DEPA 2070 – Study Report Summary

Development Pathways for Aviation up to 2070

Contents

1. Introduction

✈ The project "**DE**velopment **P**athways for **A**viation up to **2070**" (**DEPA 2070**) was conducted at the German Aerospace Center in the time frame from 2022 to 2024. It concentrated on the following strategic objectives:

1. Definition, description and evaluation of **possible development pathways** for aviation up to 2070 in consideration of major trends in special regard of air transport market and technological developments, energy availability, infrastructure requirements and potential changes on the political and social level (e.g. as a result of the European Green Deal and the Covid-19 pandemic)

2. Detailed **assessment of technology-related scenarios** and corresponding consequences for sustainability and air transport infrastructure

3. Illustration and discussion of **realistic development perspectives** of the air transport system in consideration of the long-term ecological, economical and societal impact

Similarly, to the forerunner project "**DE**velopment **P**athways for **A**viation up to **2050**" (**DEPA 2050**) two scenarios for the further development of the air transport industry were described and assessed with the intention to provide diverging future states of the aviation sector in 2070.

The first, so-called **progressive scenario** assumed an accelerated insertion and a higher market distribution of sustainable aviation technologies with the focus on CO_2 emission reductions.

Meanwhile, the **conservative scenario** was rather designed as a business-as-usual scenario assuming a later entry into service of specific aviation technologies and especially no significant progress in alternative propulsion.

As a third scenario the DEPA 2070 project developed a normative scenario to estimate which technology reduction potentials with regard to different aircraft types might be needed to reach the goal of "Zero CO_2 emissions in 2050".

2. Vehicle Roadmaps by Fuel Type

On this basis, extended scenario and technology analyses were conducted in the project in order to develop detailed technology and vehicle roadmaps for all relevant categories in passenger air transportation considering also supersonic aircraft as a new market segment within the next 50 years. The following figure shows in this respect the potential energy mix for different aircraft market segments with regard to the conservative and the progressive DEPA 2070 scenario.

It becomes clear in this respect that the progressive scenario assumes very optimistic conditions – especially for the market entry of hydrogen carriers in the mainliner segment – while the conservative scenario is rather based on a longer usage of fossil aviation fuels which is then step-by-step replaced by sustainable aviation fuels (SAF) and (hybrid)-electric propulsion. Consequently, the progressive scenario analyses more in the character of a "what-if study" what could be possible from a technical point of view if optimal conditions for hydrogen propulsion are given and adequate aircraft becomes available from 2035 onwards.

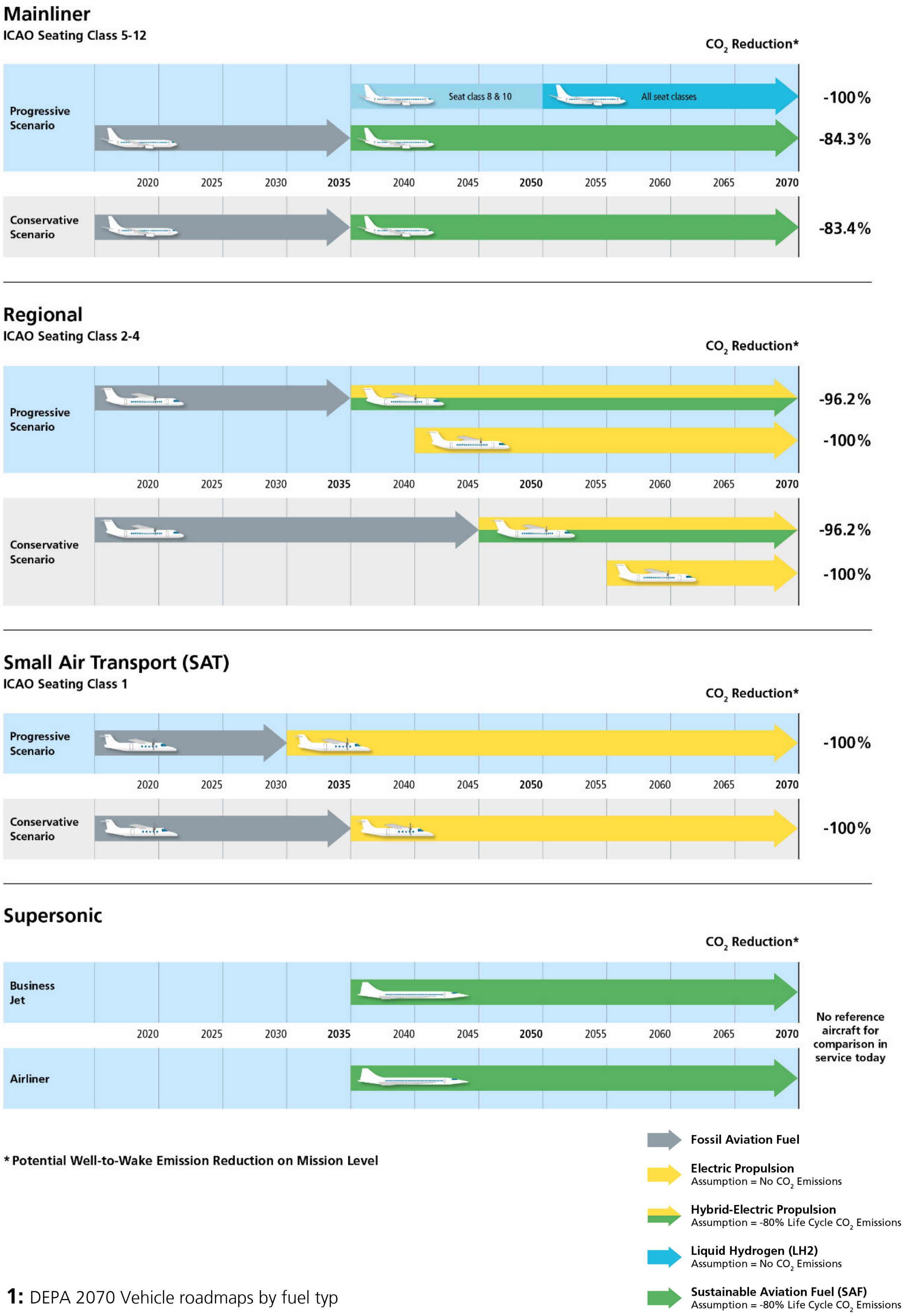
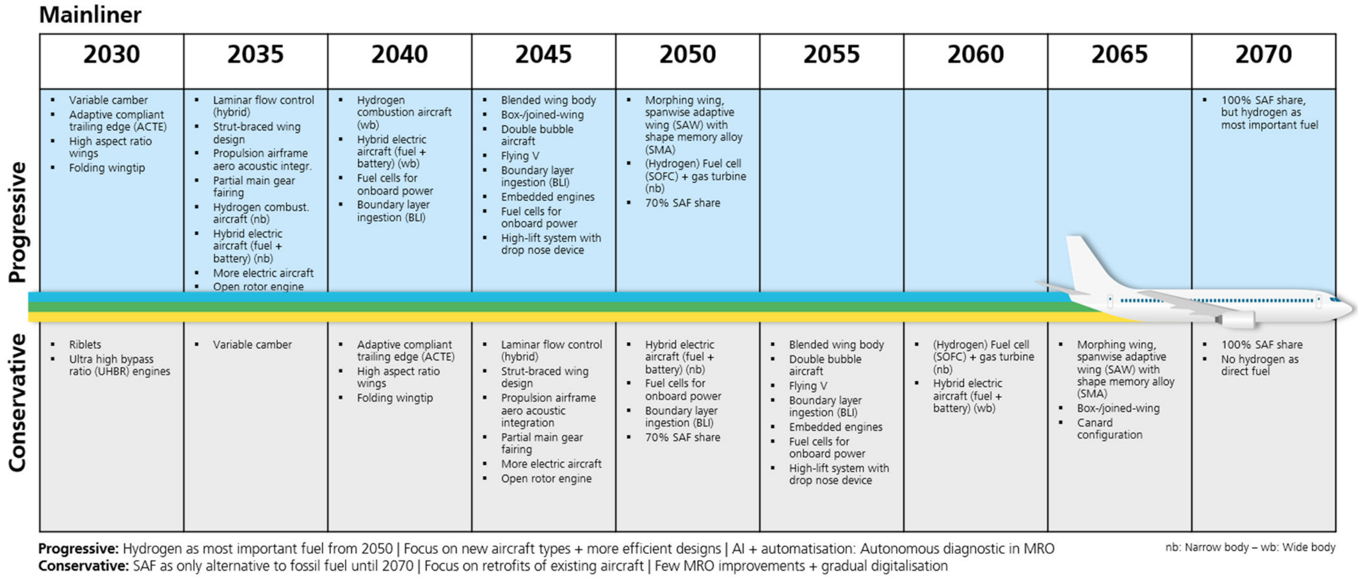


Figure 1: DEPA 2070 Vehicle roadmaps by fuel typ

2. Vehicle Technology Scenarios by Market Segment

✈ The more detailed assumptions for the two DEPA 2070 technology scenarios are also summarised in the next figures for each of the different market segments that were regarded in the DEPA 2070 study.



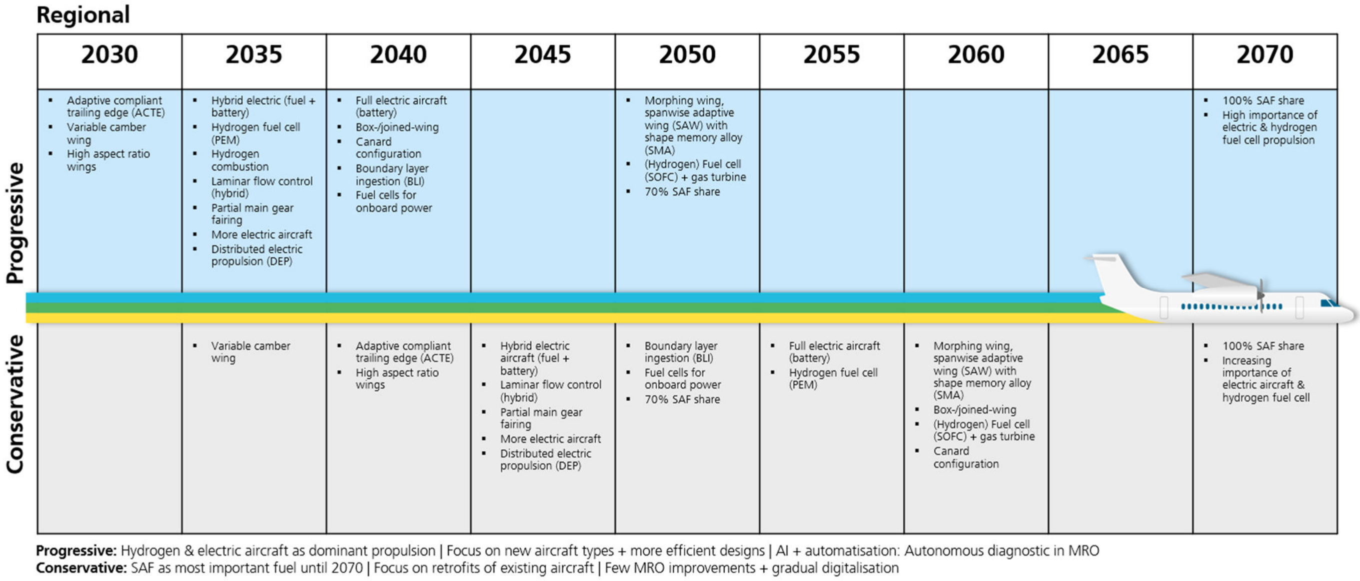
Mainliner

	2030	2035	2040	2045	2050	2055	2060	2065	2070
Progressive	▪ Variable camber ▪ Adaptive compliant trailing edge (ACTE) ▪ High aspect ratio wings ▪ Folding wingtip	▪ Laminar flow control (hybrid) ▪ Strut-braced wing design ▪ Propulsion airframe aero acoustic integr. ▪ Partial main gear fairing ▪ Hydrogen combust. aircraft (nb) ▪ Hybrid electric aircraft (fuel + battery) (nb) ▪ More electric aircraft ▪ Open rotor engine	▪ Hydrogen combustion aircraft (wb) ▪ Hybrid electric aircraft (fuel + battery) (wb) ▪ Fuel cells for onboard power ▪ Boundary layer ingestion (BLI)	▪ Blended wing body ▪ Box-/joined-wing ▪ Double bubble aircraft ▪ Flying V ▪ Boundary layer ingestion (BLI) ▪ Embedded engines ▪ Fuel cells for onboard power ▪ High-lift system with drop nose device	▪ Morphing wing, spanwise adaptive wing (SAW) with shape memory alloy (SMA) ▪ (Hydrogen) Fuel cell (SOFC) + gas turbine (nb) ▪ 70% SAF share				▪ 100% SAF share, but hydrogen as most important fuel
Conservative	▪ Riblets ▪ Ultra high bypass ratio (UHBR) engines	▪ Variable camber	▪ Adaptive compliant trailing edge (ACTE) ▪ High aspect ratio wings ▪ Folding wingtip	▪ Laminar flow control (hybrid) ▪ Strut-braced wing design ▪ Propulsion airframe aero acoustic integration ▪ Partial main gear fairing ▪ More electric aircraft ▪ Open rotor engine	▪ Hybrid electric aircraft (fuel + battery) (nb) ▪ Fuel cells for onboard power ▪ Boundary layer ingestion (BLI) ▪ 70% SAF share	▪ Blended wing body ▪ Double bubble aircraft ▪ Flying V ▪ Boundary layer ingestion (BLI) ▪ Embedded engines ▪ Fuel cells for onboard power ▪ High-lift system with drop nose device	▪ (Hydrogen) Fuel cell (SOFC) + gas turbine (nb) ▪ Hybrid electric aircraft (fuel + battery) (wb)	▪ Morphing wing, spanwise adaptive wing (SAW) with shape memory alloy (SMA) ▪ Box-/joined-wing ▪ Canard configuration	▪ 100% SAF share ▪ No hydrogen as direct fuel

Progressive: Hydrogen as most important fuel from 2050 | Focus on new aircraft types + more efficient designs | AI + automatisation: Autonomous diagnostic in MRO
Conservative: SAF as only alternative to fossil fuel until 2070 | Focus on retrofits of existing aircraft | Few MRO improvements + gradual digitalisation

nb: Narrow body – wb: Wide body

Figure 2: DEPA 2070 technology scenario for mainliner aircraft

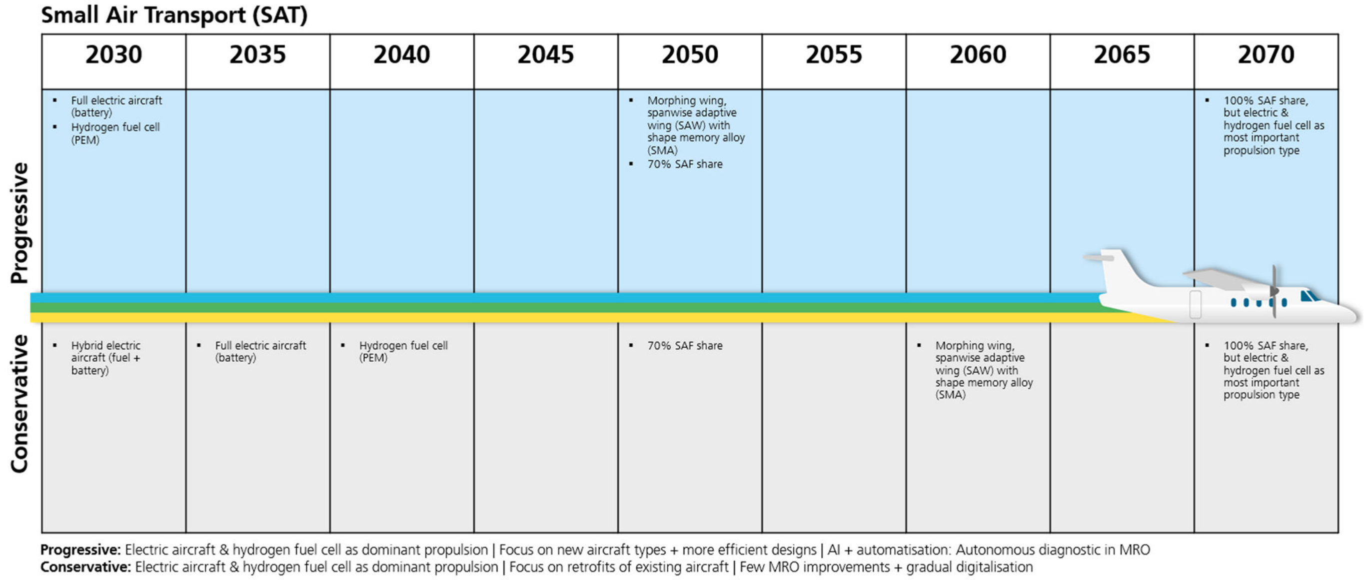


Regional

	2030	2035	2040	2045	2050	2055	2060	2065	2070
Progressive	▪ Adaptive compliant trailing edge (ACTE) ▪ Variable camber wing ▪ High aspect ratio wings	▪ Hybrid electric (fuel + battery) ▪ Hydrogen fuel cell (PEM) ▪ Hydrogen combustion ▪ Laminar flow control (hybrid) ▪ Partial main gear fairing ▪ More electric aircraft ▪ Distributed electric propulsion (DEP)	▪ Full electric aircraft (battery) ▪ Box-/joined-wing ▪ Canard configuration ▪ Boundary layer ingestion (BLI) ▪ Fuel cells for onboard power		▪ Morphing wing, spanwise adaptive wing (SAW) with shape memory alloy (SMA) ▪ (Hydrogen) Fuel cell (SOFC) + gas turbine ▪ 70% SAF share				▪ 100% SAF share ▪ High importance of electric & hydrogen fuel cell propulsion
Conservative		▪ Variable camber wing	▪ Adaptive compliant trailing edge (ACTE) ▪ High aspect ratio wings	▪ Hybrid electric aircraft (fuel + battery) ▪ Laminar flow control (hybrid) ▪ Partial main gear fairing ▪ More electric aircraft ▪ Distributed electric propulsion (DEP)	▪ Boundary layer ingestion (BLI) ▪ Fuel cells for onboard power ▪ 70% SAF share	▪ Full electric aircraft (battery) ▪ Hydrogen fuel cell (PEM)	▪ Morphing wing, spanwise adaptive wing (SAW) with shape memory alloy (SMA) ▪ Box-/joined-wing ▪ (Hydrogen) Fuel cell (SOFC) + gas turbine ▪ Canard configuration		▪ 100% SAF share ▪ Increasing importance of electric aircraft & hydrogen fuel cell

Progressive: Hydrogen & electric aircraft as dominant propulsion | Focus on new aircraft types + more efficient designs | AI + automatisation: Autonomous diagnostic in MRO
Conservative: SAF as most important fuel until 2070 | Focus on retrofits of existing aircraft | Few MRO improvements + gradual digitalisation

Figure 3: DEPA 2070 technology scenario for regional aircraft

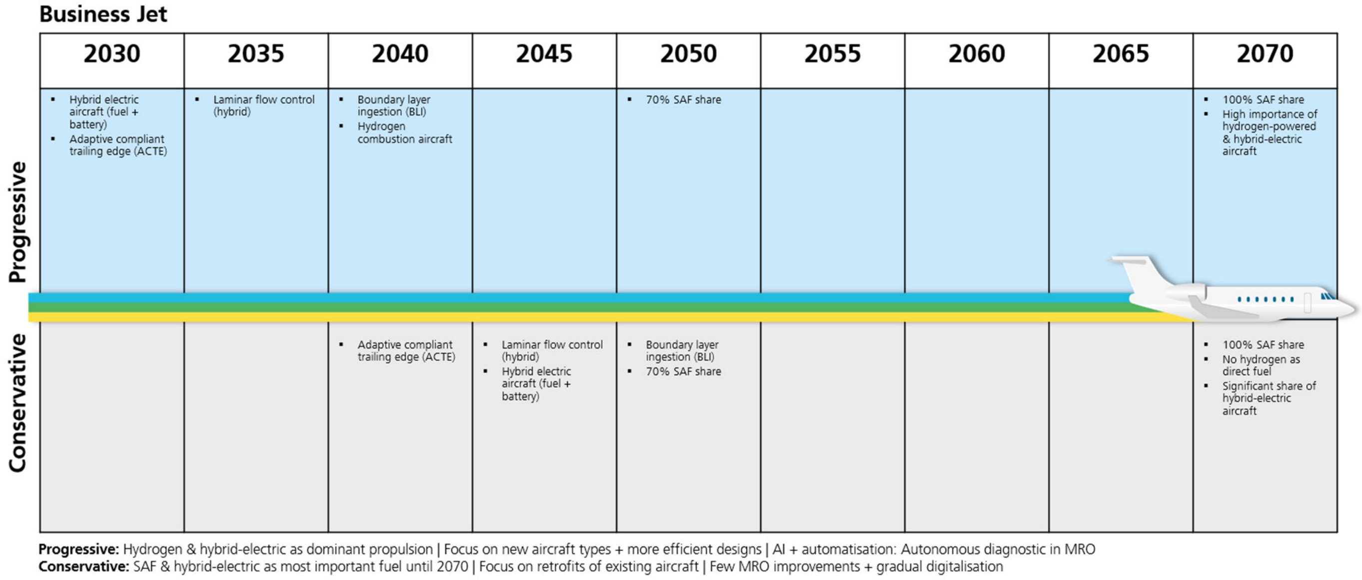


Small Air Transport (SAT)

	2030	2035	2040	2045	2050	2055	2060	2065	2070
Progressive	▪ Full electric aircraft (battery) ▪ Hydrogen fuel cell (PEM)				▪ Morphing wing, spanwise adaptive wing (SAW) with shape memory alloy (SMA) ▪ 70% SAF share				▪ 100% SAF share, but electric & hydrogen fuel cell as most important propulsion type
Conservative	▪ Hybrid electric aircraft (fuel + battery)	▪ Full electric aircraft (battery)	▪ Hydrogen fuel cell (PEM)		▪ 70% SAF share		▪ Morphing wing, spanwise adaptive wing (SAW) with shape memory alloy (SMA)		▪ 100% SAF share, but electric & hydrogen fuel cell as most important propulsion type

Progressive: Electric aircraft & hydrogen fuel cell as dominant propulsion | Focus on new aircraft types + more efficient designs | AI + automatisation: Autonomous diagnostic in MRO
Conservative: Electric aircraft & hydrogen fuel cell as dominant propulsion | Focus on retrofits of existing aircraft | Few MRO improvements + gradual digitalisation

Figure 4: DEPA 2070 technology scenario for small air transport

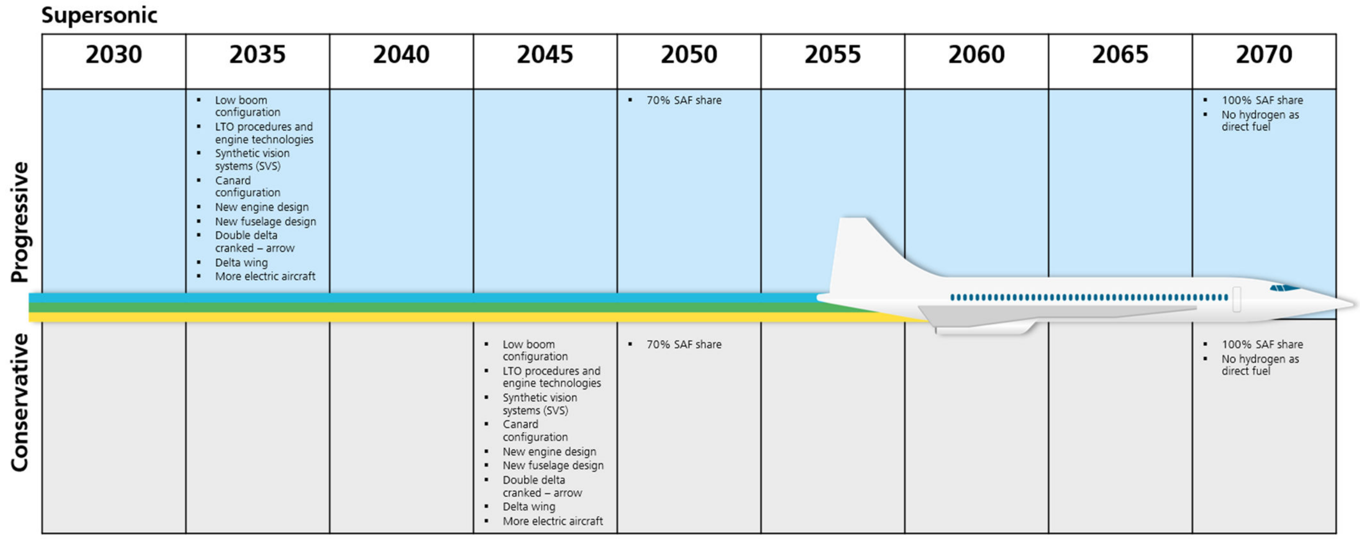


Business Jet

	2030	2035	2040	2045	2050	2055	2060	2065	2070
Progressive	▪ Hybrid electric aircraft (fuel + battery) ▪ Adaptive compliant trailing edge (ACTE)	▪ Laminar flow control (hybrid)	▪ Boundary layer ingestion (BLI) ▪ Hydrogen combustion aircraft		▪ 70% SAF share				▪ 100% SAF share ▪ High importance of hydrogen-powered & hybrid-electric aircraft
Conservative			▪ Adaptive compliant trailing edge (ACTE)	▪ Laminar flow control (hybrid) ▪ Hybrid electric aircraft (fuel + battery)	▪ Boundary layer ingestion (BLI) ▪ 70% SAF share				▪ 100% SAF share ▪ No hydrogen as direct fuel ▪ Significant share of hybrid-electric aircraft

Progressive: Hydrogen & hybrid-electric as dominant propulsion | Focus on new aircraft types + more efficient designs | AI + automatisation: Autonomous diagnostic in MRO
Conservative: SAF & hybrid-electric as most important fuel until 2070 | Focus on retrofits of existing aircraft | Few MRO improvements + gradual digitalisation

Figure 5: DEPA 2070 technology scenario for business jets



Supersonic

	2030	2035	2040	2045	2050	2055	2060	2065	2070
Progressive		Low boom configuration LTO procedures and engine technologies Synthetic vision systems (SVS) Canard configuration New engine design New fuselage design Double delta cranked – arrow Delta wing More electric aircraft			70% SAF share				100% SAF share No hydrogen as direct fuel
Conservative				Low boom configuration LTO procedures and engine technologies Synthetic vision systems (SVS) Canard configuration New engine design New fuselage design Double delta cranked – arrow Delta wing More electric aircraft	70% SAF share				100% SAF share No hydrogen as direct fuel

Progressive: SAF as only alternative to fossil fuel until 2070 | Focus on new aircraft types + more efficient designs | AI + automatisation: Autonomous diagnostic in MRO
Conservative: SAF as only alternative to fossil fuel until 2070 | Focus on retrofits of existing aircraft | Few MRO improvements + gradual digitalisation

Figure 6: DEPA 2070 technology scenario for supersonic aircraft

3. Vehicle Segment Demand Forecast

✈ Based on the underlying scenario assumptions that were also extended to aviation external developments by a STEEP (Society, Technology, Economy, Environment, Policies) analysis a detailed demand forecast that considered also future capacity constraints at airports was elaborated for the different vehicle segments. The results are displayed in the following figures, separately for mainliner and regional, as well as for SAT and supersonic air travel.

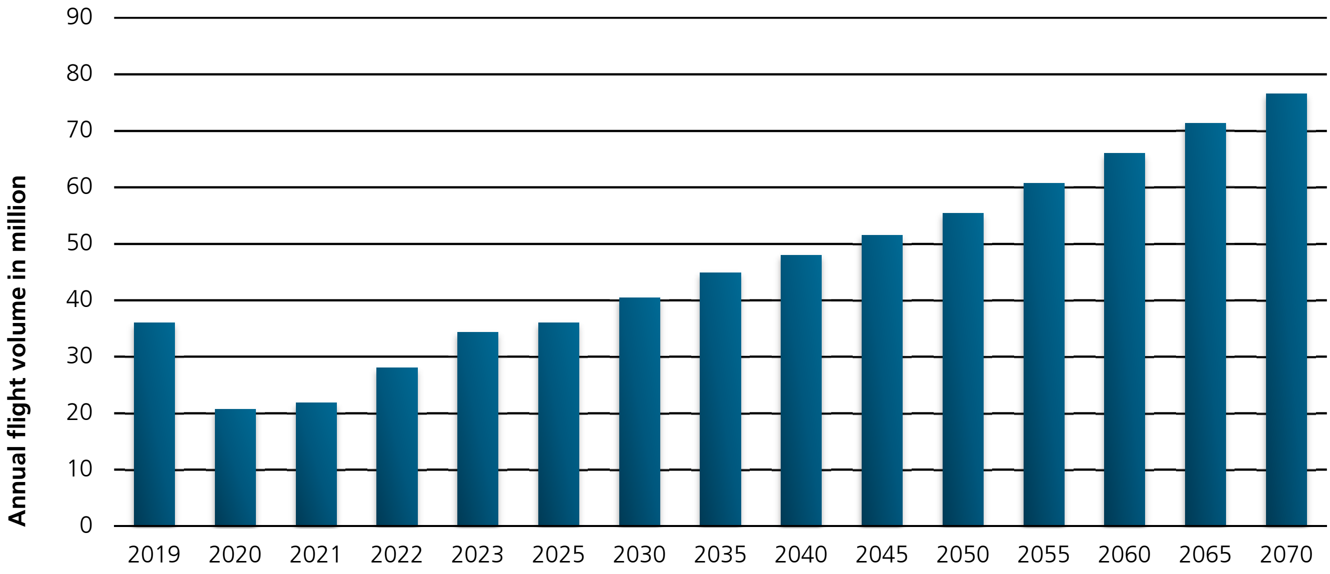


Figure 7: Global flight volume forecast up to 2070 for mainliner and regional air traffic

For the mainliner and regional market segment it can be seen that the air transport sector will face a continuous growth over the next decades. With an average annual growth rate of 1.5% the number of flights will increase in total from 36 million in 2019 to more than 76 million in 2070. Meanwhile for the SAT market segment, a flight volume increase from 1.2 million in 2019 to 2.6 million in 2070 was forecasted.

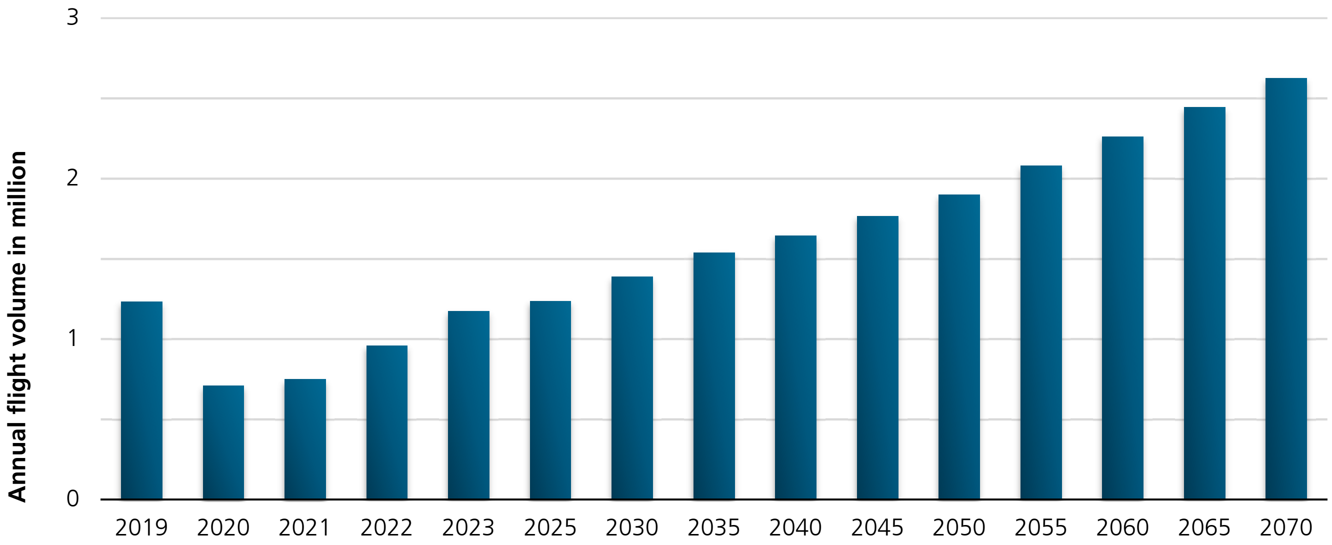


Figure 8: Development of SAT flights up to 2070

In the same time span the number of business jet flights will grow from 6.5 million to almost 14 million. As the economic growth is the most important driver in this respect the demand development can be assumed as relatively stable and the compound annual average growth rate is very similar to the one for mainliner and regional air traffic. In contrast, business jet flights as well as SAT flights will be less affected by airport capacity constraints in the future, as normally smaller airports with sufficient capacity reserves are served.

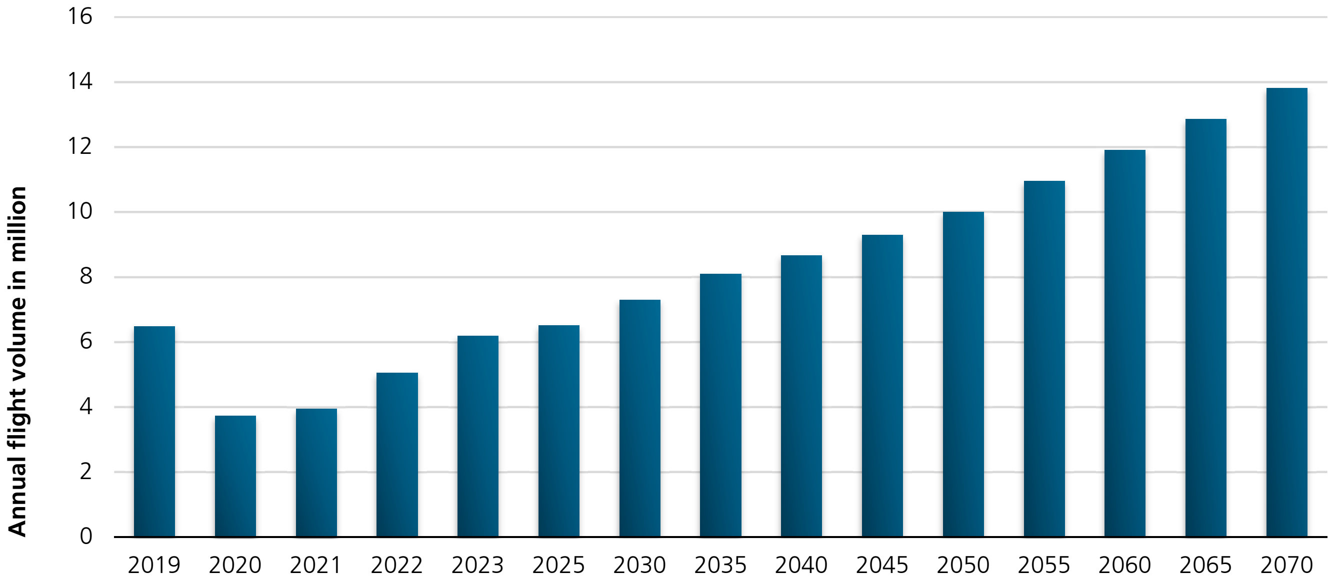


Figure 9: Development of business jet flights up to 2070

Finally, for the new market segment of supersonic air travel a split in two scenarios (a progressive one and a conservative one) was done in order to follow the DEPA 2070 scenario taxonomy and in order to address the higher uncertainty for the development of this innovative market segment.[1] To prepare the best conditions for a more detailed demand analysis in relation to mobility and connectivity effects at the same time the forecast displayed in the figure below also concentrated solely on the number of potentially new routes (and not on the number of flights) for supersonic air travel. If this key figure is considered, the difference between the two scenarios becomes evident. In the conservative scenario, the number of supersonic transport routes increases from 300 in 2030 to over 800 in 2070. Meanwhile, in the progressive scenario, more than 600 routes can already be expected for the year 2030.

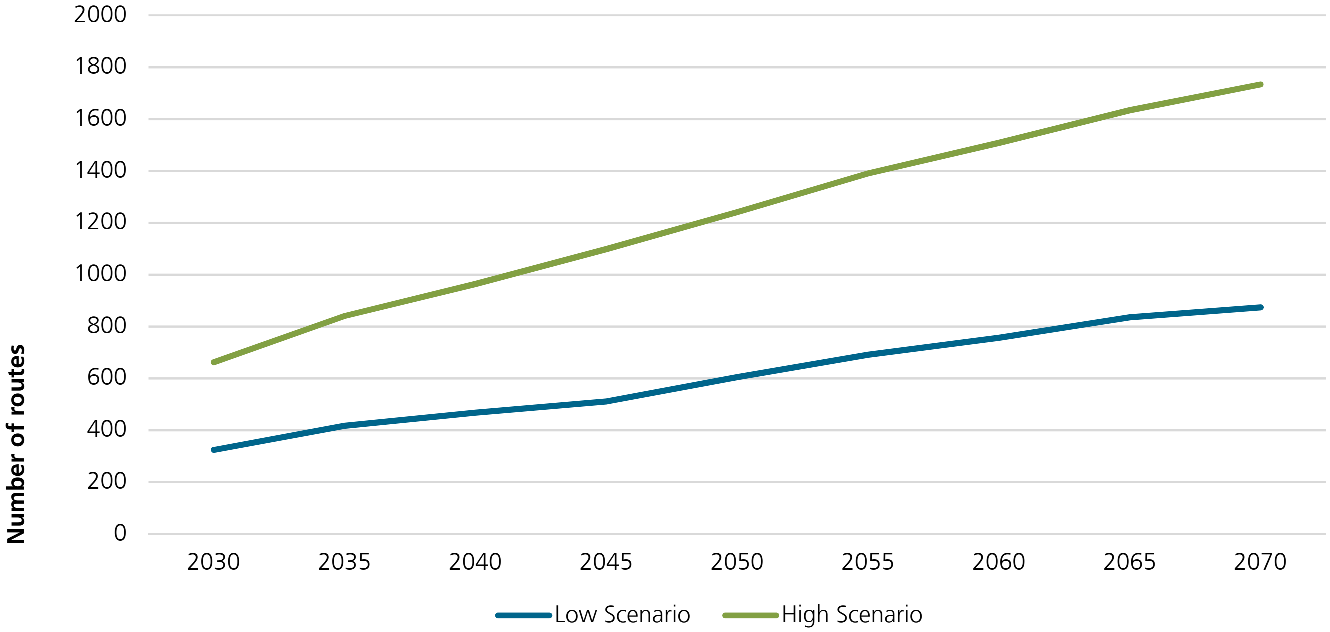


Figure 10: Number of supersonic routes in both DEPA 2070 scenarios

4. Future Fleet Development

✈ Based on the demand forecast results and the technology projections detailed vehicle design studies and assessments were carried out in the course of the DEPA 2070 project. Thus, a differentiated projection of the future fleet development could be provided. For this purpose, for all of the 13 ICAO seat categories and the two DEPA 2070 scenarios vehicle concepts were developed and evaluated according to their technical performance and their economic viability. The forecast of the global flight volume per seat class for the time span 2019-2070 (cf. figure 11) was in this respect the next analysis step to identify the need for new aircraft. For the further estimation of the development of the global fleet aircraft replacement needs were also considered. Together with the findings of the trend analysis for the air transport market, propulsion/technology development and sustainable aviation fuels the calculation for the future energy mix in aviation could be conducted. The results for the year 2070 are provided in figure 12.

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[1] Especially the entry into service and the market diffusion of supersonic air vehicles is currently unclear as there have been several postponements in the past. This is why the following analyses concentrated only the calculation of demand potentials without considering the supply side.

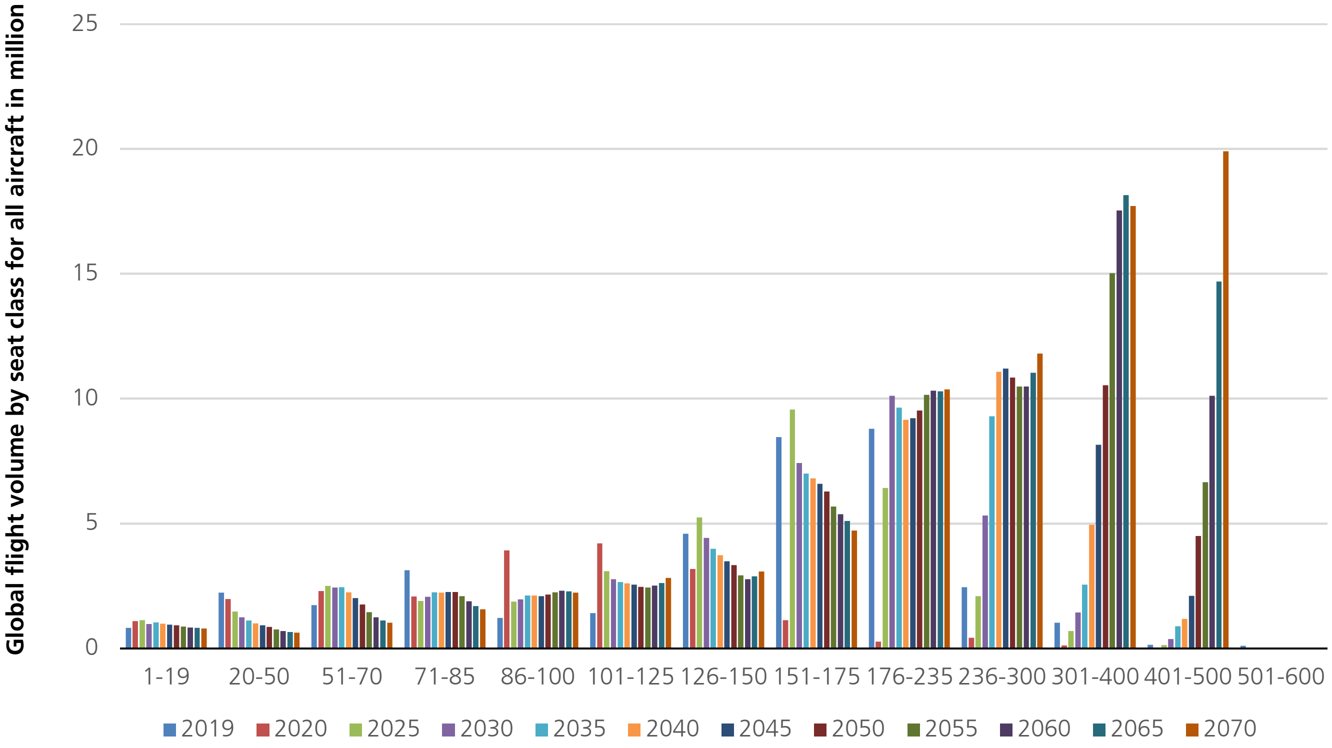

Figure 11: Flight volume by seat class

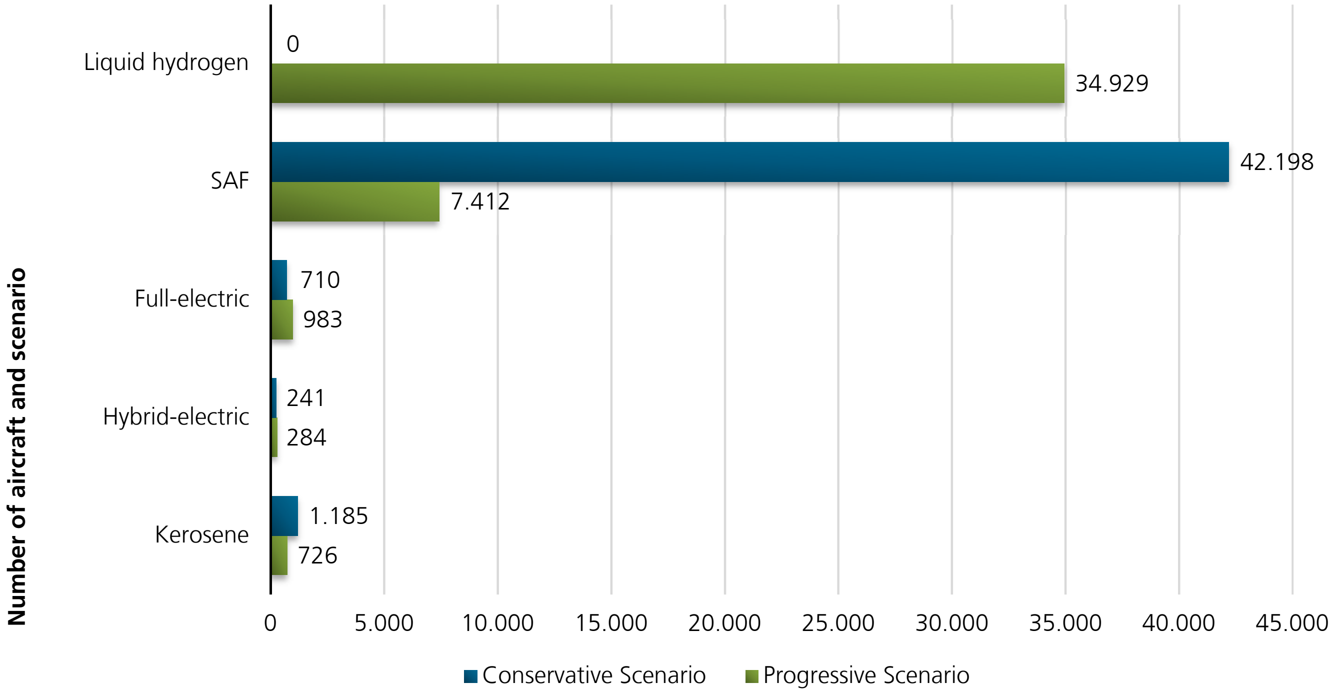

Figure 12: Fleet mix 2070 according to propulsion technology and scenario

As it can be seen liquid hydrogen has a leading role in the progressive DEPA 2070 scenario while SAF has a lower significance in this scenario. Instead, it plays a crucial role in the conservative scenario. For full-electric and hybrid-electric propulsion a smaller share of aircraft is projected in both scenarios given that distance limitations that reduce the usage opportunities for these types of aircraft. For this market segment the differences between the two DEPA 2070 scenarios become rather visible with regard to the share of full-electric aircraft. For the progressive scenario the share in 2070 is significantly higher in total figures than in the conservative scenario due to more ambitious assumptions of entry into service and market diffusion of full-electric propulsion. In contrast, the conservative scenario expects a slower progress in this field which leads to a majority of hybrid-electric vehicles compared to their full-electric counterpart. Finally, the share of kerosene-fueled aircraft is significantly reduced in both scenarios in favour of advanced aircraft propulsion.

5. Emission Reduction Potentials

✈ Thus, in general a significant CO_2 emission reduction can be reached in both DEPA 2070 scenarios despite of a nearly doubling of flight volumes in the time span from 2019 to 2070 (cf. figure 7). This change is mainly driven by technological improvement and the different energy mix in aviation. Game changers in this respect consist of the introduction of carriers powered by liquid hydrogen in the progressive scenario while SAF plays in both scenarios also an important role and is especially in the conservative scenario the key driver for the CO_2 emissions reduction. The following figure shows in this respect the total reduction potentials over the next decades for the life-cycle CO_2 emissions.[2] The life-cycle CO_2 emissions development was also regarded in relation to the forecasted traffic volumes (cf. the following figure).

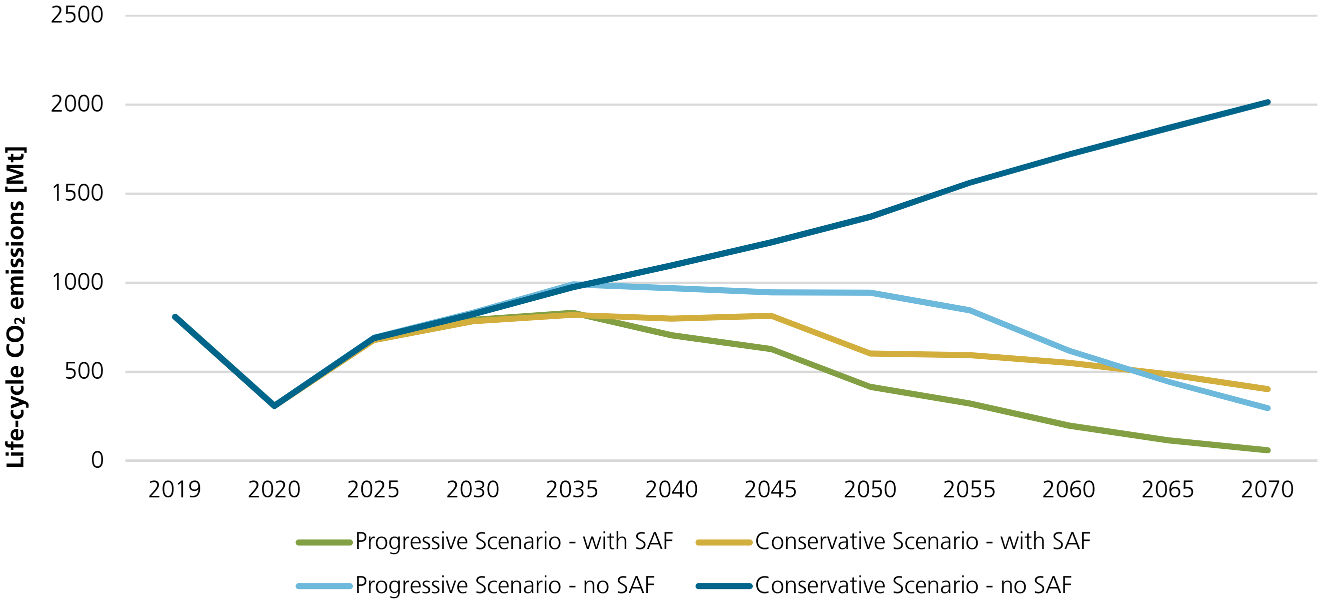

Figure 13: Life-cycle CO_2 emissions for the DEPA 2070 scenarios with and without consideration of SAF

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[2] The reduction of life-cycle CO_2 emissions due to SAF were considered with 80 % in contrast to normal Jet A-1 kerosene. SAF was treated equally in the conservative and progressive scenario.

With consideration of SAF, the life-cycle CO_2 emission levels of 2019 will never be reached again. Neither in the conservative nor in the progressive scenario. From 2030 to 2045 the increasing share of SAF is compensating the higher demand and thus higher CO_2 emissions. Because of the large increase of SAF share between 2045 and 2050 (32% to 70%), the life-cycle CO_2 emissions decrease rapidly. Also, the life-cycle emissions per 100 revenue passenger kilometres (RPK) decrease in all DEPA 2070 scenarios and are displayed in the next figure.

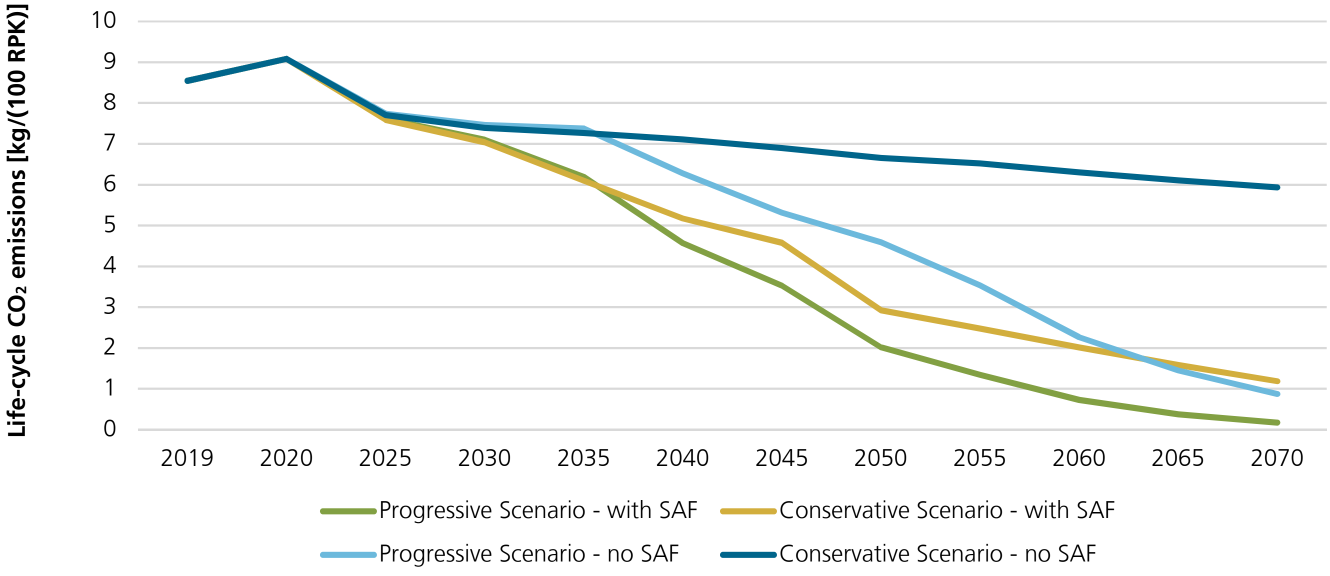

Figure 14: Life-cycle CO_2 emissions per 100 RPK for the DEPA 2070 scenarios with and without consideration of SAF

The curves show that a significant reduction could be possible in this case for all of the investigated scenarios. While the reference years 2019/2020 show the highest value of nearly 9 kg CO_2 emissions per 100 RPK already the conservative scenario, without consideration of SAF, shows a decrease of this value by 30.5% until 2070 as a result of improved aircraft technology as well as a higher seat load factor and aircraft seating capacity. The introduction of SAF leads to a further reduction of the life-cycle impact up to 86% - again compared to 2019 values. This value increases in the progressive scenario without the consideration of SAF up to a value of 90% and with the consideration of SAF up to 98%. Nevertheless, it has to be considered that the life-cycle reduction of SAF is dependent on different aspects such as SAF-type, feed stock, carbon intensity of the electricity used to produce SAF and much more.

As further part of the DEPA 2070 project aircraft noise research was conducted. In this case, technology is also a key factor to reduce total noise immissions and the resulting negative impacts. For this purpose, noise reduction technologies were investigated in the project and an additional focus was put on the further development of noise estimation and assessment methods. The challenge behind is that noise immissions are a local impact of air transportation and the noise situation differs from one airport to the other. Nevertheless, in order to estimate and assess the total impact of noise-optimised aircraft and noise reducing technologies, a more global picture is needed with regard to the status quo situation and potential future situation of a broader set of airports. In order to enable future research in this domain a new method for noise assessment was developed within the DEPA 2070 project. The big advantage here is that this method provides quick and reliable results and can be coupled with the DEPA 2070 demand forecast on airport level. Dedicated noise assessment studies in future projects are possible on this basis.

6. Economic Development

✈ As further part of the impact analysis the economic outcome of the future air transport development in terms of gross value added and employment was analysed in the DEPA 2070 project. Based on the forecasted air transport demand growth of the DEPA 2070 scenarios from around 36 million in 2019 to more than 76 million flights in 2070, the added value generated by air transport related activities will increase from 1,073 billion Euros to 2,249 billion on global scale. For the EU-27-member states it will grow from 119 billion Euros to 197 billion Euros over the next five decades. The further economic footprint in relation to air transport-related employment shows that aviation has supported around 17 million jobs on global scale and 1.9 million jobs within EU-27 in the year 2019. All of these values cover direct, indirect and induced effects of air transport's economic outcome. For the year 2070 around 37.3 million jobs on global scale are estimated as an effect of air transport growth while 2.9 million jobs could be supported by aviation on EU level. The detailed results of the economic analyses are also provided in the next figures.

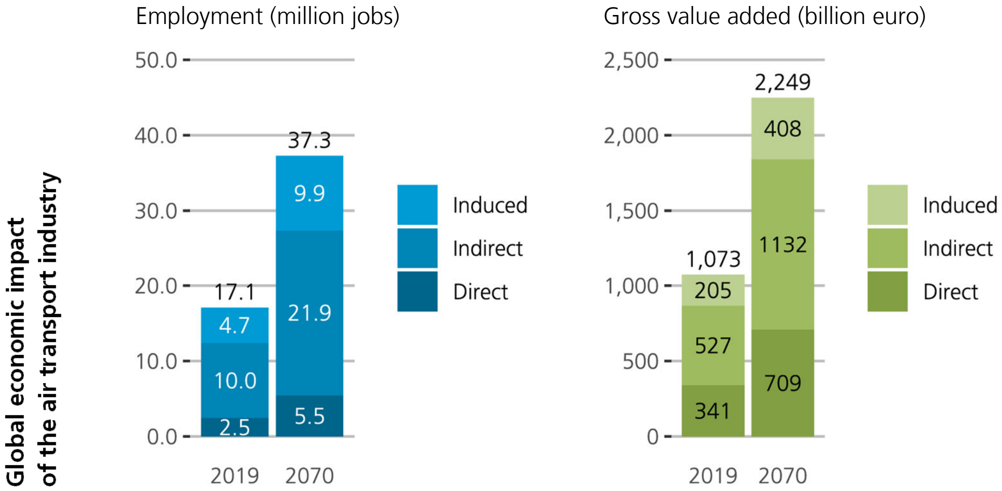

Figure 15: Long-term global economic impact of air transport – direct, indirect and induced employment effects

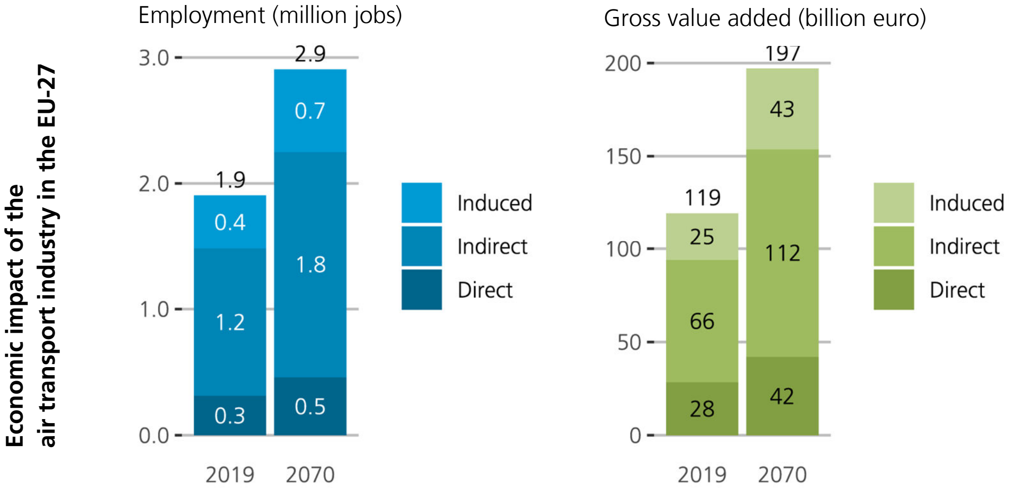

Figure 16: Economic impact of air transport in the EU-27 – direct, indirect and induced employment effects

7. Mobility Impacts

✈ With regard to mobility impacts a focus on new transport segments was put in the DEPA 2070 project. This included electric SAT solely as well as in combination with supersonic transportation. In order to estimate social benefits, it was in this context analysed how travel times for the European society could be improved. For this purpose, first, a fully electric SAT vehicle with a capacity of 16 passengers was regarded in a conservative scenario and in a progressive scenario assuming increasing ranges over the years. In the conservative scenario 4.8% of all European routes with a maximum distance of 203 kilometres could have a theoretical time advantage of at least 1 hour in 2070 when full electric SAT can be operated and is replacing car traffic. In the progressive scenario this share increases up to 64% (200,000 routes in total) with a maximum distance of 416 kilometres due to an assumed accelerated technological progress. Even if only business travel is regarded on these routes as in this market segment there is a higher willingness to pay for air transportation this travel option stays attractive. 14,726 routes in 2070 assuming a number higher than 0 business travelers/year or 2,675 routes assuming a number higher than 5,000 business travelers/year remain. Finally, it could also be shown in the DEPA 2070 project that the travel time savings and therefore the social impact might be especially high in those regions in Europe that are characterised by physical barriers or administrative borders.

A further analysis was conducted in order to check the potential CO_2 emissions reduction potential from switching car travelers that might use electrified SAT travel instead in the future. However, this analysis was solely concentrated on the theoretical CO_2 reduction potential[3] based on a certain amount of underlying assumptions, as the switching willingness of passengers is highly uncertain for the future and car travel will also be more and more electrified. Taking these constraints into account the theoretically highest possible CO_2 emission savings were again calculated for a conservative and a progressive scenario and are displayed in the next figure. While the CO_2 emissions savings in the progressive scenario with more than 300 daily electrified SAT flights in 2070 are quite high and total almost 1.2 million tons of CO_2 the conservative scenario shows a significantly lower share with approximately 0.2 million tons in total.

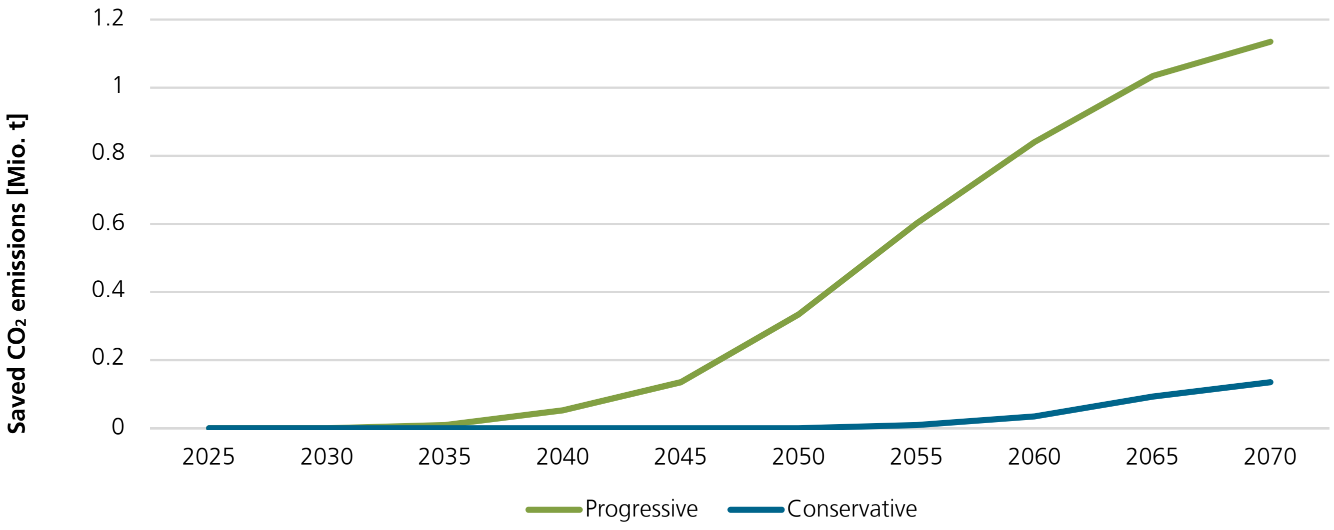

Figure 17: Saved CO_2 emissions through switching car passengers to full electric SAT vehicles; Assumption: 112,2 g/km CO_2 in car traffic, no consideration of electric car shares

[3] For example, 112.2 g CO_2 emissions/km were assumed for car traffic not considering that this share might decrease over the next decades due to a higher share of electrified cars. In addition, it was not considered for both transport market segments (car transport and air travel) if the electricity can be generated from renewable sources.

Airport Code	Airport Name	Country	SST Routes 2070	Average Time Advantage		
				SST vs. Mainliner	SAT vs. Road	SST + SAT
LHR	London Heathrow	United Kingdom	37	3.5	0.9	4.5
FRA	Frankfurt am Main	Germany	23	3.4	0.8	4.2
AMS	Amsterdam Airport Schiphol	Netherlands	19	3.4	0.8	4.2
CDG	Charles de Gaulle International	France	15	3.3	1.2	4.5
MAD	Adolfo Suarez Madrid-Barajas	Spain	11	3.9	1,6	5.5
MAN	Manchester	United Kingdom	9	3.0	1.0	3.9
LIS	Lisbon Humberto Delgado	Portugal	9	3.6	1.0	4.6
BRU	Brussels	Belgium	8	2.9	0.6	3.5
MUC	Munich	Germany	7	3.4	1.1	4.5
LGW	London Gatwick	United Kingdom	7	2.9	1.1	4.0
MXP	Malpensa International	Italy	6	3.3	1.0	4.3
ZRH	Zurich	Switzerland	6	3.6	1.1	4.7
DUS	Düsseldorf	Germany	6	2.9	0.6	3.5
HEL	Helsinki-Vantaa	Finland	5	4.5	0.3	4.8
VIE	Vienna International	Austria	5	2.8	0.8	3.6
ORY	Paris-Orly	France	5	3.4	0.8	4.2
DUB	Dublin	Ireland	5	3.1	0.8	3.9
GVA	Geneva Cointrin International	Switzerland	4	3.1	1.4	4.5
WAW	Warsaw Chopin	Poland	4	3.8	0.6	4.4
BER	Berlin	Germany	4	2.7	0.8	3.4
BCN	Barcelona International	Spain	4	2.4	1.7	4.1
TFS	Tenerife South	Spain	4	1.8	0.9	2.7
CPH	Copenhagen Kastrup	Denmark	3	4.3	0.9	5.3
FCO	Fiumicino	Italy	3	3.4	1.3	4.6
BHX	Birmingham International	United Kingdom	3	2.3	0.3	2.6
ARN	Stockholm	Sweden	2	4.5	0.8	5.3
PRG	Vaclav Havel Airport Prague	Czech Republic	2	3.6	1.0	4.6
BUD	Budapest Ferenc Liszt Interna-	Hungary	2	2.4	1.1	3.5
ATH	Eleftherios Venizelos Interna-	Greece	2	1.9	1.4	3.3
LPA	Gran Canaria	Spain	2	1.9	2.7	4.6
ACE	Lanzarote	Spain	2	1.7	1.2	2.9
GLA	Glasgow International	United Kingdom	1	3.5	1.4	4.9
OSL	Oslo	Norway	1	3.1	2.2	5.2
NCE	Nice-Cote d'Azur	France	1	2.9	1.5	4.4
SJJ	Sarajevo International	Bosnia and Herzegovina	1	2.4	1.4	3.8
RIX	Riga International	Latvia	1	2.2	1.3	3.5
LTN	London Luton	United Kingdom	1	2.2	0.5	2.7
OTP	Henri Coanda International	Romania	1	2.0	1.1	3.1
FUE	Fuerteventura	Spain	1	1.8	1.6	3.5

Time Advantage **Low** 🟩🟩🟩🟩🟩 **High**

Table 1: Time advantage of SST (supersonic transport) and SAT from airports with SST traffic in 2070 in hours

As a third part of the DEPA 2070 mobility impact study the potential of SAT feeder traffic within Europe in combination with supersonic transport (SST) which could serve European airports in the future was regarded. To identify travel time savings the innovative travel chain of SAT and supersonic air travel was in this respect compared to the traditional travel chain of mainliner routes and car travel.

Although time advantages significantly depend on the analysed routes and airports in total travel time savings of SST in combination with SAT amounted to a minimum of 2.6 hours and a maximum of 5.5 hours in total which leads to an average time saving of 4.1 hours in relation to the whole set of analysed airports. The single results for all airports covered in the DEPA 2070 study are provided in the previous table.

To conclude, there is a relevant market potential for electrified SAT and also supersonic air transport which can be exploited if the adequate technologies and transportation concepts are realised in the time span up to 2070. This goes hand in hand with significant benefits with regard to society and mobility.

8. Aviation Infrastructure

✈ The impact studies in the DEPA 2070 project were finally completed by an analysis of the needed progress in aviation infrastructure. In this respect, the outcome of the DEPA 2070 development pathways were compared with the status quo of airport infrastructure. Special emphasis was put on the required changes with regard to the potential introduction of new energy sources in aviation (i.e. hydrogen, electricity and SAF). For this purpose, challenges and constraints were analysed in regard of their short-, medium- and long-term impact.

The results are provided in the next figure.

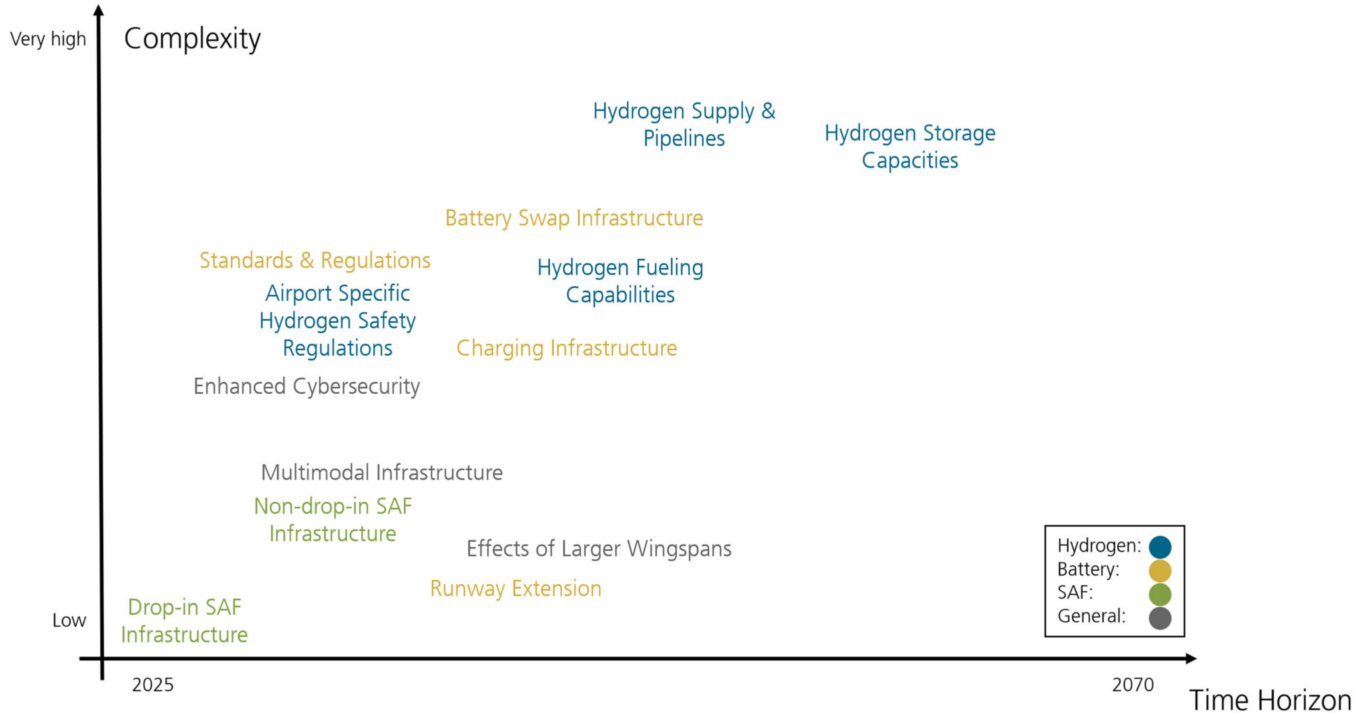

Figure 18: Infrastructure requirements in relation to the DEPA 2070 scenarios

It can be noted that with regard to the short-term (three to five years), airports are especially asked to do a strategic analysis and to elaborate detailed plans in order to set the right priorities for their future enhancement. This should optimally be done in form of scenarios as the further development in aviation as well as the framework conditions are characterised by a high uncertainty. Particularly regional differentiation, the competitive situation of each individual airport, cooperation options, capacity bottlenecks and the potential expansion of infrastructure, especially with regard to the use of new energy sources such as SAF and hydrogen, should play a major role in these scenarios. In the medium-term (five to fifteen years) the investment phase should start the latest.

However, this also creates new challenges in order to estimate and realise the right level of production and distribution infrastructure for alternative fuels. In addition, airport operations and processes have to be adapted to new aircraft types. In the long-term (> fifteen years), availability and capacity aspects might take centre stage due to increasing demand as it is reflected in both DEPA 2070 development pathways. The underlying challenges and constraints are quite complex and will require a coordinated approach of all aviation stakeholders in order to set the right priorities in the current environment.

The corresponding framework conditions and the fundamental changes of the air transport system that have to be considered in this respect and are described in more detail in the full study report of the DEPA 2070 project. Besides this, the report provides also an extended overview of the structure and approach of the project as well as its major findings and further research needs.

9. List of Figures and Tables

10. Impressum

DLR Overview

The DLR is the research center of the Federal Republic of Germany for aerospace. We conduct research and development in aviation, space, energy, transportation, security, and digitalisation. The German Space Agency at DLR is responsible, on behalf of the Federal Government, for planning and implementing German space activities. Two DLR project agencies manage funding programmes and support knowledge transfer.

Climate, mobility, and technology are changing globally. The DLR utilises the expertise of its 54 institutes and facilities to develop solutions for these challenges. Our more than 10,000 employees have a common mission: we explore Earth and space and develop technologies for a sustainable future. In doing so, we contribute to strengthening Germany's knowledge and economic base.

DEPA 2070

The "**DE**velopment **P**athways for **A**viation up to **2070**" (**DEPA 2070**) project, conducted by the German Aerospace Centre (DLR), examines the future development of passenger aviation up to the year 2070. The focus is on the analysis of trends, the development of aviation scenarios, and the evaluation of innovative technologies and their impacts on the environment, economy, and society. DEPA 2070 builds on the insights gained from the DEPA 2050 project and offers concrete perspectives for the sustainable transformation of aviation.

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