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SAT Roadmap

Version v-5.2

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Table of Contents:

Introduction

The SAT Roadmap document provides the basis for future research actions to achieve the vision of a SATS (Small Aircraft Transport System) that provides air taxi and scheduled operations using small aircraft. SATS will satisfy customer needs, both related to passengers and cargo.

The roadmap assumes that the small aircraft sector in Europe can benefit as much as possible from research, technology integration and demonstration actions performed for larger aircraft development and seamless mass passenger travel. Such actions are already identified in the ACARE SRIA.

Based on the vision for SATS, the strategic issues are identified and enablers named. From that a technology roadmap is developed that indicates areas where future research should focus on. If such actions are achieved, the European industry would be in the perfect position to capture a large part of the world market for SATS aircraft whilst the European citizen would be able to enjoy new efficient and tailored services.

SAT roadmap stipulated that the research and innovation actions identified cannot be funded solely by the industry. As a new sector in air transport is being developed, public support will be needed to support research and innovation actions for this industry. The introduction of such a system will also require some sort of stimulus involving public support. Already some experiments using existing equipment is being supported by public funds.

Both national funding and European funding should be offered in a coordinated way to enable the development of new IT systems that will enable the SATS system and enable new aircraft development projects.

Summary

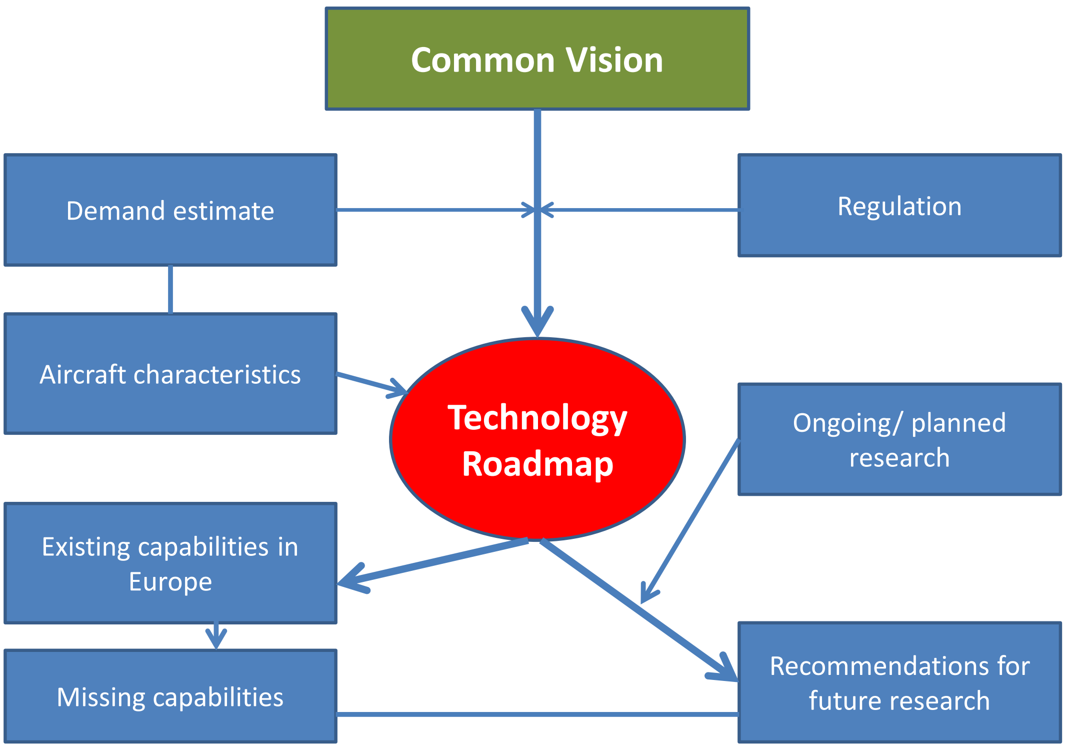
The SAT technology roadmap identifies research and technology issues that need to be addressed in the near future to enable the SAT system to become fully developed.

The SAT system will need to be supported by modern and new aircraft and an information network to establish new business models for small aircraft operations. **The SAT system will cover airplane operations ranging from 4-19 passengers for on demand air taxi (per seat on demand) transport as well as scheduled air transport to regions in Europe with limited transport infrastructures.**

The RTD roadmap is based on the requirements coming from the demand estimates. The type of demand determines the type of aircraft needed and the service model required to develop the SAT business. It also addresses the need to have a fresh look at certification issues.

New demands are translated into RTD needs.

The roadmap identifies solutions needed in the 2020 and 2035 time frame. These solutions require additional research. However the new research topics identified will be matched with already on-going and planned research to avoid overlaps. The resulting list of potential research topics will be provided to the European Commission and ACARE.



1 The SAT Roadmap - General

The SAT Roadmap project aims at delivering the following:

Definition of a **common vision** of the small aircraft passenger and cargo transport system for inter-regional mobility for on demand and scheduled air transport services with 4-19 seat aircraft.

Design of a **business case** compliant with the identified requirements which describes the relations among all the system's components.

Risk Assessment and **cost/benefit performance** of the identified new system's concept.

Identification of the **SAT requirements** in terms of **technology needs** and **regulatory issues** to be addressed.

Assessment of **current capabilities** versus the ATS demand.

Definition of a **roadmap** to fill the **technology/regulatory/operational** gaps between current capabilities versus the requirements.

Dissemination actions and establishment of a stable and well **recognised network of stakeholders**.

This report defines the Technology roadmap for the future development of the SAT system. It covers 4 main issues:

- An introduction into SAT system operations and the methodology used in the roadmap
- The identification of the capabilities to enable the SAT vision over time. Two time frames are considered: 2020 and 2035, in order to be in line with the new ACARE Strategic Research and innovation Agenda.
- The relationship between these capabilities and research topics.
- The translation of the research topics into proposed research projects over time to enable the SAT vision to be realized.

These proposed research projects will be matched with on-going and planned research and the final recommendation for RTD projects avoiding any overlaps will be published in the final report.

2 The SAT Roadmap

2.1 Introduction

Different scenarios can be envisaged for the future European Transport System depending on many factors (social needs, economy, fossil oil price and availability, environmental concerns including noise and climate change, political choices and stability).

A possible visionary European Transport System should be based on a customer oriented, and an environmentally sustainable, cost efficient, safe, seamless and intermodal passenger friendly system aiming to ensure mobility and cohesion for the European citizens while enabling economic growth.

"More people and greater economic affluence mean more mobility and more transport. Some studies suggest that the number of cars in the world will increase from around 700 million today to more than 3 billion in 2050, creating serious sustainability problems unless there is a transition towards lower and zero-emission vehicles and a different concept of mobility is introduced in an environmentally friendly way." *Communication from the European Commission. A sustainable future for transport: towards an integrated, technology-led and user friendly system. Brussels, 17 June 2009.*

One future element of such an advanced transport system will be transportation using small aircraft and small/regional airports assisted by an ICT infrastructure (Intelligent Personalized Air Transport System). This new transport mode will enable fast travel in areas of Europe where high speed trains or traditional airline connections are unavailable and substitute road travel thus alleviating road congestion problems in a customer - and environmentally friendly way. It will contribute to the goal of enabling 4 hour door to door travel all over Europe.

2.2 What is the Small Aircraft Transport System (SATS)?

SATS aims at the segment of the transport market that is not served by scheduled air transport or high speed trains, which today results in a substantial need for road travel, to answer the specific needs of business, private and other users.

The small aircraft transport mode can **fill a gap,** which exists between regular **Surface Transport** and regular mass **Air Transport.**

The challenge is to create a new mode of transport using small aircraft as well as local and regional airports enabling access to more communities in less time.

The main idea is to shift a part of passenger car trips and trucking (above 300 km) to small aircraft to improve the efficiency of European transport, relieve the congestion on roads and thus reduce the environmental impact whilst ensuring inter European door to door travel within 4 hours.

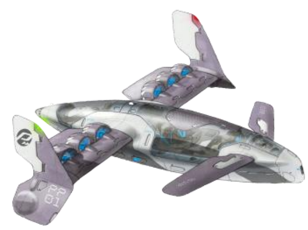
Taking into account the travel cost and the value of time saved by air travel, SATS will offer an attractive alternative to travel by car for distances greater than 300 kilometers.

The Small Aircraft Transport responds to serious challenges for the transport system i.e. spending less time in travel and creating better conditions for traveling, while meeting the following conditions compared to road transport:

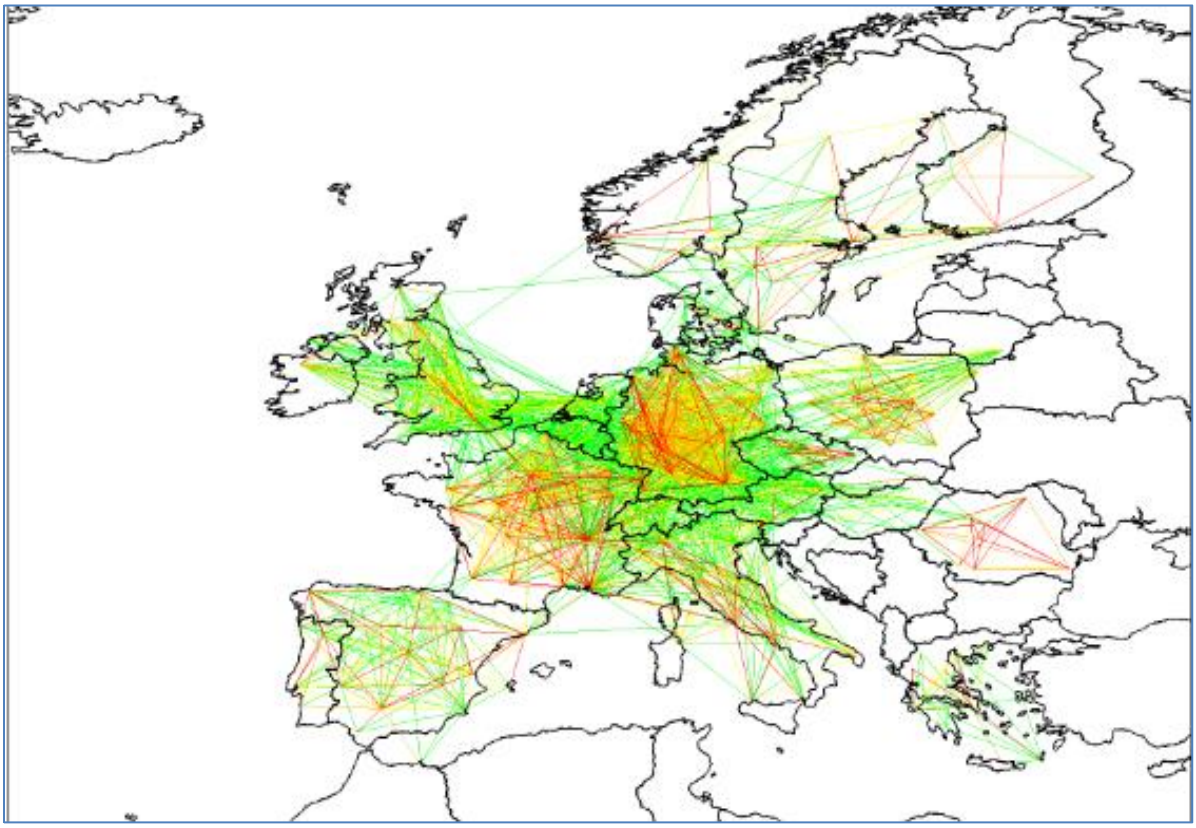
- Use less energy,
- Increase safety and security,
- Increase seamless intermodal connectivity,
- Reduce cost,
- Reduce pollution,
- Exploit more efficiently the existing infrastructure,
- Deploy intelligent transport system to achieve efficiency and easy way of reservation service and possibilities for sharing travel (per seat on demand).






A possible scenario in 2035 for the use of small aircraft is illustrated below (according SAT Rdmp D2.3 Analysis of the impact of each business case):



+100 movements a day
50-100 movements a day
20-50 movements a day
5-20 movements a day

The Small Aircraft Transport System will use small 4 to 19 seat aircraft, initially with a single professional pilot and later on using automated control & guidance, flying IMC/ IFR operations, with propulsion systems that are tailored to the missions, using the network of regional airports, supported by appropriate ATM-ATC systems and an ICT infrastructure (Information and Communication Technology) to provide an easy reservation system and per-seat on-demand air travel as well as more effective operational and administrative procedures.

SATS is different than business aircraft services or recreational flying. It provides much cheaper services to customers than the normal business aviation. Recreational flying is normally not carried out by professional pilots and has no objective to transport passengers or freight.

2.3 The economics of SATS

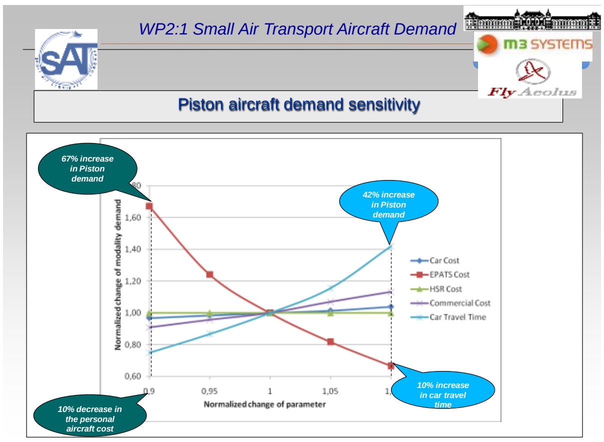
The market analysis of the SAT roadmap project has shown that integral travel cost is the major success factor for the SATS system. Integral travel cost are dependent on the fares for air services and the cost of time saved compared to travelling by other transport means. Furthermore the ease of access to the system via advanced IT solutions is a determining factor. Other factors like the safety and security perception and the external noise at regional airports are determining the success of SATS as well.

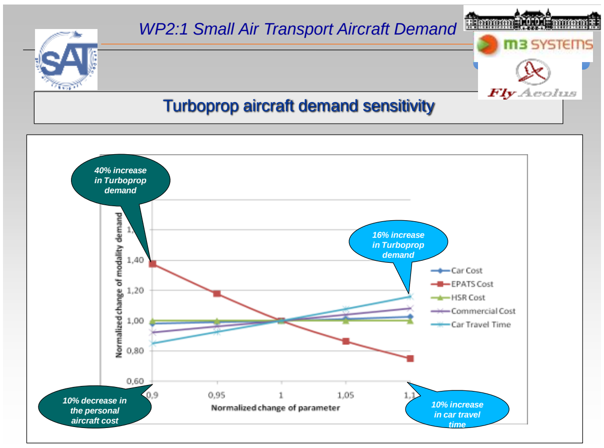
In general the demand for air transport is depending on 3 major factors: Development of GDP, fares and frequency/ service/ access. In normal airline operations the elasticity factors related to these factors are 1.5, -1 and 0,2. As SATS provides an alternative to other transport modes, the elasticity factor for fares seems to be higher than in other air transport related services.

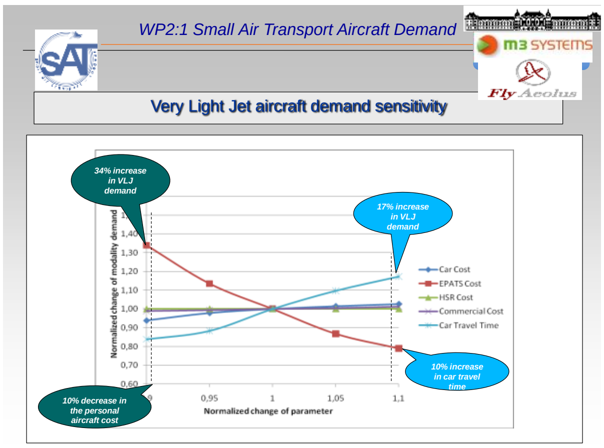
The SAT roadmap analysis has shown that fares have a big impact on demand. It is therefore essential that fares are kept to the minimum.

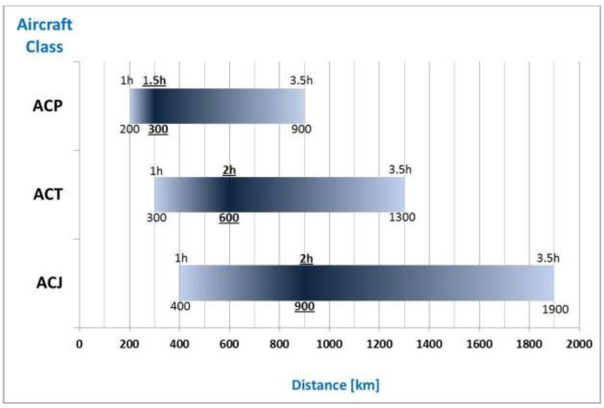
The illustration below is based on the business case using 4 seat piston engined aircraft for air taxi (on demand) transportation.

The sensitivity of demand versus fare was investigated by SAT Roadmap:







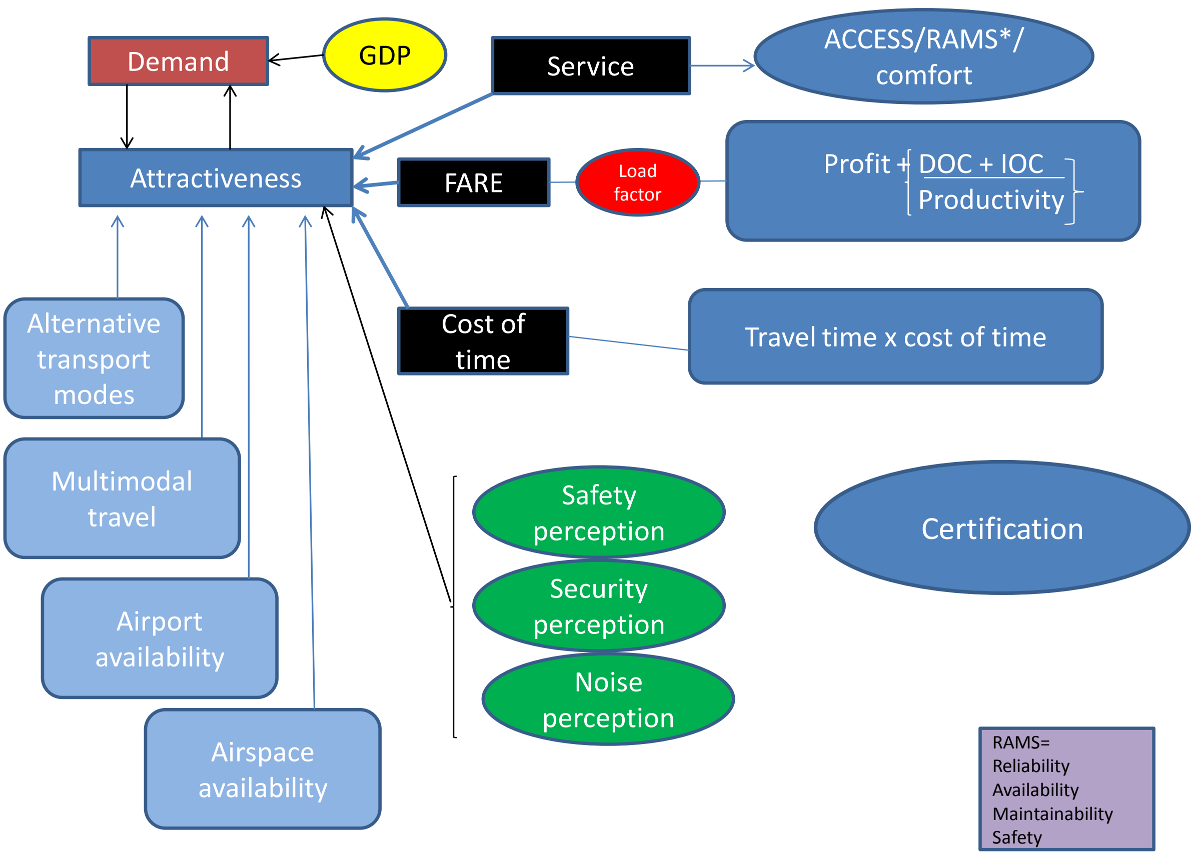


The analysis shows that a fare reduction has the biggest impact on demand for transportation by small piston engined aircraft which are assumed to cover an average distance of 300 KM. This can partially be explained by the availability of alternative travel modes like cars. The type of SATS operations over these distances will primarily be air taxi operations.

Turboprop powered aircraft cover larger distances of on average 600KM and jets 900KM. These aircraft seem to have a more stable customer base which includes scheduled services.

The analysis also showed that the success of a SATS transport option is depending on the European coverage and the number of airports that can be served by small aircraft as well as the total fleet size of SATS aircraft. Customers demand reliable and available transport services that are weather independent and safe. The issue of empty leg trajectories is important. If fares are to be kept at an attractive level, the average load factor needs to be 70% or higher. It is one of the challenges of the SATS system: in order to be successful there needs to be economies of scale both in terms of demand and in supply.

For understanding the interrelationship between the different parameters that determine the future development of the SAT operations the following illustration may help:



Determining the fare for different types of aircraft are primarily the profit margin (normally between 5-10%), Direct Operating Cost, the Indirect Operating Cost and the Productivity (defined as speed, capacity and annual usage) as well as the load-factor which is depending on fleet size and number of airports that can be served.

It is a well known fact that different definitions are used to determine direct and indirect operating cost. In order to compare different data sources, DOC is defined in this report as all cost related to operating the aircraft (both fixed and variable cost) , whilst indirect operating cost represent cost for operating an airline, which include all indirect ground staff employed by an organisation, marketing and sales as well as other general organizational cost.

Direct operating cost in this definition include the fuel cost, maintenance and spares, landing and route fees, crew cost and training cost, insurance cost, aircraft related infrastructure cost and capital cost (interest/depreciation or leasing cost).

Productivity is depending on aircraft speed, size and utilization. Aircraft flying at higher speed can make more flights per day but use more fuel and thus there is a delicate balance between productivity and cost increase. Bigger aircraft are usually more productive than smaller aircraft. This is one of the reasons why aircraft companies develop aircraft family concepts that allow the flexibility to make the aircraft type grow as demand is increasing.

SATS cost estimation

As part of Work package one, the SATS team made an elaborate analysis of cost related to 6 different aircraft: single engined and twin engined piston aircraft: single and twin engined turboprop aircraft and one Very light jet as well as a small jet aircraft. Cost were based on a 70% load factor single pilot operations for single engined aircraft and alternative annual flight hours.

In this analysis DOC was defined as variable cost (fuel, maintenance, fees and airport/ route charges, crew) as well as fixed cost (crew, hangar, insurance, training) and capital cost. Indirect cost were assumed to be 24% of the DOC. For each aircraft type the cost were calculated depending on the number of annual flight hours.

This resulted in the following table:

Aircraft class	ACP-1	ACP-2	ACT-1	ACT-2	ACJ-1	ACJ-2
Reference Aircraft	Da-40 Diamond	Pa-34 Seneca V	Pilatus PC-12 NG	Hawker Beech 1900D	Cessna Citation CJ1+	Hawker Beech 400XP
Passenger seats (no of pilots)	3 (1)	5 (1)	7 (1)	19 (2)	5 (2)	8 (2)
Vclimb/Vcruise CC	0,5	0,5	0,55	0,55	0,6	0,6
Climb to cruise level (CT) [min]	10	20	20	20	20	20
Fixed Flight Operation Time (FFOT) [min]	23	27	37	48	42	46
Waiting & Boarding Time [min]	10	12	15	20	15	18
Average Load Factor (LF) [pas/PS]	0,7	0,7	0,7	0,7	0,7	0,7
Distance/Great Circle Distance [D/GCD]	1	1	1,1	1,1	1,15	1,15
Assumptions for cost calculation						
Block speed [km/h]	244	313	463	476	654	763
Average Distance [km]	300	300	600	600	900	900

Annual flight hours [FH]		500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500	500	1000	1500
Average twenty-year operational costs 2010 [EUR/FH]	DOC	277	241	230	470	437	423	1135	929	860	1570	1358	1288	1438	1398	1371	1912	1852	1827
	IOC	100	81	75	197	158	146	622	417	350	755	545	476	726	561	506	1002	769	688
	TOC	377	323	304	667	594	570	1757	1347	1210	2325	1903	1764	2164	1959	1877	2914	2621	2515

The data show that a higher utilisation of the aircraft results in lower cost as the fixed cost are recovered over more flight hours. Furthermore the bigger the aircraft and the higher the speed, the lower the cost per passenger km.The analysis shows that single engined piston aircraft are the most expensive and can only be used in air taxi operations. The cost of larger turbo prop aircraft are compatible to the cost of driving a luxury car.

Average cost per passenger per km can be derived from this table:

SAT Airplane	Annual flying hours		
	500hours	1000 hours	1500 hours
ACP-1	€ 0,77	€ 0,66	€ 0,62
ACP-2	€ 0,43	€ 0,40	€ 0,39
ACT-1	€ 0,49	€ 0,40	€ 0,37
ACT-2	€ 0,25	€ 0,22	€ 0,21
ACJ-1	€ 0,62	€ 0,61	€ 0,59
ACJ-2	€ 0,48	€ 0,43	€ 0,42

Further analysis for reasons of comparison on the data showed that the relative impact of different cost elements could be shown as follows (variable cost elements plus crew cost but excluding capital cost per flight hour):

Cost	SAT Airplane						Average
	ACP1	ACP2	ACT1	ACT2	ACJ 1	ACJ 2	
Fuel	24%	36%	33%	36%	36%	42%	35%
Crew	25%	14%	13%	9%	15%	11%	14%
Maint	25%	29%	26%	25%	34%	28%	28%
Handle	22%	17%	5%	12%	5%	7%	12%
Fees	4%	4%	23%	18%	10%	11%	12%
Total	€ 232	€ 418	€ 844	€ 1.272	€ 1.360	€ 1.816	

This shows that the fuel and maintenance cost are major elements in the DOC whilst crew cost become more relevant with twin pilot operations. Future research should focus on the all elements of the DOC but the biggest gains can be achieved by reducing fuel, maintenance and fuel cost. Compared to today the cost of ATC on board equipment may also increase depending on the rules set by the Single European Sky. This will increase the capital cost but might reduce the ATC fees somewhat.

Validation

Information received from the Italian SATS operator during the Italian national workshop also shows the composition of DOC, IOC and the effect of aircraft size and utilization on the cost of operations. These data were received from an aircraft operator.

To gain insight of the direct operating cost two aircraft types were investigated: the Cessna Caravan (Turboprop , 9 pax) and the DH Twin Otter (turbo prop 19 pax) . Direct operating cost per hour are illustrated below:

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DIRECT OPERATING COSTS C208

Fuel	154	220 lt/h @ 0.7 Eur/lit
Oil	2	
Crew	78	Eur 6.000 net Single Pilot * 13 months
Hourly Maintenance	180	Line maint. including spares
Maintenance reserve	90	Avrg contract
Overhaul motore	55	including HSI
Handling	70	International airport, lowest fare
Landing Fees	18	
Navigation Fees	50	
Totale DOC C208	**697**	

DIRECT OPERATING COST DHC6

Fuel	280	400 lt/h @ 0.7 Eur/lit
Oil	3	
Crew	104	Cpt Eur 6.000 net + Pilot * 13 months
Hourly Maintenance	210	Line maint. including spares
Maintenance reserve	120	Avrg contract
Overhaul motore	110	including HSI
Handling	110	International airport, lowest fare
Landing Fees	25	
Navigation Fees	70	
Totale DOC TwinOtt	**1,032**	

The data show that for small aircraft operations fuel and maintenance are the most dominant factors in DOC. Maintenance cost are in this case much higher than in the SATS calculations (perhaps due to engine overhaul). Shown as a percentage of DOC in this case the different elements can be shown as follows:

Cost	Airplane	
	Cessna Caravan (single engine)	DH Twin Otter (twin engine)
Fuel	22%	27%
Crew	11% (single pilot)	10%
Maintenance	47%	43%
Handling	10%	11%
Fees	10%	9%

The aircraft operator was kind enough to provide data on indirect operating cost as well. The information received shows the following data

SAT - Rdmp Project CIRA Capua, June 5th 2012

FIXED COSTS

Indicative Fixed costs for a small operator could be as follows:

	1 Acft	5 Acft
Insurance	20,000	100,000
Lease rate	200,000	1,000,000
Training	5,000	25,000
Indirect Personnel (inc. AOC)	110,000	300,000
Commercial costs - Marketing	30,000	50,000
General costs	60,000	130,000
TOTAL	**425,000**	**1,605,000**

The data show that capital cost (leasing) and indirect personnel including AOC cost are the most dominant factors. To reduce capital cost, the acquisition cost of aircraft have to be reduced through advanced design and manufacturing, lower certification cost and availability of risk sharing capital at low interest rates. Direct operating cost constitute about 75% of the total operating cost whilst indirect operating cost represent 25% of the total.

D.O.C.

According to previous figures, and with the assumption that the
AVERAGE LEG is 1 HOUR OF FLIGHT TIME
we have the following DOC related index for the two aircraft:

C208

Seats	DOC per seat	Speed Km/h	cost seat km
9	77	270	0.29

DHC6

Seats	DOC per seat	Speed Km/h	cost seat km
19	54	252	0.22

The cost per passenger per km are compatible with the SATS data, keeping in mind that the Italian calculations are based on 1800 flight hours per year.

Annual utilization of aircraft also increases productivity as more passengers can be carried per year. Increasing productivity can be accomplished by reducing turn around time and (near) all weather operations. The Italian operator showed the effect of increasing the number of flight hours from 1200 to 1800 per year. Assuming a 70% load factor and 50% more flight hours the number of passengers transported increased by a factor of 1.5 as well.

Cessna Caravan and *Twin Otter*

	1200 flights/year	1800 flights per year
Total cost/year	€ 1.261.400/ *€ 1.663.400*	€ 1.704.600/ *€ 2.307.600*
Number of passengers/ year (70% load factor on a one hour trip)	7.560/ *15.960*	11.340/ *23.940*
cost per passenger for a one hour trip	€ 166,85/ *€ 104.22*	€ 150,32/ € 96.39

This simple calculation shows that cost can be reduced by higher utilization and the use of larger aircraft.

Targets

The analysis shows that SAT Roadmap should aim for a reduction in DOC, IOC and a high utilization rate using the largest possible aircraft to keep the fare as low as possible.

The SAT Roadmap team aims at a cost reduction of at least 50% by lowering the DOC by 38% and IOC by 10%. Furthermore it aims at high aircraft utilization of 1500 to 1800 flight hours per year.

An indicative breakdown is provided below:

Cost	Element	2035
DOC	Engine related	-/- 25%
	Airframe related	-/- 8%
	Systems related	-/- 2%
	Crew related	-/- 3%
IOC	Insurance	-/- 1%
	Leasing cost	-/- 7%
	Training	-/- 1%
	Other	-/- 1%

The relationship between the DOC and the technology roadmap can be shown in this qualitative table:

DOC	engine	airframe	systems	crew	fees
fuel	***	**	**		
crew			**	**	
maintenance	***	***	***		
handling	*	*	*	**	
fees			**		***
a/c price	***	***	***		

Certification

During several discussions in the project the issue of certification came up. In general it is felt that European certification rules for novel small aircraft are not clear, require large number of complex tests, allow subjective interpretation of the rules and are derivatives of rules that were made up for large airliners. Reference is made to the FAA regulatory framework which recognizes the SATS transport mode and avoids overregulation. As an example single pilot operations in IMC conditions is allowed in the US (except for single pilot operations with single piston engined aircraft in IMC/Night flying). In order to avoid certification to block innovation in aircraft design, flexible rules should be adopted. lowering the cost of certification and the time for certification is seen as essential.

It was also mentioned that there is little transfer of know how within the European aeronautics community, that low cost testing facilities may not be sufficiently available and that testing facilities are not always certified to perform appropriate testing. SAT Roadmap advises to look into the issue, not just by identifying DOA and MOA capabilities but also to identify qualifications for testing capabilities.

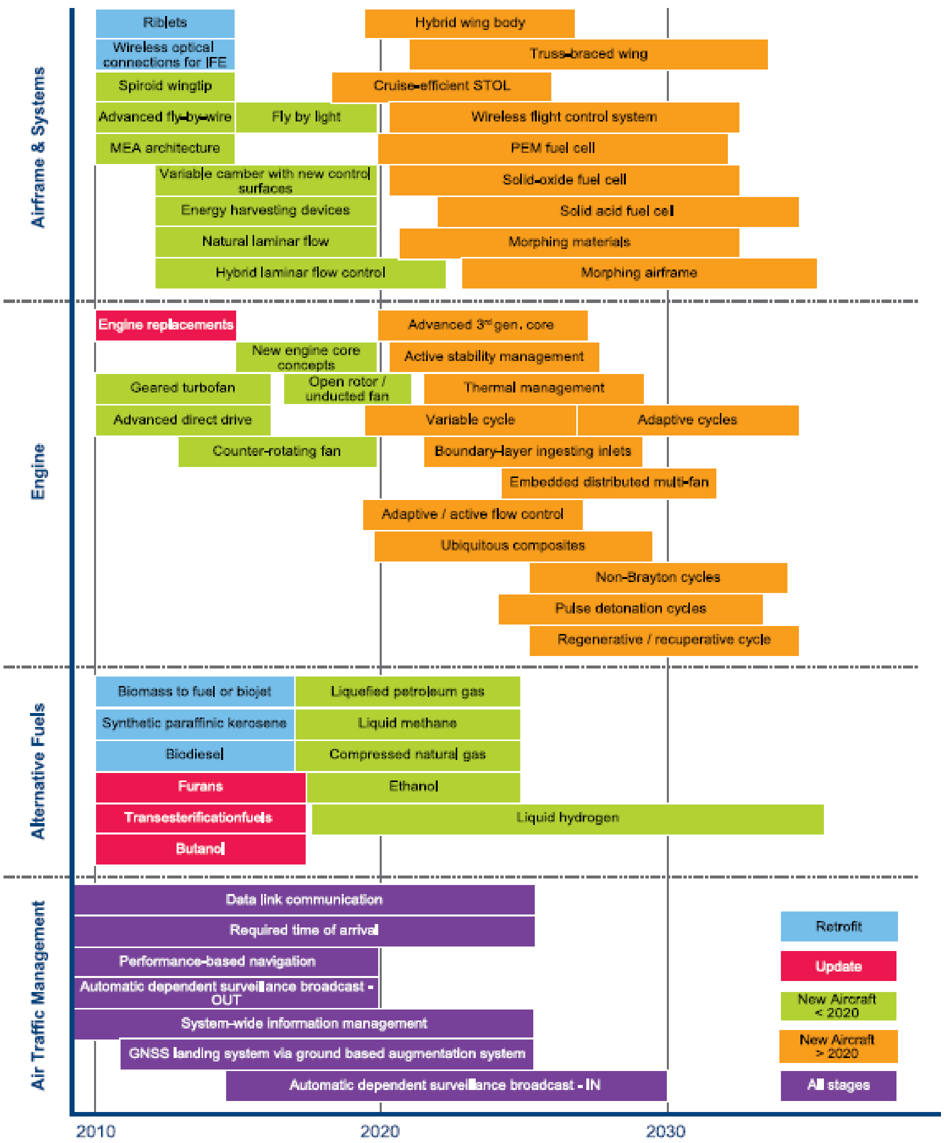
3 The technology roadmap

The 7th FP SAT-Roadmap project sets out a technology roadmap projecting the necessary research activities for the implementation and maintaining SATS in Europe. Technology challenges that will receive extra attention are: the aircraft configurations and propulsion efficiency, all weather operations, single pilot and automated operations, maintenance, noise and emission reduction, safety and security, cabin comfort as well as net-centric IT systems to support different operating models.

SATS development should be linked to SESAR ensuring compatibility with the SWIM environment of SESAR. Additionally the roadmap will also address future regulation necessary to fulfil the predefined set of requirements. The roadmap may incorporate technologies that are already being developed for larger aircraft. The Roadmap will be matched in the SAT project against already ongoing or planned research so that overlaps can be avoided in the final recommendation to the European Commission and ACARE.

The overview of ongoing and already planned research was derived from different sources, one of these being the analysis done by IATA to predict the reduction of CO_2 emissions by aviation. (ref 1)

Figure 3-1: Possible timeframes for availability of technologies

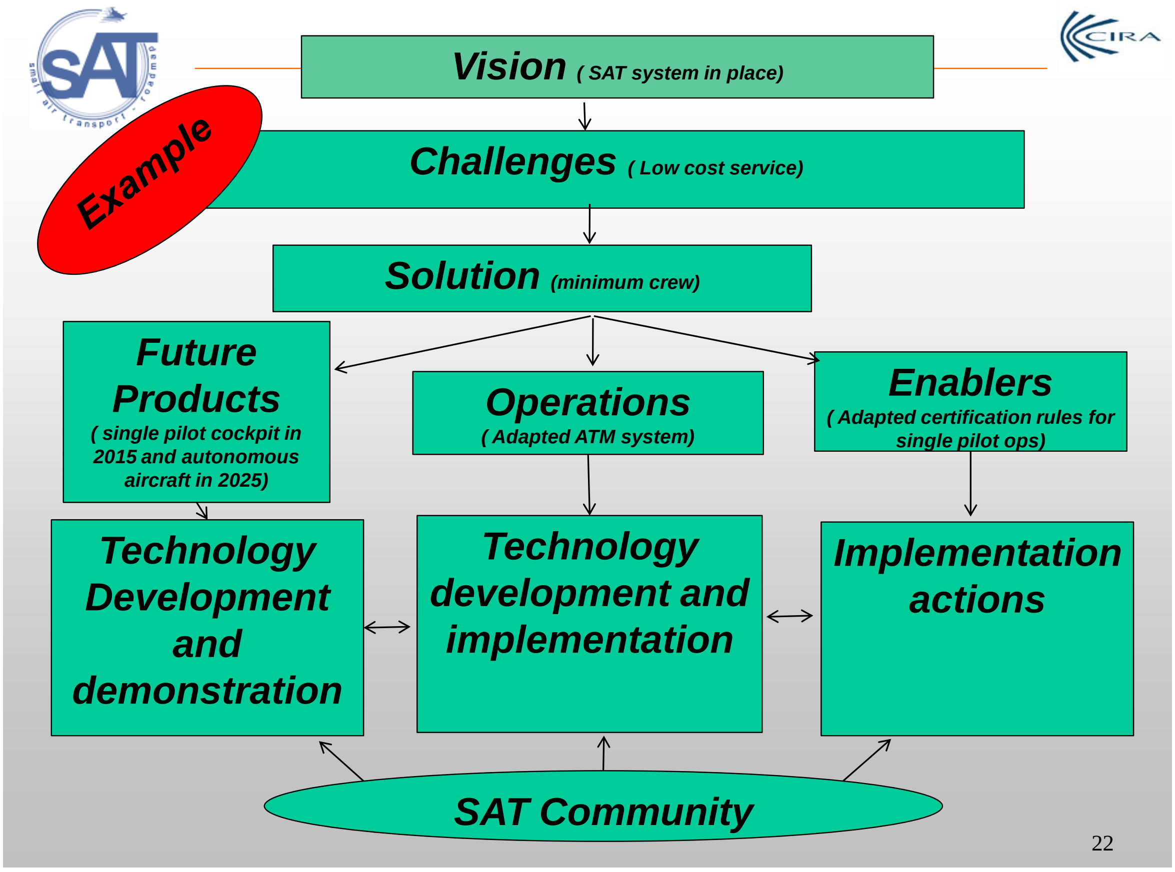


3.1 Methodology

Having agreed on a vision, next the challenges, future solutions must be identified. From that the technology roadmap can be developed, keeping in mind that the SAT roadmap covers the period up to 2035.

SAT Roadmap wants to determine what actions are needed to enable the successful implementation of small aircraft operations in commercial aviation. By breaking down the different elements the SAT roadmap can identify actions needed.

These parameters can be broken down as illustrated below, taking the minimum crew as an example.



The SAT roadmap identifies the solutions :

- for future products,
- operations and
- enablers

The analysis shows the technology areas that need to addressed to enable the SAT system. This will be matched with already on going and planned research to see where additional research is needed.

In short:

The future SAT system and its components need to be very cost effective, time effective, safe and secure, green , customer oriented and fit into multi modal transportation systems.

If the European aircraft industry wants to compete with US and other companies, it needs to develop more advanced products than the competitors. If a 40% market share is envisaged, the European small aircraft industry needs to develop step change technologies.

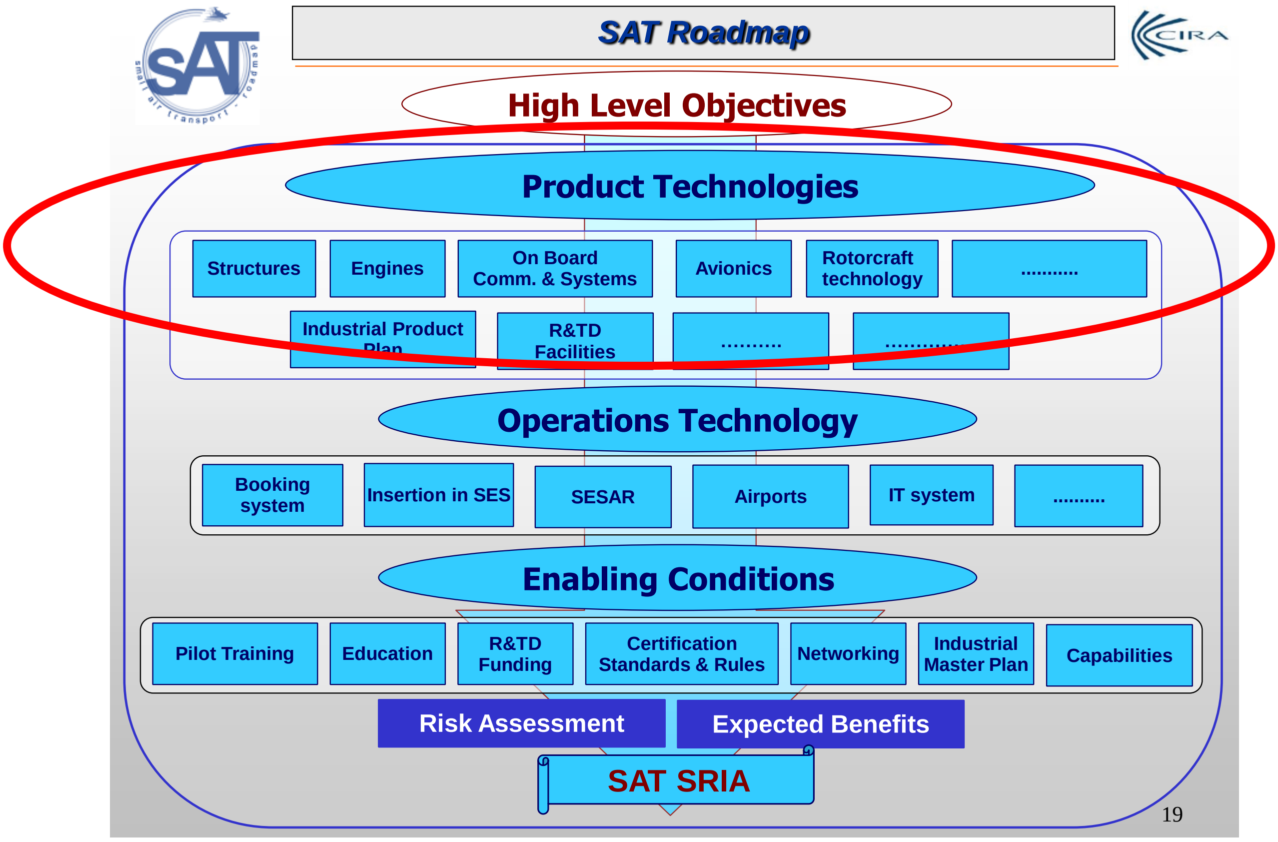
New aircraft need to cover a wide spectrum of use: covering traditional take off and landing, rotorcraft, advanced QVTOL and QSTOL configurations etc. The basic characteristics will be seating capacity of 4 to 19, cruising speed (from 300 to 800 km/h) , range (from 300 to 2000 km) and take-off and landing performances adapted to SATS airport and vertiport network.

In many cases the small aircraft operations are more advanced than regular airliner operations. Therefore the technology needed for small aircraft cannot just rely only on developments for larger aircraft. **Specific research and integration as well as demonstration activities are needed to enable the European aircraft industry to develop these new aircraft.** The IT systems that will support the deployment of the SATS system will also require research and innovation activities.

Enabling conditions need to change if the SAT transportation system is to be a success. Developing a new transport mode will require risk sharing funding methods. Besides the SATS industry in Europe is too small to engage in the substantial RTD and innovation efforts needed. Some form of public support as in the USA is needed to stimulate research and innovation. Besides research, certification rules need to be adapted and a new cost and time effective certification process needs to be implemented.

3.2 Metric analysis

A. Product technologies



Challenges for future products are:

A.1 Highly cost efficient: Low (In)Direct Operation Cost and high productivity.

This can be divided into the following elements:

Operating cost:

- reduction of fuel usage through weight savings (structures, materials, equipment), low drag and improved lift as well as improved engine performance and adaptive morphing structures
- reduction of crew cost through single pilot operations, pilotless aircraft using remote pilots (PPlane concept) or totally automated aircraft;
- reduction of **depreciation** due to **low manufacturing cost**, cost effective **certification** and large series production based on aircraft family concepts as well as standardization.
- certification based on appropriate **standards.** New certification procedures resulting in a 50% reduction in time and cost of certification.
- reduction of **maintenance cost** by avoiding unscheduled maintenance, longer maintenance intervals, aircraft self-healing and self-reconfiguration and maintenance free systems: on board monitoring via low cost HUMS
- reduction **of fees** for airports (using small airports without any ground facilities), limited ATM services reduction of insurance cost and taxes
- advanced, it-based reservation systems that ensure **high load factors** and thus **high frequencies** of flight
- no or **limited cabin crew** for scheduled services and very limited ground support

Optimized payload and speed as well as **high utilization** per aircraft :

- near all weather operations; appropriate ice protection and gust alleviation and short turn around times
- door to door delivery using **advanced configurations**
- increased **speed** over the current generation of aircraft
- increased **capacity** on thick routes thanks to air taxi model of operations

Reduction of Direct operating cost, indirect operating cost and productivity: The product achievements can be identified over time: (note: the red blocks indicate a spill-over from RTD for large airliners).

Product technologies

Highly cost efficient

Fuel reduction

	2020	2035	Metric 2035
Weight savings in structures	Advanced metallic structures	Nano technology materials	15% less weight and 15% less cost
	Advanced composite structures	Nano technologies	30% less weight 40% less cost
	Thermoplastics	Thermoplastics primary structures	30% less weight
	RTM technology		
	Third generation Glare		
			Structure € 259 per Kg, 100Kg per seat

1

Product technologies

Highly cost efficient

Fuel reduction

	2020	2035	Metric 2035
aerodynamics	Natural laminar flow	NLF	15% drag reduction
	Shape optimization Wing tip devices	Adaptive wing devices Flow/load control Advanced coatings	7% drag reduction
	Advanced high lift devices	Variable geometry airfoil Morphing wing Elastic wing	L/D ratio ...
Configurations		Includes blended wing configurations	
		Boxed wing	

2

Product technologies

Highly cost efficient

Fuel reduction

	2020	2035	Metric 2035
Equipment weight savings	Light weight, low volume avionics	Miniaturized equipment with low power uptake	Weight saving of ..
	All electric aircraft Electric actuation		
	Fly by wire Multi function auto pilot	Fly by voice inputs	
	Tabled based EFB	Tabled based avionics, HUD	
	Advanced low weight seats		

3

Product technologies

Highly cost efficient

Fuel reduction

	2020	2035	Metric 2035
Advanced engines	Compact diesel engine, multi fuel, low mass (< 0,2 l/ Km)	Electric engine Hybrid engine solutions	
	Advanced turbo prop engine	Super conductive engines	
	Small efficient turbo fan engine		
	Small unducted turbofan		
	More effective propellors		

4

Product technologies

Highly cost efficient

Reduction crew cost

	2020	2035	Metric 2035
Crew cost reduction	Single pilot operations thanks to human centred avionics	Remotely piloted vehicles, possibly with safety pilot	TRL 6 achieved
		Autonomous aircraft operations, totally automatic	TRL 6 achieved
	Advanced sense and avoid systems	Autonomous sense and avoid	Implemented
	Secure datalink	Cyber war hardened datalink	
	Self service onboard	Robotic stewards	

5

Product technologies

Highly cost efficient

Reduction depreciation

	2020	2035	Metric 2035
Low manufacturing cost	Design for low production cost	Robotics production	
	Out of autoclave composites		
	Advanced welding		
	Integration of supply chain		
	Advanced simulation for production		

6

Product technologies

Highly cost efficient

Certification

	2020	2035	Metric 2035
Reduce certification time and cost	Adapt certification as technology progresses		Reduction of cost and time by 50%
	Use simulation as certification tool	Fully simulated certification	
	EASA to participate during product development		
	New certification standards		

7

Product technologies

Highly cost efficient

Reduction maintenance cost

	2020	2035	Metric 2035
MRO cost reduction	Standard procedures	Longer maintenance intervals	50% reduction of cost
	Self healing coatings	Self healing structures	
		Automated reconfiguration	
	Maintenance free systems		
	HUMS	Telemetry of HUMS data	
	Design for MRO and retrofit		
	Advanced composite repair		8

Product technologies

Highly cost efficient

Reduction airport and ATM fees

	2020	2035	Metrics 2035
Use of secondary airports	GNSS based nav. equipment	GAAS	
	Virtual tower		
	Operations independent of ground equipment		
Low cost ATM	Airspace restructuring	Airspace segregation	
	Connected to SWIM		
	Low cost SESAR mode for SATS	Autonomous flight	
ASAS/ TCAS	Low cost TCAS	Low cost ASAS	
	VFR flight in IMC	Integration VFR/IFR	9

Product technologies

Reduced insurance cost and taxes

	2020	2035	Metric 2035
Low insurance cost by improving safety standards	Improved pilot training	Fully automated flight	
	Improved situational awareness	Full situational awareness	
	Connected to SWIM		
	No stall aircraft		
Remove ETS			Lobby for ICAO rules
			10

Product technologies

Highly cost efficient

Optimized payload, speed and utilization

	2020	2035	Metric 2035
Family class of aircraft	Family by design		
Modular aircraft design		Modular by design	Fully modular aircraft
High speed	Appropriate speed for power plant		
Supersonic speed		Supersonic jet	
Short turn around time	Quick refuelling No maintenance High speed taxi		15 minutes turn around
15 minutes flight plan	File flightplan 15 minutes before take off	On the spot flight planning (ground and in the air)	SESAR accommodates on the spot flightplans

Product technologies

Highly cost efficient

Increased speed

	2020	2035	Metric 2035
High speed QVTOL/QSTOL aircraft		Cruising speed 400miles/hour	Same as tilt rotor
High speed conventional small aircraft	Trade off studies	Advanced propulsion and aerodynamics	
High speed jets	Trade off studies against extra fuel cost		

16

Product technologies

Highly cost efficient

All weather, 24/7, ice protection, gust alleviation

	2020	2035	Metric 2035
Electric de-icing	Electric de-icing		
Coatings that will de-ice	Advanced coatings		Coating for de-icing is standard
All weather operations	All weather avionics	Connected to SWIM	99% dispatch reliability
24/7 operations	Advanced avionics	Automated flight	
24/7 operations		Whisper mode for night flying	..dB during approach
Gust alleviation		Low gust response	Ride compatible to jet
Gust alleviation devices		Gust alleviation flaps	Automated gust response

12

Product technologies

High utilization

	2020	2035	Metric 2035
Near all weather operations	Connected to SWIM		SWIM compatible
Ice protection	Anti icing fluids	Anti ice coatings	Fully certified to fly into icing conditions
	Heated boots	Electric de-icing	
Short turn around	No unscheduled maintenance	Maintenance free systems	Dispatch reliability of 99%
		Easy boarding/ deplaning	

13

Product technologies

Highly cost efficient

Door to door delivery

	2020	2035	2035
Small UAS		Small UAS for parcel/ pizza delivery	
Advanced QVTOL	Advanced helicopters	New VTOL configurations, no rotor needed	QVTOL available
Advanced QSTOL	Advanced autogyro Fan wing	New QSTOL configurations	QSTOL available
Steep approach	5-6 degree glide slope		City airports available
Novel landing pads		City airports, vertiports, rooftop landing sites	

15

Product technologies

Door to door delivery

	2020	2035	Metric 2035
Aircraft able to use all aerodromes			
QVTOL	Compound helicopter		
	Noise reduction by an increasing number of rotor blades turning at lower speed	Novel fan configurations including fanwing concepts	QVTOL fully operational
	Tilt rotor	New tilt rotor technologies	
			14

Product technologies

Highly cost efficient

Cabin crew

	2020	2035	Metric 2035
Replace cabin crew		robotics	No cabin crew cost

18

Product technologies

Highly cost efficient

Increased capacity

	2020	2035	Metric 2035
Family concept by design			
Modular aircraft		Aircraft fully modular	
Quick change cabin lay out	Quick change by design		
Ad-on luggage pods			

17

A.2 Green

Under this heading a number of issues need attention:

- **design** for green aircraft and replace **toxic** or environmentally harmful materials
- **low noise operation** (CDA, curved approaches, steep take-of and approach etc.)
- **low source noise** (for conventional aircraft, VTOL and STOL): noise shielding
- ultra efficient **engines**
- **alternative fuels and power sources** (including hybrid solutions, fuel cells and solar cells)
- **recycling and re-use**: collection of rare raw materials
- **retrofits** as provision for in the design

Greening

Design for green

	2020	2035	Metric 2035
Green is part of the design process	Green as design parameter		
Use natural fibres for composites	Natural fibres in secondary structure	Natural fibres in primary structures	100% natural fibres
Bio materials for cabin		Seats and upholstery from bio materials	100% bio material and recyclable
Replace toxic materials	REACH target	No toxic materials used	No toxic material

Greening

Low noise operations

	2020	2035	Metric 2035
Low noise approach	CDA approach, steep decent		Standard CDA with 5 degree descent
Equipment for curved approaches	Tunnel in the sky display	New avionics and high lift systems to enable evasive actions	No longer standard approaches
Use of noise preferred runways	Enhanced cross wind landings		
Noise shielding	Noise shielding in design		Noise reduction 70%
Low noise propellers	Novel propeller design		Noise reduction 70%
Low noise VTOL/STOL		Advanced QSTOl and QVTOL configurations	Noise reduction 70%

20

greening

Efficient power sources and fuels

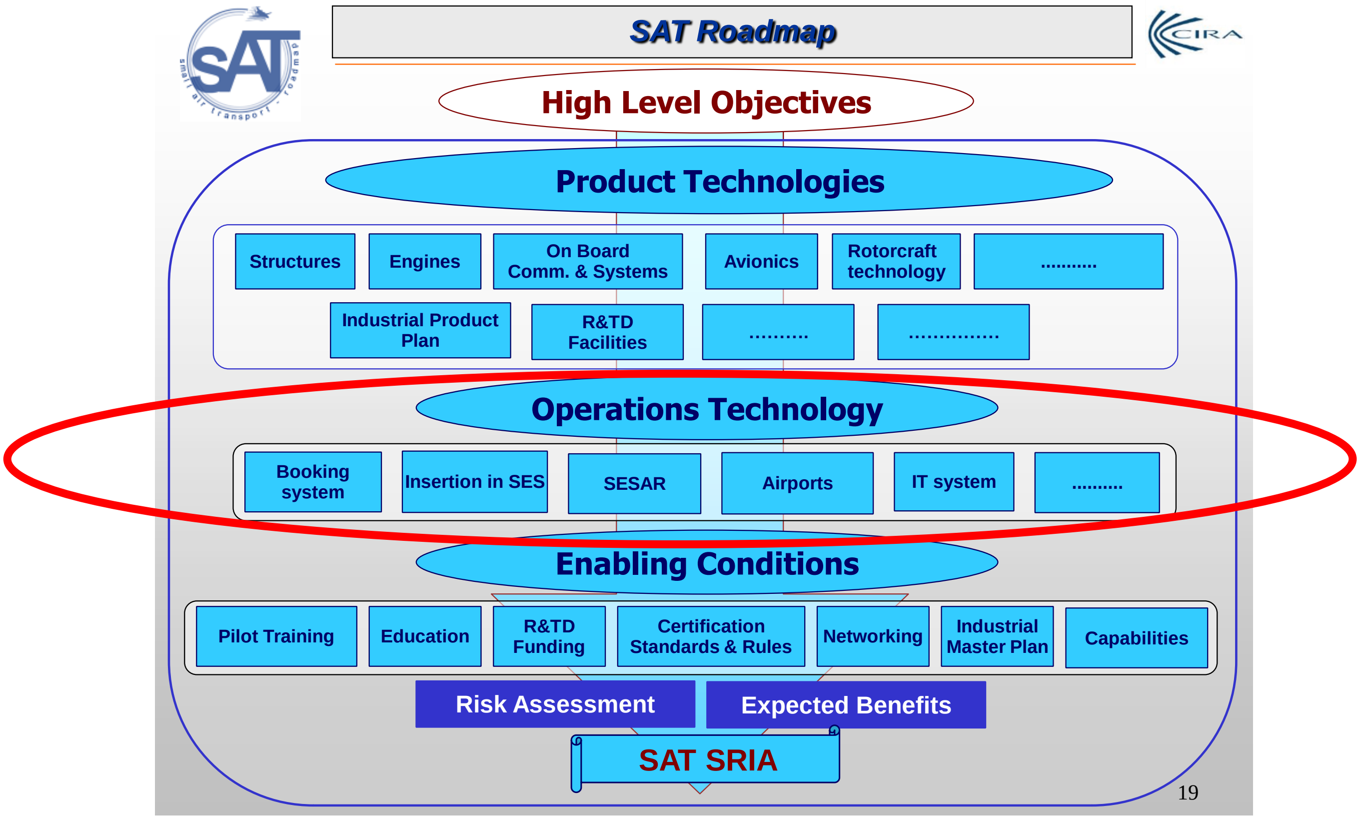
	2020	2035	Metric 2035
Advanced piston, turbo prop and turbofan engines			See fuel reduction
Novel engines: electric and superconductive	Electric engines for primary power; Hybrid engine solutions	Electric and superconductive engines	Electric or hybrid engines standard
Alternative power sources: Bio fuel Solar cells Hydrogen fuel cells	Use commercially available bio fuels, novel solar cells (70% efficiency)	Bio fuel, solar cells and fuel cells standard	No dependence of fossil fuels
Advanced light weight batteries		Light weight energy storage	On board energy storage
Kers system		Kers system in use	21

Greening

Recycling, re-use, retrofits

	2020	2035	Metric 2035
Design for retrofit			From the outset aircraft design have provisions for retrofit
Recycling	Bio materials	Recycling of composites and metal parts	Aircraft can be recycled for 90%
Re-use	Components are interchangeable		50% of aircraft can be re-used
Off the shelf components	Use of non aviation components	Strong links to car industry	
Use of social media	Tableds used in aviation		Handbooks and manuals replaced by tabled based information (paperless) 22

B. Operation Technologies



B.1 Highly time efficient

This can be achieved by :

- using regional **airports**, **vertiports, cityports** etc. without ground based navigation equipment
- advanced **ground operations systems**: advanced runway management systems
- cost- efficient **air traffic management** allowing direct routings and the missions of a variety of different aircraft
- advanced automated **(self)separation** management
- **onboard systems** that cope with new ATC
- **redesigned airspace** allowing different airspace users to operate at the same time

Highly time efficient

Landing sites

	2020	2035	Metric 2035
Use of regional, military airports	Policy incentives	Agreed practice	2500 aerodromes available
Landing sites independent of ground equipment	GNSS based on board equipment	CAT 3b landing feasible with on board equipment	Operations totally independent of ground NAV
Self separation on the ground	Vehicles and aircraft equipped with transponders		Universal use of low cost transponders
New vertiports, city airports etc		New airports available	Airport development in line with novel aircraft configurations
Connected to SWIM, CDM		Small aircraft connected to SWIM	SWIM is standard

23

Highly time efficient

Airspace use

	2020	2035	Metric 2035
Automated self separation	Low cost TCAS	Automated ASAS	Self separation guaranteed
Redesign airspace classification	Below FL195 limited ATC	No ATC below FL 195 except for TMA	Simple and efficient airspace
Low cost, volume and power uptake NAV equipment	Low cost transponders and data link	Universal equipment package	SESAR box type of equipment for 30.000 €
Advanced display units	Easy to operate equipment and displays (beyond Garmin 1000)	On ground and on board displays for total situational awareness	Operator centred displays for total situational awareness
Controller station	Pplane type of controller operations		Ground based pilot stations
Simple autopilot	Autopilot able to Accept ground commands		

24

B.2 Customer oriented

- quick boarding, deplaning and refueling: streamlined and automated passenger handling
- advanced, **it-based reservation systems,** based on new business models
- plug and play customization concepts
- an IT based **booking system** that will allow timely bookings and on time and delay free flights, based on internet broker functions
- **personalized delivery** of passengers and goods: novel cargo planes enabling door to door delivery
- **seamless travel** by connecting flight data with other airspace users and ground transportation to achieve inter modal transport
- 24/7 operations
- **Integration of different types** of traffic at airports: landside and airside terminals
- cabin environment based on the level of services required (e-connectivity)

Customer oriented

Customization

	2020	2035	Metric 2035
Quick turn around	Easy access to aircraft	High speed refuelling	Turn around in 10-15 minutes
Customer oriented cabin	Cabin optimized for type of passenger		Customer centric cabin
	Internet and phone options for passengers available		
24/7 operations	Equipment allows 24/7 operations	Gust alleviation	Smooth ride 24/7
	Electric de-icing		Certified for FIKI
Adopted terminals	Separation of mass transport and SATS transport	SATS terminals with connections to HUBs	SATS is integral element in airport design

26

Customer oriented

IT based reservation system

	2020	2035	Metric 2035
Multi modal tickets, reservation etc (see SRIA)	IT ticket base using social media	Multi modal planning, service, reservation	See SRIA
Brooker system for air taxi operations	System on voluntary basis	Established central European brooker system	Brooker system in place; All operators in Europe are connected
Seamless travel		Seamless system in which SATS is integrated	
Combination of pax and freight service	Exchange of info	Seamless integration	Seamless integration

25

products

SAT booking system

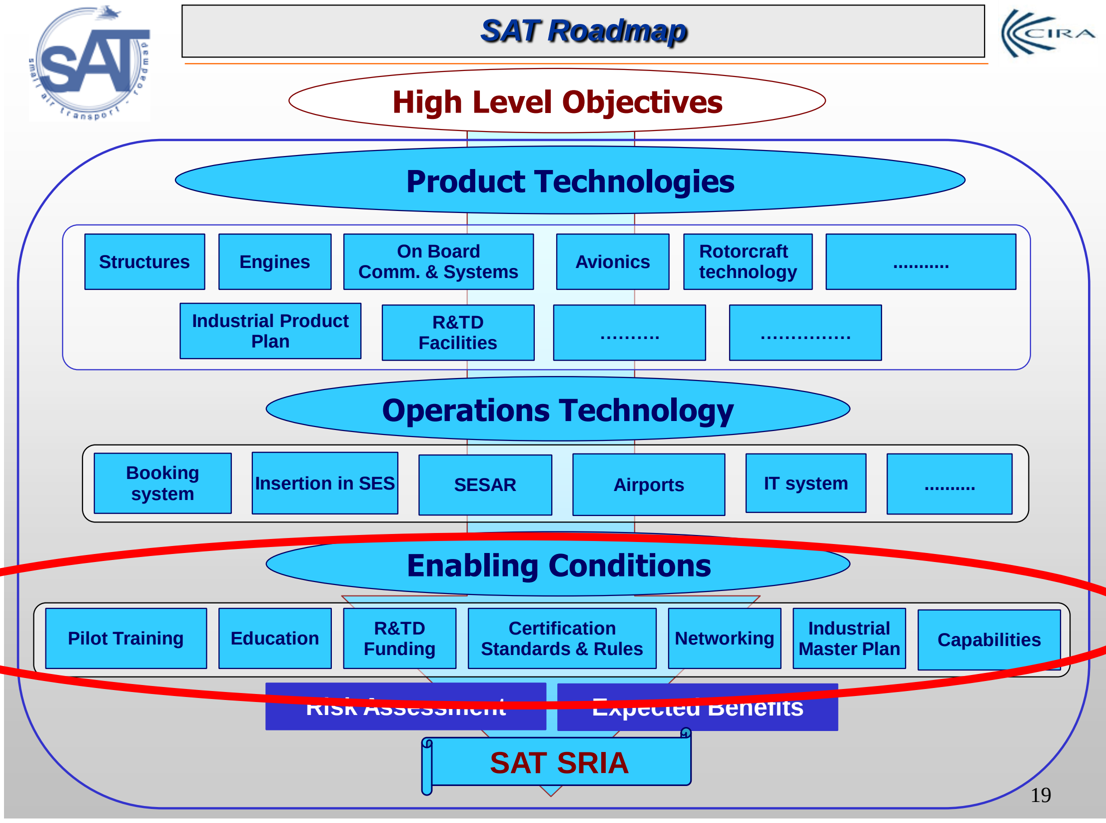
	2020	2035	Metric 2035
ICT management for SAT flight and booking	On demand software	Extension to manage all SATS stakeholders	10% of all customers use SAT travel
Apply engineering optimization techniques to passenger management	Optimize requirements	Optimization succeeded	Door to door timing for non HUB based flights
Point to point trajectory (FAB, FUA, ATM)	25% reduction in flight time	75% reduction of flight time	

33

B.3 Multi modal transport systems

SATS will be part of a new intermodal transport systems for passengers and freight. The aim is the development of customer oriented intermodal IT- and social media based travel management advisory tools that enable unbiased mobility choices, handle disruptions while travelling and respond to crisis management.

C. Enabling conditions



C.1 Safe and secure

The following issues need to be addressed:

- appropriate pilot training
- **redundant** on board systems; simple to fly aircraft
- flight data telemetry
- hazard avoidance systems on board and avoidance of loss of control and pilot friendly aircraft handling characteristics
- advanced **human centered** design
- **emergency** landing systems (parachutes etc)
- **crashworthiness** of fuselage structures, to increase survivability and reduce injuries
- passenger airbags and **crashworthy seats**
- adequate on board equipment
- improved passenger and luggage screening; fast track services
- **cyber war hardened IT** systems and avionics and datalinks
- auto recovery systems and anti manpads systems

Safe and secure

Safety

	2020	2035	Metric 2035
Appropriate pilot training	PC based training, serious gaming	Virtually reality	Pilot training in one month
Simple to fly aircraft	Aircraft is simple to operate	Stalling is impossible	Advanced design and systems to make flying a simple as driving a car
Redundant on board systems	Multiple systems	Reconfiguration and self inspection	Safety as good as in large airliners
Flight data telemetry	On board HUMS and down link	Operations base have real time information of aircraft status	Continuous monitoring of safety data
Hazard avoidance on board systems	Advanced weather info	Automated hazard avoidance systems	Hazards are mitigated automatically

27

Safe and secure

Safety

	2020	2035	Metric 2035
Human centred design and equipment	Flight equipment takes the human operator as a starting point	Air and ground equipment and controls are human design driven	The human operator is the starting point
Avoidance loss of control	Loss of control mitigated	Aircraft equipment prevents loss of control	Loss of control is no longer possible
Emergency landing system	Parachute system installed	Advanced emergency landing equipment	Emergency landings will create no damage to passengers nor aircraft
Auto recovery system	Auto recovery system installed		

28

Safe and secure

Safety

	2020	2035	Metric 2035
Crashworthy cabin	Cabin to allow ground impact	Cabin module can survive a crash	Cabin crashworthiness compatible to large airliners
Cabin designed for survivability	Injury reduction in case of crash	Cabin designed to withstand a high crash load	
Crashworthy seats	Seats designed to withstand a high crash load		
Airbags	Pilot and passenger airbags		Airbags installed
Advanced bird strike prevention	Bird strike prevention on the ground	Airborne based bird strike prevention devices	Zero birdstrikes

29

Safe and secure

Security

	2020	2035	Metric 2035
Fast track passenger and cargo screening	Speedy and nonintrusive screening	Walk true screening corridor	Passenger and luggage screening in 5 seconds
Passengers enjoy curb to plane in 15 minutes	20 minutes target from arrival at airport to gate	15 minutes from curb to plane	15 minutes stay at airport
Cyber war hardened data links	Data links are cyber war hardened		Secure data communication assured
Protection against laser lights	Windscreen will protect against laser lights		
Protection against manpads	On board laser systems and ground control	On board systems are cheap and light weight	

30

C.2 Other enablers

- establish an industrial master plan for aircraft development and production, service and MRO
- make sure there is appropriate RTD capability and facilities available in europe
- ensure adequate funding for RTD
- ensure adequate staffing is available and proper education is available

Institutional enablers

Sector wide collaboration and coordination

	2020	2035	Metric 2035
Industrial master plan for development, production and MRO	EGAMA is leading the master plan development	EGAMA has its own Industrial management group IMG	IMG within ASD on SATS aircraft established
Establish a SATS network that comprises EGAMA, operators and airports as well as Eurocontrol	Network established	Network enables the full recognition of the added value of SATS	Network operates as an advisor to public authorities
Global market share	Increasing market share thanks to innovative products	Global market share of 40% established	European industry has a 40% global market share on SATS aircraft

31

Institutional enablers

Research and education

	2020	2035	Metric 2035
SATS specific funding at national and European level is available	SATS RTD is incorporated in Horizon 2020	RTD is continued including large scale demonstration	RTD support to SATS well established
Appropriate RTD capabilities and facilities	RTD efforts on aircraft, engine and equipment as well as IT is stepped up	Well established RTD base in Europe for SATS system development	Europe is one of the main players in SATS system development
Education and staffing	Education includes specific topics for SATS	Education focused on SATS: staffing is no problem	SATS is a matue system with adequate and highly trained staff

32

4 Recommendations for future research actions

This chapter identifies future research topics for the development of the SATS system.

In order to identify these RTD topics some assumptions were made, based on the taxonomy included in the annex:

1. The recommendations in the new SRIA (Strategic Research and Innovation Agenda) of the new ACARE are followed up. That means that RTD actions are started in the following domains e.g.:
   a. Multimodal seamless transport chains
   b. Modeling of future passenger demand
   c. Better understanding on the effect of aviation on the atmosphere and understanding the impact of noise
   d. Improved certification procedures
   e. RTD ranging from TRL level 1 to 6 is performed, including large scale demonstrations on all relevant aircraft technologies
   f. An adequate RTD base including testing facilities and infrastructures is maintained
2. There is ongoing and incremental improvement of knowledge in the relevant domains like aerodynamics, aero-elasticity, aero-acoustics, propulsion, materials, construction, avionics, systems, ATM and airport development. It is understood that these activities are primarily focused on the development of large airliners and rotorcraft as well as business aviation.
3. The knowledge gained in these RTD activities are accessible for the SATS community. Also generic test facilities like wind tunnels and IT networks are open for the SATS stakeholders.

RTD actions are thus focused on novel developments in the domain of SATS products, operations and enablers.

We have identified the following domains where additional RTD actions are needed:

1. Configurations
2. Advanced structures, manufacturing and coatings
3. Advanced propulsion and alternative power sources
4. Automation
5. Cabin equipment and connectivity
6. Safety and security for SATS, emergencies
7. Training
8. ATM/ATC
9. Ground infrastructures and nodal points
10. Maintenance
11. Business models for SATS
12. IT systems to enable multimodal transport and SATS usage

In each of these domains RTD activities are identified. These are based on the maturity of the RTD actions and the metrics for 2020 and 2035.

SAT Roadmap already indicated in the Brussels scene that there is a need to demonstrate in Horizon 2020 several technology issues with regard to the SATS development.

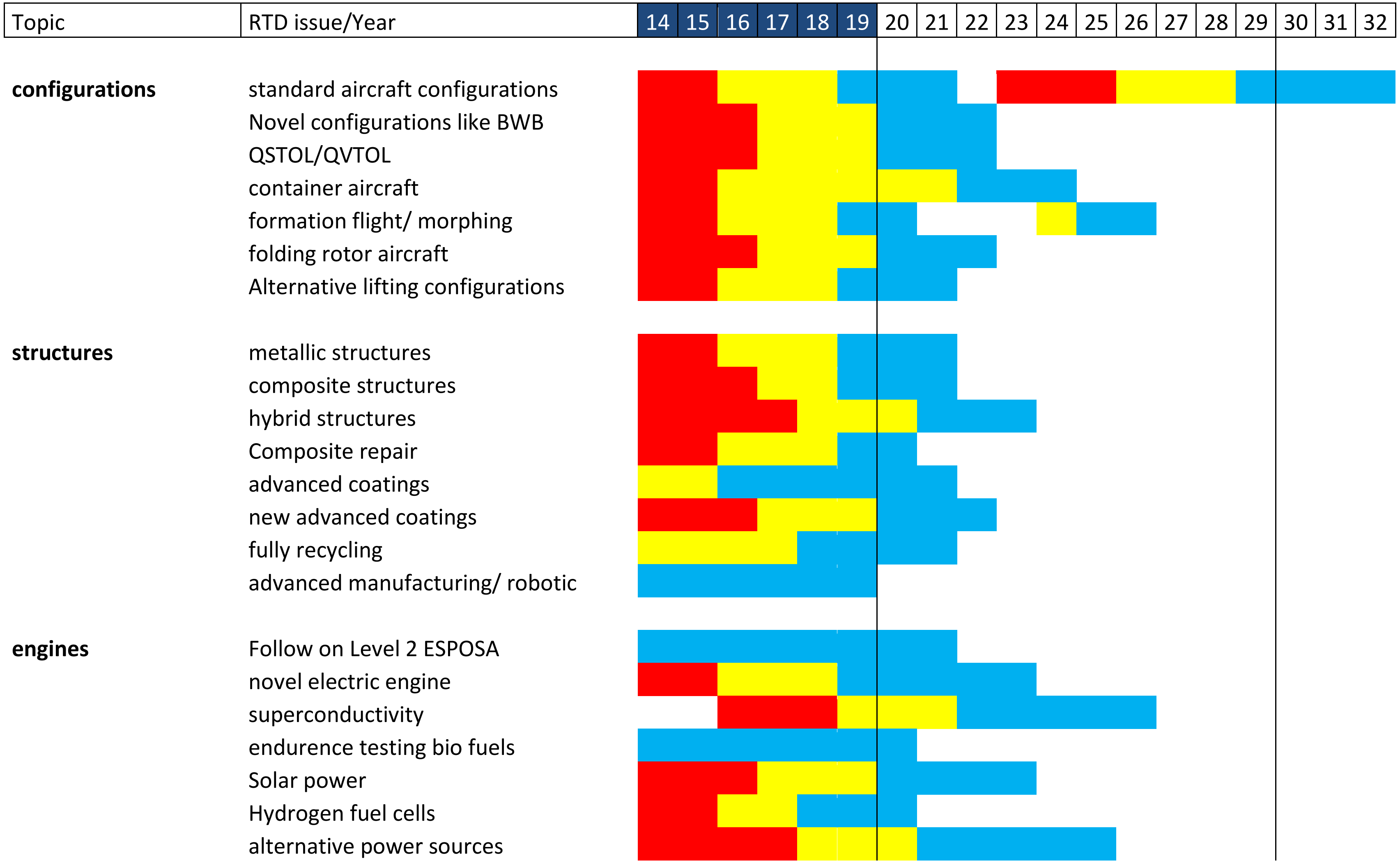
TECHNOLOGIES TO BE INTEGRATED ON DEMONSTRATOR:

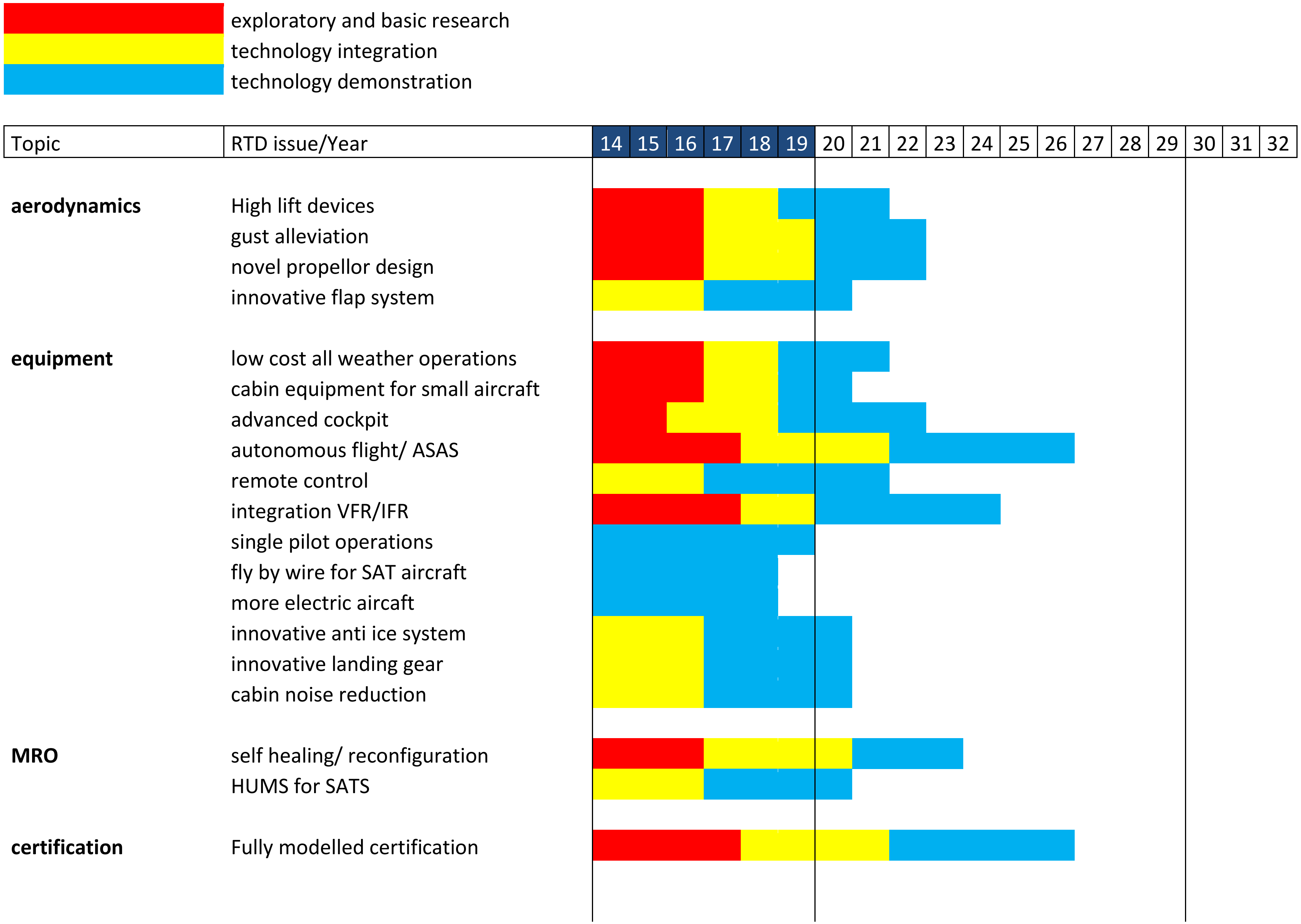
examples:

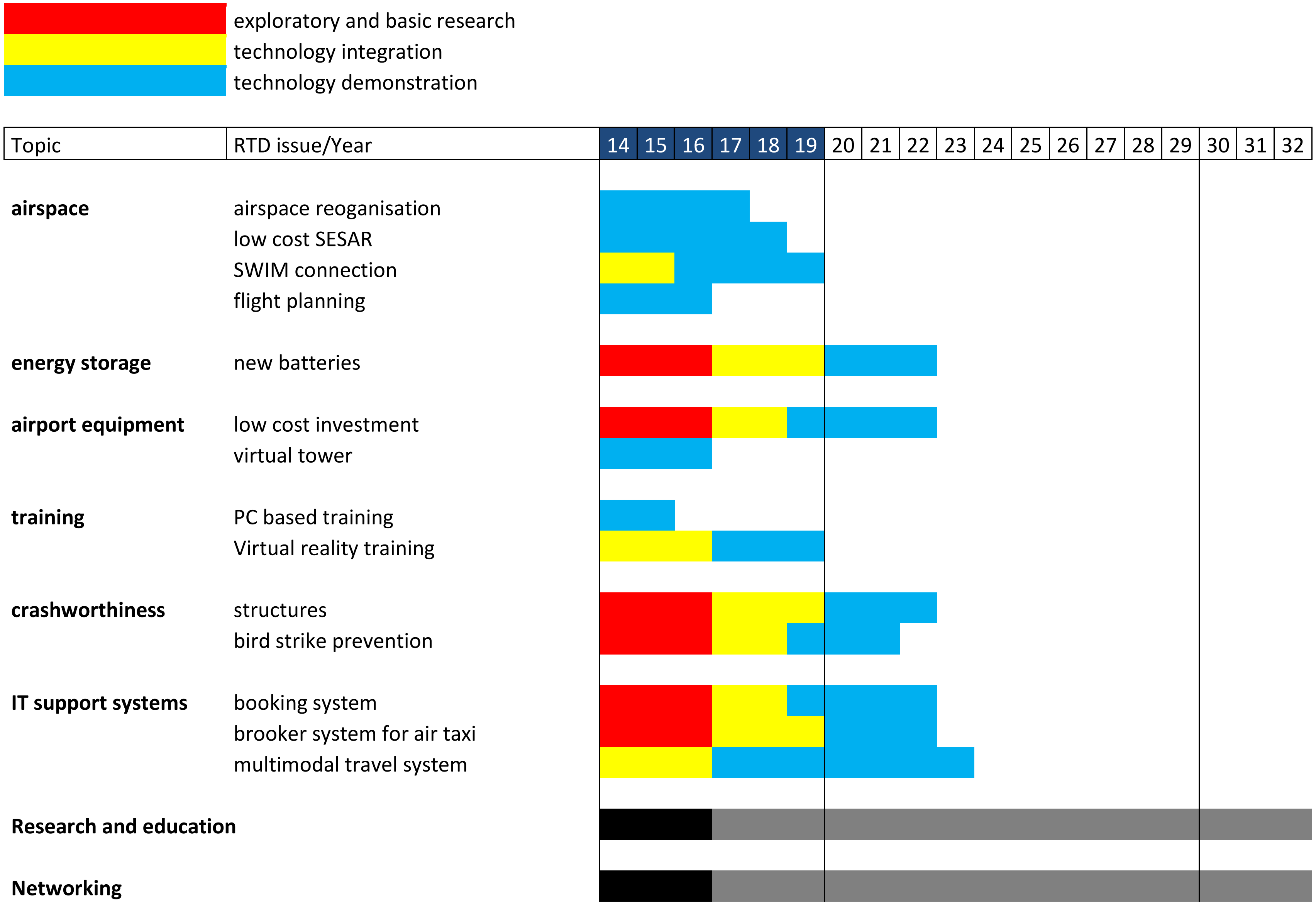
- **Efficient power plant** in the range of 250 -1000 hp and low noise efficient propeller (follow-up CESAR/ESPOSA project) + biofuels,
- **FbW** for small aircraft with EMA (f-up SAFAR project and Actuation 2015),
- **low cost** out-of autoclave **composite airframe** (f-up Clean Sky 1 and CESAR projects),
- Advanced, low cost, low weight and small volume **GA avionics compatibile with SESAR**, (f-up SAFAR, ACROSS),
- high voltage power electric generation for **more electric aircraft** systems (f-up CS 1),
- Innovative **anti-ice** system (electro mechanical expulsive f-up Clean Sky1),
- Landing gear intelligent absorbers (f-up Adland),
- Reduced cabin noise for improved **passenger comfort**,
- Improved **low speed performance** with innovative flap system (f-up Helix),
- Active load alleviation for better **ride quality**,
- operation by a **single pilot** today or remotely located pilot future (f-up SOFIA, PPlane),
- net-centric and automated fleet and transport services management (f-up EPATS, SAT, PPlane),
- IT support **multimodal travel system** (f-up EPATS, SAT, PPlane).

Brussels, 14 June 2012 Clean Sky 2 8

exploratory and basic research
technology integration
technology demonstration




exploratory and basic research
technology integration
technology demonstration
Topic
RTD issue/Year
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
aerodynamics
High lift devices
gust alleviation
novel propellor design
innovative flap system
equipment
low cost all weather operations
cabin equipment for small aircraft
advanced cockpit
autonomous flight/ ASAS
remote control
integration VFR/IFR
single pilot operations
fly by wire for SAT aircraft
more electric aircaft
innovative anti ice system
innovative landing gear
cabin noise reduction
MRO
self healing/ reconfiguration
HUMS for SATS
certification
Fully modelled certification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technology demonstration
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RTD issue/Year
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airspace
airspace reoganisation
low cost SESAR
SWIM connection
flight planning
energy storage
new batteries
airport equipment
low cost investment
virtual tower
training
PC based training
Virtual reality training
crashworthiness
structures
bird strike prevention
IT support systems
booking system
brooker system for air taxi
multimodal travel system
Research and education
Networking

If a spin off from other sectors (like SESAR) would be feasible and other funding sources like structural funds could be used, the amount of money needed from the Horizon 2020 program of the EC could be reduced. This results in a minimum request for contributions per year:

red	exploratory and basic research
yellow	technology integration
blue	technology demonstration

Topic	RTD issue /year	14	15	16	17	18	19	20
Configurations	standard aircraft configurations	0,7	0,7	1	1	1	2,5	2,5
	Novel configurations like BWB	0,7	0,7	0,7	1	1	1	1
	QSTOL		0,6	0,6	0,7	1	1,5	1,5
	QVTOL		0,6	0,6	0,8	1	1,5	1,5
	Alternative lifting configurations	0,6	0,8	1	1	1	1,5	2
Engines	Follow on Level 2 ESPOSA	3	3	3	3	3	3	3
	novel electric engine	0,8	0,8	0,8	1	1	2	3
	superconductivity			0,7	0,7	0,7	1	1
	Solar power		0,6	0,7	0,7	1	1	1
	Hydrogen fuel cells	0,8	0,8	1	1	1	1	1
Aerodynamics	gust alleviation			0,8	0,8	0,8	1	1,5
	novel propellor design	0,7	0,8	0,8	1	1	1	1
	innovative flap system	0,9	0,9	0.9	2	2	2	2
Equipment	advanced cockpit	1	1	1	1	1	1,5	2
	autonomous flight/ ASAS			0,8	0,8	0,8	1	1
	remote control	0,8	0,8	0,8	1	1	1	1
	single pilot operations	1	1	2	2	2	3	
	Fly by wire for SAT aircraft	1	1	1	1	1		
	innovative anti ice system	0,8	0,8	0,8	1	1	1	1
MRO	self healing/ reconfiguration				0,6	0,6	0,6	0,6
Certification	Fully modelled certification	0,6	0,7	0,7	0,6	1	1	1
Energy storage	new batteries	0,6	0,7	0,8	1	1	1,5	1,5
Crashworthiness	structures	0,7	0,8	0,8	1	1	2	2
IT support systems	booking system	1	1	1	1	1	3	3
	brooker system for air taxi	1	1	1	1	1	1	1
		17	**19,1**	**22,4**	**27**	**28**	**36,6**	**36,1**

In total, the requested budget (EC contribution) for level 1 projects would be € 41 million, for level 2 € 67 million and level 3 projects € 80 million over a 7 year period.

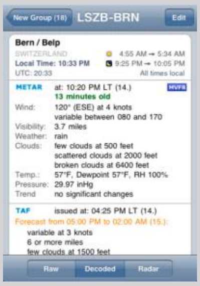
5 References

1. The IATA Technology Report, third edition, June 2009

A flight with a modern small aircraft in 2012

- Imagine you fly in a Cirrus SR22 GTS. Cirrus is an American company that has been taken over by Chinese investors.
- The airplane is costing about $612.000. With a payload of 300Kg (3 occupants with luggage) and a cruising speed of 180KTAS (334 km/h) at 8000ft, you have a range of 500nm (926Km) including 45 minutes reserve fuel in case you to have to divert to an other destination.
- The aircraft is equipped with 12 inch Garmin Multi Function Displays (MFD).

- Navigation is simple thanks to the Jepperson Chartview system that is linked to GPS and shown on your MFD.
- You file a flight plan with your iPad using rocketroute.com, download the TAF/ METAR information on your iPad via the app of Aero-weather (Pro).



- Additional TAF and METAR as well as weather radar updates and Stormscope information are received during your flight thanks to the Garmin Perspective Global Connect system which can also be used to make phone calls and to communicate by text messages(via the Iridium satellite network).

- The aircraft is equipped with FMS, an autopilot coupled to a go-around option, Altitude Heading Reference System, yaw damper, Traffic Information and Terrain Warning (TAWS-B), Electronic stability protection, Level button and stall protection. The pilot is checked by a Hypoxia Check/automated Descent mode. Lightning detection and an ADS-B transponder is standard as is the DME.

Equipped with the Garmin Synthetic Vision and infrared Enhanced Vision System (EVS) you receive a perfect picture of the outside world on your MFD even under the worst weather conditions.

- The small aircraft is well equipped to operate in all kinds of weather. For example it is certified for FIKI (Flight Into Known Icing). In case you encounter icing conditions you use the on-board de-icing equipment that is made up of 2 pumps, 2 reservoirs holding 8 gallon of TKS fluid. It will spray de-icing fluid over the wing, windshield, elevator and vertical tail.

- The aircraft is also equipped with a parachute that can be used in case of an extreme emergency.