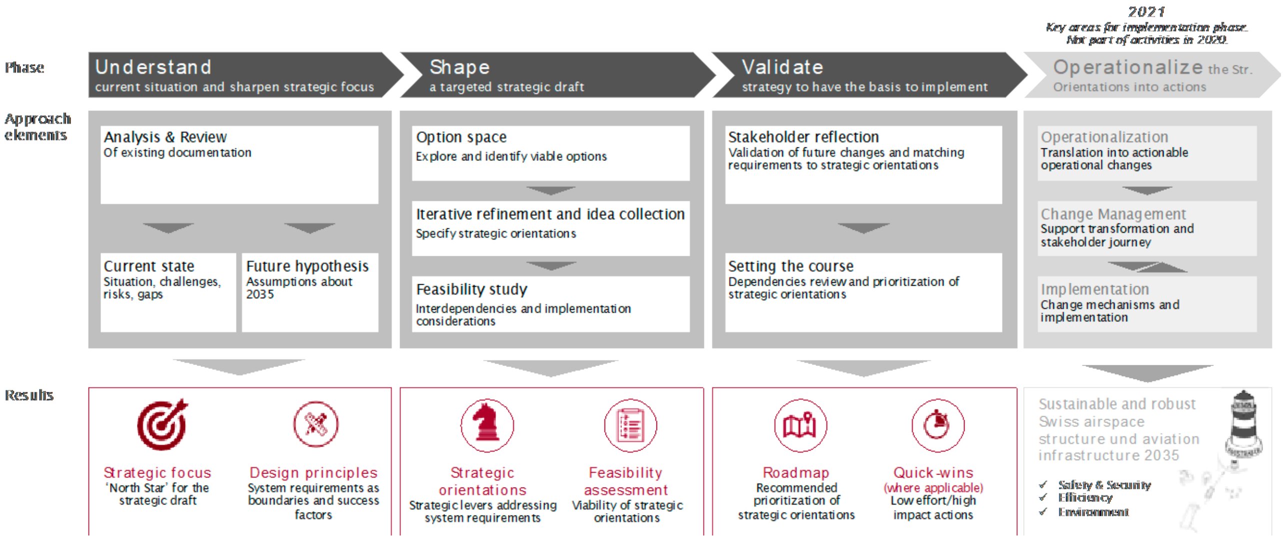


Figure 3: Strategy development approach

Phase 1: Understand

Understanding the current situation (i.e. internal and external drivers) and developing the requested future scenario is considered as the basis for the new draft strategy. The purpose of 'Understand' is to develop a solid ground for the strategic draft to be built upon and to set the focus of the proposed strategy.

In order to do so, PVL strategy- and market insights and NLR-expertise are analysed to identify the current bottlenecks and challenges within the Swiss aviation system, as well as relevant trends and evolutions (see chapter 2) and place these in the context of the AVISTRAT vision dimensions and system components (see section 3.2 and 3.3).

Phase 2: Shape

The 'Shape' phase will define the goal-oriented strategy into concrete SO's, using a variety of tools and methodologies, ensuring connection with all *Areas of Action* (AoA) as defined by AVISTRAT: the three *Target Areas* (TA): 'environmental impact', 'safety and security', and 'performance' and the *System Requirements* (SR) 'infrastructure', 'management' and 'regulation'.

To make the SO's more understandable and to ease mutual comparison, each SO consists of the same structure:

- ***Overarching goal*** – Description of how the SO contributes to the higher level AVISTRAT Vision
- ***Description*** – Description of what the proposed SO entails and what the key components are, including scope and main drivers
- ***Assumptions*** – overview of the main assumptions underlying the SO. The assumptions highlighted refer to things that are expected to happen in the near future, focusing on things that are fully or partially outside the control of FOCA. The assumptions in general are linked to major societal and technological trends and evolutions.
- ***Recommended actions*** – Recommendations for specific actions in the Action Areas 'Air & Ground Infrastructure', 'Regulation', and 'Management' from the AVISTRAT Vision
- ***Predicted effects*** – Predicted effects of the SO on Target Areas 'Environment', 'Security & Safety', and 'Performance' from the AVISTRAT Vision
- ***Feasibility & implementation considerations*** – Overview of implementation obstacles

Based on the challenges identified in section 2.3, the SO's have been grouped into four themes:

1. Quality of Life
2. Climate Challenge
3. Safety & Security
4. Fair Airspace Access

The four themes complement the System Requirements and Target Areas as defined by FOCA as is shown in the table below.

Table 3: Mapping of system requirements, target areas and SO themes

<table>
<tr><th colspan="2">AVISTRAT Vision</th><th>NLR-PvL strategy</th></tr>
<tr><th>System Requirement</th><th>Target Area</th><th>SO theme</th></tr>
<tr><td>Significantly reduce the burden of aviation on the population (SR6)</td><td rowspan="3">Environment</td><td>Improving quality of life (section 4.1)</td></tr>
<tr><td>Significantly reduce the burden of aviation on the environment (SR5)</td><td rowspan="2">Addressing the climate challenge (section 4.2)</td></tr>
<tr><td>Reduce other environmental pollutants (SR7)</td></tr>
<tr><td>Enable all state safety and security tasks of the Swiss government (SR8)</td><td rowspan="2">Safety and Security</td><td rowspan="2">Safe and secure aviation (section 4.3)</td></tr>
<tr><td>Set socially acceptable risk levels and continuously monitor risk performance (SR9)</td></tr>
<tr><td>Enable access to airspace according to socio-political needs (SR10)</td><td rowspan="7">Performance</td><td rowspan="5">Ensure fair airspace access (section 4.4)</td></tr>
<tr><td>Manage prioritisation according to socio-political needs (SR11)</td></tr>
<tr><td>Create conditions that enable Swiss aviation users to compete internationally (SR12)</td></tr>
<tr><td>Provide required aviation services transparently and cost-effectively (SR13)</td></tr>
<tr><td>Allow aviation users to plan use and infrastructure investments for the long term (SR14)</td></tr>
<tr><td>Create favourable conditions for training highly-qualified personnel (SR15)</td><td>Safe and secure aviation (Section 4.3)</td></tr>
<tr><td>Allow room for creativity and innovation (SR16)</td><td>Integral part of all SO's</td></tr>
</table>

Phase 3: Validate

The last phase will be the validation phase, in which the proposed draft strategy will be adapted as needed based on client input, and finally prioritized to put together a comprehensive proposed implementation roadmap. The goal is to propose a prioritization of SO's according to a comprehensive decision framework, leading to a general roadmap and (if available), potential quick wins. Beyond the feasibility assessment and implementation considerations, an analysis of the dependencies, as well as conflicts between aims of SO's provide further insight to enable the definition of an overarching roadmap during the consolidation phase following in 2021. In the AVISTRAT programme, stakeholder consultation will take place prior and after the current strategy development phase, but not during this phase.

3.2 Future scenarios and strategy focus

Section 2.1 provides an overview of general trends in the AVISTRAT *Environment Areas* 'Society & Politics' and 'Technology & Innovation' on the road to 2035. However, depending on geopolitical developments and global, national and local policy decisions, multiple hypotheses for 2035 can be developed. The association of European Research Establishments in Aeronautics (EREA) recently created 4 alternative future hypotheses for the year 2050 in the context of aviation (research and development) (EREA, 2020). The scenarios are summarised in the table below.

Table 4: Overview of the EREA scenarios for 2050

	World view	Resulting aviation ecosystem
Scenario 1 – ***'Mad Max'***	Deglobalisation and increased nationalism and populism leading to a highly fragmented and instable world of free market economies with little regard for climate change or public annoyance. Protectionism leads to low levels innovation.	Aviation is an expensive, luxury product for the few. There are few industrial players with no innovation and limited R&D. Challenges related to climate adaptation are severe.
Scenario 2 – ***'Tech for you'***	A highly fragmented and competitive world with islands of free market economies. High R&D expenditures, but low-economy-of-scale production and a short-term focus.	Air mobility is part of a flexible, local multi-modal transportation system with a focus on door-to-door mobility.
Scenario 3 – ***'Stripping down'***	A politically stable world consisting of a few highly organized blocs of power. Global harmonization, markets are organized through incentive-based regulation. This results in high predictability, but slow progress and little consumer choice.	Emphasis on standardized, generic solutions for sustainable, intermodal travel. There is limited and highly controlled mobility due to sustainability objectives and incentives.
Scenario 4 – ***'Optimising together'***	A world driven by cooperation and collaboration leading to harmony, standardization and overall stability and growth.	Aviation solutions are available for all journey segments. Mobility as a whole is growing and fully sustainable.

Each future scenario consists of assumptions on politics, economics, society, regulation and governance, environment and technology. Among others, the scenarios differ in their assumptions on globalisation, centralised or decentralised governance, and levels of R&D investments. Which scenario is most relevant for the Swiss aviation system of 2035 will only be revealed in time. However, using these scenarios, it is possible to determine which future offers the best fit with the AVISTRAT Vision.

In case of nationalism, populism and protectionism (Mad Max)

If nationalism and populism become dominant this will lead to a deglobalized, fragmented world. While this trend might favour some factions in the short run, overall innovation is stifled by protectionism. As a result, aviation will remain as an expensive luxury good for the few with little innovation and R&D. Indicators for this scenario are a withdrawal from international institutions, replacement of international agreements by national rules, increasing inequality, a low priority for sustainability and a reduction of R&D.

In case of deglobalisation (Tech for you)

If the trend of continued globalisation is reversed, e.g. through increasing populism and nationalism combined with the global shock of the COVID-pandemic, this could lead to a highly fragmented world of local, free market economies. In this scenario all aspects of aviation are purely market driven, but due to fragmentation only small, local markets exist that drive up the cost of aviation. Due to deglobalisation, the demand for air travel will decrease. Conventional aviation generally only provides long-haul services and has become less convenient because of global fragmentation and the restrictive bilateral agreements. Drones on the other hand show great potential for implementation in logistics chains, farming and surveillance. Limited the availability of fossil fuels provide incentives for the production and use of Sustainable Aviation Fuels (SAF). The environmental impact is thus primarily reduced due to a reduction of air transport and adoption of SAF. Indicators for this scenario are a rejection of international institutions, a return to national instead of international rules and requirements and a focus of local markets over international trade.

In case of highly regulated globalisation (Stripping down)

In the scenario where the trend of globalisation continues and is combined with strong, centralised governance, aviation is driven by prescriptive regulation rather than market demand. Nations are organised in a few blocks, with global harmonisation among these blocks. Flying is only allowed when there is no more sustainable alternative leading to a shift to rail and road transport on all but the long-haul flights. Ticket prices are very high. Sustainability is the key concern in planning and operating flights and takes precedence over journey time, flight frequency and convenience. The general public avoids air travel due to climate and safety concerns leading to a very low demand. Progress and innovation are slow, but stable and predictable. Sustainable, generic solutions for intermodal transport are encouraged. Electric Urban Air Mobility will begin to complement the local public transport system as are drones for logistics. The market for OEM becomes more difficult, providing incentives to develop more sustainable air transportation options for the future. Indicators for this scenario are an expansion of federal structures and international institutions, global consensus on the need for sustainability, an increase of incentive-based regulation, and a stronger grasp of government on R&D programmes.

With cooperative globalisation (Optimising together)

In the final scenario where the trend of globalisation continues but is combined with decentralised cooperation and collaboration, the aviation market is much more competitive. Global institutions and legal frameworks still encourage standardisation and harmony, but the sector is still free to respond to market demand. Sustainability goals are set through shared, common values (akin to the UN development goals). R&D investments and innovation are high leading to rapid progress in more seamless and more sustainable transportation options. Sustainability- and quality of life challenges are solved through collaborative mechanisms. Economic progress, availability of sustainable air travel, and global collaboration lead to a surge of demand and offers the incentive to develop a full suite of highly interconnected door-to-door mobility chains. Indicators for this scenario are the strengthening of international institutions, global sustainability goals, including consensus on the tools and approach to realise the goals, a fully liberalised global market, an increase of blue-sky R&D programmes.

3.3 Strategic focus

The EREA scenarios provide four different outlooks on the future. The first on (Mad Max) is easily discarded as undesirable, but the other three offer relevant takes on 2035 and beyond. The ambition as laid out in the AVISTRAT Vision aims for an internationally competitive Swiss aviation sector. This favours a globalized world in which Switzerland actively takes part in international institutions. If global consensus on the major challenges (described in Section 2.3) can be achieved and shared goals can be set, the highest value can be achieved through cooperation and collaboration. On the topics and areas where this proves to be unfeasible, top-down goals will have to be set and enforced leading to some loss in speed and value, but an increase in stability and predictability.

The general trends described in Section 2.1 set the option space of **what can be achieved** through specific actions in the 'Action Areas'. The 'System Requirements' from the AVISTRAT Vision provide input on **what is desirable to achieve**. The EREA scenarios provide the **context** in which the strategy draft will be implemented. Looking at the system requirements and mapping them on the main challenges identified in Section 2.3, four SO themes for the SO's can be identified. Their relation is shown in the table below. Each SO theme consists of multiple SO's that, by using specific actions in the three Action Areas (infrastructure, regulation and management – Areas of Action 06 to 08) as defined in the AVISTRAT Vision in order to meet the system requirements.

4 Proposed strategic orientations

This section contains the proposed SO's which are grouped in four categories: 'Climate Challenge', 'Quality of Life', 'Fair Airspace Access' and 'Safety & Security'. The rationale behind this setup of the orientations is explained in Section 3.3.

Quality of Life • (Air) mobility as a service • (Perceived) noise reduction • Local Air Quality (LAQ) improvement • Community participation	**Climate Challenge** • Stimulate use and production of Sustainable Aviation Fuels (SAF) • Net-Zero-50 airports • Towards full-electric domestic General Aviation (GA) and pilot training • Multi-modal integration
Safety & Security • Integral risk management • Integral security framework • Public oversight on governance	**Fair Airspace Access** • Airspace allocation • Best-equipped-best-served • Continued adoption of U-space

To make the SO's more understandable and to facilitate mutual comparison, each SO consists of the same structure:

- ***Overarching goal*** – Description of how the SO contributes to the higher level AVISTRAT Vision
- ***Description*** – Description of what the proposed SO entails and what the key components are, including scope and main drivers
- ***Assumptions*** – overview of the main assumptions underlying the SO. The assumptions highlighted refer to things that are expected to happen in the near future, focusing on things that are fully or partially outside the control of FOCA. The assumptions in general are linked to major societal and technological trends and evolutions.
- ***Recommended actions*** – Recommendations for specific actions in the Action Areas 'Air & Ground Infrastructure', 'Regulation', and 'Management' from the AVISTRAT Vision
- ***Predicted effects*** – Predicted effects of the SO on Target Areas 'Environment', 'Security & Safety', and 'Performance' from the AVISTRAT Vision
- ***Feasibility & implementation considerations*** – Overview of implementation obstacles

This structure will be used to describe all SO's in both this document as well as in the separate 'Management Summary'.

4.1 Quality of Life

Quality of Life (QoL) is the combination of factors that determine the overall satisfaction with life. Aviation can have a significant impact on people's quality of life, through annoyance about noise or worries about safety, but also through the ability to visit friends, family or go on business trips. More than just noise and economic impact, the impact of aviation on quality of life is about aviation in relation to the public and its contribution to peoples living environment.

4.1.1 (Perceived) noise reduction program

A recent elaboration of the non-acoustic factors of aircraft noise annoyance indicates that good communication and participation are essential in creating trust in the relationship between airports and residents (Heyes, Hooper, Raje, Dimitriu, & Hudson, 2020). Non-acoustic factors such as noise sensitivity, the attitude towards the airport and the predictability of noise exposure play a role in the perception of noise annoyance. This predictability can also partly be reflected in noise mitigation measures. Information about the predicted use of runways or the predicted time of the day during which air traffic can be expected help residence to plan their activities and make a positive contribution to the perception of noise annoyance.

Overarching goal

It has been found that the perception of noise annoyance has acoustical and non-acoustical aspects. By addressing both, the acoustic and the non-acoustic aspects of aircraft noise annoyance its perception might be less negative. By improving the resident's quality of life and by practicing open and transparent community engagement, those non-acoustic aspects of annoyance can be addressed in favour of a better (perceived) balance between positive and negative aspects of aviation. This provides the potential to reduce negative attitudes towards an airport.

Description

Airports worldwide are working on numerous aircraft noise mitigation measures. However, these are often assessed separate from the impact on resident's quality of life instead of being part of an integrated approach. Little is known about the value of individual mitigation measures for residents and their impact on resident's quality of life. For example: What influence does a sound-insulated window have on the quality of life of residents close to an airport? Which aspects of social involvement can improve the quality of life of local residents? And with that: which actions and strategies provide the greatest positive impact on the resident's quality of life?

A first step can consist of conducting an audit in which existing measures are identified in relation to local quality of life indicators. The elements of quality of life relevant for an airport dependent on the specific situation and the context. Such elements can refer to the amount of traffic, the proximity to buildings, but also whether the airport has experienced strong growth and any conflicts from the past.

Possible indicators that are related to the resident's quality of life and important for airports are:

- Noise level in L_{DEN}[5] as a measure of average noise level
- Number of noise events above certain lower limit, whether or not broken down into day-night, for peak noise
- Number of complainants (individuals)
- Ground-based CO_2- and NO_X-emissions
- Site-specific risk contours as a measure of safety
- Investments in greenery, recreation and sports in the vicinity of the airport
- Number of internship / training places, guest lectures at local schools
- Number of full-time workplaces
- Supporting local economy and surrounding local companies
- The provided mobility and accessibility to public transport
- Not too much air traffic during very early or very late hours during the weekends

[5] Loudness (day-evening-night), common measure used to indicate annual noise dosage, e.g. around airports

In this way, quality of life becomes measurable and reveals any gaps that can be approached. Through proper implementation and monitoring, the impact of mitigation strategies can be measured and the effectiveness of measures can possibly be increased. In addition, monitoring makes the complex interaction between airports, the environment and noise annoyance towards a more open to discussion. In that way more transparency between citizens and governments can be ensured and contribute to a new approach to the challenges surrounding exposure, noise annoyance and aviation (Roosien et al., 2018).

Assumptions

Worldwide mobility and with that flying became part of many people’s lifestyle. It can be expected that people will like to keep flying and that aviation will further grow. Simultaneously, people will have other needs such as housing. In many regions cities and airport regions grow closer together as both expand. By looking at the broader picture of peoples living environment and quality of life aviation can make a positive impact on its surrounding neighbourhoods. If people are able to life close to airports, in houses of good sound insulation, filtering system for clean air and a transparent and predictable forecast of air traffic noise exposure might be accepted more. With the current technology aircraft create noise that might annoy people. With the approach to improve quality of life annoyance might be limited and the basis for constructive conversation is provided.

Recommended actions

When taking non-acoustic factors of aircraft noise annoyance into account the following conclusions are recommended to consider.

Infrastructure

Interventions in the (urban) living environment that create a pleasant soundscape such as creating greener areas by adding plants or water installations, may contribute to a reduction in noise pollution (Lugten, Karacaoglu, White, Kang, & Steemers, 2018).

Management

Participation and predictability seem to go hand in hand with less noise annoyance. In addition, people seem more sensitive to an increase in noise than to an equivalent reduction in noise. This means that a shift from noise exposure to a new group can lead to an increase in nuisance, even if the total noise exposure decreases or if fewer people are exposed. From the airport's perspective, it makes sense to focus on factors that have a major impact on the acoustical part noise annoyance and corresponding mitigation strategies. However, taking non-acoustic factors into account may provide a powerful option to reduce the negative association with aviation and to reduce noise annoyance.

In the context of noise annoyance, it is often a small but vocal group of people who are heard. However, the opinion of the people who actively protest against (changes in) the flight operation or those who strongly support aviation are not necessarily shared (to the same extent) by the group at large. Clear, easy-to-understand communication targeted at a broad audience and long-term, can help reach this group, the silent majority, who don’t have the time and/or desire to actively engage in the sometimes-heated noise debate. The aim is to treat the community as a whole as equal partners by providing them with information that helps them understand the impact of (changes in) the flight operation on their daily lives. Comparison charts or maps free from complex technical language or interactive simulations can help achieve this goal (Derei, Hogenhuis, Hoolhorst, Veerbeek, & Speijker, 2019).

Other considerations

Sound sensitivity may contribute to annoyance. Fear that a plane will crash also seems to contribute to noise annoyance. These factors are also difficult to measure, especially with a large population, and difficult to influence.

Expectations about future noise exposure or changes in the exposure seem to strongly influence the perceived annoyance. Attitudes towards aviation also seem to have an influence in the way that a positive attitude leads to less nuisance experienced. The influence of economic ties with aviation has not been sufficiently researched.

Predicted effects

Environment
The predicted effects of noise reduction programs taking peoples quality of life, acoustic and non-acoustic factors of annoyance into account is a better relationship with between airports and their neighbourhood. By providing transparent information about the impact on the environment and compensation actions, the safety and security around airports and the expected performance and flight planning will provide the residents with a certain control of the situation allowing them to escape and to better cope.

Performance
The positive aspects of aviation and its advantages will be more visible to the residents. By having constructive conversations between airports and residents more understanding and trust can be created. Some of their needs might not be feasible but the effort to listen to people's needs and worries will already create a better bond between stakeholders, hopefully leading to a more constructive debate, more progress and fewer planning delays.

Feasibility & implementation considerations

A transparent and interactive way of community engagement and participation demonstrates confidence that the airport wishes to have a positive influence on the living environment. Showing "goodwill", which shows that the airport and its surroundings share certain values, priorities or goals, also contributes to confidence and trust in the airport (Mayer, Davis, & Schoorman, 1995). For this it is important to clearly define environmental agreements in order to create feasible expectations together with all stakeholders. The possibility of participation of stakeholders and especially local residents on the subjects and the implementation of environmental agreements ensures that support is created and the agreements are accepted. In this way it is possible to work on the balance between economic factors and quality of life. It is indisputable that agreements made must be honoured. Not doing so causes damage to the relationship that cannot be easily repaired. The impact and influence of the airport on each indicator differs depending on the location and the desired operational change. In addition, interactions between different QoL indicators or overlap may also arise. Non-acoustic factors often influence the perception of nuisance caused by aircraft noise and are directly linked to the quality of life of local residents.

Overall, there seem to be more prominent factors influencing participants' quality of life than aircraft noise annoyance or sleep disturbances, such as worries regarding safety and noise annoyance in general. However, these variables still have an influence and, if addressed, could positively influence quality of life in regions surrounding airports. Reducing aircraft noise annoyance might therefore have a positive impact on the residential satisfaction of people living close to an airport. Further, aspects such as worries concerning safety and noise annoyance in general (also regarding other noise sources) may be targeted with certain interventions, thereby further improving quality of life.

4.1.2 LAQ improvement program

Overarching goal

From Vision statement: in the course of the goal-oriented continuing development of the aviation system, a reduction of the current and future impact on the population and the environment caused by air traffic is assured.

Regarding QoL, the impact of the aviation system on the local air quality and therewith the health of the population living near the airport is a matter of concern. To decrease this impact of the aviation system the emissions of pollutants by aviation on and near the airport must be decreased and - ideally - avoided.

Description

The effect of aviation on Local Air Quality (LAQ) is mainly limited to the airport and communities near the airport. However, also further away from the airport passenger and freight transport to and from the airport may still have some impact on local air quality.

Besides the amount of pollutants emitted by emission sources and the location and altitude of these sources local air quality also depends on aspects like meteorological and terrain conditions. Both airborne and ground emission sources are relevant: the airborne sources being the aircraft main engines during take-off and landing on the airport in the lower part of the atmosphere (up to 3000 ft with respect to the airport altitude), the ground sources being the main engines of taxiing aircraft, the aircraft auxiliary power units, ground service equipment including ground power units, airport air and ground side traffic and transport to and from the airport. Though current emissions are mainly from fossil driven engines, also other emission sources exist like the particulate matter from tyres, brakes and tarmac during aircraft touch-down and braking. Currently a transition from fossil fuel to electrical/ hybrid systems with lower emissions can be observed, especially with respect to road traffic, however it is expected that electrical and hybrid engines will also be used much more in aviation in the next decades. The use of SAF is also expected to reduce aviation emissions. For more information on these see also Chapters ‘Net Zero 50 airports’ and ‘Stimulate use and production of SAF’.

In general, the species of concern in air quality studies are nitrogen oxides and particulate matter. Regarding particulate matter the emphasis in recent years is more and more on the impact of ultrafine particles (UFP) on health. Recently, a study of the Dutch National Institute for Public Health and the Environment around Schiphol airport showed that short term exposure to UFP may indeed impact health. A comparable long-term exposure study is still in progress.

Regarding improving airport air quality, the two largest Swiss airports (Zurich airport and Geneva airport) - among many other airports - are examples of airports that are already taking a lot of measures to improve local air quality on and near the airport and that are continuing to do so. As expressed in Chapter ‘Net Zero 50 airports’ emissions will have to be minimised at all airports.

Assumptions

The assumptions made for this SO are that from now to the year 2035:

- Aircraft main engines are becoming more fuel efficient, but not necessarily cleaner regarding NOx emissions.
- Road traffic and ground service equipment will become more fuel efficient and cleaner.

Recommended actions

Both Zurich Airport and Geneva airport are already applying a lot of measures to improve local air quality. Since about thirty years Zurich Airport is designing and implementing measures to improve local air quality. Examples of these measures are the use of fixed energy ground power (FEGP) and preconditioned air (PCA) systems to provide aircraft on-board electricity and air-conditioning and the use of electrical airside vehicles. Zurich airport is to further reduce their emissions stepwise and is aiming for zero emissions in 2050. Geneva airport is also applying many measures to decrease emissions. Examples of these measures are the use of heat pumps to cool or heat aircraft before take-off, the increasing use of electrical or hybrid vehicles/machines on the platform and fixed energy systems for (parked) aircraft. Both airports support the use of public transportation by passengers to and from the airport.

Local air quality will improve when total emissions of pollutants decrease. The emissions of pollutants and carbon emissions are -in general - closely related. Though the current target is zero emissions in 2050, from the health perspective it is preferable to minimize emissions as much as possible as soon as possible (for instance in 2035). To this end it is recommended to collaborate with the airports and – together – investigate what is needed to speed up the change to a zero-emission airport.

Infrastructure

<u>Systems</u>

Local air quality depends among others on the total amount of emissions. Preferably these emissions should become zero. The recommended actions mentioned in chapter 'Net Zero 50 airports' are therefore also applicable to improve local air quality. The infrastructure of the airport should facilitate a clean energy supply, use zero emission ground support equipment and vehicles on the aprons and airport air side, apply fixed electrical ground power system to provide on-board electricity and pre-conditioned air (when applicable) to the aircraft and promote and support green (multi-modal) transportation to and from the airport of passengers and freight. By applying these recommendations, the use of - for instance - the kerosene driven aircraft auxiliary power units (APU) and the use of diesel ground power units (GPU) are avoided as much as possible. Also, the emissions of the aircraft main engines for taxiing should be avoided by introducing systems like eTaxi, Wheeltug, Taxibot and electrical towing systems.

<u>Procedure</u>

By introducing/applying an ATM Departure Management (DMAN) any emissions during taxi delays between the platform and runway take-off with running main engines are avoided.

Regulation

<u>NOx based emission charges</u>

Though the aircraft are becoming more fuel efficient, they are not always cleaner with respect to NOx emissions. This is because one of the ways the aircraft may become more fuel efficient is by increasing engine operating temperatures. However, these higher temperatures may lead to more NOx emissions since engine NOx production strongly depends on temperature. The introduction/use of NOx emission-based landing charges may be used as an incentive for the use of low NOx aircraft engines on the airport.

<u>Mandatory use of FEGP and PCA</u>

The use of airport FEGP and PCA may replace APU operation for providing on-board electricity and air-conditioning. Since in this way unnecessary APU emissions are avoided the use of the available FEGP and PCA at the gate should be mandatory whenever possible.

Flight procedures
Furthermore, mandatory (reduced thrust) take-off and landing procedures should be examined to investigate possible environmental improvements. This should include assessment of carbon emissions, emissions of pollutants and noise impact on the habitants near the airport.

Management
It is recommended to consider the introduction of SAF at the airport since these may lead to lower emissions. By co-operating with the other companies operating on the airport aprons and premises the use of zero or low emission equipment and procedures must be promoted.

Predicted effects:

Environment
By further applying or introducing the above recommended actions the environment will benefit and local air quality will be improved.

Performance
In general, the performance of the airport in terms of capacity, and on time operation will be the same or may even be improved.

Feasibility & implementation considerations
The recommended actions are in principle all feasible. Zurich Airport and Geneva Airport have already introduced quite a number of measures. The introduction of SAFs and the further replacement of fossil fuel equipment/vehicles by their electrical versions is expected to be a matter of time. However, the speed with which the change to a zero-emission airport operation can be performed depends among others on economic and technological considerations. Regarding the economic considerations it must be considered that airports operate in a competitive environment with other airports nationally and internationally, and also with other modes of transportation. A level playing field is important. From a technological point the development and introduction of new zero and low emission systems and infrastructure at the airport also takes time.

4.1.3 Community program focused on participation and simpler complaint handling

The SO “Community program” contributes to the AVISTRAT vision by providing recommendations for community engagement strategies. Providing people with an opportunity to actively be engaged in changes of flight procedures, having the possibility to express their concerns and ask questions, could enhance their (perceived) control and expand their coping capacities.

Overarching goal
The overarching goal of community engagement is to limit or reduce complaints, create understanding for each other and ideally being able to trust each other. Community engagement help to carry out good stakeholder and expectation management. If people understand the motivation for changes or actions and they have the feeling of being heard they are less likely to complain. A basis for constructive conversation can be created.

Description

A consultation procedure should be implemented early on in the decision-making process for a potential flight path change or other operational changes. In that way the surrounding communities and residents can be engaged. Often, potential flight path changes can lead to less aircraft noise exposure for some communities, but to a higher aircraft noise exposure for others. Integrating the results of the consultation procedure, a decision can be made regarding the shift of exposure and the impact of a potential adapted flight path.

The consultation should not have any decision-making authority and serve only for further consideration regarding the decision-making process. The aim is to engage the public and allow political representatives and residents to share their opinions, concerns, and ideas regarding a potential flight path change. The procedure and the decisions being made has to be transparent and facilitate tracking and understanding of the proposed routes and a potential change. The current flight path or operational procedure should be compared with other alternative options.

It is often useful that a specialized impartial moderator with a good sense of the local context leads the procedure (Heyes, Hooper, Raje, Dimitriu, & Hudson, 2020). A mix of different kind of events provides different kind of stakeholders with the possibilities of engagement. Such a mix could consist of public informative events, citizen group meetings and political stakeholder meetings. Information regarding the meetings, the procedures and the results should be publicly available on a website or any other kind of public platform or my mail. The informative events should be public and provide all residents of the region with the opportunity to inform themselves about the procedure, ask questions and share their opinions. To engage people from the general public, a citizen groups can be conducted with a number of randomly selected residents from the affected areas. By choosing random sampling, it was intended that recruitment of “regular” residents, whose opinions may otherwise be unheard (the so-called silent majority), would be ensured. The political stakeholders consist of representatives from each community engaging community representatives such as the mayor, the head of the environmental department or another expert from the community. It is expected that all group meeting will take place several times. The meetings include a first introductory meeting, an expert-workshop to discuss relevant topics with the expert committee and an experimental meeting where the original and the alternative procedure will be visually and acoustically presented. Additionally, participants will be asked to fill in a questionnaire about their overall perception of quality of life, the difference of different flight procedures and the impact of the operational flight procedure.

After the consultation procedure has ended, a final decision can be made by taking all opinions into account to decide whether the new flight procedure will be permanently adopted or whether the original flight procedure will be retained.

Assumptions

It is possible that residents may not feel that the consultation procedure itself does have a direct effect on their quality of life. There has been little evidence found on the direct link between the air traffic related interventions and people’s quality of life. Directly questioning people about the link between an intervention and quality of life may not reveal any apparent relationship as participants may not be consciously aware of the way in which a consultation procedure affects them. On the other hand, it has been shown that the ability to make choices to escape the exposure of aircraft noise is perceived as a beneficial effect on quality of life. If people are sufficiently informed about the expected aircraft noise exposure, they can decide how to plan and organise their daily activities. In that way people can feel empowered and in control again. Recent research has revealed a number of critical success factors which may contribute to the development of interventions that are more nuanced in meeting residents’ expectations and needs, and, thereby, of increased likelihood of influencing their lived experience.

Recommended actions

Management

The recommendation is to design consultation procedures that includes open-ended questions to provide participants with the opportunity to expressed a degree freedom in expressing themselves. Conducting a consultation procedure to engage the public by means of transparent communication and execution can be beneficial for the airport and for the community. The community has the opportunity to participate and to share thoughts and concerns and the airport can handle complaints during a conversation. The airport has the opportunity to address the resident's quality of life and include their opinions in the decision-making process. The implementation of any interventions should take the following criteria into account:

Participation/Fairness

The capacity of the intervention to include residents in the decision-making process. Community engagement strategies with different meeting or workshops can be carried out to give residents the option for engagement in decision making processes. It is important to make sure that the information is transparent and understandable. The size of the groups and the combination of stakeholders can be varied to create room for more depth and understanding or for a broader view of the bigger picture. Often using tools such as illustrating changes in a graphical way instead of sound levels or the demonstration of operational changes by virtual simulations provide effective approaches. If information is collected from people, for instance by questionnaires, there should be feedback on how the information will be used. An important aspect with respect to fairness is understanding. That could be regarding the motivation of a change or the consequences for other people.

Health

The capacity of the intervention to lower the pollution, noise, and stress effects of air traffic and to improve sleep of residents. Possible option to reduce noise exposure are insulation programs or air filter systems for houses. Educating people about their options for optimal use of their living space in relation to noise exposure might help to improve current situation by applied different methods or settings.

Social life and leisure

The capacity of the intervention to lower the impact of air traffic on these activities. Airports can provide social activities by creating attractive shopping areas on site, guided tours of the airside or exhibitions. Providing well developed connections and the accessibility to high quality public transportation enables people to carry out leisure activities.

Living environment

The capacity of the intervention to address the indoor AND the outdoor impact of air traffic. Transparent and reliable information on expected aircraft operations and flight schedules can provide residents with the opportunity to choose their current location depending on the planned actions. So, can a barbeque in the garden be carried out on day on which less air traffic is forecasted. Another option is flying less during very early morning hours during the weekends. In that way people have the opportunity for sleep without sleep disturbance.

It is only by fostering effective communication and open dialogue between an airport and its surrounding communities that steps can be made towards successful interventions that are fair, of value to residents and reflect authentic joint-working towards mutually agreed solutions.

Predicted effects

Performance

The ability to speak about each other's position, motivations and doubts will help to better understand the other party. Complaints or doubts based on non-acoustic factors can be identified and used to help reduce the annoyance due to aircraft operations, hopefully leading to a more constructive debate, more progress and fewer planning delays.

Feasibility & implementation considerations

There are a number of considerations that may assist airports as they move forwards to development of new interventions. We consider the following issues to be central to improved airport thinking about residents and quality of life:

- It is important to know what you are trying to do and to establish from the start what methods you can use to evaluate whether you have achieved your goals.
- There needs to be a consensus between airport operator and residents about what is seen as effective.
- Airports would benefit from efforts to gain a better understanding and awareness of QoL in their communities.
- Use citizen science approaches to engage with communities rather than using what can appear to be random consultation methods.
- Think about new methods of assessment of success (e.g. well-being evaluation techniques).
- Airports may find it helpful to address the apparent lack of understanding in the community of how the operator's contribution could be beneficial to residents.
- Try to work innovatively to share aviation benefits with residents.
- Ask residents what they expect or wish for.

The involvement of residents needs to be genuine and an effective participation. The intervention and associated air traffic changes may be more likely to be acceptable to the public if people feel that they have been able to fairly contribute to the decision-making. Proper community engagement requires early involvement, transparency, having a voice that is listened to and having a real choice.

4.1.4 (Air) mobility as a service

Overarching goal

The SO "Air Mobility as a Service" contributes to the two topics in the AVISTRAT vision, namely 1) Technology and Innovation and 2) Environment.

Technology and Innovation: *The aviation system should therefore be designed in such a way that the use of new solutions optimizes the use and management of the structures: Compared to the current, more rigid design of the aviation system, the access and use options of different users should be designed in a more flexible and needs-based manner.*

Environment: *AVISTRAT-CH has set itself the ambitious goal of ensuring, in the further development of the aviation system, that the pollution caused by air traffic for the population and the environment is reduced compared to the pollution caused today by each transport unit. The focus on the load per transport unit is based on the fact that the acceptable level of the total load (and thus not least the acceptable quantity of transport units) is a socio-political question*.

Description

Mobility as a Service (MaaS) is regarded an essential element in sustainable transportation. The basis of MaaS are technological innovations (smartphones, apps) and the societal trend of regarding sharing equivalent to owning.

MaaS is the concept where transportation is offered as a service, without an on forehand determined means of transport and where the means of transport are shared. It is a type of service that through a joint digital channel enables users to plan, book, and pay for multiple types of mobility services. MaaS assumes different modes of transport, services are offered through a digital platform and pricing based on time spend or kilometres travelled (thus independent on the transport means). A MaaS-provider forms the bridge between the mobility request (traveller, users) and the mobility offer (carrier). MaaS is more than the moving of people and goods; it offers a combination of services: advice, information, ticking and payment. Examples of MaaS in Switzerland are the existing car sharing systems from Mobility[6], with over 1500 stations and self-service bike sharing systems, though the latter may be regarded “normal” bike rental as well.

The main challenges for integrating the air component in MaaS will be to:

1. Establish the air component within the city environment, and;
2. To set up the interconnection between different modes of transport.

Using the air-dimension in urban transport

Adding the air-dimension to the urban transport system will add to transport capacity, higher accessibility and affordability of the transport system. The use of air mobility will be an enabler to achieve the strategic goals on society, environment and performance towards the transport system. Societal acceptance (safety, noise, privacy and visual pollution) play an important role in the achievement of using the air-dimension.

Interconnecting modes of transport

Traffic flows from ground transport will need to be coordinated with air traffic flows, where in between the multi modal station will provide seamless travel for the passengers. For operating air transport in cities, vertiports or drone-ports are envisaged. This effects the urban design. Another part of the city’s infrastructure is the proposed CNS infrastructure (Communication Navigation Surveillance). CNS infrastructure will be less visible but will definitely be necessary as well. The city that allows urban air mobility will be a smart city that will apply an enabling infrastructure to communicate with the drones, e.g. for communication with the pilot and for sending Unmanned Traffic Management (UTM) messages. In the I2V / V2I (Infrastructure to Vehicle / Vehicle to Infrastructure), use of the frequency spectrum and defined communication protocols need to be agreed. Only through this smart communication, the city will fully benefit from the use of urban air mobility.

Assumptions

The main assumption for this SO is linked to the sharing economy. It is assumed that **people will increasingly share goods and services** (flat sharing, car sharing systems, …). This trend is assumed to be a precondition to further facilitate MaaS as increasing number of shared transportation systems provide a more fine-meshed network to enable a seamless door-to-door travel experience.

Other assumptions applicable for this SO are similar as those assumed for the SO ’Multi-modal integration’.

[6] https://www.mobility.ch/de/privatkunden

Recommended actions

Regulation

- The challenge will be to have regulation ready in time to allow urban air operations.
- Standards for communication and other technical interconnections need to be adopted to use in aviation.
- Set up a legal framework to oblige service providers to collaborate and allow the multimodal approach.

Predicted effects

Environment

Making use of MaaS instead of individual ownership transportation systems and transportation providers will allow for a decreased overall size of the transportation fleet whilst still answering to the transportation demand. This, combined with discouraging individual ownership, will lead to an increased environmental awareness.

Performance

The individual transportation systems will be used more efficiently due to higher occupancy rates. It is expected that this will increase the overall Swiss transportation performance.

Feasibility and implementation considerations

There is a limitation on this system when it comes to peak demand periods. The sharing and MaaS economic model have limitations during moments of excess mobility demand. This can be managed by planning and forecasting well in advance the transportation needs.

There are also considerations to be made when looking at the unmanned transportation aspect within MaaS. Technical challenges concern the flight beyond "corners", radio communication and electromagnetic interference and the occurrence of hyper local weather conditions. A high level of automation will be required. Traffic management and the link to Air Traffic Control (ATC) will require the development of concepts where the concept of providing traffic services by air traffic controllers will cooperate with the highly automated concept of drone traffic management. Unmanned Traffic Management (UTM or U-space) will allow large numbers of drones to be managed automatically.

4.2 Climate challenge

The Paris agreement shapes the current environmental policy in Europe. The agreement aims to limit global warming to "well below 2 degrees centigrade". However, the Paris agreement only considers national (domestic) flights. Nationally Determined Contributions (NDC's) as part of the Paris agreement, aim for a reduction the carbon emission of national flights of 49% with respect to 1990-levels by 2030 and 80-95% with respect to 1990-levels by 2050. International flights are governed by the aviation industry itself via market-based measures that adopt the goals of the aviation branch of the United Nations (ICAO). ICAO aims to reduce the carbon emissions of international flights by having "carbon-neutral growth" by 2020 and by realising a reduction in carbon emissions of 50% with respect to 2005-levels by 2050.

For countries with a small domestic aviation impact on emissions such as Switzerland, the ICAO goals will be more stringent than the Paris agreement.

4.2.1 Stimulate use and production of Sustainable Aviation Fuels (SAF)

Overarching goal

Just like other sectors, aviation has to reduce its carbon footprint. However, while road and rail can rely on electrification, the high weight of batteries (relative to their capacity) make full electric aircraft not feasible for longer ranges (>500 km) and higher capacities (>19 passengers), at least with the technology predicted for 2035. The use of SAF that capture CO_2 during their production is potentially one of the most promising ways to address the climate change effects due to aviation since they can be used in the long-range, high-capacity aircraft that are responsible for most of the emissions. This SO links to the global goal to have net-zero carbon emissions in 2050 and to the AVISTRAT Vision statement to reduce the current and future impact on the population and the environment caused by air traffic.

Description

Avoiding severe climate impact affects all sectors in society such as industry, communities and all modes of transport. Ways to address climate change are fuel efficiency improvement, use of electrical drive systems, use of zero net-carbon fuels and carbon offsetting. When considering modes of transport aviation is probably the mode that faces the largest challenge since fuel efficiency is already relatively high and the weight of electrical propulsion systems is still far too high to be implemented in large commercial aircraft. Carbon-offsetting aviation emissions in other sectors also has its drawbacks since aviation will continue to emit carbon emissions and these have to be compensated through long-term, stable offsets, which will have its challenges. Therefore, the use of SAFs is promising for aviation since (almost) net-zero carbon emissions may be possible without increasing aircraft weight and operation. For shorter distances other transport modes are expected to replace aviation.

Current status is that SAFs are hardly being used in aviation. The main reasons are that the cost/price of SAFs are a factor higher than the cost of fossil kerosene and the availability of SAFS is currently very limited. Also, not only aviation will apply SAFS but also other sectors may compete for these fuels. Nevertheless, the current pressure to avoid severe human-induced climate change is expected not to decrease next decades, so the need for SAFs is also expected not to decrease.

Use of SAFS decreases net carbon emission with respect to the use of fossil kerosene. Besides that, their use is expected to also have an effect on other emissions which are of importance to local air quality around airports. In general studies indicate that emissions of, for instance, particulate matter, decrease by the use of SAFs, improving local air quality.

Assumptions

The assumptions made for this SO are that:

- the need for net-zero climate change impact due to aviation remains

- the need for transportation of people and goods will grow
- airlines need a level playing field to operate in the international arena
- price and availability of SAFs in relation to those of fossil kerosene are also determined by international agreements on carbon costs (like the EU Emission Trading System, EU ETS).

The production and use of SAFs is largely dictated by its price in relation to the price of fossil kerosene. For now, the price of sustainable aviation fuel is a factor higher than fossil kerosene. To lower the price of SAFs the scale of production of SAFs has to increase significantly (economics of scale), the fossil fuel price including its carbon cost has to increase (the price of the alternative has to become higher) and further research and development is still needed. Another important reason that SAF production levels are still low is that producers need sufficient assurance of return of investment.

Recommended actions

Air and ground infrastructure

An ambitious target – In terms of a high percentage of SAF to be used in all aircraft operating from Switzerland – will support the transition to SAF. However, before setting such a target it is recommended to further investigate what target level is obtainable for airlines operating in the Swiss environment. Furthermore, it is recommended to investigate the possibility in which ways new plants that produce SAFs can be supported in Switzerland. Is it for example possible to guarantee a minimum demand for SAF so a potential producer acquires a sufficient guarantee for return of investment. A related question is what the cost and availability of energy is in Switzerland, since SAF production may require a significant amount of energy and if this is relatively inexpensive this may support the introduction of a plant.

Regulation

Another action recommended is to investigate the possibility of prescribing mandatory blending percentages of SAF with fossil fuels. The Norwegian and Swedish governments are expressing this option. An issue here is how to cover the extra cost of SAF with respect to fossil fuel when operating in the international arena. The higher, the more ambitious this blending goal will be, the higher the price difference to cover will be.

Management

Since aviation is internationally operating sector and domestic airlines need a level playing field as much as possible it is recommended that the Swiss government works together with other government to address climate change in relation to aviation and also seeks cooperation in the relevant international institutions. A good example of this is that Switzerland has linked its greenhouse gas emissions trading system (including aviation) with the EU emissions trading system (EU ETS) since 1st January 2020. In this way carbon costs of fossil fuels are addressed. As currently the production of SAF is not yet widely secured, operating internationally could increase energy security, as it can increase available sources.

Predicted effects

The predicted effects for this SO considered are environment and performance.

Environment:

Stimulating the production and use of SAFs will decrease the climate change impact of aviation. Depending on the type of SAF used it may also improve local air quality around airports.

Performance:
It is expected that a significant future use of SAFs will be needed to meet the growing demand of transport or sustain current aviation volume. The use of SAFs will have no significant impact on the aviation system in the sense that they can be exchanged with fossil fuels (currently to maximum blending percentages) in the aircraft and in the airport infrastructure. The energy content of SAFs is also very much alike the energy content of fossil fuels, so no impact on aircraft performance is expected.

Feasibility considerations

In order to successfully stimulate the production and use of SAFs in aviation in Switzerland there are several considerations to make. The most important one is the price and availability of SAFs. As long as the price is a factor higher than the price of fossil fuels airlines won't be able to compete in an international environment, unless the price difference is somehow addressed by Swiss government, by international agreements or by businesses/passengers increasingly aware of the effect on climate and therefore willing to pay a bit more for their flight. Another important consideration is to provide guarantees to producers and airlines that there will be sufficient demand and supply of SAFs. Though initially the price of SAF will be relatively high as compared to fossil kerosene, an increase of production facilities may lead to more research in the field of production methods of SAFs which may lead to more efficient production methods lowering the price of SAFs.

Implementation considerations

The international goal is to have net-zero carbo emissions in 2050 over all sectors. Switzerland may lead the way by setting an ambitious goal for use of SAF in 2035 (see before). In order to reach this ambitious goal, SAF needs to be accessible, available and affordable – there needs to be a continuous energy security for continuous supply. Furthermore, the affordability of SAF should be reasonable in order for airlines to invest in the use of SAF. If the prices are still too high (as is currently the situation), incentives should be put in place to facilitate and stimulate the use of SAFs at higher prices. However, as the production of SAFs are costly processes, the price of SAF is not expected to decrease in the short term. Furthermore, the various production processes require different feedstocks and result in different cost/prices, which makes the pricing of SAFs a complex process. These are considered the largest obstacles for wider implementation of SAFs.

4.2.2 Net Zero 50 airports

Overarching goal

The SO "Net Zero 50 airports" aims to achieve net zero emissions in 2050 of all airports in Switzerland. This SO contributes mainly to two topics in the AVISTRAT vision: Environmental Impact and Infrastructure and Spatial Planning. In the AVISTRAT-CH vision the future aviation system reduces the burden on society and the environment. Hence, in managing the burden on society and the environment, the transition to net zero emissions in 2050 of all airports in Switzerland will require investments and changes in infrastructure and spatial planning of the airports to ensure safe and efficient operations.

Description

The climate impact of airports can be effectively mitigated by reducing the emissions such that the net emissions of all operations, complete life cycles included, amounts to zero.

Airport emissions can be divided in three scopes, which have been defined by Airports Council International (ACI)[7]:

- Scope 1: emissions owned or controlled by the airport operator
- Scope 2: emissions from the off-site generation of electricity and/or heating/cooling purchased by the airport operator
- Scope 3: emissions owned or controlled by airport tenants and other stakeholders working at or around the airport

For each of these scopes, the emissions can be reduced through the implementation of operational improvements such as the electrification of operations and processes or by implementing sustainable alternatives resulting in reduction of waste and by-products.
The extent to which investments and infrastructure adaptations have to be made, depends on the current so-called maturity level of the airports.

The maturity levels defined by the Airport Carbon Accreditation[8] indicates the efforts of airports to manage and reduce their carbon emissions through 6 levels of certification:

- Level 1: "Mapping"
  Airports certified at Level 1 have mapped their annual carbon emissions and reported this in a carbon footprint report.
- Level 2: "Reduction"
  Airports certified at Level 2 have fulfilled all requirements of "Mapping" and additionally are able to show evidence of effective carbon management procedures, showing a reduction in carbon footprint, for emission Scope 1 & 2.
- Level 3: "Optimisation"
  Airports certified at Level 3 have fulfilled all requirements of "Mapping" and "Reduction" and additionally have widen the scope of its carbon footprint to include (a range of) Scope 3 emissions. Furthermore, airports need to have engaged with third party operators to reduce wider airport-based carbon emissions.
- Level 3+: "Neutrality"
  Airports certified at Level 3+ have fulfilled all requirements of "Mapping", "Reduction" and "Optimisation" and additionally offset their remaining Scope 1 and Scope 2 carbon emissions using internationally recognized offsets.
- Level 4: "Transformation"
  Airports certified at Level 4 have aligned their carbon management ambition with global climate goals and have transformed their operations to aim for absolute carbon emission reductions, while also strengthening their stakeholder engagement. At this level, airports have set out a policy commitment to absolute carbon emissions reductions.
- Level 5: "Transition"
  Airports certified at Level 5 have successfully implemented all requirements of "Transformation" and are compensating for their remaining carbon emissions by offsetting.

This SO covers the goal of "net zero" emissions by 2050 of all airports by 2050. Therefore, Swiss airports should be certified at level 3+ or higher.

Assumptions

- The need for transportation of people and goods will grow

[7] https://aci.aero/about-aci/priorities/environment/acert/
[8] https://www.airportcarbonaccreditation.org/about/6-levels-of-accreditation.html

- The need for net-zero climate change impact due to aviation remains
- The infrastructure facilitates green electrification of operations and processes at the airports
- The environmental awareness of passengers and society will increase → flying from net zero airports will contribute to travel decisions of passengers
- The technology will enable net zero airports

Recommended actions

The recommended actions under this SO depend per airport on its current maturity level.
According to their Airport Carbon Accreditation (ACA) maturity level (see "Description" of this SO), Basel (EuroAirport Basel Mulhouse Freiburg) is an accredited airport scoring in **level 2: Reduction,** Zurich Airport scores at **level 3: Optimisation**, and Geneva Airport even at **level 3+: Neutrality.** The remaining airports in Switzerland have not been certified following the ACA, but are assumed to be at level 3 or lower. It is assumed that all airports other than those certified by the ACA, would score at level 3 or lower. Therefore, the recommendations in this section are aimed at those airports that need to reduce their carbon emissions, set up their carbon reduction management and engage their third parties in their carbon management.

Overview of expected measures for ACA-certified Level 2 (or lower) Swiss airports:

Air and ground infrastructure

The infrastructure of the airport should facilitate a **clean energy supply.** This clean energy supply consists of combined heat and power sources and renewable energy sources, which can be both on-site or off-site. As options for alternative fuel airport vehicles, such as electric, hybrid or hydrogen ground vehicles, will be exploited to work towards net zero emissions, the airport's infrastructure needs to adapt to alternative fuel vehicle processes. Furthermore, **supply-chain related emissions** should be **examined** and **reduced**, which could be stimulated by reducing waste and using on-site available (recycled) materials.

Regulation

The airports should implement "**low energy design**", such as inclusion of carbon reduction studies in new projects and set up standards for refurbishment and new build.

Management

A **carbon reduction management programme** should be set up. Airports should assess their potential for **energy demand reduction** through audit, measurement, management and automated meter reading.

Overview of expected measures for ACA-certified Level 3 Swiss airports:

Air and ground infrastructure

If not yet implemented, airports could provide Fixed Electrical Ground Power (FEGP) and Pre-Conditioned Air (PCA) to aircraft at the airport gate to reduce emissions. Furthermore, airports could electrify ground operations both airside and landside. Examples of **airside operations** that could be electrified are taxiing (electric taxiing, towing or Taxibot) and ground vehicles for inspection and cargo transport. Also, **landside operations** can be reduced through electrification and **sustainable transport** to and from the airport should be stimulated and facilitated for both passengers and employees. Airports should **invest in flexible infrastructure** such that the airport is robust to disruptive changes in aircraft technology, such as opting to change infrastructure and operations to hybrid or full electric flight, and thus accounting for the possibility to deploy charging stations, battery swap stations or hydrogen storage spaces.

Regulation

Incentives to encourage the use of efficient vehicles (hybrid-electric or fully electric) through parking fees could be considered. Additionally, the use of polluting cars could be discouraged by starting with higher parking fees and ultimately limiting certain polluting vehicles such as cabs. Incorporating **carbon and energy considerations into existing third-party leases or contractual conditions** will further stimulate the reduction of carbon emissions.

Furthermore, airports should further exploit ATM improvements which could reduce LTO cycle emissions from aircraft. However, aircraft operations at reduced CO_2 emissions could result in increased non-CO_2 emissions, which negatively affects the local air quality.

Management

Strategic partnerships with key airport operators should be formed to collaborate on investment projects and opportunities to facilitate sustainable aviation, such as the production of green electrical energy or SAF. Furthermore, intense collaboration with key business partners is recommended, such that they understand airport policy, goals and objectives and can support implementation of carbon management. An example is working with airlines to reduce the use of APUs and taxiing times to reduce carbon emissions.

Other

In order to **effectively involve third parties in their carbon management**, airports can provide training to third parties on energy efficiency and carbon management techniques. Perform formal airport-wide schemes to encourage and facilitate take up of specific **reduced energy personal or operational practices** of both airport employees and personnel. An example is to facilitate car sharing programmes, clean vehicle schemes, invest in electrical car parking spaces, or minimise waste.

Predicted effects

Environment

This SO will reduce the impact of airports on the environment in terms of carbon emissions. As non-CO_2 emissions are not the focus of this SO, the impact on local air quality will require more attention. As this SO also affects the surface access of airports, namely the stimulation of climate-friendly transport options such as travelling by train, electric buses, cars or taxis or car-sharing, it has a secondary positive effect on the reduction of emissions of road vehicles to and from the airports.

Security & safety

The electrification of airport operations over larger scales imposes higher peak loads on the electricity grids of airports. These electricity peak loads need to be properly accounted for and caution should be taken in the design and management of this infrastructure.

The generation of green energy on-site also imposes extra risks to the airport related to the electrical grid. These risks are very dependent on the airports resource needs and lay-out and therefore will need further airport-specific research. Furthermore, a notorious risk of electric vehicles is the ability of the batteries of the vehicles to catch fire. Since this is a chemical fire it cannot be extinguished and one must simply wait until the chemicals have fully burned out. However, for small ground vehicles (with small capacity batteries) this risk is not considered very high as the likelihood is considered small.

Performance

Charging times of electric vehicles are considered to be longer than fuelling times of fossil fuelled ground vehicles. This would introduce delays in the operations of an airport, even if charging- slots and times are optimised. An option to account for the long charging times of batteries is to pre-charge battery packs at destined charging stations and swap out empty batteries with fully charged batteries. This, however, introduces an extra complexity in battery pack charging and battery swapping optimisation schedules.

Feasibility and implementation considerations

Considering that the largest airports in Switzerland have been certified following the ACA, achieving net zero by 2050 for entire Switzerland is realistic. Smaller airports are generally more flexible to change their operations, but might need support in terms of financial needs.

The airports that are already ACA certified can aid the smaller Swiss airports that have not yet been certified on their road to Neutrality and share their specific experiences. It is expected that key stakeholders, together with airports, will need to perform large investments in equipment and infrastructure. Specifically, airports at ACA Level 2 and lower will need to perform large investments.

4.2.3 Towards full-electric domestic GA and pilot training

Overarching goal

The goal is to set up infrastructure and resources for full-electric domestic General Aviation (GA) and pilot training. This SO contributes to two topics in the AVISTRAT vision: Environmental Impact and Infrastructure and Spatial Planning. In the AVISTRAT-CH vision the future aviation system reduces the burden on society and the environment. Electrifying GA and pilot training allow lower investments (both in costs and infrastructure) than electrifying commercial flight and is therefore considered to be a realistic and effective SO to reduce climate impact of aviation. Furthermore, lessons learned from this SO will be very helpful in electrifying all aviation.

Description

Full-electric aircraft have a large potential of reducing climate impact, as the in-flight emissions will be zero. It is expected that full-electric aircraft will be operational for short-range distances on the medium term. Full-electric domestic general aviation should therefore be operational on the medium term.

- Current airports need infrastructure change
- Aircraft fleet will change

Research to sustainable pilot training has led to digitalizing more parts of the pilot training such that only necessary parts of pilot training need to be executed in the actual aircraft. The electrification/digitalization of pilot training implies full simulator training, exploiting the advantages and possibilities of virtual reality and augmented reality and development of “flexible” simulators (see recommended actions).

As the industry will shift to full electric aircraft on the short-medium term, pilots need to be (re-)trained to operate electric aircraft. Pilots already certified to fly kerosene aircraft need to take a conversion course. This course consists of both theoretical and practical training. However, the pilot training for electric aircraft is however not the focus of this SO.

Recommended actions for full-electric GA

Air and ground infrastructure

To facilitate full electric GA, airports frequented by GA need to adapt their infrastructure and provide charging stations and/or battery swap stations. This also means that the turnaround-time and procedures will need re-assessment for full electric aircraft and subsequent optimisation is needed.

The departure and approach procedures for electric aircraft should be optimised with respect to their noise, climb- and descent characteristics. As the noise of electric aircraft is of different frequency and lower magnitude compared to fossil fuelled aircraft, and the climb- and descent characteristics differ, the departure and approach procedures of electric aircraft could differ from those of fossil fuelled aircraft.

Regulation

During the transition period to full electric GA, electric GA should be incentivised to stimulate electric flight. Over the longer term, fossil fuelled general aviation aircraft should be fully replaced by electric aircraft.

Management

During the transition period, airports frequented by GA should set up a management plan to handle both fossils fuelled and electric aircraft. This requires assessment of operational needs and resources to properly divide the airports resources and capacity between both types.

Recommended actions for full-electric pilot training

Air and ground infrastructure

Pilot trainings are currently optimised to reduce the emissions, by combining actual in-flight training with simulator trainings and virtual reality. To facilitate full electric pilot training with zero emissions, a requirement is that all aircraft types can be trained either in a fully electric aircraft or digitalized, while aided by flight simulators or virtual/augmented reality. For this end, it is important to identify the various learning goals of a specific flight training and translate this to different means which does not require actual flight in a fossil fuelled aircraft. Flexible flight simulators provide different configurations such that multiple flight trainings can be given in one facility, rather than needing to acquire multiple facilities. Currently, trainings are being designed which are focused on the different needs and possibilities for zero emission flight training.

Predicted effects of full-electric domestic GA

Environment

Full-electric domestic GA will have a positive impact on climate change in terms of reduction of CO_2 emissions and other non-CO_2 emissions, such as NO_x and PM. While general aviation in Switzerland is relatively large (66% of civil aviation aircraft movements in 2019[9]), the share of CO_2 emissions of domestic civil aviation flights in Switzerland is relatively small compared to international flights in 2019 (see Figure 5).

[9] https://www.bfs.admin.ch/bfs/en/home/statistics/mobility-transport/cross-sectional-topics/civil-aviation.html

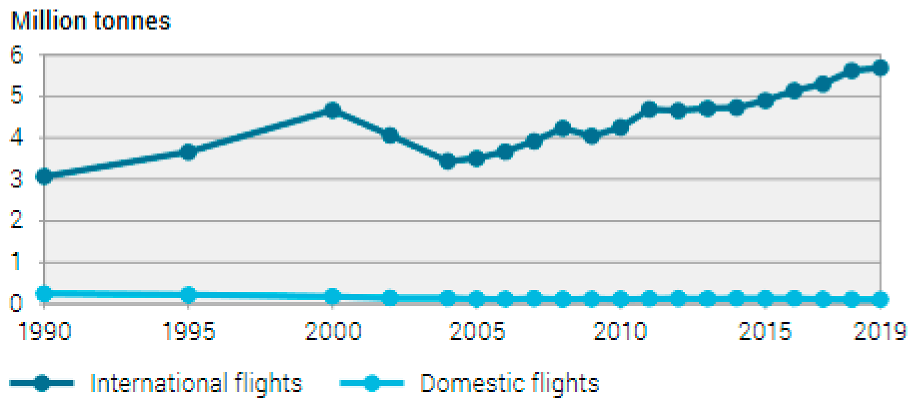


Figure 5: CO_2 emissions of Swiss civil aviation, including general aviation. Source: FSO, FOCA - civil aviation statistics

Therefore, full-electric GA of both domestic and international flight would yield an even larger positive impact on climate change. The local air quality of regional airports frequented by domestic GA however, will improve considerably.

Security and safety

A large safety concern of full-electric aircraft is the risk of the batteries to catch fire. While the likelihood of this is very small, the severity of the impact of the hazard is very large. The problem with this is that it concerns a chemical fire, which cannot be extinguished, but will only die out when the chemical fuels have completely burned out.

Performance

The energy density of aircraft batteries should improve, in order to meet the performance demands of electric aircraft in terms of weight, range and power. In 2035, performance improvements should support domestic electrified GA, but for longer range flights, improvements are needed.

Predicted effects of full-electric pilot training

Environment

Full-electric pilot training will have a positive effect on climate and local air quality, but the effect will be rather small in comparison to the total Swiss aviation sector

Security and safety

As pilots will spend more time in a digitalised environment, concerns can be raised of the handling qualities of pilots in actual aircraft. However, if the pilot trainings are properly optimised and technology will continuously develop and improve, this risk can be mitigated.

Feasibility and implementation considerations

Full-electric domestic GA and pilot training are both considered feasible on the short-medium term. As currently electric flight is feasible for short-range flight, full-electric GA is feasible for Switzerland on the short-medium term. Implementing this SO requires private users to invest in electric aircraft, which is a large investment. Incentivising electric flight could stimulate general aviation pilots to switch to electric aircraft and all airports frequented by domestic GA have to facilitate electric flight (charging stations). Furthermore, the electric energy supply needs to be green, in order to maintain a positive impact on climate change. This electric energy could be generated both on-site and off-site.

4.2.4 Multi-modal integration

Overarching goal

The SO "multi modal operation" contributes to two topics in the AVISTRAT vision: efficiency and traffic management. In the AVISTRAT-CH vision all users should have fair and easy access to airspace and aviation infrastructure. The multi-modal connection will make the airport more accessible and eases traveller's overall journey. Traffic management includes the operation of and access (priority rules) to existing infrastructure and the planning of new infrastructure. With multi-modal integration operation, priority rules and planning need to be synchronized along multiple transportation modes so that the combination of modes can become more efficient than before.

Description

Multi modal operation refers to the transport of goods or passengers combining different means of transportation, so called 'transportation modes. Modes of transport can be very high-level, e.g. air, water, and land transport or more specific, e.g. scheduled passenger air transport or high-speed rail transport.

The principle of multi modal transport is that a single journey is completed with at least two different modes of transport under a single contract for maximum ease and with synchronised processes for maximum efficiency. From the perspective of aviation, multi modal implies that a flight is preceded and/or followed by a journey performed with another mode of transport, e.g. train, bus or metro and that the entire trip. Or in the future: a combination of an (self-driving) taxi and a personal air taxi. No matter the combination of modes, all transport modes must be efficiently connected with little waiting time for the passenger and must be carried out under one single ticket.

Single ticketing

Some successful examples of multi modal ticketing already exist such as the Oyster card[10] for public transport in London and the "OV chip card" for all public transport in The Netherlands[11]. Switzerland has the Swiss Travel Pass[12] for train, bus and boat. Some airlines offer a single ticket including the trip to the airport, such as KLM in Amsterdam and some places in Canada[13] and Lufthansa, that offers a combined air-rail ticket in cooperation with Deutsche Bahn[14] but this is still relatively rare. In the 1970's there used to be airlines who offered a single ticket for a plane ticket including transfer from the airport to downtown by helicopter (or vice-versa). This early example of multi-modal integration (and urban air mobility) was quite successful until a number of high-profile incidents, rising public annoyance and a fuel crisis put a stop to commercial, urban helicopter operations.

"I am also a ship" - Ad campaign by the Zurich Public Transport Association ZVV

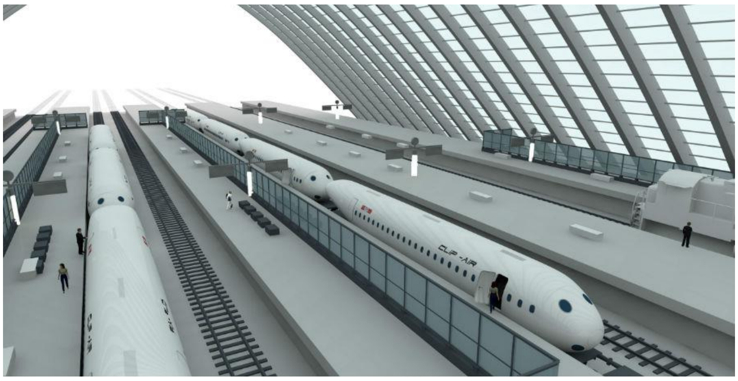
Integrated processes

[10] https://oyster.tfl.gov.uk/oyster/entry.do
[11] https://www.ov-chipkaart.nl/home.htm#/
[12] https://www.swiss-pass.ch/
[13] https://www.klm.com/travel/nl_en/plan_and_book/ticket_information/travel_by_train_or_bus_on_a_KLM_ticket/index.htm
[14] https://www.lufthansa.com/us/en/lufthansa-express-rail-fly

Even if combined ticketing is offered, the connection to and from the airport are usually not integrated in the airport processes. The rail-mobility-provider and air-mobility-provider are mostly unable to impact each other's processes or are even unaware of each other's progress. Thus, if a train is delayed it is just bad luck for the passengers who need to catch a flight. Passengers from other modes of transport are "delivered" at the train or bus station, where they must enter the airport processes from the start. A more efficient multi modal approach would be to offer these passengers a fast processing through check-in, luggage drop-off and security. The Swiss Federal Railways (SBB) offers a service for passengers from Zurich International Airport that allows them to have their luggage picked up and checked in from a home address or hotel or have their luggage delivered when arriving at the airport[15]. Passenger security checks still take place at the airport however.

Multi modal cargo transport is also concerned with the development of containers that will fit in aircraft and are suited for other modes of transport. Cargo transportation by air regularly use Unit Load Devices (ULD), standardized containers that are specially designed the aircraft cargo bay. While efficient for air transport, these containers are less convenient to stack in harbours or load on trucks or train carriages.

In the future, multi modal transport units for passengers may be designed that offer the possibility to stay inside the cabin during a combined rail and air trip. An example is the detachable capsule that is designed in the Clip-Air study[16] of the Transportation Centre at Switzerland's Federal Polytechnic Institute of Lausanne (EPFL)

	
Conventional air cargo containers	Clip-Air multi modal passenger transport

Assumptions

The first assumption to make within this multimodal SO is that as long as the Swiss (and worldwide) demography grows, **the need for transportation of people and goods will grow** as well. As elaborated by the Federal Statistical Office of Switzerland, in all forecast scenarios the Swiss population will indeed grow at least until the year 2050[17]. The types and means of transportation might shift over time, however the overall need for transportation and mobility will continue growing.

The second assumption is related to **increased environmental awareness** of the population, and the shift in European and Swiss politics and society to stimulate and favour environmentally friendly transportation and mobility solutions. The assumption is that this leads to short distance air travel by using conventional combustion engine powered planes being gradually **replaced by other, more sustainable ground-based solutions** (e.g. trains) when technically feasible. Although there is no official definition of short haul by international organization such as ICAO or IATA, it is assumed

[15] Flight luggage: all-round service including check-in | SBB
[16] https://www.railway-technology.com/features/featureclip-air-the-future-of-multi-modal-transport-5008951/
[17] https://www.bfs.admin.ch/bfs/en/home/statistics/population/population-projections/national-projections.html

here that short haul flights are all flights covering a distance of **less than 1000 km** in distance. This assumption, applied to Switzerland would mean an overall reduction of national flights using the conventional combustion engine powered planes.
We also assume the electrification for road transport will continue leading to a wide availability of sustainable options for personal road transport and road transport of cargo in 2035.

This shift away from short haul air travel will last at least **until there is a full-electric option for short haul air travel, which is not expected for 2035**. There are several initiatives for short haul sustainable air travel, however these are all very limited in terms of endurance and number of passengers or cargo that can be transported. It is assumed that no sustainable (i.e. electric or other sustainable propulsion methods) short haul aircraft that can carry anywhere between 50 and 100 passengers will be available in the 2035 timeframe.

The next assumption is related to technological readiness of urban air mobility, and in particular urban air taxis. It is expected that technological developments towards urban air taxis will be reaching maturity as of 2030, however initial large-scale commercial availability will only start towards 2035[18].

Finally, it is assumed that the rail network of the neighbouring countries, in particular the high-speed rail networks, will be further developed.

Recommended actions

The recommended actions for this SO are categorized according to: air and ground infrastructure, regulation, management and others.

Air and ground infrastructure

To have a good functioning and efficient multimodal transport system, it is important that the different transport modes are well connected and adapted to each other, both geographically as well as process-wise (e.g. timetables, ticketing). It is recommended, that for airports with high commercial passenger flights to have at least also a railway or metro connection at the airport, as cars, busses and taxis do not lead to most efficient passenger streams and lead to heavy traffic and corresponding traffic jams in the immediate vicinity of the airport. Switzerland already has a good starting position, of the three largest International airports in Switzerland (Geneva, Zurich and Basel), only Basel does not have an appropriate railway infrastructure available at the airport terminal site. It is therefore recommended to favour Geneva and Zurich for further passenger development, unless investments are made for the Basel airport to connect to the rail transport network more closely.

Regulation

From a regulatory perspective it is recommended that the Swiss government puts in place a regulatory framework that facilitates the multimodal transport development. This framework needs to address current short comings related to single ticketing and compliance to safety and security standards. For example, what happens if a passenger misses a connection due to a delayed transportation mode with another type of transport (e.g. the passenger misses his flight due to delay in the train trip if all is in one ticket. Who will be held responsible and ensure that the passenger gets appropriately compensated?). Other than facilitating multimodal transport development, it is also recommended to oblige all transportation providers to allow cooperation and to make sure all databases in terms of ticketing and timetables are connected.

[18] EC, *Strategic Research and Innovation Agenda – Digital European Sky*, July 2020, Draft edition 01.00

Related to safety and security, standards, means of compliance and oversight needs to be developed that combines the rigor of aviation processes with increased flexibility. Liability can otherwise be a difficult show-stopper to tackle. For example, what happens if a slip in the rail security process leads to an aviation incident or vice-versa? This requires the adaption of an integral safety and security risk management system for the multi-modal system including common risk indicators, incident reporting and integral oversight.

Management

Multi-modal integration requires different modality operators to collaborate even if they compete for overlapping travel segments. This requires a shared goal and business model that can provide synergy which in turn requires an understanding of each other's needs, wants and operation. It is therefore recommended to drive collaboration and exchange of ideas by stimulating multi-modal conferences or inviting different modalities to weigh in on challenges related to new forms of transportation such as drones or urban air mobility.

The following high-level roadmap is drawn based on the description above:

- Map commercially relevant airports for good intermodal connectivity. Especially the position of Basel EuroAirport should be considered to be developed further. Geneva and Zürich could be interesting airports to start experiments.
- Stimulate cooperation between transport providers to offer integrated ticketing for the full journey. Align strategies for all modes of transport. One overall strategy will be necessary, instead of a strategy for aviation, rail, road, etc.
- Participate in international working groups to create consensus in national and international politics to support multi-modal travel as the way forward.
- Invest in (ground) connectivity of other modes of transport to/from the airport.

Predicted effects

The predicted effects for this SO are categorized according to: environment, security and safety and performance.

Environment

This particular SO mode will make it easier to replace travel segments of short haul air travel with sustainable rail or road options. This can lead to a significant reduction of carbon emissions for this segment as electric short-haul air travel is not yet feasible by 2035. With respect to the overall impact of aviation, the effect is limited as most emissions are caused by long-haul air transport for which no real alternative modes exist. The environmental impact can be nullified if the shift to more sustainable modes for the short-haul lead to increased capacity for long-haul air transport or if multi-modal transportation increases the ease of travel to such an extent that the demand for (long-haul) travel surges.

Security and safety

Connecting all systems from the different transportation providers leads to an increased security risk if standards are not harmonized to the same level or if performance indicators are not homogeneous. For parties that are less used to intense security requirements, such as road and, to less extent rail transport, this requires an adaption phase. A failure in one system might have an impact on the other systems, therefore negatively impacting the multimodal transport possibilities. Slips in security for one mode must not trickle down to other modes. From a safety perspective there is less of an expected or predicted impact as the travel segments are still physically separated.

Performance

This SO is all about the performance of the overall transportation system. It will contribute to European goals such as a maximum duration of 4 hours door-to-door travel from anywhere to anywhere in Europe. This goal is set for 2050.

Moreover, the capacity of airspace will increase as the short haul flights will be replaced by more sustainable solutions, therefore freeing capacity for long-haul and intercontinental flights. The downside of these increased performance parameters is an increased complexity of the overall system, in connecting all different data bases, timetables, booking and payment systems.

Feasibility considerations

In order to make a multi-modal transport system feasible in Switzerland, there are several obstacles to overcome. The most important one is that the system will become increasingly complex due to the increasing number of involved stakeholders and systems. The most pronounced example in this aviation context is the dependency on non-aviation stakeholders (e.g. rail and road). Moreover, there is a strong dependence on the neighbouring countries. Switzerland cannot push multi-modal integration independently if its neighbours are not willing to cooperate.

From a technology perspective however, there are no major blocking points that would impact feasibility at this stage. There is, except for urban air taxis, no technologies that are not mature enough that would block further development of a multimodal transportation system. The main difficulty will be to link the different transportation modes, which would all have its own processes.

4.3 Safety & security

In Switzerland, as in most other European countries, safety for people, the environment and infrastructure should be guaranteed if there is an anticipated increase in traffic. With regard to security, a framework must also be created for the authorities involved, which allows the state's security tasks to be guaranteed at all times. The last SO in this section is about public safety oversight on Swiss based service providers. It enables risk-based oversight by assessing the governance in an organization.

4.3.1 Integral Risk Management

Overarching goal

The Swiss government has envisioned that in Switzerland, comprehensive risk management ensures the safety and security of people, the environment and the infrastructure. The content of this SO contributes to the overarching goal by optimizing the risk management process on airport level. The concept has its basis in integral risk management processes. Collaboration between key stakeholders can be seen as the most important element.

Description

In aviation, each service provider needs to have its own Safety Management System (SMS) as prescribed by ICAO Annex 19. An important element of an SMS is the determination of a safety policy and to design and maintain risk management processes. The natural focus of these management systems is the scope of the individual organization. Some risks however are not completely in scope of a management system of an individual organization. Rather, it involves interaction between organizations, meaning that the operation of one organization can impose a safety risk on another operation or, to mitigate the risk for one organization, actions by other organizations are required. A good example is the risk of runway incursions. It involves the airport infrastructure, procedures and handling of ATC and the procedures and handling of airlines. Furthermore, to mitigate the risks concerning runway incursion the organizations are dependent on each other. Runway safety is therefore not solely dependent on the achievements of each individual organization, but also on the way the organizations interact. It is therefore out of the managerial control of just one organization. These interactions and interrelated activities are called the *interfaces*[19]. Hidden in those interfaces are numerous dependencies, trade-offs, and opportunities for improvement, which will not be or poorly be addressed if all those organizations solely address those interfaces within their own SMS. ICAO and EASA recognize the significance of interfaces for aviation safety and provide SARPs with respect to interface management.

ICAO (Doc 9859) states: *"It is necessary to support the management of interfaces across the aviation system"* and *"It* [the scope of SMS] *includes interfaces within the organization, as well as interfaces with external organizations that contribute to the safe delivery of services."* EASA prescribes that aerodrome operators make arrangements and programs with other organization active on the aerodrome and of any significance for safety[20]. However, real hands-on guidance is yet to be developed.

This concept is about integrated decision-making in networks of mutually dependent actors. Within this context, integration refer to a strategic cooperation regarding safety across organizations. The concept includes the creation of an additional 'layer' of risk management on top of existing SMSs of the individual organizations. The respective risks can be investigated collaboratively and safety analysis can be conducted proactively. Sharing information via data and expert judgements enables better insights, improvement, conclusions and mutual understanding.

The level of integration depends on the scope of the system, does the IRM System (IRMS) focus solely on safety risks of the interfaces, or are other domains such as capacity or environment considered. The result of adequate integration in this form is the overall reduction of safety risks in the system as a whole. The 'whole' refers to the boundaries of the ISMS, for example, an airport (as an entity). A good real-life practice of this interpretation of integration is the joint sector ISMS of multiple organizations active on Amsterdam Airport Schiphol.[21] The Schiphol ISMS as an organisation is not a regulated entity, not by ICAO definition nor by the Dutch State. The organization exists to enhance safety across the interfaces of the partners and is situated in a government covenant. The joint sector Integral ISMS applies the safety management principles of ICAO Annex 19 and EASA to the management of interface risks. A difference compared to a 'normal' SMS is that there is no accountable executive for the sector as there does not exist a hierarchical relation between the participating organizations. However, this can be solved by creating a top safety action group, whose members are the accountable executives of each participating organization.

This strategic concept focuses on achieving cross-organizational cooperation and provides the aviation sector with an answer to the increasing complexity of the air transportation systems and the interrelated aviation activities between organizations. While most airports typically have an intra-organizational periodic meeting about safety concerns, this concept is takes that to the next level. Reciprocity is a key value of this process. By adding this concept, an aviation system can be created that is able to dynamically respond to new user needs and emerging threats (proactive and predictive), in close cooperation with relevant stakeholders, in line with the AVISTRAT-CH Vision.

Assumptions

The assumption is that all organization are intrinsically motivated to better manage the operational risks on the interfaces between organization. Several investigations of accidents and serious incidents show that the risks at the

[19] 'Interfaces" are made explicit in the safety regulation concerning changes to the functional system of air navigation service providers. See Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-ATM/ANS.OR Common requirements for service providers

[20] European Commission. (2014). Requirements and Administrative Procedures related to Aerodromes (139/2014). Luxembourg: Official Journal of the European Union

[21] Integrated Safety Schiphol, 'Safety in the Dutch Aviation Sector'<https://integralsafetyschiphol.nl/>

interfaces between organizations are an important factor in the further improvement of safety. Given the increasing complexity and intertwining operations, organizations are already mutually dependent on each other for a safe and effective operation.

Recommended actions

Regulation

First, the government, or more specifically FOCA, will have to make the case for a joint sector integrated risk management system towards all that need to participate. That includes, the biggest airports in the country, ground handlers, Swiss Airlines and other mayor airlines with a hub on Swiss airports, Skyguide, and more. FOCA can learn from existing practices in Europe, in particular Joint Sector ISMS Schiphol[22] and the Luton Safety Stack[23]. The roles of each party involved must be the result of mutual agreements.

Secondly, the collaboration needs to be formalized. This can be done in a covenant or in adding regulation which includes the roles and responsibilities of all parties involved. Special attention should be given to the role of the government and in particular to the role of the aviation authority (oversight). The option should be kept open that the State only plays a facilitating role as part of their Safety Promotion activities, but is not a formal part of the integral risk management organization.

Management

Third, a manual has to be developed that describes the system in terms of:

- Scope;
- Processes;
- Responsibilities;
- Roles;
- Risk management method addressing;
    - hazard identification
    - risk analysis
    - risk classification
    - risk prioritization
    - risk mitigating measures
- Document control and data.

The substance of the manual has to be developed in close cooperation between all stakeholders.

Other

One of the key elements of a successful process towards the identification and management of risks, is the development of adequate IT tools for data collection, storage and (automatic) links between data, risks, barriers, trigger events, et cetera. This system should be fed with safety information from numerous sources.

[22] https://integralsafetyschiphol.com/
[23] https://skybrary.aero/bookshelf/books/4159.pdf

Predicted effects

Environment

An improvement in safety reduces the probability of accidents, hence reduces public anxiety.

Security and safety

Implementation of these concepts does not have a direct impact on safety or other domains. However, it facilitates better management of Safety and better management of safety in conjunction with other management domains, like capacity and environment. The benefits and applications of these concept are almost limitless:

- All organizations are better aware of the (safety) risks it is exposed to, primarily because of a more integral view on the hazards of the operations. A (complex) problem can be assessed from different (operational) perspectives, allowing for better decision-making.
- Against the background of the AVISTRAT changes, the integrated risk management system can provide input for the public debate and politics. Thereby the impact of the changes due to AVISTRAT on safety, but also performance and environmental impact could be communicated to society. In addition, the decision-making process can be made more inclusive and transparent making it more likely to prevent resistance.
- With respect to aviation safety, this concept contributes to a high standard of safety in the Swiss civil aviation sector.
- This integration by means of cross-organizational cooperation provides the aviation sector with an answer to the increasing complexity of the air transportation systems and the interrelated aviation activities between organizations.
- The data and information produced by IRM can, probably under pre-conditions about liability, be used by FOCA for their supervision. Since risks are the scope of the system, the data and information can help realize a more risk-based oversight approach.

Feasibility considerations

For a joint sector integral risk management to work properly, all accountable managers should be intrinsically motivated for extensive collaboration on bringing the safety standards to the next level. That intrinsic motivation is not a given. The safety accountabilities in aviation are fixed by regulations, most of which laid down in European regulation and worldwide standards. In this context parties are not allowed to transfer safety responsibilities other than accountable managers of their own. Therefore, this concept requires that decisions are instead made by consensus. The need that the top of all organizations is intrinsically motivated is thereby evident. Organizations can be reluctant in sharing information and giving other organizations insight in their operation. However, because there is no competition on safety, and with good agreements, it is possible.

While some legislation[24] might give some starting points for the legislative and control branch of the government to put some light pressure on organizations to pay more attention to the interfaces and their risks, a clear legal obligation for organisations to participate in such an extensive collaboration project is missing.

Ideally, the authority is involved so that they can incorporate the insights and knowledge out of the integrated risk management system into their Risk based oversight. However, supervised organizations may be inclined to withhold

[24] Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Authority, Organisation and Operations Requirements for Aerodromes, part ADR.OR.D.025 Coordination with other organisations

sharing of essential information or may be inclined to fewer commitment if the information can be used in the formal oversight.

Implementation Considerations

It makes the most sense to enrol this integrated risk management (IRM) concept on the busiest airports of Switzerland, which naturally are exposed to most risks on interfaces. Note that here integrated risk management is described on airport level, where airport refers to the entity and not the airport as an individual organization[25]. The scope of the integration may also be defined differently, for example it could focus on the complex airspace around Zurich Airport, with its 17 TMA's and many General Aviation activities in close proximity of the airport. The resulting risks can then be managed in a more formal collaboration construct, with stakeholders like Zurich Airport, Swiss Airlines, Lufthansa, Skyguide and representatives of the many General Aviation airports and most active General Aviation organizations.

4.3.2 Integral security framework

Overarching goal

Security[26] is an important element in AVISTRAT-CH vision, whereby security also explicitly means the military security tasks. The need for a high security standard is high among all players and should therefore undisputedly remain a top priority. Security is a broad concept, the requirements for civil aviation is described in [ICAO Annex 17] and [Regulation (EU) No 300/2008], which states that every State is required to develop a National Civil Aviation Security Plan (NCASP). Each Contracting State shall establish and implement a written NCASP to safeguard civil aviation operations against acts of unlawful interference, through regulations, practices, and procedures, which take into account the safety, regularity and efficiency of flights. That's just the civil side of security, of course there is also a military side. Cyber-attacks pose a significant threat to the safe and efficient operation of modern military aviation systems.

This proposed SO aims at ensuring that the critical systems, infrastructure and people are appropriately protected from traditional and non-traditional emerging threats by developing an integral and inclusive national aviation security framework. In short, an (updated) national aviation security framework is needed to make sure that the aviation system is a trustworthy and dependable environment, so that aviation stakeholders will be able to rely on services and information provided by others for the accomplishment of their operational objectives. In addition, it is needed so that the system-of-systems is capable to adapt and therefore, to withstand new threats without significant disruptions.

Description

As the world of aviation is growing ever more interconnected and digital, both the civil and the military air traffic infrastructure are considered to be a target for unlawful actions. In a system where physical and software components are deeply intertwined, as in many systems used in aviation, the risks of cyber security incidents that could directly impact the safety of the air traffic system and society are increasing. Examples are the use of drones in urban-areas where security attacks could divert the drone from its intended flight plan and harass (emergency) flights, or the hacking of aircraft systems in flight and sabotage critical systems. Recent investigations by hackers, researchers, and flight authorities raise questions if the performance of the current, and thus far successful, safety management found in aviation is sufficient and appropriate to address the emerging hazards posed by cyber threats, especially in the light of new technology like the widely accessible drones.

[25] The airport as an organization is part of the airport as an entity, just like Air Traffic Control (Skyguide), airlines, ground handlers, and others.
[26] Security: the efforts to avoid damage caused by unlawful interference by third parties.

From a strategic perspective, in order to maintain a high security and safety level, it is crucial to re-examine existing security efforts by the aviation and defence community and combine the viewpoints of various stakeholders including researchers, industry, military flight agencies, civil flight authorities, airlines, airports, manufacturers, and air traffic control into a new security framework, which allows the state's security tasks to be guaranteed at all times. It is thereby crucial to continue on the learning paths already set, such as harmonizing regulations with neighbouring countries after flight collisions in the Swiss-controlled airspace, for example the accident Überlingen in 2002. By supplementing existing civil regulation where necessary, the Swiss civil and military authority must now equip the Swiss aviation system with a security framework that, by design and sufficient through-life support, will ensure the Swiss critical systems and infrastructure are appropriately protected from traditional and non-traditional emerging threats.

Assumptions

The need for a new security framework that is both future-proof and developed in an inclusive process is the ongoing digitalization of all aspects of society and the cyber threats resulting from that. Other relevant aspects are the growing entanglement of 'the digital' and 'the analogue' and the emergence of new airspace users, in particular drones that are increasingly becoming available for a broad spectrum of operator types, including private individuals. Another assumption is that there is always a threat of individuals or groups that have malicious intentions or perform actions that are a security threat.

Another important assumption that justifies the need for a new framework is that society cannot solve the security risks without intervention of the government. To solve the societal problems resulting from the aspects discussed above, effective regulation is needed and/or military equipment. Aviation stakeholders understand that a common strategy and framework is necessary to take control of the future evolutions.

Recommended actions

Regulation and Management

A strategic framework for maintaining a high level of safety in Swiss includes the production of a regulatory framework. The whole framework should be embedded in ICAO Annex 17 requirements, military and society needs and a for Swiss specific analysis. The development should contribute to an Aviation cyber-resilient system, which under attack, can maintain its essential functionalities. That includes the civil aviation and military aviation. In addition, it should contribute to self-strengthening by adopting a "built-in security" approach, which considers security objectives that need to be achieved along with traditional operational and safety objectives.

This requires the creation of a national aviation security committee tasked with the development of a framework. It should be based on an inclusive process, under the direction of FOCA[27]. The following actions should be considered.

It is essential that the development of framework is an inclusive process to make sure the substance is shared along the entire Swiss aviation community; therefore, the following tasks should be included in the process:

- Liaison with international organization concerning matters of civil aviation security;
- Liaison with government departments concerning matters of civil aviation security;
- Liaison with military departments and organizations concerning matters of military aviation security;

[27] https://www.easa.europa.eu/sites/default/files/dfu/Cybersecurity%20Strategy%20-%20First%20Issue%20-%2010%20September%202019.pdf

- Identify possible forms of collaboration in relation to stakeholder needs, such as good practices, information on new threats and vulnerabilities and, finally, the need for mutual support for threat analysis, incident response and management;
- Develop and agree upon a methodological approach, based on solid industry standards, to introduce the risk assessment in both the ground and air domains for critical systems;

As input for the security framework, it is essential to know the 'things' that need to be secured in Swiss aviation and the things that impose the highest security risks, therefore:

- Identify the Swiss aviation 'critical systems' and their minimal functionalities;
- understand the level of protection required (confidentiality, availability and integrity) of these systems;
- Perform a national integral security analysis, identifying the highest security risks and identify future risks.

As input for the security *regulatory* framework the following should be done:

- Perform an (gap) analysis on prevalent security framework(s) in Swiss aviation, based on EASA and ICAO guidelines and the results of the previous tasks;
- Develop a new regulatory framework based on the results of the previous tasks;
- identifying the best possible implementation, articulation and means of compliance for all the legal requirements for cybersecurity in aviation that are to be published or amended.

Predicted effects

Security & Safety

The effects of an (updated) aviation security framework is maintaining a high level of security while contributing to managing safety risks (derived from security incidents). An updated regulatory framework based on a gap analysis between EASA and ICAO regulation and guidelines means that Swiss Security regulation and policy is compliant with international standards and requirements. In addition, it contributes to continuation of a high aviation performance in Switzerland.

Feasibility & implementation considerations

The quality of process towards the development of a security framework is critical. Uncoordinated and exclusive developments of aviation regulations and associated compliance requirements will address security and cybersecurity risks in a dissimilar way, resulting in competing and potentially conflicting requirements and unnecessary burdens for aviation stakeholders and competent authorities

4.3.3 Public oversight on quality of governance

Overarching goal

With respect to safety, the AVISTRAT vision is strongly based on identifying comprehensive and valid (safety)risk criteria, safety performance indicators and targets and solid risk management, including monitoring. This also facilitates risk-based oversight by the civil aviation authority. The underlying assumption in this vision is that safety is more or less quantifiable and measurable. However, in reality it has proven to be a challenge to identify valid criteria to serve as a reference for base risk-based oversight

In practice, safety and risk in aviation are often hard to quantify. For the CAA of any country it is therefore hard to really perform risk-based oversight. For this reason, the transition from compliance-based oversight towards system and risk-based oversight is still ongoing. In this SO an additional oversight strategy is presented: the public oversight on quality of governance or board[28] oversight. It contributes to the overall management of safety and risks in the Swiss Aviation system. It enables risk-based oversight from another perspective than performance-based oversight.

Description

Traditionally, oversight is performed by FOCA by means of formal inspection-audits and formal approval of the documents supplied by the supervised organizations. The nature of this form of oversight is highly normative. In doing so, the authority assesses the situation in an organisation and compares it with legislation and regulations. In 2013, the Dutch Scientific Council for Government Policy (WRR) recommended that an authority must look beyond the boundaries of legislation and regulations, in search of risks and threats for the entire system it supervises[29]. Safeguarding public interests should be taken as the starting point in oversight. Oversight also has a reflective function in this regard: identifying and setting on the agenda developments that affect the safeguarding of public interests.

The safety policy and safety targets of an organization are determined by the highest executives of an organisation, the board. The policy and targets have a strong steering function within an organisation. The executives are responsible for providing enough means and resources to achieve those targets. The realisation of those targets is partly dependent on the management of hazards and the identification of risks. For example, for an organisation to have a high level of safety, it must identify and manage safety risks. The acceptance of risks is ultimately a responsibility of the executive branch (more specifically of the accountable manager). Furthermore, the board has to provide enough means and resources for risk control measures. Finally, the executives are an important element in an organizations culture. From a top down perspective, they can encourage a certain (safety) culture.

This highlights that the board of an organization is an important element in managing safety within an organisation. Their conduct and decision-making affects strongly the risks an organisation is exposed to. Their behaviour is both a potential source of risk and a safeguard at the same time. By looking at the governance[30] of an organisation, that encompasses the conduct and decision-making of accountable executives, a certain interpretation can be given to risk-based oversight. Important questions are “How does decision-making take place?” and “which considerations and sentiments play a role in this?”.

Management-oriented oversight has common ground with system oversight. In system oversight, external oversight focuses on the quality of ‘quality systems’ and ‘safety systems’ or business processes of the parties under supervision. Governance and the company board and management form part of the system. In board-oriented oversight, the board and the management are the object of supervision. Not the systems, but they themselves are the primary leverage point for quality improvement. With board-oriented oversight, the external supervisor enters into a dialogue with the board about the definition of quality and possibilities for improvement, in order to stimulate the quality of services. The inadequacy of checks and balances and the risks of co-optation, collusion and "capture" has often been pointed out for inadequate management of public interest. For that reason, board-oriented oversight can have positive effects on decision-making in those organisations.

[28] Please note that depending on the scope of the oversight, management oversight is also a possibility.
[29] WRR. (2013). Toezien op Publieke Belangen. WRR-rapport 89. Wetenschappelijke Raad voor het Regeringsbeleid. Amsterdam University Press, Amsterdam
[30] Governance refers to structures and processes that are designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation

The trend towards governance-oriented oversight is consistent with a development in which the role of the government is shifting towards meta-governance: control of the networks and administrators who bear direct administrative responsibility for public interests, like safety[31]. Board members have become the point of contact for the external supervisor. Relevant talking points are the operational risks and the management of those risks. The policy theory of governance and board-oriented oversight is that by supervising the board, the external supervisor can stimulate the administrative responsibility for quality assurance and can better determine the intensity and interpretation of external supervision that are necessary to ensure compliance with legal requirements and field standards. Management-oriented oversight works indirectly because it creates preconditions for the quality of services, like safety.

Assumptions

It is currently not possible to fully perform risk-based oversight solely by means of compliance oversight and performance oversight (including system oversight). Compliance based oversight is seen as very labour-intensive and also has further disadvantages[32] (Helderman & Honingh, 2009). For example, traditional compliance supervision would cause too little a stimulus for learning, and important dependencies within systems that partly determine the output, are missed. Performance based oversight has the flaw that safety cannot be directly measured. Therefore, we use proxies, like risks, to measure safety performance. Those will never get the full picture of safety. The assumption is that this will not change, and the need for another oversight model to fill the gap will always be there. Public oversight on governance is a model that can give substance to that gap.

Recommended actions

Regulation

This concept is not new in public administration. It is probably already widely used in different branches. However, few practices are known in aviation industry, mainly because the oversight there is compliance and performance oriented. In addition, there is not a clear regulatory framework to perform oversight on the governance of an organisation, or to perform oversight on the handling and decision making of board members and other management.

A first step is therefore to perform research about the legality of this oversight model. Is there any legal anchoring of the performance of board members and managers and other governance aspects (for example in the liability law)? If so, is it providing a framework or standard to base the oversight on?

Whether the answer is yes or no to both questions, it probably needs further elaboration towards a solid assessment framework, including tools to achieve behavioural change (for example with sanctions), for inspectors. Please note that this model of public oversight might not need legal anchoring. It could be based on mutual agreement with the organisation subjected to oversight. For example, it could be part of a coherent agreement about less supervisory burden and more risk-based oversight. The board and/or managers provides the authority with valuable insights about the governance of the organisation that must be used for targeted oversight.

Rules acquire meaning through the interpretation given to them by people. It is therefore relevant to also consider the people who have an executive and steering role at all levels of the organization in supervision. The competences, skills, management style, etc. are at least as important for the functioning of the SMS as the rules. Either if it is legally anchored or not, this model of oversight can increase value to public interests.

[31] Kooiman, J., & Jentoft, S. (2009). Meta-governance: Values, norms and principles, and the making of hard choices. Public Administration, 87(4), 818-836.
[32] Helderman, J.K. en Honingh, M.E. (2009). Systeemtoezicht: Een onderzoek naar de condities en werking van systeemtoezicht in zes sectoren. Den Haag: Boom Juridische uitgevers

Management

It is important to create an assessment framework for inspectors to perform predictable and consistent oversight. This framework must be developed considered the following:

- There are situations in which a "good" professional judgment is the dominant trigger for action. In complex situations, behaviour is difficult to standardize and program and it is therefore particularly important to think and discuss and reflect upon considerations. If thinking (reflective improvement) is the goal, more open norms may be beneficial.
- Key concepts in a well-functioning safety management system are: integral, intrinsic and boardroom driven. Integral means that there is a common picture of the problem that must be tackled. That is not self-evident within a single organization. Intrinsic means that the activities are carried out with a sincere conviction and not just because training has been followed or because an outsider says they must. Boardroom driven means that the highest management acts as a role model for the rest of the organization. This are all subjects for an assessment framework for oversight on governance.

Predicted effects

Safety

Performing oversight on governance and thereby encouraging administrative responsibility can lead to a higher quality of service along three lines:

- First of all, board-oriented oversight can possible have an agenda-setting effect, because the focus on management quality assurance of the external inspector influences the internal agenda of the management of the institution.
- Subsequently, board-oriented oversight means that the board knows that its own role is more on the radar of the external inspector. This can lead to more widely considered decisions and better overall decision making.
- Finally, board-oriented oversight at a more individual level may strengthen the "perceived accountability of directors, with predominantly positive effects on their decisions and actions.

Well-functioning governance within organisations can prevent many problems, such as a less assertive approach to financial problems, breaches of integrity and shortcomings in compliance.

Performance

The main focus of this SO, of safety oversight, is enhancing safety performance of all organisation. Safety and overall performance go hand in hand. With better focus on governance within an organisation, it may result in better overall performance management.

Feasibility considerations

Public oversight whereby inspectors act explicitly in the name of public interest, like safety, requires that three conditions are met, related to the core values of public oversight. Oversight must be impartial, must be independently positioned and must be accountable to the public. Independence is a formal status and impartiality is a characteristic of an attitude.

It must be prevented that the attitude of the inspector to the person subjected to oversight shifts from reflecting and signalling to consulting. When, over time, an inspector starts to identify with the interests and objections of the sector, independent supervision is at risk. This is also referred to as "adhesion" or "regulatory capture"[33].

It can be argued that the operational sector has substantive knowledge (about the operation), expertise and relevant data, and that the role of the authority can therefore be limited to (remotely) assessing the processes, without diving into the content. An inspection that "remotely" fulfils the supervisory role and thereby verifies whether sufficient controls are in place for effective safety management can be a recipe for reduced oversight burden for the sector. However, too much confidence from the authority in the self-reliance and expertise of the person under supervision has gone wrong more than once. Safety management in Switzerland[34] two decades ago, the Nimrod safety case[35] and the certification of the Boeing 737 Max[36] are examples of how well-meaning organizations are slowly and unnoticed losing their grip on safety. Rasmussen[37] and Dekker[38] call this "drift into danger" or "drift into failure". Oversight on the governance and board dynamics of an organisation provides an extra barrier for this to happen.

If this oversight model is implemented by FOCA, their inspectors must participate in the board processes of the organisations, while retaining its own role and responsibilities. It should *not* act as an advisor for the organisation under supervision. It should strengthen its reflective function (signalling and putting it on the agenda). This requires a more horizontal relationship between inspector and person(s) subject to supervision, involving constructive interaction. In short, the method of inspection, the method of sanctioning and the knowledge and skills of the inspectors will be different from traditional supervision.

This segment is completed with the special notion that this oversight model is especially suited for collaboration constructs like the SO proposed in 4.4.1: Integral Risk Management.

4.4 Fair airspace access

The current Swiss airspace is limited in volume due to the relatively small size of the country (+/- 41.000km^2), however is a very busy airspace with high number of commercial operations, mixed with many military and general aviation operations. Due to the mountainous nature of the country, there are also many national flights, which would not exist in other EU countries with similar sizes but without mountains (e.g. the Netherlands, Estonia). As highlighted in the introduction, there are many national and international airports, both for civil (commercial and non-commercial) and military usage. It is in the ambition of FOCA to keep this volume available for the highest number of users, as highlighted in the AVISTRAT Vision, in order to maximize the benefits of the airspace. The key challenge will be to keep the airspace dynamically (both in time and in geographic location) accessible for a variety of different users, while ensuring a low complexity of the airspace (complexity of airspace further developed in chapter 5.4.3), a minimal environmental impact and (as always in aviation) a highly safe and secure airspace.

[33] Posner, R.A. (1974). Theories of economic regulation. Working paper No. 41. Center for Economic Analysis of Human Behavior and Social Institutions, National Bureau of Economic Research, New York.
[34] NLR rapport 'Aviation safety management in Switzerland', 2003).
[35] Lord Haddon-Cave. The Nimrod review, 2009.
[36] House Committee on Transportation and Infrastructure. The Boeing 737 MAX aircraft, preliminary investigative findings, 2020.
[37] Rasmussen, J. (1997). Risk management in a dynamic society, a modelling problem, Safety Science Vol. 27, No. 2/3, p. 183-213.
[38] Dekker, S. (2011). Drift into Failure: From Hunting Broken Components to Understanding Complex Systems.

4.4.1 Airspace allocation by AMC using predefined BPPR for civil, military and GA

Overarching goal

The SO “Airspace allocation by Airspace Management Cell (AMC) using predefined Booking Principles and Priority Rules (BPPR) for civil, military and General Aviation (GA)” contributes to three topics in the AVISTRAT vision: efficiency, traffic management and infrastructure and spatial planning. In the AVISTRAT-CH vision all users should have fair and easy access to airspace and aviation infrastructure. The division of airspace in time and space/volume should be made in a way that is satisfactory for all stakeholders: commercial Aviation, general aviation, military aviation, government (Police, REGA,…) and the upcoming market of drones. Drones are mostly expected to fly in Very Low Level (VLL) airspace, and the management of this will be elaborated in chapter 5.4.4. The design of airspace should be done on the basis of needs and the management of it should be controlled in a flexible manner.

Description

The current way of defining airspace is mostly done on a static basis, the class of airspace and its operations is defined in the national AIP and usually does not change very often. In Switzerland there are some areas that can be reserved for military training and operations, general aviation or special events (e.g. the World Economic forum in Davos). These main reservations are done now in the beginning of the year and agreed upon with the aviation community. This process is not very flexible and doesn’t always allow the most efficient operations as if it would be done on a day-by-day basis. The weather is the most common example of a factor that cannot be planned a year in advance, however, it can have a major impact on a specific military training or operation. For this reason, it is recommended to go for a more flexible way of using and reserving airspace.

Flexible airspace

In fact, airspace should not be seen as purely military or civilian, but as a national asset, as indicated in a vision defined by Eurocontrol[39]. The introduction and further elaboration of Advanced Flexible Use of Airspace (AFUA) is one of the tools that will allow the Swiss airspace to remain ‘future-proof’. The proposition of AFUA is to have airspace planned and used in a flexible way and on a day-to-day basis by all categories of airspace users. Within such a concept there could be one or multiple (e.g. corresponding to the current FIR’s) AMCs, the centres that are responsible for attribution of airspace to the different users on a pre-tactical level. The target of such an AMC will be to try to meet the requirements of the civilian and military user needs. Overall network performance can be one of the measures to evaluate this attribution. The attribution can be adapted on a day to day basis, making the allocation of airspace temporary. Users can be informed by already existing notification measures (e.g. NOTAM) about these reservations, or by a still to be developed system, the BPPR.

For implementing this concept, system support tools are needed to deal with the new situation. These tools should be centralised and automated systems that are driven by users. The system support tools will include interactive charts, also with user interfaces for mobile and handheld devices. The adoption of AFUA stands or falls with an easy-to-use system that is accepted by all stakeholders!

The Daily Airspace Bulletin Switzerland (DABS) is a good initiative in this direction, however further evolution is needed. This kind of tool should be interactive and not only informative (now information is only displayed about current status, but requests for airspace reservations cannot be made here). The current reservation systems are evaluated as complex

[39] https://www.eurocontrol.int/concept/advanced-flexible-use-airspace

and time consuming. Also, the current DABS is mainly intended for general aviation, however also commercial aviation could benefit from such a tool as some military training areas go into altitude bands used by airlines.

Local and sub-regional airspace management support system (LARA+) is a software package developed by Eurocontrol and can be seen as an advanced CDM platform, enabling amongst others the AFUA principles and increases situational awareness of civil and military stakeholders. Allows strategic planning and airspace activation processes.

In order to optimise the usage of the airspace, there should also be a possibility to dynamically reserve only very specific volumes of airspace, such as for example connecting corridors and transits. These corridors will just serve to feed traffic within/towards a certain airspace volume. Corridors/transits lead to a slight increase in complexity, however the benefits of keeping a larger volume available for other airspace users largely outweighs this drawback.

Harmonisation

Another topic to address when looking at the airspace is the harmonisation of the different rules and exceptions across the country. From interviews with local experts[40] it deemed that this is still a major issue in Switzerland, and should be tackled. Aviation is by nature an international environment, especially commercial aviation. However, in Switzerland there are also many international general aviation activities, pilots from all over Europe come to Switzerland to enjoy flying in the beautiful Alps. For these reasons all the rules, standards and also expectations of airspace users should be the same. It is not recommended to make ‘Switzerland specific rules’ as this will lead to additional complexity. There is a clear need to update and harmonise between sectors, volumes and airports. A simple example is the minimum hand over or radar vector altitudes. These are not always aligned with each other, causing for problems during the operations impacting the overall efficiency. The IT and ATC systems play an important role in this, and it should be investigated if there is room for a nationwide update programme.

Clustering and centralisation

Another possibility to increase the overall efficiency and flexibility of the Swiss airspace system is to cluster certain airspaces or cluster certain operations within the airspace. An example is to make dependencies between the departure and arrival flows between different airports. The dependencies would be time based. By doing this it is possible to centralize the traffic services by means of for example remote towers. An advanced departure and arrival manager will be necessary tools for this. With this solution airports can remain accessible and benefit of a wide set of ATS services, without increasing the overall number of air traffic controllers.

Assumptions

The main assumption, in line with the AVISTRAT Vision CH, is that the Swiss system is becoming overcrowded and too complex and expectations are that without changes the number of infringements and other incidents will increase and overall perceived satisfaction of the different stakeholders will decrease. To make such big changes as described before there is a strong need for all involved stakeholders to support this change process, the assumption is therefore that the political process is open for changes and willing to negotiate. There will be no strong blocking arguments from certain user groups or stakeholders both national and international (i.e. the neighbouring countries).

Furthermore, it is assumed that there will be no radical changes in the military training and operations needs in the coming decade (e.g. no fifth-generation fighter introduction). This means that the current sizes and location of the military airspaces are sufficient. The change will be in how and when they will be operated (e.g. introduction of corridors) rather than in their overall volume.

[40] Interview held with Swiss airspace experts from BAZL on 18th November 2020

The final assumption is based on the need for automated and continuous data sharing, that all stakeholders are willing to following such a data sharing process in order to make a CDM process possible.

Recommended actions

Air & Ground structure

Firstly, it is recommended to investigate what specific system support tools are required for implementing the more flexible concepts of Airspace. Examples of existing systems are already listed in the paragraphs above. An overall update of the ATM systems could be the trigger to do so, as from interviews with local experts it deemed that many systems are outdated.

Regulation

Secondly, it is recommended to follow the international standards as much as possible and avoid making 'Swiss only' rules and exceptions

Management

The last recommended action is to set up a specific working group that has a very clear mandate. The changes required in the Swiss airspace system require support from all involved stakeholders, and one of the problems today seems to be conflicts of interest in the political space that block any kind of change in the airspace or in the operations. The possibility to involve an external mediator should be further investigated.

Predicted effects

Environment

- Increased flight efficiency when not avoiding otherwise reserved/segregated areas (reduced track miles, with all corresponding benefits as reduced fuel burn, CO_2 emissions, …)

Security & Safety

- Simplification of overall airspace system, including the planning and booking system

Performance

- Reduction in airspace segregation needs and thus overall increase of airspace usage efficiency
- Increased overall availability of airspace
- Increased flight efficiency when not avoiding otherwise reserved/segregated areas (reduced track miles, with all corresponding benefits as reduced fuel burn, CO_2 emissions,…)

Feasibility and implementation considerations

The main feasibility considerations are linked to the given benefits to the overall aviation ecosystem and not one stakeholder in particular. The new designs and operational principles should cover all basic needs of the different stakeholders and in such a way become acceptable for everybody.

4.4.2 “Best equipped best served”

Overarching goal

The SO “Best equipped best served” contributes to three topics in the AVISTRAT vision: efficiency and traffic management. In the AVISTRAT-CH vision all users should have fair and easy access to airspace and aviation infrastructure. To support the vision, stimulating innovation, meeting environmental goals and strategies to avoid flying with outdated, polluting aircrafts a change is necessary. In order to do so, this SO’s goal is to introduce a prioritization scheme based on equipment.

Description

Historically the ATM services are provided on a ‘first come first serve’ principle, with for example the departure or engine on clearances given to whoever asks first. This concept however does not stimulate airspace users to fly with the latest type of aircraft and equipment. Hence, the main assumption is that the latest technology is more beneficial for all sorts of environmental reasons (noise, pollution, etc.). This SO proposes a shift in principle towards a reward system for more preferable technologies, instead of the ‘first come first serve’ principle. This reward system is referred to as ‘best equipped best served’ or as the ‘most capable, best served’ principle. The concept is to provide ATM benefits (e.g. priorities, access to specific routes, timeslots, …) to aircraft with best CNS equipment (i.e. avionics) or with best engine technology (noise and fuel consumption). The system can be complemented with a punishment system, for example to block aircraft to take off or land during specific time slots.

This principle of ‘best equipped, best served’ is often used to accelerate uptake of certain technologies. A good example is the uptake of electric vehicles in Norway. The country wanted to get rid of the polluting combustion engines in their car fleet, and came up with various of benefits for users of electric vehicles. For example, electric cars could start using certain bus and taxi lanes, and did not have to pay a city tax. It is expected that the same principle can be applied on the airspace and its users, in order for the airspace to become more efficient whilst trying to reduce the environmental impact. While Switzerland is compared to Norway and other Nordic countries frequently, it can be generally said that in Switzerland there is still quite some development potential regarding environmental perspectives in structures and regulations. Below are two examples how this principle could be tailored towards an ATM operation. Further examples are numerous.

- Example 1: Only allow aircraft with small noise footprint to fly a more direct/shorter route over inhabited areas. Louder aircraft will be obliged to follow a longer route avoiding the inhabited areas.
- Example 2: Only allow gliders with FLARM (or other collision avoidance technology) on-board to fly in specific areas where high concentration of gliders is expected.

The system is already in place to some extend in Switzerland with routes that are only RNP capable or RF capable, however these routes often were not published with the idea of rewarding the final users but rather the ATC operation. This should be further developed and focus on these benefits. In terms of avionics, PBN can be a key enabler for this SO. For engines and aircraft noise it is more difficult to divide into environmental scales.

The principle can also be applicable for the upcoming drone market. It is with this principle possible to only allow drones over specific areas if they have the correct equipage. An example is highlighted below:

- Example 3: Only allow drones in urban areas when equipped with highest available safety equipment (Sense and avoid, Robust datalink, Recovery systems, …). Allow drones with less safety equipment to fly only over rural areas where risk of incident/accident involving people or personal property is less

Assumptions

The main assumption here is that, especially given the Corona pandemic, the airspace users and operators will have the financial capabilities to invest in newer technology. The second assumption is that all or the majority of stakeholders will support a system that prioritizes and incentivizes according to equipment levels and configuration. Thirdly, this SO favours performance-based regulation over prescriptive, specification-based regulation.

Recommended actions

Regulation

- Set up a legal framework where the punishment aspect of the operations can be enforced, as well as where the benefits can be claimed

Management

- Depending on the financial capabilities of all stakeholders, it is recommended for the government to put a financial support program in place that will support the airspace users with their investments.
- There should be a clear definition and awareness campaign about the actual benefits and how they can be measures and enforced.
- Boost innovation and stimulate usage of latest technology.

Predicted effects

Environment

- Decreased environmental impact of the individual operations

Performance

- Increased adoption and usage of latest technology. On the long run the airspace users will all have the desired capability (=the most advanced state of the art).
- Increased efficiency of the ATM system.

Feasibility and implementation considerations

There are several considerations to be made with regards to the feasibility of this SO:

- There is an existing challenge with this principle to find the right balance between the individual operations and the overall airspace and network performance. As not all users will have the desired state of equipment, especially in the beginning phases of new technology, it is possible that some issues of mixed mode traffic appear.
- With this mixed mode operations, there is an increased workload for ATCOs. The ATCOS have to consider yet another aspect in the way they handle their traffic and operations.
- The predictability of the overall concept will decrease as it will not always be known in advance what the capabilities are, especially with foreign airspace users.

As in the SO of Airspace Allocation, the major implementation consideration is here to follow a stepped implementation approach and start off with easy measures in one specific TMA. The lessons learnt and proven benefits will help with overall acceptability and will facilitate further implementation.

4.4.3 Continued adoption of U-space for VLL airspace (incl. VFR traffic) especially in urban regions

Overarching goal

U-space is the traffic management services for drones and consists of services offered as a set of agreements, protocols, communication means and standards that together will ensure that the growth of unmanned traffic takes place in a controlled and regulated way. U-space offers services that must ensure safe and efficient use of the airspace by specifying a link to air traffic control for manned aviation.

The SO "adoption of U-space" contributes to several topics in the AVISTRAT vision (sentences in between quotes are references to the document):

- Societal Trends and Policy = "This means that changes in terms of needs (e.g. emerging demand for electric flight taxis) must be anticipated …";
- Technology and Innovation = "further developments of existing technologies as well as disruptive innovations (e.g. U-Space) as well as the advancing automation and autonomy of systems will continue to strongly shape aviation in the coming years …";
- Efficiency = "The aviation system enables long-term planning of the use of and the access to airspace and aviation infrastructure. The aviation system leaves room for creativity and innovation …";
- Infrastructure and Spatial Planning = "… the future structural design of airspace and aviation infrastructure should be able to deal with these technological and socio-political developing changes dynamically." Also, here it is mentioned that the "… structural design of the aviation system should allow safe, flexible and easy use … of the aviation ground infrastructure …"
- Regulation = "The regulation should react more quickly to new requirements - for example, to new user needs (e.g. needs of drone users …";

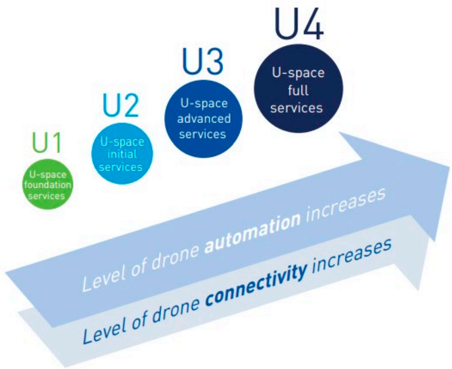
The topics environment and safety are affected by the introduction of U-space as well, be it that these elements are directly interwoven with the introduction of U-space, hence not mentioned above as contributing to environment or safety.

Description

U-space will become part of the airspace system, where in a cost-effective way, real-time access to all airspace users, manned and unmanned, can be granted and where a large number of operations can take place simultaneously. This will enable drone operators to plan and execute their missions in an optimal way.

U-space is going to play an important role in the use of drones and will become an enabler for new applications and operations. EASA[41] is responsible for defining EC-wide regulation that is also available to Switzerland. This European-wide approach will ensure interoperability between the different countries and it is expected that Switzerland will apply the rules as well and make them national regulation.

U-space phasing is set up by SESAR, through the definition of a number of services, clustered in phases U1 to U4. Phase U1 is the foundation phase on which the more complex services will build; while phase U4 provides the full services, though their exact definition is not yet provided.



The (U-space Blueprint, 2017)[42] does not provide a timeline for the implementation of different services, but most U1 services will need to be implemented in 2021 after availability of the EC-regulation. Around 2030, U3 will be operational[43], which implies that drones will be able to fly in all airspaces, including busy areas with many drones and together with manned aviation. Capacity will be managed and conflict detection will be available, either on-board the drone or on through a connection with a ground-based service. Many functions will be automated.

The conceptual specification of U-space is set up by SESAR and is called CORUS (Concept of Operations for European UTM Systems)[44], and aimed at providing services. These services can be provided by different (commercial) stakeholders as component in the total package of U-space services. U-space Service Providers (USSP), or Drone Service Providers (DSP) are responsible for the service-oriented functions like planning, monitoring and detect-and-avoid. EC's vision is to allow an open marked, where drone-operators can use the USSP of their choice and services are offered at competitive prices. Interoperability is guaranteed by the use of European or world-wide standards. Very specific services can be provided by specialized parties, such as meteorological service providers.

The proposed EC-regulation addresses the following U-space services, based on (but not 100% compliant with) the CORUS-services:

- The network identification service shall allow the continuous processing of the remote identification of the UAS throughout the duration of the flight and provide it to authorised users in an aggregated manner.
- The geo-awareness service shall provide:
  (a) information on the applicable operational conditions and airspace constraints within the U-space airspace;
  (b) UAS geographical zones, relevant to U-space airspace;
  (c) dynamic airspace restrictions temporarily limiting the area with the U-space airspace where UAS operations can take place.
- The flight authorisation service shall provide the authorisation for each individual flight, setting the terms and conditions of that flight.
  The traffic information service provides the UAS operator with information on any other conspicuous air traffic, which may be in the proximity to the position or intended route of the UAS flight.
- The tracking service shall comprise UAS telemetry messages with actual information about the UAS flight sent from the unmanned aircraft, flight plans, and identification information from UAS operators and other U-space service providers.

[41] EASA Opinion 1/2020, *High-level regulatory framework for the U-space*, RMT.0230
[42] SESAR, U-space Blueprint, 2017, ISBN: 978-92-9216-086-9
[43] Joachim Lücking, What is the EU Doing to Deliver the U-space?, Madrid, March 2019
[44] EUROCONTROL, *CORUS, Concept of Operations for European UTM Systems – U-space Concept of Operations*, October 2019, ed. 03.00.02

- When weather information service is provided, it shall:
  (a) collect weather data to maintain safety, supporting operational decisions of other U-space services;
  (b) provide the UAS operator with weather forecast and actual weather information either before or during the flight,
- The conformance monitoring service shall enable the UAS operators to verify whether they comply with the requirements of operating as UAS operator and terms of the flight authorisation.

Currently, the EC-regulations have not yet been approved, so slight changes may be possible. The regulations are expected to be published in 2021.

U-space is an essential element to guarantee the safety of unmanned and manned aviation and is already partly deployed in Switzerland through the service that is provided by the U-space Service Provider (USSP) AirMap in cooperation with FOCA. As, Europe promotes an open market, which is expected to be rolled out in the next five to ten years, it may be expected that more USSPs will enter the Swiss U-space market.

Switzerland has been a front runner in the use of drones for a long time and a country where many drone operators look at with envy. Starting already decades ago with military applications of the use of large drones that were accompanied with chase planes for safety, Switzerland has deployed medical services with small drones in B-VLOS conditions for a long time. For this, Matternet deployed drones carrying medical lab samples for some time near Lake Zurich.

U-space will be an important stimulus to allow drone operations in complex environments as it offers planning, guidance and monitoring of drone flights. A safety assessment is part of this work. In cities, U-space must be linked to Urban Air Mobility, which includes transport of passengers by drones and beyond visual line of sight operations.

Assumptions

The assumptions below are linked to major societal and technological trends and evolutions.

Firstly, drone operations will continue to grow. All relevant forecasts expect the number of applications to increase and e.g. the COVID-crisis has shown our dependency on timely delivery of goods and the need for a more fine-meshed network of delivery services. Though not every market will evolve with the same pace, drones have demonstrated their capabilities and we are only starting to discover the possibilities. A specific market is the taxi-drone that will reduce ground congestion and improve the mobility of citizens.

The second assumption is that technology will not form a bottleneck in the development of U-space services and in the performance of drone-operations. Automation of flight has been an important enabler for the drone-market and already many drones do not require the intervention of pilots any longer. The same applies to the ground-based functions. Though issues as *detect-and-avoid* are not yet fully solved, it is expected that the following years will bring significant steps towards full implementation. A precondition is the connectivity, where 5G will offer significant steps. Attention is necessary to the Urban Air Mobility (UAM) market with special technological needs.

Thirdly, it is assumed that drones will be accepted by society. Social acceptance of drones concerns their safety (both from people flying taxi-drones as from people on the ground – third party risk), environment (noise and visual pollution) and privacy. The issue of social acceptance is currently taken up by many parties, where the societal and economic relevance of use-cases is a major factor in having people accept the use of drones.

Recommended actions

The recommended actions for this SO are split into: air and ground infrastructure, regulation, management and others.

Air and ground infrastructure

The introduction of drones and the roll out of U-space will have significant impacts on the air and ground infrastructure. Though large fixed-wing drones will operate at the existing airports and use existing airspace infrastructure, smaller drones will ‘invade’ parts of the airspace and require new ground facilities.

U-space will initially be set up for the Very Low Level (VLL) airspace, i.e. up to 500 ft. Above Ground Level (AGL). This part of the airspace is, generally speaking, not used by current manned aviation. The proposed EC-regulation indicates manned aviation to use the U-space services when operating in U-space airspace. Parts of the airspace should be indicated as U-space Airspace therefore. It is recommended to start with the definition of a number of protypes U-spaces airspaces, where experience is gained and the lessons learned can be used to create more U-space airspaces in Switzerland.

The ground infrastructure, specifically in cities, will consist of droneports or vertiports, which are dedicated structures to operate drones from. They can be compared to the airports for manned aviation and offer facilities in line with their operational use. For example, for package delivery, a logistics centre can be included while for passenger transports, screening areas are necessary. Initially, droneports will be located on the rooftops of tall buildings. As urban planning takes considerable time, it is recommended to start including vertiports in urban master planning and start with setting up a master plan for one of Switzerland’s cities as soon as possible. Later, as more cities join, a national master plan needs to be developed.

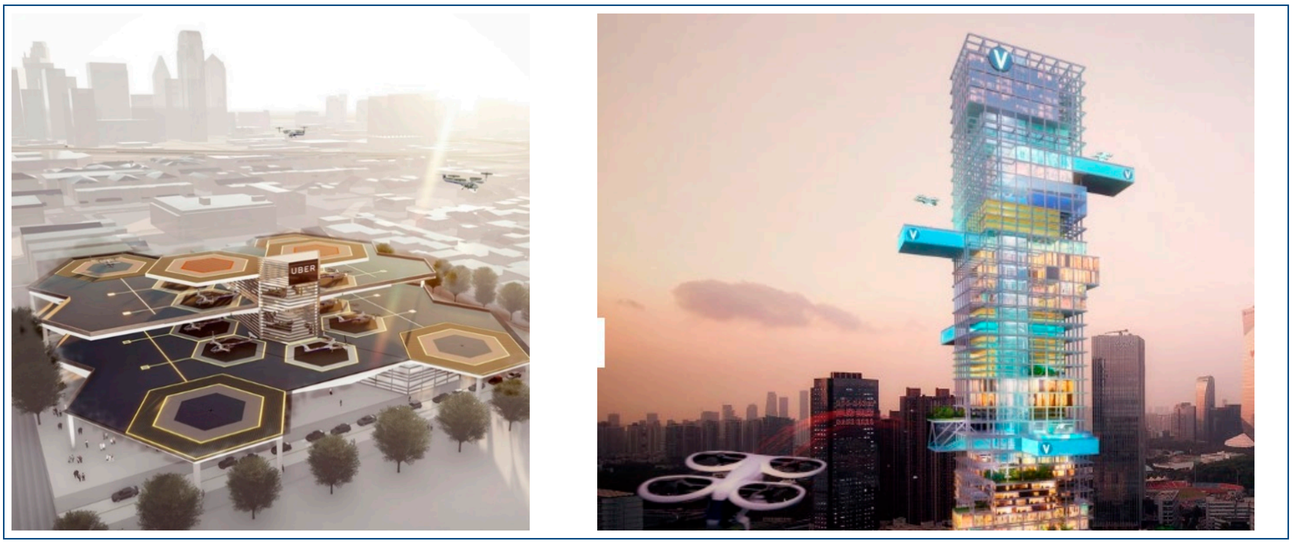


Figure 6: Droneport examples from Uber and Airbus

Regulation

U-space will be regulated internationally through EC-regulations to allow interoperability for USSPs and to offer an international market for commercial drone operators. EC-regulation is expected in 2021, giving the states one year for the implementation. To roll out U-space, apart from installing laws and regulations, activities to ensure airspace management at VLL will be necessary. Just as well, a Common Information Service (CIS) will need to be made available and a process for the certification of USSPs needs to be established. Most probably, the ANSP will be the responsible party to implement the CIS. Also, international alignment needs to ensure interoperability. Already, The Netherlands has published a U-space Action Plan for the roll out of initial U-space services in the next five years. It is recommended to also set up an Action Plan for Switzerland and to initiate the activities for the implementation of the EC-regulation.

Management

The roll out of U-space involves many stakeholders of which the government and the ANSP are the most important ones. Together with the government, the ANSP will need to set up the basis, e.g. in The Netherlands, the U-space Action Plan divides the responsibility between both parties. That means that the governance structure is set up with multiple responsibilities for the ANSP, together with financial obligations. It is recommended that to start setting up a program structure and to allocated resources to the roll out of U-space.

Others

One factor that is not to be underestimated is the role of the public. Social acceptance of the use of drones is a crucial factor in the future use of drones. It is recommended to set up an awareness campaign for the public. As already started in Switzerland with the Matternet blood sample delivery program, services with social relevant will have best acceptance.

One special stakeholder group needs attention: the General Aviation (GA). When operating in established U-space airspace, manned aviation will have to adhere to the rules of U-space and will be treated on an equal basis as drones. This is a situation that is fully unprecedented by GA, but in the end, they might benefit from the improved services as well. It is recommended to start an awareness campaign with GA.

Predicted effects

Environment

U-space is not aimed at addressing environmental issues, though the use of drones has definitely stimulated the use of electric propulsion systems. In the next decade, battery technology will improve, while for longer flights, hydrogen propulsion is the most viable choice.

Security and Safety

U-space offers a significant contribution to the safety of aviation by

1. Providing information on drone flights. Every drone will send its identification and location to the U-space system so that e.g. airport operators and the ANSP will be provided with a clear and concise traffic situational awareness;
2. Provide information on where to fly and where not to drone operators and drone pilots, making drone flights themselves safer.

Misuse of the systems must be detected by good security systems, both for cyber security as for the security of objects from intrusion by drones.

Performance

U-space will boost the performance of drones. It will enable a large amount of use cases that cannot be carried out without good information on the location and identification of drones. Beyond Visual Line of Sight (B-VLOS) operations become possible if the drone location can be constantly monitored through a U-space service. Also, UAM cannot be realized without dedicated U-space services for typical urban aspects as localization of objects, ensuring safe flight during radio communication issues and dealing with hyper local weather events.

Feasibility and implementation considerations

In order to offer U-space services in Switzerland, there are several obstacles to overcome. Regulations and legal issues will need to be dealt with after the publication of U-space regulation by EC in 2021. An early start and international alignment are necessary for a successful approach towards this.

For the technical implementation of U-space, again the organisation and alignment of stakeholders seems to be the most important issue to deal with in the next year. Technical blocking factors are not foreseen. Technical issues do, however, still need to be tackled in urban environments, where limited experience (world-wide) with the use of drones is gathered. Only a small number of cities has already carried out experimental flights though the number will increase significantly in the next years with a dedicated UAM-programme from SESAR and support from EC.

The most important technical hurdle for the use of air taxi's is the certification issues. As these drones carry passengers, the aircraft will need to be dealt with in the *certified category*. No experience with the certification of unmanned aircraft exists as of yet and the first certified drone to carry passengers is still to be delivered. Several (commercial) market studies have proven to be too optimistic about the future of "flying cars". Volocopter forecasted their first drone-flight in 2018 and PAL-V in 2019. They have both not yet flown certified products (though PAL-V is close to). The conflict between regulation that requires proof of safety and the manufacturers not being able to prove so remains.
U-space is offered as a set of services that will build on each other. Some will need to be provided by qualified entities, where for the ANSP, the drone AIM (Aeronautical Information Management) and Common Information Service (CIS) are the most important. It needs to be considered by FOCA to develop these in-house or to acquire commercial systems. N.B. At the moment, these systems do not exist at the commercial market.

5 Implementation of strategic orientations

This section takes a step back from the SO's described in section 4 to assess their broader impact on the system requirements, how they complement or degrade one another and, finally offers consideration for implementation.

5.1 Broader impact

As explained in section 3.3 in the table, the AVISTRAT Vision's system requirements are closely linked to the SO's. This section maps the high-level impact of the SO on the AVISTRAT system requirements. A single SO can impact multiple system requirements.

System requirements related to the target area 'Environment' are most affected by the SO's belonging to the themes 'Quality of Life' and 'Climate Challenge'. Most have a profound positive impact on these system requirements. System requirements related to the target area 'Safety and Security' are most affected by the SO's belonging to the themes 'Safety and Security' and 'Fair airspace access'. The effects are mostly positive with the exception of those SO's that introduce new airspace users or heavily rely on new technology (e.g. 'Towards full-electric domestic GA and pilot training'). The system requirements related to the target area 'Performance' are affected by many different SO's, in different ways. SO's related to the themes 'Safety and security' and 'Fair airspace access' have a strong, positive impact by offering new opportunities or minimising risk. SO's related to the themes 'Quality of Life' and 'Climate challenge' have a mixed impact: some increase the cost of necessary services but improve predictability required for investments in return. In addition, these SO's can offer new business opportunities related to sustainable aviation.

Table 5 provides an overview of the relation between SO's and system requirements. Intersections with + have a largely positive impact on the system requirement. Intersections marked by - have a mostly negative impact on the system requirement. Intersections marked by +/- can go both ways depending on other factors. This overview is meant to provide a high-level understanding of the impact. To assess the true impact, a detailed implementation assessment is requirement. Depending on implementation, positive effects can be increased and negative impacts can be mitigated.

Table 5: Impact of SO's on System Requirements (SR)[45]

	(SR6) Public burden	(SR5) Environmental impact	(SR7) Other pollutants	(SR8) Safety & security missions	(SR9) Risk levels & risk performance	(SR10) Fair access	(SR11) Manage prioritisation	(SR12) Swiss competitiveness	(SR13) Cost-effective services	(SR14) Plan-able for use and investments	(SR15) Enable training	(SR16) Creativity & innovation
Noise reduction	+	+	+	+/-			+	-	-			
LAQ improvement	+	+	+				+		-			
Community	+									+		+
Air-MaaS	+/-	+/-		+	-	+		+	+	+	+	+
Stimulate SAF	+	+	+				+	+	-	+		+
Net-zero-50	+	+	+		-			+	-	+		+
e-GA and pilot training	+	+	+		-		+	+	+	+	+	+
Multi-modal	+	+						+	+			+
Integral risk	+				+			+				+
Integral security	+			+	+							
Public oversight	+				+			+	+			
Airspace allocation	+/-					+	+	+	+	+	+	+
Best equipped...	+	+	+		+	+	+	+				
U-space in VLL	-	+/-		+	-	+	+	+	+	+	+	+

[45] The colors in the table help recognizing similar themes among SO's and system requirements, they do not imply any ranking or desirability

5.2 Dependencies

All challenges identified in section 2.3 are difficult in themselves: cutting carbon emissions in a growing market (pre-COVID) without a readily available green **and** lightweight **and** energy solution is not easy, no matter how you distribute flight tracks aircraft noise continues to create both winners and losers, and maintaining the high-levels of safety while also inviting new airspace entrants is daunting. It gets even more complex when combining these challenges as this strategy concept does. Not all SO's are complimentary to one another. Below we identify the most apparent dependencies.

SO's that lead to an increase in flight movements or relocate flight movements typically are at odds with the themes 'Quality of Life', 'Climate challenge', and 'Safety and security' but complement the theme 'Fair airspace access'. SO's that decrease or maintain the number of flight movements typically complement 'Quality of Life', 'Climate challenge', and 'Safety and security' but are at odds with the 'Performance' impactors from the theme 'Fair airspace access' and specific SO's such as 'Air mobility as a service' and 'Multi-modal integration'. Also, among themes with a high degree of synergy or even within themes, conflicts can occur: 'Towards full-electric domestic GA and pilot training' might lead to an increase in movements that albeit quieter per movement could still cause an overall increase in annoyance. Measures that reduce the noise footprint overall might still cause an increase for some specific communities and vice-versa. Also, some abatement procedures or powertrain options might result in a crossroad between either noise or climate impact reduction, but not both at the same time.

Table 6 shows the synergy among SO's. Intersections with + go well together, either because they strengthen each other's effects or because they enable one another. Intersections marked by - dilute or conflict one another. Intersections marked by +/- can go both ways depending on other factors. As is shown, most SO's are complementary to one another.

Table 6: SO synergy matrix

	Noise reduction	LAQ improvement	Community	Air-MaaS	Stimulate SAF	Net-zero-50	e-GA and pilot training	Multi-modal	Integral risk	Integral security	Public oversight	Airspace allocation	Best equipped	U-space in VLL
Noise reduction		+	+	-		+	+				+	+	+	-
LAQ improvement			+	+/-	+	+	+	+				+	+	
Community				+/-		+	+				+	+	+	+
Air-MaaS						+	+	+	+	+	+	+	+	+
Stimulate SAF						+		+	+		+		+	
Net-zero-50							+	+	+	+			+	+
e-GA and pilot training									+	+	+	+	+	+
Multi-modal									+	+	+			+
Integral risk										+	+	+	+	+
Integral security											+	+		+
Public oversight														+
Airspace allocation													+	+
Best equipped…														+
U-space in VLL														

5.3 Implementation considerations

Each SO discussed in section 4 provides an opportunity to improve a set of system requirements. However some come at a cost of degrading other system requirements, some conflict with other SO's and some rely on other developments before the can be effective. Also, resources required for implementation are scarce. Therefore, some sort of prioritisation is in order. Prioritisation is first of all matter of choice. It is up to FOCA and the other Swiss stakeholders to weigh the relative importance of the three target areas as these can sometimes be conflicting and might impact stakeholders differently. In order to facilitate this trade-off, the following section provides an objective overview of the considerations for implementation.

The first consideration is the scope of the SO. Some SO's have a national impact, whereas others have only local effects. National is not necessarily better than local, as differences in context might require a targeted approach. For example strategies that reduce noise annoyance and improve community relations around Zurich International Airport are not relevant for a small airstrip high up in the Alps. The second consideration is the impact of the SO on the three target areas in relation to the identified obstacles for implementation. The higher the (positive) impact and the fewer the obstacles, the more desirable the SO becomes. Most SO's can have both positive and negative impacts on the system requirements.

Table 7 gives an overview of the impact of the SO's in relation to the identified obstacles, all taken from section 4. Again, this overview is meant to provide a high-level understanding of the impact and feasibility. To assess the true impact and feasibility, a detailed implementation assessment is requirement. Depending on implementation, positive effects can be increased and negative impacts can be mitigated.

Table 7: SO feasibility considerations

	Scope	(TA) Environment	(TA) Safety & Security	(TA) Performance	Socio-political feasibility	Technical feasibility	Management / business feasibility
Noise reduction	Local	+		-	+/-	+	+
LAQ improvement	Local	+		+/-	+	(+)	+
Community	Regional	(+)		(+)	+/-	+	+
Air-MaaS	Regional		+/-	+	-	(+)	-
Stimulate SAF	National	+		+	(+)	-	-
Net-zero-50	Local	+	(-)	(+)	+	(+)	-
e-GA and pilot training	Regional	+	(-)	+	+	+	(-)
Multi-modal	Regional / National	+		+	+	+	-
Integral risk	National	(+)	+	(+)	(-)	+	+
Integral security	National	(+)	+		(+)	+	(-)
Public oversight	National	(+)	+	(+)	(+)	+	(-)
Airspace allocation	National	(+)	(+)	+	-	+	+
Best equipped…	National	+	+	+	(+)	+	-
U-space in VLL	National + local zoning	-		+	-	+	-

Based on these results a 2x2 implementation matrix and a rudimentary prioritisation can be defined per SO theme. Both impact and feasibility scores are normalised values in between 0 and 1.

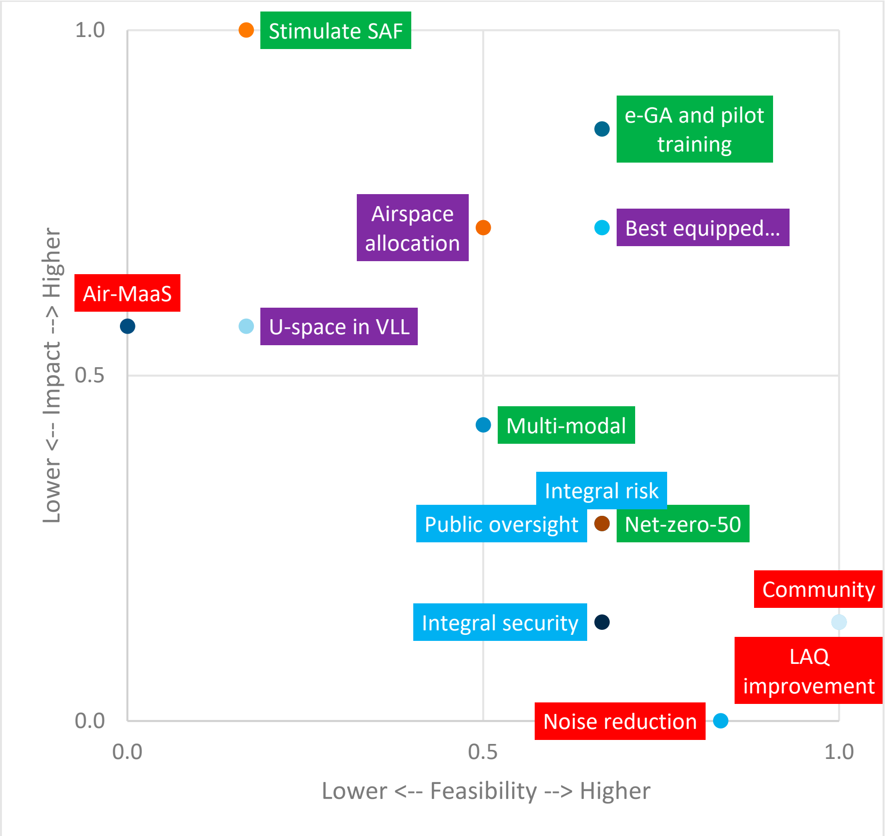


Figure 7: 2x2 implementation matrix

5.3.1 Prioritisation for Improving QoL

Priority

Improving the 'Local Air Quality' combines a high (local) impact with a relatively high feasibility, especially from a socio-political objective. 'Noise reduction' also has a high impact but can be more challenging from a socio-political viewpoint due to a heated debate and vested interests of airports and certain community groups. Also noise reduction does not address the climate challenge unless noise is the bottleneck for traffic growth. Another SO, albeit from a different theme, with potentially a strong impact on noise reduction is 'Best equipped, best served'.

Quick win

Improving dialogue through a community programme can be considered a quick win due to a high degree of feasibility.

Longer-term

Introducing 'Air Mobility as a Service' potentially has a tremendous impact, albeit more related to 'Performance' system requirements. For implementation socio-political and management / business obstacles need to be overcome.

5.3.2 Prioritisation for Climate Challenge

Priority

'Electric GA and pilot training' have both a good impact on the 'Sustainability' and 'Performance' system requirements and a high degree of feasibility. Although the impact on the climate is relatively low due to the low baseline climate impact, 'electric GA and pilot training' offers strong business opportunities and synergy with other SO's. The SO with the largest environmental impact by far is 'stimulating SAF'. Despite implementation difficulties, it is highly advisable to address this challenge as soon as possible as SAF is one of the few short-/medium-term solutions to reduce the carbon emissions of long-range air transportation. Another SO, albeit from a different theme, with a potentially strong impact on the Climate challenge is 'Best equipped, best served'.

Quick win

Continuing and expanding the 'Net-zero-50 airports' program can be considered a quick-win with a positive impact on local emissions and health.

Longer-term

'Multi-modal integration' can serve as a longer-term ambition. Although the technology is mostly there, implementation requires solving difficult management and business challenges. In order to ensure a positive impact of the SO on the environment, it should be monitored whether the increased capacity due to a shift to rail or road transport won't lead to an increase in long-haul flights.

5.3.3 Prioritisation for Safety & Security

Priority

All three SO's from the theme 'Safety & Security' lower the risk levels and improve monitoring capabilities and are equally feasible. 'Integral risk management' and 'public oversight' also a positive impact on the 'Performance' system requirement and should thus be prioritized. All have excellent synergy with the SO 'Best equipped, best served' and are prerequisite for the SO's 'Airspace allocation', U-space in VLL', and 'Air-MaaS'.

Quick win

'Integral security' has less of an impact on other system requirements and hence a lower impact overall but does also improve 'safety and security missions' (SR8). Given the high feasibility, the SO 'integral security' is a quick win.

5.3.4 Prioritisation for Fair Airspace Access

Priority

The SO 'Best equipped, best served' has a broad impact even beyond the 'Performance' system requirements. In addition it is the most implementable SO of the 'Fair Airspace Access' theme.

More ambitious is the 'Airspace allocation based on AMC using predefined BPPR' SO, with far reaching impact even beyond the 'Performance' system requirements. Its implementation will be challenging however, both from socio-political as from a management point of view. even beyond the 'Performance' system requirements.

Longer-term

Another SO with a potentially high, but still uncertain impact is the implementation of ‘U-space in VLL’. This SO can be a real enabler for an entire new wave of airspace users but has a large set of implementation obstacles ranging from technical obstacles, to public embracement obstacles, safety obstacles and management- and business obstacles.

6 Conclusion and key takeaways

After an assessment of current trends, vision reports and the AVISTRAT Vision four main challenges can be identified for the Swiss aviation system of 2035:

- ***Climate challenge:*** Reduce the overall environmental impact of aviation with light-weight solutions for long-range, high-capacity aircraft in a growing market (before COVID) for air transport at acceptable costs.
- ***A positive impact on the Quality of Life:*** Move beyond stagnant debates on aviation noise to a fairer distribution of the benefits and burdens of aviation.
- ***Safe and secure aviation:*** Set acceptable levels of risk and monitor current risk levels while allowing new groups of airspace users to enter the airspace.
- ***Fair airspace access for existing and new entrants:*** Grant existing and new users access to the scarce airspace resource according to socio-political needs, despite sometimes conflicting interests.

Future scenarios are based on assumptions on politics, economics, society, regulation and governance, environment and technology. Which scenario is most relevant for the Swiss aviation system of 2035 will only be revealed in time. However, it is possible to determine which future offers the best fit with the AVISTRAT Vision and is worth striving for. Four potential scenarios created by the Aeronautical R&D group EREA were assessed to determine the optimal scenario for Switzerland in 2035. The ambition as laid out in the AVISTRAT Vision aims for an internationally competitive Swiss aviation sector. This favours a globalized world in which Switzerland actively takes part in international institutions. If global consensus on the four main challenges can be achieved and shared goals can be set, the highest value can be achieved through cooperation and collaboration. On the topics and areas where this proves to be unfeasible, top-down goals will have to be set and enforced leading to some loss in speed and value, but an increase in stability and predictability.

The general trends set the option space of **what can be achieved** through specific actions in the 'Action Areas'. The 'System Requirements' from the AVISTRAT Vision provide input on **what is desirable to achieve**. The EREA scenarios provide the **context** in which the strategy draft will be implemented.

Looking at the system requirements and mapping them on the main challenges, four SO themes for the SO's can be identified. Each SO theme consists of multiple SO's that, by using specific actions in the three Action Areas (infrastructure, regulation and management – Areas of Action 06 to 08) as defined in the AVISTRAT Vision in order to meet the system requirements.

The SO's that have been created are:

Quality of life • (Air) mobility as a service • (Perceived) noise reduction • LAQ improvement • Community participation	**Climate challenge** • Stimulate use and production of SAF • Net-Zero-50 airports • Towards full-electric domestic GA and pilot training • Multi-modal integration
Safety & security • Integral risk management • Integral security framework • Public oversight on governance	**Fair airspace access** • Airspace allocation • Best-equipped-best-served • Continued adoption of U-space

Each provides an opportunity to improve a set of system requirements:

- System requirements related to the target area ‘Environment’ are most affected by the SO’s belonging to the themes ‘Quality of Life’ and ‘Climate Challenge’. Most have a profound positive impact on these system requirements.
- System requirements related to the target area ‘Safety and Security’ are most affected by the SO’s belonging to the themes ‘Safety and Security’ and ‘Fair airspace access’. The effects are mostly positive with the exception of those SO’s that introduce new airspace users or heavily rely on new technology (e.g. ‘Towards full-electric domestic GA and pilot training’).
- The system requirements related to the target area ‘Performance’ are affected by many different SO’s, in different ways. SO’s related to the themes ‘Safety and security’ and ‘Fair airspace access’ have a strong, positive impact by offering new opportunities or minimising risk. SO’s related to the themes ‘Quality of Life’ and ‘Climate challenge’ have a mixed impact: some increase the cost of necessary services but improve predictability required for investments in return. In addition, these SO’s can offer new business opportunities related to sustainable aviation.

In addition, some SO’s come at a cost of degrading other system requirements, some conflict with other SO’s and some rely on other developments before the can be effective:

- SO’s that lead to an increase in flight movements or relocate flight movements typically are at odds with the themes ‘Quality of Life’, ‘Climate challenge’, and ‘Safety and security’ but complement the theme ‘Fair airspace access’.
- SO’s that decrease or maintain the number of flight movements typically complement ‘Quality of Life’, ‘Climate challenge’, and ‘Safety and security’ but are at odds with the ‘Performance’ impactors from the theme ‘Fair airspace access’ and specific SO’s such as ‘Air mobility as a service’ and ‘Multi-modal integration’.
- Also among themes with a high degree of synergy or even within themes, conflicts can occur: ‘Towards full-electric domestic GA and pilot training’ might lead to an increase in movements that albeit quieter per movement could still cause an overall increase in annoyance. Measures that reduce the noise footprint overall might still cause an increase for some specific communities and vice-versa. Also some abatement procedures or powertrain options might result in a crossroad between either noise or climate impact reduction, but not both at the same time.

Finally, resources required for implementation are scarce. Therefore, some sort of prioritisation is in order. Prioritisation is first of all matter of choice. It is up to FOCA and the other Swiss stakeholders to weigh the relative importance of the three target areas as these can sometimes be conflicting and might impact stakeholders differently. This report provides objective considerations for implementation:

- The first consideration is the scope of the SO. Some SO’s have a national impact, whereas others have only local effects. National is not necessarily better than local, as differences in context might require a targeted approach.
- The second consideration is the impact of the SO on the three target areas in relation to the identified obstacles for implementation.

Based on these results a 2x2 implementation matrix and a rudimentary prioritisation were defined per SO theme.

- ***Priority for QOL:*** Improving the 'Local Air Quality' combines a high (local) impact with a relatively high feasibility, especially from a socio-political objective. 'Noise reduction' also has a high impact but can be more challenging from a socio-political viewpoint due to a heated debate and vested interests of airports and certain community groups. Also noise reduction does not address the climate challenge unless noise is the bottleneck for traffic growth. Another SO, albeit from a different theme, with potentially a strong impact on noise reduction is 'Best equipped, best served'.
- ***Priority for Climate Challenge:*** 'Electric GA and pilot training' has both a good impact on the 'Sustainability' and 'Performance' system requirements and a high degree of feasibility. Although the impact on the climate is relatively low due to the low baseline climate impact, 'electric GA and pilot training' offers strong business opportunities and synergy with other SO's. The SO with the largest environmental impact by far is 'stimulating SAF'. Despite implementation difficulties, it is highly advisable to address this challenge as soon as possible as SAF is one of the few short-/medium-term solutions to reduce the carbon emissions of long-range air transportation. Another SO, albeit from a different theme, with a potentially strong impact on the Climate challenge is 'Best equipped, best served'.
- ***Priority for Safety & Security:*** All three SO's from the theme 'Safety & Security' lower the risk levels and improve monitoring capabilities and are equally feasible. 'Integral risk management' and 'public oversight' also a positive impact on the 'Performance' system requirement and should thus be prioritized. All have excellent synergy with the SO 'Best equipped, best served' and are prerequisite for the SO's 'Airspace allocation', U-space in VLL', and 'Air-MaaS'.
- ***Priority for Fair Airspace Access:*** The SO 'Best equipped, best served' has a broad impact even beyond the 'Performance' system requirements. In addition it is the most implementable SO of the 'Fair Airspace Access' theme. More ambitious is the 'Airspace allocation based on AMC using predefined BPPR' SO, with far reaching impact even beyond the 'Performance' system requirements. Its implementation will be challenging however, both from socio-political as from a management point of view. even beyond the 'Performance' system requirements.

These four priority recommendations conclude this report and can serve as starting point for the next phase of the AVISTRAT programme in which all input is consolidated into a balanced and futureproof strategy for the Swiss aviation system of 2035. We cannot wait.

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The combination of in-depth insights into customers' needs, multidisciplinary expertise and state-of-the-art research facilities makes rapid innovation possible. Both domestically and abroad, Royal NLR plays a pivotal role between science, the commercial sector and governmental authorities, bridging the gap between fundamental research and practical applications. Additionally, Royal NLR is one of the large technological institutes (GTIs) that have been collaborating since 2010 in the Netherlands on applied research as part of the TO2 federation.

From its main offices in Amsterdam and Marknesse plus two satellite offices, Royal NLR helps to create a safe and sustainable society. It works with partners on numerous (defence) programmes, including work on complex composite structures for commercial aircraft and on goal-oriented use of the F-35 fighter. Additionally, Royal NLR helps to achieve both Dutch and European goals and climate objectives in line with the Luchtvaartnota (Aviation Policy Document), the European Green Deal and Flightpath 2050, and by participating in programs such as Clean Sky and SESAR.

For more information visit: **www.nlr.org**

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