Strategic Research Agenda

VOLUME 1

Advisory Council for Aeronautics Research in Europe

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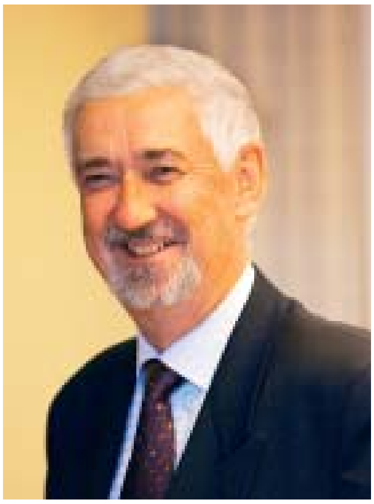
Foreword



It is rare for a great international community, one of the world leaders in its field, to assemble and publish an agenda for its technological development over the next two decades. In an industry as large, complex and technological as the air transport system it is a monumental task and has involved more than 250 people. Its preparation underlines the importance attached to research and technology. Without it there can be no progress and none of the social aspirations for a better environment, safer travel, more security or the benefits of a more competitive Europe can be realised. All of these hopes for the future depend upon new solutions being conceived and implemented and these all depend upon Europe having the technological capability.

ACARE has taken the bold decision to extend the Strategic Research Agenda even further, taking risks in the belief that a joint, coherent plan for technology is worth the chance that some of the forecasts may need to be updated in time. Only by establishing this Agenda does ACARE feel that it can help to realise the benefits of security, safety, economics and free traffic flow.

Europe needs an air transport system as part of its fundamental enabling architecture for the future that will continue to serve all the aspirations of its more than 455 million people. Only by the representatives of all the sectors of activity; manufacture, air traffic control, airports and airlines, together considering the technical challenges that lie ahead and developing plans to deal with them can this be delivered. But this agenda does much more than look inwards to the exciting things the sectors must do. It also lays down the paving stones that future generations will walk upon for research investment, education, research co-operation, and new mechanisms for harnessing the best skills and abilities of Europe's vast industrial potential. This is a document for Europe and not only for the air transport industry.

It has been my privilege to be the Chairman of ACARE during the last year and to see this second edition of the Strategic Research Agenda emerge. It moves the thinking onwards from the first edition. It offers many more detailed opportunities to Europe. It describes a world class community ready to serve the people of the world and the needs of Europe to stay at the very front of progress. I commend it to you.

Section 1

- Executive Summary

Executive Summary

The air transport industry is large, important and complex. It makes a massive contribution to the prosperity of Europe, both in terms of a globally competitive manufacturing sector providing goods and services, and also in terms of promoting the effective transfer of people and goods within Europe and globally. The industry is forecast to grow in importance. Its contribution to European GDP could extend to influence more than an eighth of the whole. Employment related to the industry (taken to include manufacturing and the operational aspects of airlines, airports, air traffic control, policy and regulation) is already 3 million in Europe and set to rise to 5-7 million by 2020. It is, therefore, entirely appropriate that the work to develop a strategic research agenda for the industry, begun in the late 90's, should be taken forward again in this 2nd edition.

This edition of the Agenda extends the first edition in important ways. It widens the range of situations that are considered by recognising the work done in the meantime to identify a number of scenarios. Their technical implications are considered through a series of focused High Level Target Concepts (HLTC) that emphasise a number of different aspects to create pools of technology for deployment to whichever scenario actually develops. Some of these technologies will need to breakthrough in their ability to provide substantially increased performance that cannot come from evolutionary progress. It also includes the "Towards the Future" section that looks forward beyond 2050 and to the situations that will demand radical and novel solutions from new generations of aviation engineers. All of these features underline, with so much to do, how the sense of challenge and excitement of the air transport industry will certainly not be less in the 21st Century.

The HLTCs deal with a wide variety of issues each related to the overall objectives of the initiative: to meet society's needs and to establish a world leadership position in competition. These twin objectives are inseparable and are both fed by such issues as competitive responses to the problems of congestion and the environment. They also deal with operational aspects of passenger safety and comfort, and with the provision of choice and good value. Important changes have already taken place in the world context for the sectors, not least with the attacks on the USA in 2001 and subsequent actions against terrorism worldwide. So security is now a principal plank of consideration and numerous technologies will play their part in making air travel secure whilst minimising the imposition of new congestion or frustration for passengers.

To achieve the economic and social aspirations of Europe requires that success in world markets be achieved. Each of the situations considered needs technology acquisition and exploitation to deliver its benefits. Not all the technologies will be new of course. Much of the work will be devoted to bringing together existing technologies to achieve new solutions that deliver new experiences to the ultimate stakeholders in the industry – the citizens of Europe. This will require extensive demonstration and validation in realistic operating conditions to meet the demanding safety and environmental constraints on the sector, and to reduce commercial development risk. Technologies will need to be imported from other sectors of importance, such as the ICT industry. This will present new challenges.

Not all that needs to be done lies within the grasp of the industry. Some issues are fundamentally public in nature (security, safety etc) and deserve both attention and funding from the public sector. Matters of regulation and policy depend on government. The establishment of new mechanisms for collaboration, for sharing public funding and for the education and mobility of research workers also depend on government action in the Member States and in Brussels. These mechanisms and priority actions are identified in this Agenda.

The Agenda describes in outline a set of technical activities that is essential to sustain and extend the vast industry that is air transport. The challenges are increasing, in number and in scale. Some of the issues are of fundamental public concern, such as security and environmental impact. The social needs of citizens are, in their broadest sense, matters for government. But there are also matters that are wholly or mainly for the industry, sustaining competitive abilities, increasing the efficiency of collaboration, improving the passenger experience. All of these matters, both public and private in origin, need to be taken forward more aggressively. In identifying the next steps the Agenda has recognised the importance of encouraging more debate, and research, about the impact of aviation on the atmosphere where the issues are still not well understood. ACARE intends to press the nations, the EU, airports, airlines and the ATM community to address the new business models that will be necessary in the future. It will promote more international debate about the far-term consequences for and of the aviation transport world. To facilitate greater European efficiency of research it will encourage better links between the Member States and their collaboration on matters of aviation research within the framework of the Agenda. Finally it will propose actions that will lead to the establishment of a European repository of aviation knowledge and act as a centre for new studies of the issues that are outlined in the Agenda.

Events since the last edition of the Agenda have demonstrated the importance of air transport, and the need to sustain and develop it for the common good. This edition makes more concrete some of the recommendations and considers their wider implications. There is no less urgency to begin the implementation of the measures recommended that there was in 2002 and monitoring progress is a further recommendation.

Key findings

1. SRA-1 has been a success and this has contributed to SRA-2, not only in the confidence that ACARE has had in extending the scope but in the feedback that ACARE has had from SRA-1. SRA-1 has been adopted as **the** reference for a number of national and institutional bodies that have established their research programme using it as a guide e.g. FP6, French and German National Programmes, EUROCONTROL and an increasing number of industry stakeholders. This is helping with the transparency of programmes and with collaboration. As this process develops we expect to move on to using the Agenda to improve the efficiency of the research process and to highlight those activities that are most value-adding and also those which are duplicative for no good reason. The Agenda will give a strong, common background for this.

2. Wealth generator – Air transport is in itself a significant contributor to European wealth. The resultant benefit is spread across all Member States, either as a result of its direct contribution (2.6% GDP and 3 million jobs) or, even more importantly, as a consequence of its lubrication effect on all modern economies enabling our life-style and the way we do business. Its total contribution to the economy is estimated in excess of 10% of GDP.

3. The Agenda is more robust – This edition of the Agenda reflects alternative socio-economic scenarios and their associated technologies in the holistic approach advocated by ACARE and it is thus more robust than SRA-1. It also provides an indication as to the importance of each separate technology and the timescale of its importance. It presents important new planning aids to research programmers.

4. European research needs more money – re-analysis has shown that, taking an encompassing view of the research needed and the necessarily associated facilities and demonstrators, about 65% more funding is now required over the 20 year forward view than is presently being invested. Whilst this expenditure is not evenly paced there is clearly an urgent need to see a reversal in the trend to decreasing amounts of research funding assigned to air transport research at national level.

5. European research needs more people – The Industry may face a shortage of skilled young people in the future, partly due to demographics and partly due to the reduced attractiveness of the aerospace business as it may be perceived by young people. Future graduates will need additional skill sets most notably in multi-disciplinary approach, excellent communication skills, open mindedness and cultural awareness.

6. Research needs to be more efficient: The research funds used across Europe must be better co-ordinated with less duplication of work that has no justification for being conducted. This could perhaps start with areas of common societal interest (safety, security, environment, ATM). Some examples of progress are already evident such as the joint action between EUROCONTROL and the EC.

7. Implementation monitoring: The Observation Platform is launched – it will provide a snapshot of current status, trend over time and together will guide and inform future research programmes and will facilitate better co-ordination.

8. Money alone is not enough: The creation and funding of research programmes will be to no avail unless European companies are encouraged to retain their European bases and to conduct their own research in Europe. In addition to the work outlined in the Agenda a number of policy actions are needed to ensure that the entire community involved in the aircraft and air transport sectors sustain a coherent and stable future. Part of this policy challenge is to ensure that the competition between major regions is recognised as a major factor in the development of industrial plans. Stability will be encouraged by equality of treatment both inside and outside of Europe.

9. Action is required by each Member State if the full contribution of their own industry is to be fully exploited.

Section 2

- The economic impact and strategic importance of air transport in Europe
- Recalling SRA-1 and its impact
- Alternative world scenarios
- Taking SRA-2 forward

The economic impact and strategic importance of air transport in Europe

The scope of Air Transport

The European air transport sector, defined as airlines, airports, Air Traffic Management and the manufacturing industry, comprises more than 130 airlines, operating across a network of over 450 airports with some 60 air navigation service providers (ANSP). This complex set-up forms a unique global network linking people, countries and cultures – and plays a vital role in the further integration and development of the enlarged Europe.

Air transport is increasingly becoming more accessible to a greater number of people who can afford to travel by air, both inside and outside Europe, for leisure and business purposes. This is evidenced by the fact that last year the European air transport system moved more than 1 billion passengers and 14 million metric tonnes of freight through its airports whilst handling more than 12 million movements over the same period.

In addition, the sector supports tens of thousands of suppliers and manufacturers across a wide range of industries and nations. Their competitiveness is clearly demonstrated by their commercial success in the global market and the trade surplus of € 2.2 bn that they create. In the field of large commercial aircraft, accounting for a major part of the capital equipment of the world's airlines, Europe now sells more than the US in terms of both the airframes and engines for them. Europe also has strong positions in the business jet and civil helicopter market and a major proportion of the airborne and ground equipment is also supplied from Europe.

This success is founded upon the skills and knowledge of its employees. The research work that established that knowledge has been sustained and built up over decades of investment underpinned by a consistent strategy for achieving competitive products.

The benefits of Air Transport

Benefits manifest themselves as ripples of prosperity moving out from the activity. **From the direct and indirect** impact of the sector and its own trading, through the **induced** economic effect caused by the spending of earnings from the sector to the **reliance** effects on a wide range of businesses, including the related ones of tourism, hotels and the like.

For the first time at a European scale the economic effects of air transport have been comprehensively examined. The results of these studies fit comfortably within the range and scope of other studies and comparators. The study establishes categorically the economic importance of the air transport industry.

Whilst contributions naturally vary between nations, cumulatively the sector generates € 220 billion of direct added value for the EU economy representing some 2.6% of Europe's GDP. To achieve this the sector employs 3.1 million people, many of whom are highly skilled which in itself represents a source of competitive advantage.

These benefits alone would be noteworthy but air transport also lubricates the overall economy, providing its citizens with access to a full array of goods and services thereby improving their overall quality of life. The greater speed and accessibility that comes from air transport is a key contributor to globalisation, with many businesses unconnected with air travel building air transport into their business approach. This dependence on air transport amounts to some 18% of all international trade, and underlines the dependence of the broader economy on air transport and travel. This effect is most acutely evident in the Tourism sector, which is dependent on air transport for at least 6% of its 12% GDP contribution.

The contribution of air transport to the EU's economy is estimated therefore to be well over 10% or, expressed differently, it currently makes an impact on the economy over three times its own size and this is set to grow as globalisation increases.

A further benefit results from the sustained investment in R&D (typically around 12% of sector turnover) over an extended period which has spawned a great many innovations such as Structural Analysis tools, Computer Aided Design (CAD) and composite materials which are now used in many disparate non-aerospace sectors. These pioneering innovations have not only been spun-out but have themselves been subject to constant improvement over time, pushing the envelope of performance still further and passing this into general use.

The future

The Air Transport sector contribution to GDP will continue to grow. Despite the effects of 9/11, SARS and the IRAQ war the sector forecasts that over the next decade, both passenger and freight traffic is expected to increase at an average 4-5% p.a., (with freight slightly higher) both significantly above global GDP growth: in air transport terms, this implies a doubling of traffic about every 16 years.

ACARE therefore expects the sector **will create between 2 and 4 million new jobs** by 2020, even assuming continued productivity gains at historic levels, with the GDP contribution of the air transport sector increasing from **2.6% to about 3.3%**. The contribution to the wider economy through reliance effects that enable a diversity of businesses to succeed better is expected to rise from its present 8-10% to, perhaps, 11-13%. That this will be factored to an EU of 25 countries in place of the present 15 will mean that the economic importance of the sector is enormous.

Fast Facts

Value Added	€ 220 bn
EU GDP	2.6%
Jobs	3.1 m
Trade surplus*	€ 2.2 bn
Airlines	130
Airports	450
Passengers	1 bn
Freight	14 m tonnes
ANSP	60
Movements	12 m

** Figure limited to manufacturing industry*

The prizes for Europe in achieving the goals set for this sector are enormous. Every country in the EU will benefit. Every citizen will be able to trace some tangible strand of advantage.

But in a highly technological industry, with other nations eager to compete, the key to sustained performance is through applying superior knowledge. Only by embarking on a commitment to sustain the superior knowledge that had been built up, to refresh and enlarge it with new technologies, to train new people in its potential and to create the mechanisms for its application can our present economic position itself be sustained. Today's abilities are built on yesterday's investments. In looking to 2020 we are identifying the investments that are needed today for continued success tomorrow.

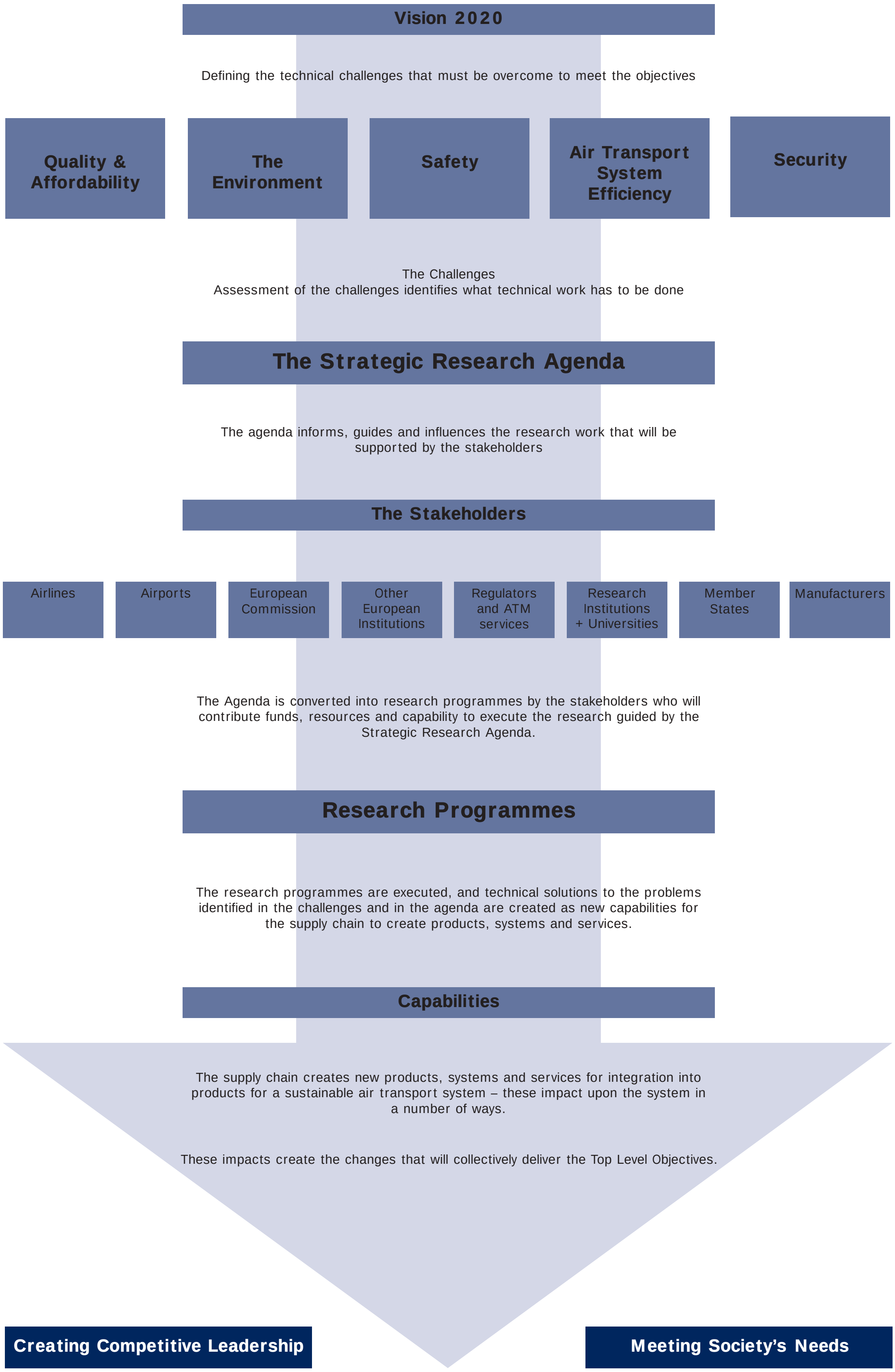


Figure 1: SRA edition 1 process flow diagram

Recalling SRA-1 and its impact

In January 2001 senior members of the air transport industry published a new view for the future of the Air Transport System. As figure 1 shows, Vision 2020 was an innovation for Europe and proposed the simultaneous achievement of two Top-Level Objectives:

- Meeting society's needs
- Leadership for Europe

In supporting these objectives in the preparation of the Strategic Research Agenda four specific challenge areas were extracted, which were later augmented with a fifth "Security" in response to the events of September 2001. These 'Challenges', defined as the key issues to be successfully tackled in progressing towards the Top Level Objectives, each had identified constituent goals that contributed to the necessary achievements.

The Strategic Research Agenda in its 1st edition was published in October 2002. It consisted of an Executive Summary and two volumes of material prepared by working groups under the direction of the newly formed Advisory Council for Aeronautics Research in Europe. Its contents are summarised below under the Challenges.

Quality and Affordability – The Challenge of delivering products and services to airlines, passengers, freight and other customers whilst increasing quality, economy and performance for sustained international competitive success.

Goals –

- Reducing travel charges
- Increasing passenger choice
- Transforming air freight services
- Creating a competitive supply chain able to halve time-to-market

Environment – The Challenge of meeting continually rising demand whilst demonstrating a sensitivity to society's needs by reducing the environmental impact of operating, maintaining, manufacturing and disposing of aircraft and associated systems.

Goals –

- To reduce fuel consumption and CO_2 emissions by 50%
- To reduce perceived external noise by 50%
- To reduce NOx by 80%
- To make substantial progress in reducing the environmental impact of the manufacture, maintenance and disposal of aircraft and related products

Safety – The Challenge of sustaining the confidence of both the passenger and society that commercial flying will not only remain extremely safe, notwithstanding greatly increased traffic, but will reduce the incidence of accidents.

Goals –

- Reduction of the accident rate by 80%.
- Reduction in human error and its consequences

Air Transport System efficiency – The economic needs of Europe's citizens, international competitiveness and the convenience of passenger and freight customers' demand that rising traffic shall not exacerbate the downsides of congestion, delay and lost opportunities.

The Challenge is that the efficiency of the whole system must be substantially increased. This will require radical new concepts to be introduced.

Goals -

- To enable the Air Transport System to accommodate 3 times more aircraft movements by 2020 compared with 2000
- To reduce the time spent by passengers in airports to under 15 minutes for short-haul flights and to under 30 minutes for long-haul*
- To enable 99% of flights to arrive and depart within 15 minutes of their advertised scheduled departure time, in all weather conditions

Security – The Challenge is to identify measures that will improve security, on a global basis, within a highly diverse and complex system and against a strong backdrop of increasing traffic.

Goal -

- Zero successful hijack.

Assumptions used for SRA-1

- Air traffic volume in 2020 would be 3X the 2000 figure.
- Social priorities would continue to be a balance between economic prosperity that favours trade, commerce, employment, etc and an increasing desire to enjoy these within an overall quality of life and responsible management of the environment.
- In relation to the USA there would continue to be a healthy mixture of co-operation and competition against a backdrop of shared democratic values and sound economies. SRA-1 assumed no shocks to the international system by war or natural disaster.

Against these challenges and goals specific "Contributors" were identified which represented the constituent elements contributing to the achievements of the goals.

Each Contributor has associated with it a timed set of technical and operational solutions, which were not mutually exclusive, and which, if appropriately funded, researched and applied would be capable of meeting the Vision 2020 goals.

In support of the more technically orientated work outlined above a number of enablers were defined which would act transversally in support of the technical delivery. The enablers were research infrastructures, education, certification and qualification, competitive supply chain and trans-European synergy. Both project based and broad based mechanisms were proposed to realise these enablers

Examples of project based mechanisms were

- **Technology Integration Platforms** would be concerned with ensuring that technical concepts work reliably in integration and at the scale of the full system needs.
- **Large scale research test-beds** which would be needed in Europe on a scale most likely unaffordable by single companies or countries, and which could be used flexibly by the whole supply chain for testing advanced systems.

* *The airport throughput process should be capable of delivering the goals, leaving passengers the choice to enter and exit the process at will.*

Examples of broad based mechanisms were

- **Mechanisms in support of improving the research infrastructure in Europe.** Improving the capability and utility of the European research infrastructure is an important investment in the future. The opportunities for Pan-European collaborative research efforts to exploit the very best research capabilities, both human and capital, rest in testing facilities, R&T programme structures, and collaborative mechanisms.

- **Mechanisms to support the ambition to realise the untapped energy and expertise of Europe's technology supply chain.** New mechanisms would raise the levels of awareness by both customers and suppliers to very much higher levels. Customers would have better information on the capabilities of suppliers whilst suppliers would exercise better knowledge of what opportunities exist.

Key findings of the SRA-1

- The **Top Level Objectives, even though ambitious, are achievable in Europe**, if the challenging Strategic Research Agenda, prepared by ACARE, is adopted, implemented and its results deployed into practical products and services with a high level of commitment.

- The SRA provides strategic directions for solutions and R&T road maps to achieve the Top Level Objectives as outlined in Vision 2020. The objectives **are not achievable without important breakthroughs, both in technology and in concepts of operation** – evolutions of current concepts will not be sufficient.

- Delivering these European ambitions will require substantially more output from the European aeronautic research community which must devise **new ways to make the system of research, in all its forms, more efficient.**

- Delivering the Top Level Objectives **will require a number of additional and significant Pan-European enabling mechanisms within the European Research Area.** Five areas for new mechanisms are identified: the European research infrastructure, the supply chain, certification and qualification, education and Trans-European synergy of research.

- **It is clear that more investment from both public and private sources will be needed** to support the research.

- The aspirations for European leadership will only be achieved if the climate in Europe remains conducive to retaining and advancing core competence, capacities and centres of aviation research. The ambition of SRA-1 is for the European stakeholders to succeed in the global market, both by competition and by collaboration, from a strong, effective European base. **This requires that major corporations, which increasingly have international links and options, continue to invest their resources in Europe. From its side Europe must provide a receptive environment, ensuring equal competitive footing with other countries and economic regions, to encourage those investments to remain in Europe.**

The Impact of SRA-1

Following publication of the 1st edition of the Strategic Research Agenda nine dissemination events were held across Europe during the period November 2002 to March 2003. Speakers presented the structure and content of the SRA to relevant national or, in the case of EUROCONTROL, to specialist audiences.

As expected there was some variation in the themes raised by delegates. At the top level there was consistent acclaim and support for the SRA and for the dissemination event. The main message that speakers managed to get across to audiences was that the SRA was not only for specialists in European collaboration but relevant to a wide range of people in the aviation community.

The concept of using the SRA as a tool for the better alignment of technology programmes with the needs of the future also received widespread acceptance. In a number of cases this has led to a move to create agendas that are compatible with the SRA and will serve both to feed into the SRA and to illuminate it. Examples include the EU FP6, French National Programme, German National Programme, EUROCONTROL, DLR and an increasing number of Industrial companies.

The scale of the SRA and the clear evidence that no single nation could afford to pursue the whole range of technologies to the degree necessary also found a favourable response. This has encouraged the use of the SRA as a catalyst for new thinking by the ACARE stakeholders about which areas should be included in their priorities and the extent to which they should rely upon collaborative efforts (e.g in the publication of the United Kingdom's Innovation and Growth study).

The SRA was widely seen as being a valuable start but received significant commentary about the need for it to be taken forward to implementation and further development. This has led to the creation of an 'Observation Platform' to monitor, analyse and present the rate and depth of SRA implementation progress.

Whilst SRA-1 was the first step of a long journey, it clearly needed, and was planned to have, further development. Most of these areas for development were known prior to publication. The second edition of the Agenda continues in aspiring to address the technological needs of Europe but with more examination in SRA-2 of possible alternative futures, choices and uncertainties for air transport. The first step in this was clearly to define the scenarios and a process was put in hand at once to begin this.

Alternative world scenarios

Introduction

The purpose was to identify a small number of alternative world scenarios presenting views for the future air transport that are different from the standard "Vision 2020" used as the baseline for SRA-1. One aspect of the baseline had been traffic growth. This was expected to continue in a steady progression. ACARE now has a different view of this. The historic plot of traffic growth (figure 2) shows that perturbations occur and, if they are widely spaced, the growth resumes along the earlier pattern. However, if the disturbances are frequent and / or sustained the impact on the traffic flows could be depressed to a new steady state. ACARE wanted to take these and other effects into account.

The key objective was to enhance the overall credibility of SRA-2 by providing a shared stakeholder view of the impact of different external factors affecting the air transport system, and of the risks and opportunities associated with each of the identified scenarios.

The scenario workshops

Scenario workshops constitute a well-established methodology for testing the robustness of assumptions in a wide range of fields. A scenario is characterised by a consistent description of a possible future situation and by the developments leading to this situation. *The scenarios address what may happen not what will happen.*

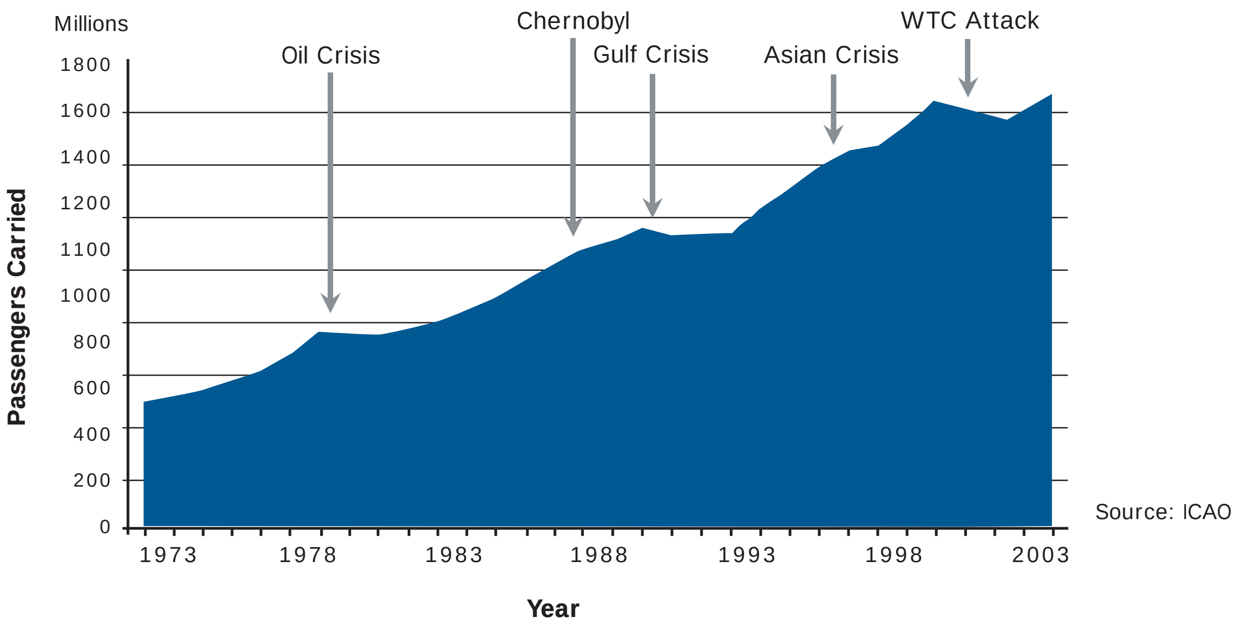


Figure 2: World Scheduled Revenue Traffic by year

The ACARE workshops were attended by a diverse range of participants from a cross section of the air transport industry (manufacturing, airlines, airports, ATM), national and EC institutions, environmental research etc. Assisted by facilitators the stakeholders were asked to expose their views on a wide range of topics dealing with possible future developments.

The scenario workshops were focused on the Civil air transportation of passengers and cargo taking a Global view but having a European focus for decision making through to the year 2020. The product of the workshops was the three following scenario *storyboards*, shown graphically in figure 3, and described hereafter.

Alternative scenario 1 "Segmented Business Models":

Economy – GDP will grow at a strong average of around 4% as the result of globalisation, economic and political stability with Asia / Pacific experiencing higher growth. Financial markets believe in the business models for investment, thus releasing the required capital. Increasing yield is thus part of this model and is not jeopardised by increasing but moderate energy prices. New business models (e.g. offering lower fares) will enable this to happen.

Politics – Some instability will still be evident largely in the poorer and less developed nations. There will be stability in oil producing regions, thus allowing segmented markets to operate in a sustainable manner.

Greater liberalisation facilitates greater flexibility in different market segments. Legislation / certification issues become more streamlined thereby allowing earlier product introduction and decreasing operating costs and, therefore, increasing affordability.

Society – Segmentation offers better choice for travellers and generates more passenger movements, the majority of which are leisure related. Improvements in ATM system and airport processes increase punctuality and reliability, which are a strong demand from the travelling public. Global political stability improves public perception of security and safety, allowing streamlined airport security measures that enable a rapid "hassle free" throughput of passengers.

Ecology & Energy – Some business travel will be focused on flying passengers directly to city centre locations thereby leading to greater attention to lower noise and emissions. For the freight segment, and to a limited extent in leisure, noise and emissions are less of a pressure as a result of a move towards dedicated freighter and leisure airports which are built in "remote" locations and do not face the same environmental pressures. They are able to operate effectively and efficiently by virtue of good supporting ground infra-structure and transport links. Air transport in general is identified as a contributor to global climate change leading to higher environmental awareness and emissions charges.

General Air Traffic – Passenger air traffic (RPK) will increase strongly at an average of around 6-7% world-wide p.a., primarily as a result of strong GDP growth, political stability, increased globalisation and population growth. Freight air traffic (RTK) will increase by 7-8% p.a.

Infrastructure – For Europe and US airport capacity limitations are overcome by building dedicated airports to meet demands and converting existing military and other airports. Greater public expenditure on ground connections and infrastructure allows more of these "remote" airports to be used. Greater political stability allows the "military only" airspace to be reduced.

Airlines – The number of airlines will increase as new operators target different market segments, including niche segments. Operating yields increase for both passenger and freight as a result of the customer base being prepared to pay for the tailored services on offer.

Alternative scenario 2 "Constrained Air Traffic Growth":

Economy – Although GDP will grow strongly with an average around 3% p.a. from economic and political stability air traffic will be constrained by environmental concerns. GDP in US, Japan and Europe is expected to grow between 2% and 2.5% per year whilst GDP growth in developing regions (Southeast Asia, Latin America, India) may average 3-4%. China is expected to have the fastest growing GDP with an average of 5-6% p.a. Airlines have improved their financial situation due to stabilised yields. Air transport is again an interesting business; return on investment is comparable to other sectors.

Politics – Political stability increases in good global economic conditions. The middle-East region is considered stable and the United Nations plays a strong role in international negotiations. Advanced negotiations of air transport agreements on a global level are expected to lead to a global liberalisation. As a first step, the bilateral contracts between Europe and the US and Japan will be replaced. Strong and far reaching political and legal requirements in safety / security and environment imply increasing efforts for certification on a global level.

Society – The travelling public (esp. in business) has high expectations for punctuality and reliability. Increasing responsibility is put on airlines for delayed flights (leading to compensation requirements).

Statistically safety is not a major problem, but the growing traffic leads to increasing number of accidents and greater public awareness.

Ecology & Energy – Oil demand rises everywhere and fastest of all in China. The world's energy resources continue to meet the growth in energy demand, but the growth in oil prices leads to more investments in alternative energies and fuels. As airports expand there will be increasing exposure to noise nuisance. Urban spread leads to more environmental issues. Air transport is identified as a major contributor to global climate change thus leading to higher environmental awareness. Aviation fuel environmental taxes are applied and alternative fuels are being investigated.

General Air Traffic – Despite economic growth, passenger air traffic (RPK) will increase on average by only 3% p.a. world-wide, as environmental constraints bite. Business travel growth exceeds leisure travel growth. Freight traffic will grow strongly at 9-10% p.a. as demand for high value goods surges. Average ticket prices will increase.

Infrastructure – Europe, US and Southeast Asia will experience capacity limitations despite technical and process improvements across the air transport system. Airfreight partly evades capacity problems (and emission / noise constraints) by using remote airports.

An increase in fees and taxation is applied (measured as a proportional increase in direct operating cost). There are additional fees and taxes on fuel, environment and for ground support services.

Airlines – All networks will experience higher traffic density. Business travel in the upper ticket price level and the rate of capacity and aircraft utilisation is increasing. Airlines have improved their financial situation with stabilised yields, even with increasing fees and higher kerosene prices. Traditional airlines operate with very high technology in strong alliances. Low cost carriers maintain a fragmented structure without alliances.

Alternative scenario 3 “Bloc Building”:

This scenario postulates an increasing tension between the EU and the US and between those and Asia, leading to the formation of socio-political blocs in contrast with the globalisation trends of 2000. The drivers leading to this condition are economic, religious and political.

Economy – GDP on a global level will stagnate at about 1% p.a as the flow of goods and services between the blocs decreases. Access to financial market will be limited within blocs. Within increased inter-bloc protectionism, additional taxes for bloc-to-bloc flow of capital and goods will appear. Energy prices will grow as a result of oil resources within blocs reducing and religious conflicts that arise in the oil-rich regions of the Middle-East. Access to oil resources will be restricted, driving prices up.

Politics – The political picture is split between “within blocs” and “between blocs”. Within blocs there is greater political stability, especially in the EU. This sees the US as a common “competitor” for all EU countries, which build “Fortress Europe”. There is, however, an increased tension between blocs, leading to an atmosphere reminiscent of the past cold war, but one where NATO has been dissolved to avoid US involvement in European defence affairs. The World Trade Organisation becomes ineffective with growing protectionist attitudes between blocs.

Society – The threat of terrorism, especially religious, makes people increasingly sensitive to security issues. This is curbing traffic growth as people travel less and for shorter distances, avoiding far-away destinations for vacations. The resulting air traffic growth will be stagnant at about 1 to 1.5% p.a. This reduces pressure on the whole air transportation system.

Ecology & Energy – Constrained traffic growth will drastically reduce all the associated environmental consequences. The environmental awareness of people will be affected and global climate aspects will become less important as more urgent concerns such as security emerge.

General Air Traffic – There is a trend towards a more “point to point” type of traffic within blocs. Between blocs air traffic is generally decreasing, mainly through much reduced business travel. The only region of the world to grow substantially is Asia, due to its faster growing economy.

Infrastructure – The slow growth in traffic volume will cancel or postpone most problems associated with capacity. There will be no need to increase airport capacity, much less to build new ones or to shift to radically new paradigms for ATC. The situation is of course quite different in Asia, which experiences a strong economical and air traffic growth. Here new airports will be built.

Airlines – A major consequence is the disappearance of global airline alliances, which have no reason to exist in the protectionist environment which heavily penalises foreign players. There will be an increased consolidation of airlines within blocs. Low cost airlines will exist only within blocs and will dominate the scene with a great share of the market as passenger yields stagnate and will prompt new low-cost business models to guarantee airline survival. Given the rise of short haul travel, both for leisure and for business, competing transport modes will increase shares. In particular high-speed railway networks will be developed or expanded and will prove an efficient alternative to short flights.

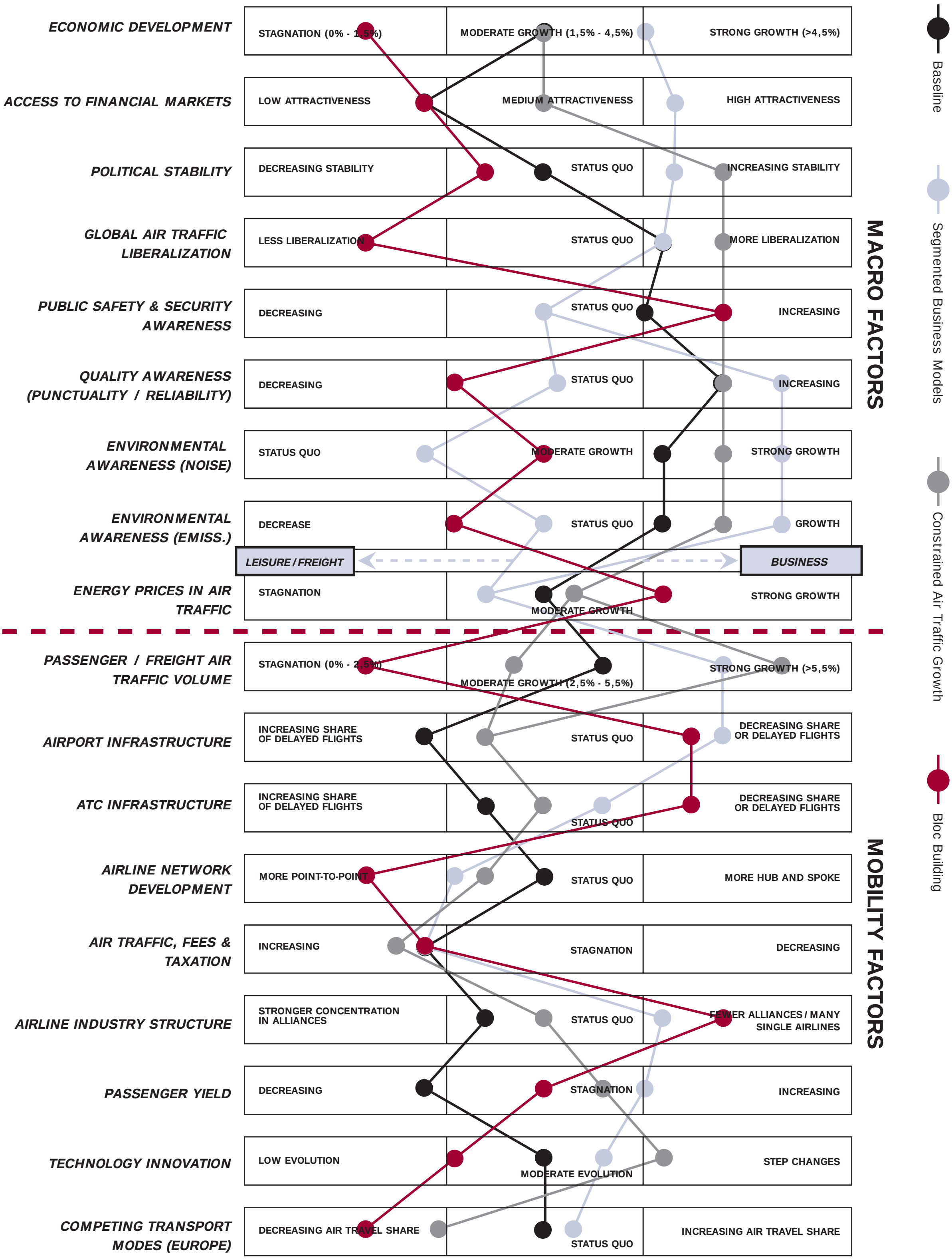


Figure 3: The ACARE Scenarios

Taking SRA-2 forward

From its retrospective review of the first Agenda ACARE had concluded that in the second edition it should:

- Take a more comprehensive and holistic view of the Air Transport System, including the perspective of operators within it, relating the influences on each of the stakeholders to each other and to their operations.
- Identify areas of uncertainty, variance and choice so that the range of possible future options can be explored and assessed. The main plank for this would be the scenario workshops that were to be held in the interval and the subsequent development of High Level Target Concepts.
- Integrate the further work done by all the stakeholders in building up their interpretations of the SRA. Consolidating the developing views of the stakeholders to ensure that their views and the development of the related technologies are running in harmony. Especially this would address the work on airports that had not been thoroughly covered in SRA-1.
- Take a longer view, in addition to continuing to work on a threshold of 2020, so that the medium term work can be illuminated by the possibilities for the long-term future.
- Bring the work in SRA-1 on institutional and infrastructure issues closer to the needs of the technologies and thereby support their delivery by identifying the specific areas of priority action that need to be taken by agencies in Europe and the nations.
- Improve the presentation that connects the necessary technologies with the underlying narrative of the scenario in which they will operate.

Within these points it was also important to address new areas of uncertainty. Vision 2020 was a singular projection of the future that described a world with no major alterations to the currently projected trends (i.e. with respect to environment, air traffic and economic growth). SRA-1 was produced against this outlook as the most likely singular view of the future landscape and it established that, provided there were breakthroughs in certain key areas, then the vision could be materialised with the concurrent achievement of all the Vision 2020 goals.

One of the key development areas of SRA-2 has been to examine the sensitivity of the Agenda to alternative views of the future. These future views, discussed in the previous section, are determined by the sets of unique characteristics that describe different drivers of the air transport system (GDP etc...) and the Challenges to it (Environment, security etc...). By exploring the technology implications of each of these unique characteristics along a particular research axis not only has it been possible for the analysis to identify the technologies and solutions needed under those conditions but also to see how they would be used within a system operational context. This analysis and its subsequent representation is through the use of High Level Target Concept (HLTC's) which extend thinking to a moderately extreme view in five different directions: protecting the environment, saving time, improving security, increasing choice and reducing cost.

The High Level Target Concepts selected, all considered within the 2020 timeframe, are :

- The highly customer oriented air transport system
- The highly time efficient air transport system
- The highly cost efficient air transport system.
- The ultra green air transport system
- The ultra secure air transport system

The HLTCs are not of equal 'intensity' or coverage. Those for the 'Highly Cost Efficient' and 'Highly Customer oriented' have a greater coverage of the air transport system than do, say, those for 'Ultra Secure' or 'Ultra Green' but the basis of their formation is the same. They each take an aspect of the ATS and explore its extension to identify the technology needs.

The value of the HLTCs is in identifying a set of technologies, or creating a technology pool, that is brought out by considering the special characteristic that the HLTC emphasises. A comprehensive study of all the technologies that need to be developed for a complete Air Transport System against a set of conditions for the future would necessarily draw on all, or anyway on most, of the HLTCs.

As an example the Ultra Secure HLTC describes a set of technologies that would be emphasised in a system especially concerned with security but some of these technologies would also be used in other HLTCs, although perhaps not with the same intensity or range. Likewise the Ultra Secure HLTC would draw upon the technologies described in the Time Efficient HLTC for advances in Air Traffic Control systems. As figure 4 shows, we see the HLTCs as individual pools of technology that are identified by the HLTC and upon which we can draw in variable and flexible ways for the future.

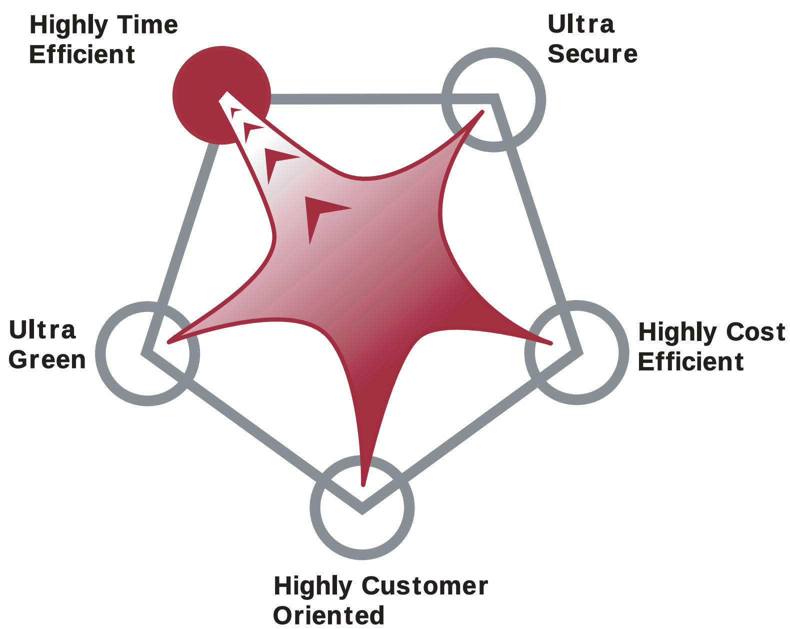


Figure 4: Schematic diagram showing how technology influence flows from each of the HLTCs to each of the others

Safety however is a special case and is notable by its absence in the HLTC list – intentionally so. Safety is not a factor that can be traded-off since it is a fundamental pre-requisite for air transport. SRA-1 tackled the Challenge of Safety by identifying a number of Contributors which were aimed at improving the basic relationship of accidents to traffic density at least as fast as the rise in traffic. Against these Contributors a suite of technology solutions were proposed ranging from airborne self separation assurance systems through to synthetic 3D vision capability. It was also documented that this “system research” would need to be supported by basic research into hardware, software and human centred design enabling technologies.

In support of the safety research technologies, SRA-1 argued that new concepts for the air transport system would also be needed and these have been better elaborated in SRA-2. Whilst safety is an essential element in all HLTC's it was felt that the most demanding traffic volume and highest complexity of the Air Transport System arose within the Highly Customer Oriented HLTC and therefore Safety would specifically be dealt within this concept.

In the passage of time no complete HLTC's will be chosen and none rejected. The competitive pressures of the market, the force of regulation, the state of the world and national economies as well as the strength of public opinion will all play a part in shaping the world we actually live in and the part air transport will need to play in it. HLTCs are therefore about identifying technologies that need to be developed. They are not models of the future from which we can chose one or more that suit us. The technologies embraced by the HLTCs will all need to be developed but at speeds and intensities relevant to the developing world.

ACARE also wishes to provoke even more outlying thought and to spur the consideration of new technologies. The section entitled “Towards the Future” shows some features of an air system far beyond 2050 and along with the HLTC 's forms an integral part of the Agenda. Taken together the HLTCs and the pioneering innovation described in “Towards the future” provide a much better insight into the range of problems and of likely solutions than in SRA-1. They will stimulate the system-wide, cross-disciplinary research so strongly needed to develop optimised solutions for a high performance air transport system.

Figure 5 shows the inter-relation of all these strands of activity and how they will allow the two top level objectives to be realised.

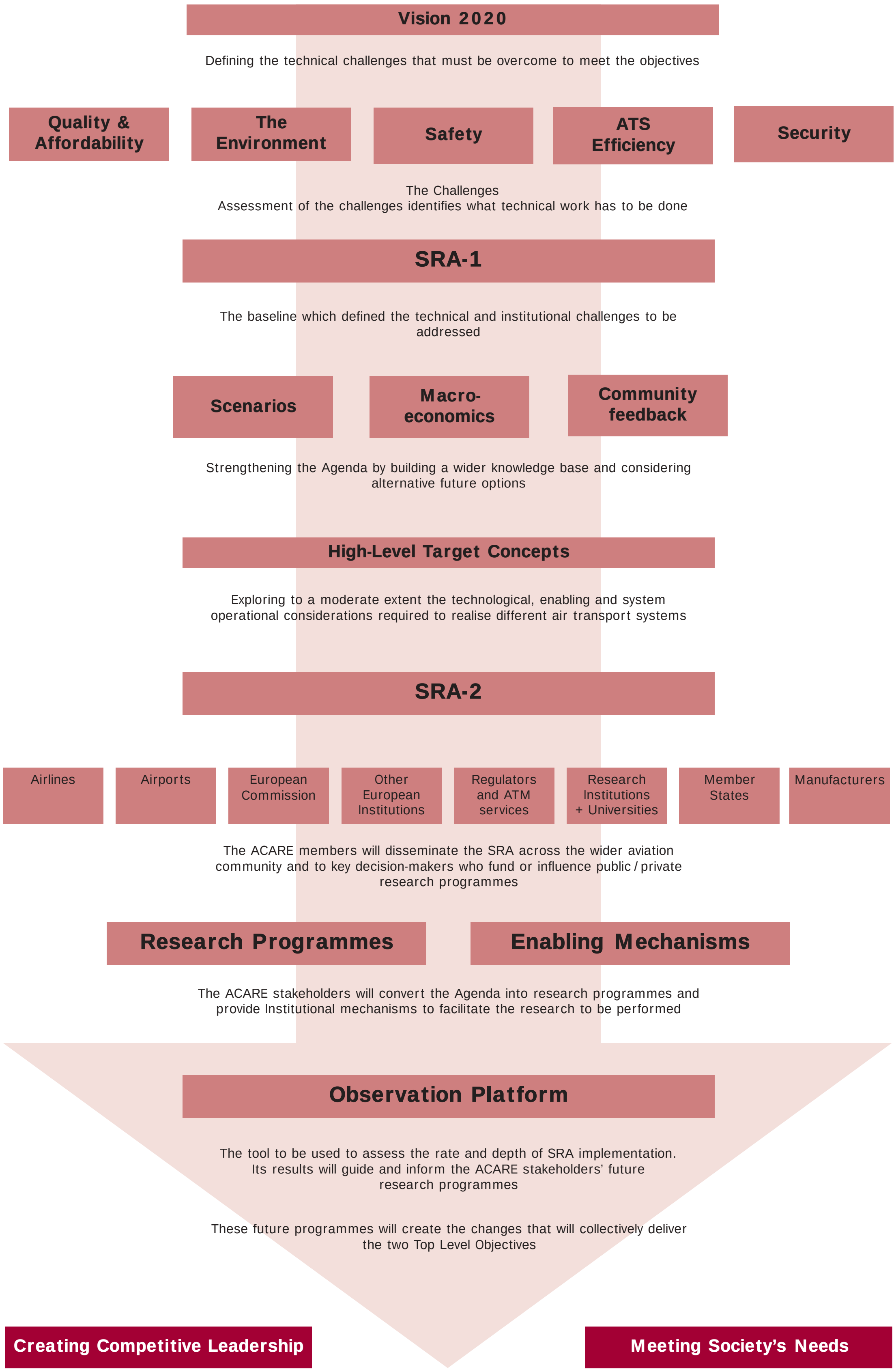


Figure 5: SRA edition 2 process flow diagram

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Section 3

- An introduction to the structure of the High Level Target Concepts
- The Highly Customer Oriented Air Transport System
- The Highly Time Efficient Air Transport System
- The Highly Cost Efficient Air Transport System
- The Ultra Green Air Transport System
- The Ultra Secure Air Transport System
- Towards the Future – an assessment of long term possibilities

An introduction to the structure of the High Level Target Concepts

The sections that follow set out the 5 High Level Target Concepts for the work to 2020. Each of the HLTCs is assembled around a common framework of sections and they may be easily compared with each other. This similarity of structure is important as the HLTCs are not intended individually to describe a full context for the air transport system but to represent one of the pools of technology that any real situation could draw upon.

The first section "concept" explores the basic philosophy of the HLTC and its particular line of emphasis and links the HLTC to the most valid of the scenarios from those studied in the scenario workshop.

The next section sets out, as if they are already in 2020, the implications for the main actors in the air transport system and how they would respond to the pressures of the HLTC. Each starts with the operators (airlines) before elaborating in a systematic and standardised manner the impact on airports, aircraft and ATM.

The third section refers back to SRA-1's Challenges and shows how each HLTC must compromise and trade between conflicting needs. It does this schematically showing which of the Challenges (Environment, Safety etc) are affected very positively, positively, neutrally or negatively.

The following section addresses the research infrastructure required to realise the concept and particularly addresses the technology validation and demonstration that would be needed.

The fifth section identifies those non-technical aspects that would be implied and are highlighted by the emphasis of the concept. These issues may concern new needs for regulation, policy, or identify new areas that need international or inter-stakeholder agreement. Even if some of the situations we face in the future do not need all of these, or to a different degree, the work of the HLTCs has identified areas for timely consideration of these aspects. The action for these areas is often outside the industry of air transport and frequently concerns the engagement of governments at both national and European level.

Each concept has associated with it a schematic diagram that describes the concept graphically. The technologies themselves that underlie the concept are captured in Volume 2 and are traceable either by target concept or through system component (ATM / AP / AC).

The Highly Customer Oriented Air Transport System

The concept

The Highly Customer Oriented Air Transport System proposes a quantum leap in passenger choice and schedule flexibility. With a trend away from hub-oriented operations to more convenient point-to-point travel, increasing numbers of individuals on leisure and business travel fly in small to medium size aircraft including supersonic business jets for long range operations. New large aircraft such as the A380 accommodate large-scale movement of economy passengers on dense routes.

The concept is especially relevant to the Segmented Business Models Scenario which envisages a world driven by strong growth in GDP with its consequential (3.5 fold) increase in air traffic relative to 2000 arising in a relatively safe and secure world where environmental concerns are not dominant.

Freight movement by air has become increasingly important as the growth in globalised markets and underlying economic growth leads to increased demand for transport by air.

Given that this HLTC is associated both with the largest traffic growth and the maximum complexity of the Air Transport System, safety (and the associated intention to reduce accidents rates by 80% with reference to 2000) is specifically dealt with in this concept despite being an essential element in all HLTCs.

Implications for the Air Transport System

Within this overall concept for greater choice the principal sectors of the ATS each have to contribute specific new services, although in a well integrated way, if the concept is to be fully effective.

Airlines

The high volume of traffic and intense competition by 2020 has prompted airlines to offer customers the services that they want – whether this is in terms of route, schedule, facilities or otherwise. Airlines publish extensive combinations of service from their main bases. They now offer specific services from smaller airports where they sense that the market exists. The airline, for example, provides 'all-business' class travel from city centre to city centre or from door to door.

Many of the options available are capable of being fitted to basic aircraft but may not represent a permanent allocation to that role. Indeed the management of the fleet remains important to ensure that aircraft are equipped for the services that are being offered.

A key customer preference is reliability of schedule and airlines have developed new business models that enable this to be virtually guaranteed to passengers. Delivering on this means new relationships between the airlines and the airports and with ATM so that the whole system is devoted to sustaining schedules.

Tickets are booked on-line and passengers issued with an electronic ticket keyed to their national ID number which is not transferable – there is some carry over from the ideas of the Ultra Secure HLTC here.

Airlines work with Internet brokers to keep their information current and although all aircraft have almost all-weather capability they keep the information updated in real time to allow passengers to compensate if necessary. Arrival on time is regarded as the vital characteristic but airlines also communicate any delays in departure so that travel to the airport can be adjusted.

The major change to maintaining schedules was the establishment of the 'gate-to-gate' journey trajectory that encompassed the processes of loading, taxiing, take-off, cruise, landing, taxiing and disembarkation. The trajectory is allocated to areas of responsibility and passengers have clear routes to claim high compensation for deviations. This has made remarkable improvements to schedule maintenance.

There is an increased number of Freight Carriers who operate a wider range of aircraft types including specialist vehicles for heavy lift cargo (300t) over relatively short distances to avoid road traffic congestion.

Perishables and high value goods are moved quickly around the world, encouraged also by the lowering of costs for airfreight. This involves both bulk freight movement and small size "personalised" delivery from both dedicated freight airports and passenger terminals in a range of different aircraft types. Inter-modal links for freight are an important aspect of the transport infrastructure.

Airports

Airports are adapted to different types of journey and vehicle types and within large airports there is also more customisation of passenger area and services.

Clustering of city airports with associated interlinking infrastructure allows optimisation of current locations and runway capability whilst regional airports grow in number and capacity to meet the increased need for point-to-point connections. City "vertiports" are designed for the operation of VTOL air vehicles inside densely populated areas, while dedicated freight airports are often located in out-of-city areas, allowing 24-hour operation and providing for rapid distribution via nodes in the national motorway and rail network.

Inter-modal transport is paramount in providing the passengers with increased flexibility in getting to and from the airport. This provides the opportunity to separate the landside part of the airport terminal from the airside with secure transport links between the two. Landside terminal buildings are often in city centres or at convenient connecting points on highways thus removing much of the congestion that existed around major airport terminals. Taxi services are available from all landside terminals to the eventual destination.

The processes for check in, security, immigration and customs are harmonised and non-invasive in nature. Fast security clearance forms an essential part of the on-schedule service. Fast track facilities are provided for premium fare paying passengers who are transported quickly through the airport terminal to the gate. There is a range of facilities for business and leisure passengers with lounges for each type of passenger including transit passengers. Passenger movement through the airport is speeded up by the more extensive use of moving walkways, automated vehicles, particularly in older airports with long walkways. Baggage for all passengers is tagged with active electronic tags that identify the passenger, the flight, the departure and the destination and allow the baggage to be monitored throughout the airport.

Runway capacity has been increased and this increases the choice available to passengers by increasing flights spread over a 24-hour period and by reduced separation times at peak periods with take off and landing sequences tailored to each aircraft type. Personalised air vehicles and different aircraft / helicopter types require the new procedures and technologies to ensure safety and all weather operation.

As for the support for this more flexible airport new systems like the advanced Departure and Arrival Management Systems and the Advanced Surface Movement Guidance and Control Systems (ASMGCS) for all ground vehicles (including trucks, cars, buses,…) ensure adherence to schedules with the proper level of safety for all the airport operations as the traffic increases.

Airports are specialised to service specific traffic types. Integration of different types of traffic into the same airport is organised according to the most common types of service needed. Low-density airports use self-separation landings and take-off. Dedicated Freight airports use automatic landings and take-off and in due course will be equipped to handle pilot-less aircraft. High-end airports use the same all weather features as in the 'Time Efficient' HLTC.

The timescale of change is as much determined by the speed at which the airport and ATM infrastructure can be changed as by the availability of technology. In the longer term however, airports will have separate landside and airside terminals joined by ground and air transportation links with the same levels of security. Large airports are increasingly being serviced by a number of these landside terminals, geographically dispersed including one close to the airport for those passengers who wish to join the system at the airport itself either by car, helicopter or personal air vehicle. The procedures for processing the passengers is as defined in the 'Time Efficient' concept.

Aircraft

A wide choice of airframe / engine configurations range from large wide body (inc. blended wing) aircraft, medium size aircraft, business jets including super-sonic, advanced tilt-rotors and helicopters, specialised freighter aircraft, etc. A wider use of personal / general-aviation vehicles for business or leisure purposes is also part of the scenario. At any specific airport the range of aircraft is more limited as it responds to the roles being operated from that airport.

A wide selection of comfort items and in flight services is provided on request and with the proper security levels by the implementation of a "plug-and-play" customisation concept. This includes areas for seating, working with full connectivity to the outside world (office in the sky concept with in–flight connection to the web, e-mail, telephone etc), sleeping, eating and drinking, communication, exercising, and personalised flat screens for games or gambling in all classes. Medical services have been enhanced to serve the needs of passengers. The performance and control of cabin microclimates provides increased comfort levels.

Aircraft choice has been improved by the capability of aircraft to take off, fly and land in all weather conditions whilst reducing the number of accidents in line with ACARE goals. Safety remains a very important aspect of aircraft design.

These capabilities have required new integrated Multi Mode Receiver Systems and Advanced FMS on board the air vehicle to ensure improved, curved precision approach, automated 4D trajectory conformance monitoring and, when needed, 4D trajectory negotiation via secure data link with the ground.

A new system integrates the three main functions dedicated to the monitoring of the principal external hazards (Traffic, Ground and Weather) obviating the need for the crew to cope with three separate dedicated systems (TCAS / ACAS, EGPWS and Meteo Radar, including turbulence / windshear detection). This – together with new advanced Human Machine Interface capabilities – drastically reduces the total reaction time of the crew allowing precise and quick recovery actions in emergency situations.

To satisfy the demand for different types of freight, transport dedicated fixed wing aircraft have been designed without the penalties associated with passenger driven requirements. Low noise signature to allow 24 hour operation is essential whereas flight speeds are often lower than passenger aircraft. In order to reduce crew cost, and since the flight path requirements are less demanding, freighter aircraft are the first fully automated aircraft to interface with the ATM system.

A second type of 'door to door' freight aircraft has been developed to provide services that were only possible by rotorcraft freighters but are now also provided by 'Lighter than air' configurations or hybrids which combine 'lighter than air technology with fixed wing or tilt rotor designs. Very large payloads are air transported to avoid the congestion problems associated with road transport.

Air Traffic Management

The challenge for the ATM system is sustaining the reliability of greatly increased flight-scheduling flexibility, day and night, in all weathers. It sustains this for a wide range of aircraft types, sometimes with unconventional flight profiles (e.g. tilt-rotors) and associated operating characteristics whilst catering for the increased traffic volume.

Airspace is organised into separated volumes for the different types of operation. These differences correspond to different airspace users. Expressway routing provides conflict free, shortest distance flying for aircraft that have the equipment to sustain it. Other, older aircraft are supported with more traditional ATM but pay for this with different quality of service (e.g. delays, longer routes etc.).

These separate operational volumes are changed according to weather, capacity and traffic type, helping to sustain the range of choices open. An overall monitoring system permanently oversees the performance of the system, the allocation of traffic to different modes of operation and potential issues to be resolved.

The main operational mode is governed by a 4D trajectory management system, complemented by airborne self-separation assurance functions. Within this "airspace", highly organised structures (expressways) operate within traffic flows established between high-density city pairs. Low-density airspace are served by autonomous operations, using automated flight information systems and self-separation assurance.

Mixed airspace takes into account all legacy systems and aircraft, transition to and from different types of airspace. Its operations are based on a mixture of 4D trajectories, 'conventional', ground-based ATM, with specific tasks (sequencing, merging) mostly delegated to the cockpit.

'Conventional' ATM is enhanced through the extensive use of data linking, which enables automation of routine tasks. New decision support tools (e.g. conflict detection solutions) have been developed, and controllers now use an 'auto-control' function, very similar to the 'autopilot' for the cockpit, which automatically solves minor control problems through aircraft speed adjustments.

A traffic allocation collaborative system takes into account users choice and capability and assigns them to a given operational mode with particular features (price, quality of service, size etc). This traffic allocation system issues a contract, which principally takes the form of a 4D trajectory. This trajectory is more or less restrictive according to the chosen operational mode, and is permanently monitored so as to prevent any airspace boundary infringement.

Freight traffic is provided with specific services, taking into account cockpit automation, and impact on regular passengers' traffic. Specific low-level routes are provided to rotorcraft, and incorporated into the different airspace.

Separation management is based on 4D 'conflict-free' trajectories as the first filter in premium airspace and dense traffic areas with self-separation or ground control as the second filter. At a later stage, 'Highly Interactive Dynamic Planning' (HIDP) systems will enable aircraft to have automated, conflict free trajectories.

Self-separation is the default mode for low density traffic.

Automated freight traffic receives automated 4D trajectory management.

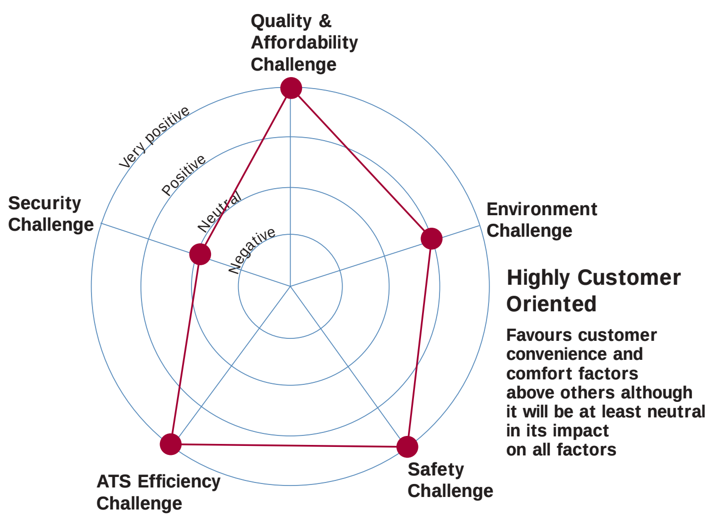
Safety

Any steps aimed at reducing the accident rate by 80% will inevitably involve a set of measures and ten Contributors have been identified for this. They are:

- Eliminate Controlled Flight Into Terrain (CFIT)
- Minimise the factors that lead to loss of control
- Maintain safe separation between aircraft.
- Minimise atmospheric hazards
- Realise effective and Safer approaches and landings
- Realise effective and safer ground operations
- Identify and Prevent future hazards
- Increase survivability and reduce injuries in aircraft incidents and accidents
- Ensure effective and reliable human performance
- Improve methods and tools for engineering and certification.

These Contributors and the underlying analysis of safety issues is unchanged from the assessments made in the first edition of the Agenda. The technologies needed to deliver these changes are, however, more closely identified and will be addressed by the technologies in the remainder of this HLTC and by technologies from other HLTCs.

Links to SRA-1 Challenges and Goals



Research Infrastructure

A number of essential, large-scale Technology Integration Platforms will be needed to bring this HLTC to fruition, mainly connected with the provision of safety features. They are:

- The Visual Cockpit
- Atmospheric Hazards Prevention

- Manager of Aircraft Trajectory
- Enhanced Navigation, Guidance & Control System for A/C Trajectory Protection and Recovery
- The Vision Airport Tower
- Human centred Analysis and Demonstration for Integrated Air Transport
- Integrated platform for system Development, Safety analysis & Certification
- Secured Airport Demonstrators
- Knowledge Management System for Human Factors Integration

Enablers

Key enablers for a system devoted to passenger convenience will start with effective inter-modal infrastructures for the arriving and departing passengers. These will include the range of ground transport but may also involve transfers to and from rotorcraft at verti-ports.

The freedom of airports to be able to develop their facilities including appropriate planning regulations will be key in enabling the new services.

Regulators will need to ensure that appropriate qualification and certification processes are in place for the operations described (new ATM approaches, pilot-less aircraft etc).

External developments in the ICT and security sectors that will provide reliable and efficient computer systems and security screening machines will be important enablers of the whole HLTC.

SECTION 3

Highly Customer Oriented HLTC

The Highly Time Efficient HLTC

The concept

A highly time efficient system is firstly one that is predictable and reliable, in which all stages of the journey are known and can be depended upon. Then it is a system in which each process has been honed down to represent the minimum time spent consistent with the overall reliability of the system.

This HLTC emphasises a step change in the dedication of the ATS to maintaining schedules that minimise the time spent and wasted by travellers. The concept is relevant to the scenario “Segmented Business Model” with its high GDP growth rate and the consequent rise in traffic to 3.5x the 2000 figure but also makes an important contribution to other scenarios.

The concept envisages an air transport system in which passengers have enough information to make intelligent and suitable choices from the options being offered to them – one of which is often the Highly Time Efficient.

Creating a Time Efficient system must deal with the most significant single opportunity for reduced journey time – reducing the time spent in airports. For journeys of short or medium duration this is now a significant proportion of the whole journey but reducing it is a matter for all the participants in the system, airports, airlines, ATM, and passengers. Addressing this issue will certainly deliver a more time efficient system but could also generate technologies for use in a more environmentally sensitive system by allowing reduced aircraft speeds for no increase in journey time.

Implications for the Air Transport System

Airlines

The first responsibility of the airline is still in 2020, naturally, to manage the movement of passengers from their arrival at the airport to their safe arrival at their destination. To achieve that in a predictable, highly time efficient system requires that the airline looks to many aspects of its operations. In confirming that time efficiency is consistent with its business plan and strategy it will consider the following:

- The suitability of its aircraft to sustain the services on offer and that they are fitted with the necessary on-board computer systems that allow the aircraft to maintain the planned trajectory.
- Flight crew trained in the processes.
- Connections to appropriate on-line seat brokers who can sell seats over the web and offer a transparent set of travel options to customers.
- Alliances with other airlines to enable the airline to offer connecting flights with the same emphasis on time efficiency.
- New ‘business models’ for these operations in conjunction with the airports and ATM providers.
- Participation in the passenger compensation system that assigns responsibility according to the induced travel delay between airline, airport and ATM.

Airports

The key part of highly time efficient (HTE) working – that of predictability and reliability – conditions all airport operations. It must deal with more than one service to passengers. It must be able to handle HTE processes but also the legacy and other ATM systems that will be in use. As HTE is adopted some airports devote almost their whole operation to this travel mode, those who have to deal with a wider variety of traffic must be more cautious. For an airport that has a major part of its operation devoted to this 4D or trajectory mode the necessities are:

- New business models for the allocation of slots to airlines that underpins reliability of schedule. For airlines the slot becomes an absolute and unique commitment to the airline for the time.
- A streamlined and automated passenger handling system that makes the arrival at the airport, checking-in, baggage surrender and passage to the departure gate as swift , smooth and automatic as possible. Basic identification, baggage check-in and flight checks are at entry to the airport. Security checks take place immediately before boarding at the departure gate. Passengers have unique travel ID numbers for themselves and their flight.
- On-schedule aircraft management systems that present the aircraft to the departure gate in enough time to load before departure on schedule. In adverse weather this includes de-icing stations and routine cleaning and re-stocking.
- Disciplined departure gate management. The gate must close to new arrivals and passengers must board the aircraft 'on time'.
- Links to the airline information network that allows the airport to supply and obtain information to the network. Airports need to be open (and honest) with the status of flights that is communicated to ticket brokers and the public.

Whilst these arrangements apply to the airport terminals out on the airfield there are other needs:

- A runway management system able to adjust for weather, with wind-shear and vortex monitors, and able continuously to adapt separation distances to circumstances and to minimise them.
- A surface taxiway system that can be used in all weathers.
- Integrated surface management systems that allow take-offs, landings, taxiing and servicing to be co-ordinated with full A-SMGCS capability to improve predictability.
- Fast and efficient aircraft handling and servicing systems. These must deal with a variety of types working on different flight modes. Increasingly these include under-ground systems that permit "roll-over" of the aircraft for de-icing and other servicing.
- Systems that are compatible with highly efficient 'trajectory' controlled movement across and into and out of the airport.

Many of these systems need to be fast and effective but the underlying need at airports is for a commitment to reliability, the ability to deploy the systems when they are expected so that airlines and their passengers may depend upon them.

Aircraft

Although there are fundamental needs for the aircraft to have the electronic systems needed for trajectory management these are but the start of the changes that are implied by this HLTC. Some of these are:

- Aircraft should be planned to have adequate margins of performance (especially on long haul) to allow trajectory schedules to be met.

- ATM compatible capability for zero-visibility surface movement on the airfield.
- Streamlined boarding patterns for multi-door embarkation.
- Comprehensive on-board facilities for passengers for business functions that widen the range of services the airline is able to offer.
- Communications that allow the aircraft crew to be part of the aircraft / airport / ATM loop whilst in the airport area and able to send and receive voice and data.

Air Traffic Management

One of the most important components of the system is the ATM. The issue of time efficiency is equivalent to the introduction of high predictability within the ATM system. For ATM to be fully predictable, the main aspects to be considered are the absorption of non-predictable events especially weather and congestion.

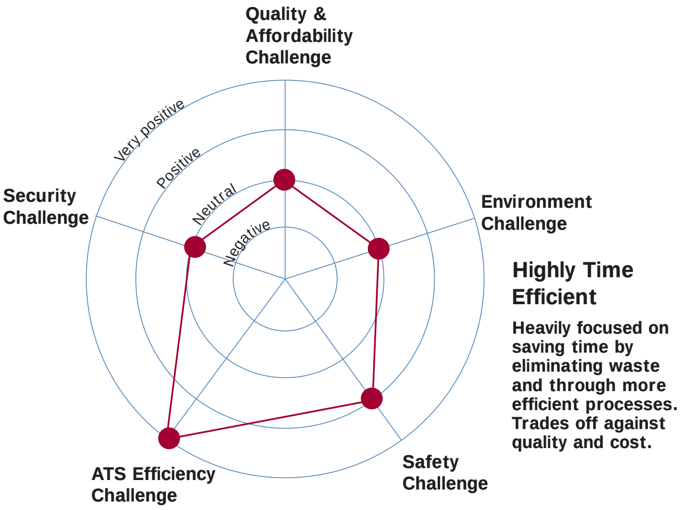
Unfortunately, weather will never become fully predictable, nor manageable, but it is felt that one can mitigate its effects by organising the airspace dynamically so as to minimise its impact on traffic flows. As far as airports are concerned, which in Europe are the first to suffer from bad weather situations, all weather landings / take-off equipment will become mandatory, and pilots or controllers will be equipped with enhanced / synthetic vision systems.

The congestion issue will be solved by a more rigid organisation of traffic, according to aircraft capability as well as aircraft operators needs (time efficiency may have different meanings for different types of operators). Parts of the airspace will implement a specific type of operations, with specific attributes (price, quality of service, equipment requirements). Hence, dense city-pairs will, for instance, be served by "express-ways", which give access to a "reserved", high-capacity airspace, to suitably equipped aircraft and according to a given price.

The increase in predictability is likely to be based on a time and space (4D) trajectory, detailed and binding (becoming a "contract") to the appropriate level according to the chosen type of operations. The "4D trajectory management system" will be supplemented by autonomous separation, in which aircraft ensure on their own that they are appropriately separated one from another, for instance on express-ways or in low density airspace. In other zones "conventional" ATM, rendered highly efficient by the use of new technologies and automatic support to human controllers will be used, or finally by a mixture of the two.

The general philosophy of the ATM operations under the time efficient HLTC will be one of more discipline in the system, in which all actors, ATM aircraft operators and airport operators, will exchange dynamically information on the exact status of their operations.

Links to SRA-1 Challenges and Goals



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Research infrastructure

Centres Of Excellence – COEs – should be identified by research laboratories in co-ordination with industrial partners who will provide inputs and validation based for all elements of a time efficient ATS. The work may be split between those COEs for Air Vehicles and Technological Infrastructure and those for; Operational Procedures within the airspace; Technological Infrastructure and Operational Procedures at airports; and Aeronautical Weather.

Strong co-ordination between the programmes focusing on the different sub-fields will be necessary to assure compatibility of the different developments. There should, desirably, be a shared analysis and direction for the Technology research between Industrial and Research participants.

Several TIPs will be necessary. Four that apply to this HLTC are:

- En-route Approach;
- Airport Approach and TMA;
- Airport Terminal – landside and airside;
- Aircraft in the Managed Airspace

each led by either a major Industrial or major Research Centre for the different sub-elements. They must be interconnected to allow total system validation in addition to demonstrations within their field-of-competence. These validations, including flight test validation, will associate all the necessary actors from Air Vehicle, Air Traffic Management, and Airport sectors.

Common data-definitions and common application interfaces should be defined across the research infrastructure. Standardised sets of performance criteria should be used to allow comparisons of the findings.This would allow the process of combining of solutions in different sub-fields into new, harmonised, system prototypes to be accelerated, as it would the transition into the actual system.

Enablers

Extended system-wide Simulation and Time Management tools will be vital both to understand the situations by simulation and also to assess the validity of solutions by simulation or demonstration.

The general change from today's first-come first-served principle toward a first-planned first-served philosophy has to be accompanied with the necessary regulations and training of the operational personal in respect of time efficiency. Special training centres will be needed to educate and train staff in best-practice time efficient procedures (especially dealing with system failures and degraded performance).

The time of operational staff (pilot / controllers) should be allocated to take part in experiments and simulations on a regular basis. This will help the research to achieve operational acceptance in an early state of system development and give operators early insight to developing best practice, and allow their introduction progressively from the present.

New criteria for people behaviour and society acceptance will need to be added to the conventional technical criteria in certification and qualification.

Three other enablers are key to this HLTC. Firstly the availability of inter-modal transport infrastructures that will reliably and predictably ensure the speedy transfer of passengers through the system. These may involve trains, buses, verti-ports for rotorcraft or other means of arrival and departure of passengers. Secondly developments in high-speed security scanning equipment that is fast, reliable and non-intrusive as well as being capable of multiple-frequency scans. Thirdly is the need for a progressive implementation of standard sizes for cabin and hold luggage that allows more reliability and time saving.

The Highly Cost Efficient Air Transport System

The concept

This HLTC focuses upon all of the costs that arise in the whole air system design and operation. It explores technologies that would allow a very different view to be taken of cost in a system designed to accommodate it. It envisages that all costs, both hardware and operating costs, are considered, and all manner of contributory costs from aircraft to ATM, airports to airline operations, and from maintenance to service provision.

Business imperatives will always drive costs to be cut and competition will continue to be a measure of businesses that do this well. This HLTC does not dwell on these normal, well-known and continuing discriminators of individual business success. The HLTC describes a set of transportation offers that could be available but leaves room for operators to select other offers if they suit them better.

The scenario with greatest relevance to this HLTC is the "Segmented Business Model" with its high GDP growth rate and consequent increase in air traffic (3.5 times the level of 2000) but, as with other HLTCs, the technologies identified would find uses in other scenarios.

Implications for the Air Transport System

Airlines

The implications for the airlines are very significant. The pressure of cost efficiency has changed their processes for making decisions about aircraft purchase. Airlines are very experienced in operations of 2000 but these are extended by the new transport options available to them. The option of zero maintenance aircraft and long airframe life are being factored into their calculations. These new options open up new perspectives on operations that also need to be assessed.

Airlines in 2020 have a wider range of choice and the impact of this Cost Efficient HLTC has progressively created a tendency towards a long-term dependency on selected aircraft types for sections of the airline fleet. For small airlines this has extended the single fleet supplier ideas of today and for larger airlines segments of their fleet are remaining with a given type for many years. Within these fleets or sub-fleets the aircraft is benefiting from progressive upgrading of individual systems. Because the basic aircraft has a very long life its resale value is being sustained for appreciably longer than today and this too serves to reduce the cost of operations.

Although freedom of aircraft choice remains open to airlines and depends upon their marketing strategy the widespread adoption of the ideas in this HLTC has tended towards the development of more standard, and therefore more basic, aircraft that can be customised to the purchasers needs. What matter to airlines is whether the market benefits of a cost efficient system expressed in lower fares are more or less profitable for them than continuing with the system of 2000.

As also described in the Time Efficient HLTC airlines are co-operating with e-ticketing through web-based travel brokers that allow passengers wide choice of flight schedule. Part of this move to electronic identification of ticket holders is seen in the co-operation of airlines with ground transport to the airport where airline travel codes are used to pre-sort passengers and their luggage.

As the influence of the HLTC extends throughout the ATS the exercise of choices by airlines to work in more flexible ways outside of the HLTC concept is becoming relatively more expensive – and more difficult to justify.

Airports

Airports embody a number of changes to their operations to help deliver a highly cost efficient system. Airports are designed for 24 hour operation (and embody many of the low noise aircraft / operations features of the Ultra Green HLTC). Equipment is thus being used more intensively.

Airports and the ground transport system to the airport are designed in 2020 to operate efficiently together and for the speedy automatic connection of passengers with their destination in the airport. This automation of the system reduces costs by reducing the need for supporting personnel.

Check-in procedures have been speeded-up and enable boarding gate check-in and security to be completed quickly. Airports collect hold baggage at the airport entry and monitor its location throughout the airport system until it is loaded. Passengers are similarly monitored as they move around the airport with passenger ID, baggage items, flight number being the key identifiers.

Runway utilisation at busy airports is maintained at an optimum level with taxiing and ground handling co-ordinated with runway use. The value of the flights serviced by an airport is thus maximised and their individual cost reduced.

Specialised airports service freight operations and have appropriately specialised inter-modal connections.

Reduced turn-around times are leading to increased gate and aircraft utilization

Aircraft

In order to maximise the concept of the High Cost Efficiency in this HLTC the key characteristics of the aircraft are stretched beyond the path of normal extrapolation from 2000.

A maximised standardisation of the aircraft and its systems has resulted in cheaper manufacturing, operation and maintenance. For the manufacturing and design phases large production volumes achieved their objectives from a lower number of separate types of aircraft and components and are able better to exploit the effects of 'learning curves' and thus reduce unit costs.

In addition to the lower maintenance cost from the smaller variety of aircraft and spares, designs aiming for zero maintenance with in-flight monitoring allow increased aircraft utilisation and are leading to lower operating costs. Further increased utilisation of aircraft is achieved through shorter turn-around times.

In the operating phase aircraft use more airborne capability and automation for route keeping and separation. This allows more versatility in operation, and gives optimised planning and dispatching characteristics for the operator. Reduced requirements for flight crew in the cockpit further lowers the cost base for operating the airplane.

Aircraft have only a minimum basic equipment fit, but are capable of route and passenger customisation, according to differing mission needs. The minimum equipment list provides the performance for discharging basic missions but is adaptable to other missions by customisation. This includes minimum flight deck equipment, range capability as well as cabin items. A cabin design optimised for "no frills" operation is an option available to the airline, depending on the way it plans to operate its fleet.

At the end of the life cycle a higher residual value for a given age of aircraft will also improve the cost-of-ownership base of the aircraft.

There are some certification issues associated with upgrading the software on aircraft by uploading new variants but this has been successfully tackled in the military domain where it has been common for some time. The management of software certification is also handled well in those aircraft which are already software intensive.

Air Traffic Management

The airspace of 2020 is designed to create the lowest costs. This means in particular that it is as generic as possible, and that specific airspace requirements are kept to the minimum. This encourages ATM systems in Europe to be off-the-shelf, with specific functional classes according to traffic density or complexity. The systems architecture is built according to performance targets that are a compromise between cost and efficiency.

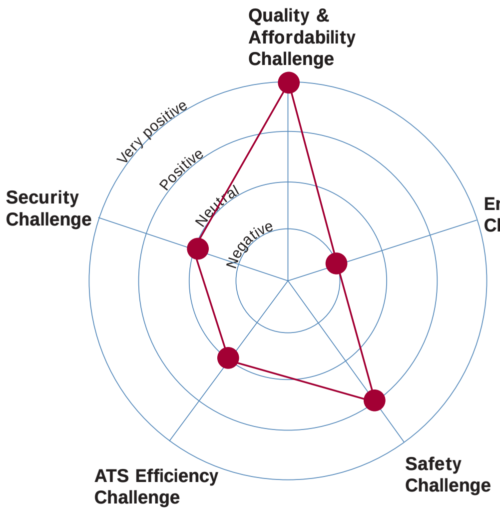
The route network is also a compromise, between an efficient to fly and efficient to control network. All capacity shortages (for instance due to weather conditions) are dealt with exclusively through ground holds, with no airborne delays incurred by aircraft operators.

The ATM system is based on 4D-trajectory management systems, complemented by 'conventional' ATM of which specific tasks are delegated to the cockpit using Airborne Separation Assistance functions when this is deemed more cost-effective. In low density airspace, aircraft are responsible for self separation and use automated flight information services.

Airports are equipped for nominal case, or planned, operations, with the consequence that non nominal conditions (for instance due to severe weather) result in significant disruptions.

Low density airports use self-separation landings and take offs and make use of Ground-Based augmentation systems for IFR landings. Enhanced / synthetic vision enable 24 hours and all weather landing capabilities without the need of costly ground infrastructure.

Links to SRA-1 Challenges and Goals



Highly Cost Efficient

Takes a systemic view of the possibility of fundamental reductions in cost through co-operation of the parties.Trades off environmental concerns for cost.

Research Infrastructure

The highly cost efficient ATS research and technology solutions will need a number of simulation and testing capabilities and infrastructure, such as the following:

Simulation capabilities

- Simulation of the supply chain (manufacturing) and decision making strategies (implications of automation, single / no pilot operations, man / machine interface)
- The development of models to optimise the efficiency of the whole operational ground / flight / ground cycle. Life cycle cost driven multidisciplinary optimisation (air and ground operation, aircraft / airport / ATM environment)
- Reliability and maintainability implications (advanced passenger health monitoring system PHMS).

- Modelling passenger and baggage flows (inter-modal, in the airport, boarding)
- Simulation of Disposal / Recycling processes and their cost implications

Testing and integration capabilities

The following Test & Integration capabilities will have to be developed:

- Autonomous (single / no pilot) flight operations
- Large scale ATC tracking for autonomous operations
- Networked flight or mission simulators
- Generic ground environment test and training facilities

This will form the rationale to establish appropriate TIPS accordingly.

Enablers

To support the progression towards technologies for this "Highly Cost Efficient Air Transport System", several aspects of the overall picture must be addressed at 'system' level to permit the real benefits to be understood fully and application to be effective. These system studies include – but are not limited to – Air vehicles, Ground and Air services, Inter-modal communications and transfers and Aircraft operations, and maintenance and disposal.

To enable the benefits to be evaluated the assessment at system level requires modelling tools and validation demonstrations which can handle the full scope of Air Transport System Operations. This must range from vehicle design and manufacture through disposal and all aspects of ground and air operation with an understanding of the dynamics of interaction between the inter-modal transfers as well as air-system specifics. These major features will need to be supported by large-scale technology demonstrators that should involve complete aircraft / airport scale trials.

Key enablers to permit progression towards this HLTC will be:

- Revision of the regulatory policy and regulatory framework for aircraft construction and operations including regulations for standardisation of air vehicle design and construction
- Standards for components / equipments, for airport equipment and for flight operations processes.
- Simplified standard re-certification routines
- Airport planning (e.g. market driven vs. Community-wide planning)
- Land use and planning policies surrounding airports.
- Regulation and standardisation of transport links and interfaces to the Air Transport System (including efficient separation of traveller from luggage / non-essential personal items at place of departure and reuniting at destination).
- Developments in the security equipment sector (Multi-spectral scanning machines, automated handling and screening etc.) – a reflection of needs is described in the Ultra Secure HLTC.
- Developments in the ICT sector (surveillance sensors, pattern recognition software, RF tags etc.) as for the Ultra Secure HLTC.
- Demonstration of system capability and safety that positively influences public perception and acceptance.
- Development and demonstration of advanced automated ATM routines to minimise or eliminate the need for "real-time" Air Traffic Controllers.

The Ultra Green Air Transport System

The concept

The concept stretches the world's sensitivity to environmental damage and examines possible technological responses to it.

The most relevant scenario to the Ultra Green HLTC is "Constrained Air Traffic Growth" under which there will be an increased public awareness in industrialised as well as in emerging countries of the need to protect the environment. These broader concerns about global climate change, local air quality and noise will lead to air transport being identified as a major contributor to environmental damage.

The Ultra Green ATS HLTC addresses the whole range of vehicles for a future air transport system including passenger, freight, rotorcraft and supporting ground vehicles.

The concept of Ultra Green implies an ATS with tightly regulated limitations on emissions and noise, not only on a pro-rata basis but also on an absolute basis that is very challenging even given the constrained growth of the scenario.

Implications for the Air Transport System

Three issues are contained in the Ultra Green: two are local, noise and air quality and one is at the global scale of climate change. Local issues can be addressed with some confidence but the mechanisms of climate change are not yet well understood.

Climate change, or the greenhouse effect, is a global issue and strongly linked to CO_2 and NOx emissions, but also to soot, particulate, water vapour, etc. These emissions all contribute to complex changes in the physical and chemical properties of the atmosphere which may depend on flight altitude and atmospheric conditions. In particular condensation trails created by water vapour and particulates are suspected to have a significant effect on global warming. Although SRA-1 has set ambitious goals for reducing emissions, the effect of these on climate change is still not fully understood and further work is needed in this area.

Airlines

By 2020 the main contributions of the airlines to the better environmental conditions will have been in the following areas:

- By introducing new, quiet aircraft with new energy efficient and emissions reduced engines.
- By encouraging the use of the largest aircraft that their routing programme will sustain with high load factors. This may include combining routes in some cases.
- By favouring shorter stage lengths and abandoning extreme stage lengths for intercontinental journeys where there is substantial fuel cost. By introducing slower cruise speeds even though these conflict with passenger convenience and journey time. These have been negotiated with airlines and airports with some difficulty as strong passenger and commercial resistance has been expressed. For long haul flights low-drag new Blended Wing Body aircraft are being introduced to save fuel.

3

- By working with airports and ATM to introduce and sustain low-noise approaches and departures, eliminate "circling" and reduce taxiing. Airlines strive to create low impact signatures for their fleet as this makes express passages through the airspace possible.
- To co-operate with the use of better environmental products in aircraft servicing. New aircraft enable airlines to make a low environmental impact with their MRO processes.

Airlines are attracted in 2020 to more alliances to maximise aircraft use and to extend the range of passenger services on offer.

These major efforts by the airline, at considerable cost in terms of aircraft and training, have become progressively enforced as Ultra Green is applied. On the positive side the benefit for the airlines have been the opportunity of operating quiet aircraft throughout 24 hours.

Airports

Airports play a significant role in the Ultra Green world of 2020. The first requirement on an airport is that it should be built and operated according to Green processes. The technologies for this are well known and can be applied wholeheartedly to airport buildings and installations. They include solar power, energy efficient construction and operation, and the minimisation of resource use through water, chemicals etc. Disposal techniques are in accordance with standard Green practice.

In the area of specific airport operations new alcohol-based de-icing fluids are more environmentally sensitive and their application leads to less waste and pollution.

Implementation of best practices for hazard management is common for airport operations to reduce environmental risks associated with fires from aircraft and from catastrophic explosions of the large fuel reservoirs in the airport vicinity. All ground vehicles, including tugs, catering trucks, fuel trucks, passenger buses, servicing cars etc., meet stringent emission criteria. This has been achieved by having hydrogen engines or, with the advent of high energy density batteries, by electrical power. These offer the benefit of zero emissions and less noise without sacrificing endurance and power. As a further step in the development of green vehicles, fuel cells will offer a virtually zero emission propulsion system at point of use.

Transportation to and from the airport, long a major contributor to pollution and overall annoyance to the public, is progressively becoming either all electric or electro-magnetic for much reduced noise and emissions. This is extending to personal vehicles from the progress in light materials, electric and fuel cell propulsion.

New airport designs have, in 2020, reduced the distances for taxiing from the terminal to the runway, cutting the associated noise and emissions. Advances in electric propulsion have enabled the use of an aircraft's own APU to power the aircraft to and from the runway and thereby to minimise the on-ground use of jet engines for taxiing.

In the longer term newly designed airports will have fully automated servicing points available from the ramp pavement or from the terminal building without the need for service vehicles.

Dedicated airports for freight have emerged near to natural transport nodes designed from the outset to allow 24-hour operation without noise and nuisance.

In conventionally located airports, new models for take-offs and landings with 4D precision control, have optimised flight profiles that minimise the noise impact on populated areas. However, this has relied upon research into more exactly what aspects of noise the public regards as offensive. The relatively straightforward methods of both measurement and analysis of today do not fully explain the high relative importance attached to aircraft annoyance within communities.

Land-use planning has been addressed at every large or medium airport. The imposition of noise to new buildings and the subsequent restriction of operations by this building encroachment is prevented by a mixture of greater land ownership by airports and more restrictive planning decisions.

Aircraft

The aircraft and its equipment has also been a major contributor to pollution and it plays a key part in reducing it in 2020. Aircraft or rotorcraft and engine offered a large potential to achieve the CO_2, noise and other emissions reduction goals.

CO_2 emissions are directly related to fuel burn. Fuel burn has been reduced through aerodynamic improvements, weight reduction and fuel-efficient engines and systems. Laminar flow technology provided the largest aerodynamic potential however for sustained economical use its complexity has had to be drastically reduced by innovative technological concepts.

Novel aircraft concepts such as the blended-wing body or high aspect ratio / low sweep configuration have perhaps brought the technological breakthrough needed to reach the 50% CO_2 reduction goal.

Adaptive structures in the airframe allow the aircraft to be consistently operated at design conditions, leading to more fuel-efficient missions. These adaptive structures also provide substantial reduction in system complexity and weight, obviating the need for additional control surfaces.

For engines a series of difficult trade-offs presented themselves. Increase in By-Pass Ratio to further decrease the fan and jet noise increases drag and weight. Increasing the overall pressure ratio and the turbine inlet temperature improves the engine thermal efficiency and hence reduces CO_2 but, without improved NOx control technology, increases NOx emissions. New technology concepts have been needed to compensate for this effect.

For the global impact the NOx emissions mitigation has resulted from aircraft and engine improvements. On the aircraft side, the take-off weight and range of aircraft both have an effect on the amount of NOx produced. On the engine side, engine technologies are the most important contributor to emissions reduction. In order to meet the 80% NOx reduction, it has been necessary to introduce new combustion and injection systems. For local impact, reducing fuel burn without increasing either the overall pressure ratio or turbine inlet temperature has the effect of reducing all other emissions. Combined with the objective of 50% fuel burn (associated with CO_2) reduction, a 60% reduction of combustor NOx leads to the 80% NOx reduction in cruise. Therefore the NOx reduction effort has been focussed on combustor technologies, such as lean combustion technologies.

The next step will be the availability of alternative fuels (e.g. liquid H_2, bio fuels, synthetic fuels, LNG) or power sources (e.g. fuel cells), provided that it is demonstrated that they can reduce radiative forces.

Technologies that shield or lower the noise produced by conventional aircraft or engines, such as low noise component design, landing gear fairing, and advanced acoustic panels, have been developed. Novel engine technologies (Ultra High By Pass Ratio, geared fan, contra-fan, etc.) have allowed engines to produce less direct noise.

However any further increase in By-Pass Ratio as well as most noise shielding technologies increase drag and weight. For this reason, there is a limit to noise reduction without more radical changes in aircraft designs and configurations. The development of appropriate tools able to handle design tradeoffs on a multidisciplinary optimisation basis has been an important element of the research.

In the longer term, active noise control techniques benefiting from new knowledge on micro and nano-technologies will allow aircraft noise to be reduced further.

Steep take-off and approach has substantially reduced the noise footprint in the airport vicinity. New high-lift systems designed for high climb rates at take-off and quiet drag generation at approach enable aircraft to perform such procedures without compromising cruise efficiency. Efficiently integrating Ultra High Bypass Ratio engines and exploiting their potential for blown flaps and in-flight thrust reversal enhances high-lift performance.

The noise measurement and certification practices of 2000 did not reflect the real annoyance caused to the public. A complex set of factors (physical, human, sociological, psychological) contributes to the feeling of discomfort due to aircraft noise. Studies have been undertaken to better understand these effects and provide more adequate noise measurement procedures.

Rotorcrafts also participate dramatically to reducing emissions to allow 24h operation in populated areas, for passengers and freight delivery, allowing also the increase of civil operations (police, medical evacuation,...) without public disturbance. The noise reduction has been addressed in low level cruise flight, as well as landing and take-off, through innovative and adaptive rotor aerodynamics combined with large rotor speed variation, and new turbo-shaft engine architecture which also reduce CO_2 and NOx emission. New flight control systems allow safe, steep take-off and approach procedures independent of other aircraft operations.

The air vehicle has been designed for low environmental impact throughout its life cycle from manufacture, through service operations to disposal.

Air Traffic Management

The airspace is, by 2020, designed to incorporate “green routes or areas” in which suitably equipped aircraft can fly. This “green network” will provide incentives to aircraft operators to invest into green technology in order to be able to fly optimal (in terms of cost and quality of service) routes. These green airspace volumes may vary according to atmospheric conditions and demand, and a dynamic airspace management system defines their boundaries tactically (typically, the day before operations).

Each aircraft has an “environment signature” (noise, gaseous emissions, pollution) that is mandatory and registered by aircraft operators in their flight plans.

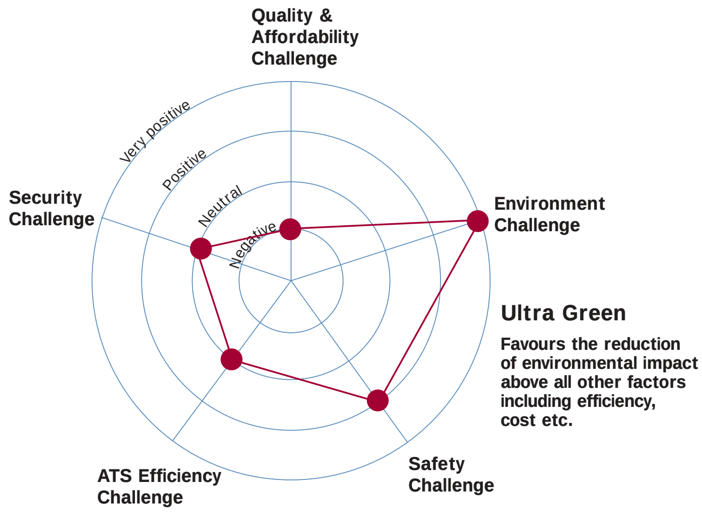
A regional / centralised entity has sophisticated environmental impact assessment tools which, given the ‘environmental signature’ of the aircraft, the Origin – Destination and desired departure / arrival time, computes the “optimal” 4D trajectory. Each trajectory may not be optimal for each particular flight, but is globally optimal. This trajectory takes into account local constraints (airports or geographic zones), meteorological environment (winds, temperature and pressure, humidity), and individual contribution to globally defined environmental performance indicators.

A real time environment monitoring system computes the environmental impact of air transport. Processes set quotas for air transport, which if reached, can lead to flight cancellations. These cancellations are collaboratively discussed with operators, in order to make sure that all constraints (operational, technical, and economic) are taken into account.

The 4D trajectory is the basis of a "contract" between the aircraft operator, and the ATM services. Changes to this trajectory are kept to the minimum. The 4D-trajectory is as conflict-free as possible, remaining conflicts being solved either automatically or manually through ground operators' intervention. Such intervention may be delegated to the cockpit using Automatic Separation Assurance functions in specific parts of the airspace.

Airports are most constrained by environmental considerations. A real time airport environment monitoring system processes environment signatures, and advises the use of specific approach or departure procedures (steep climb or descent, distributed noise footprint, composite approaches,...) according to 'environment budgets' (usually geographically distributed around the airports)

Links to SRA-1 Challenges and Goals



Research Infrastructure

The green ATS research and technology solutions will need a number of enhanced capabilities and infrastructure, including the following:

Simulation capabilities

These will include, as examples, those for CFD (Computational Fluid Dynamics), prediction tools for noise (Computational Aero Acoustics), models to optimise take-off profiles, as well as models of noise annoyance and models integrating the effects of emissions generation, species evolution and global decisions support.

Testing capabilities

These will include, for example, enhanced facilities for high Reynolds Number and aero-acoustic wind tunnels. Separate engine test facilities will be needed.

Advanced measuring techniques

The new technologies imply the need for appropriate and advanced measuring techniques and equipment for use in, for example, boundary layer measurement, acoustic measurement under cryogenic conditions and the measurement of combustion phenomena.

The following TIPS will be most associated with this HLTC:

- The Environmentally Friendly Aircraft;
- Environmentally friendly Rotorcraft and
- Vision Airport Tower.

Enablers

It is clear to ACARE that the measures described in this HLTC need be founded upon a sound international policy for any future 'Green' ATS to be fully effective. Only from such a policy agreement can technological and other measures flow with confidence. The timescale for such considerations is pressing if wasted or misdirected research is to be avoided.

A mechanism based on the ERA-NET concept should be created to co-ordinate national and European approaches to perform environmental research related to air transport. Such a mechanism on the environment should be advised by experts from the technological research and development community, airports, airlines and representatives of the communities living near airports.

European Centres of Competence should be established for research into Climate Change and the Atmospheric effects of air transport and for Noise.

Other key enablers will be:

- Availability of an inter-modal infrastructure (including the availability of vertiports for rotorcraft).
- Airport planning (e.g. market driven vs. European-wide planning).
- Land use policies.

The Ultra Secure Air Transport System

The concept

This HLTC focuses especially on creating security for the traveller, guarding him against direct terrorist attack of any form and against attacks to the travel system that will create inconvenience and disruption. It is especially relevant to the scenario for "Bloc Building" in which there are deep tensions between the blocs of Europe, the USA, SE Asia, China, and the Middle East etc that lead to security fears and an associated low traffic level (1.3 times the 2000 value). In emphasising security the HLTC trades off other desirable attributes such as efficiency, cost etc.

The HLTC has a wide scope – concerned both with the threat and the response. For the threat it envisages any kind of attack being made e.g. direct, indirect, biological, systemic, virus or any other. It includes any kind of target in the air transport system; the aircraft, the ATM system, the airports, the booking systems etc. This wide field has been underscored since the 2001 September 11th attack in the USA.

In providing a response the standard that the HLTC aspires to is an absolute one; it must not be possible for an attacking force to penetrate the security measures and succeed in creating injury, loss, damage or disruption. The range of protective systems it considers is wide. It covers not only the technologies needed but comments also on the regulations and the processes required, for example in clearing crew members for employment.

Implications for the Air Transport System

At the system level there are some fundamental needs. The air transport system must know who its passengers and employees are. This implies the creation of databases at the personal level with unique ID for each person – and biometric ID is the only method presently known. It must be capable of dealing with such identification already possessed by the passenger or staff member as well as with creating a record for new travellers. This mixture of recorded information carries other consequences; the need for regulations for its use, maintenance and accessibility, the control and authenticity of information obtained from multiple sources and its reliability. The data must also be capable of being used, at least in part, by all the main parties to a traveller's journey. These include the airline, the airport, the ATM system, and the booking agent, each has a part to play in building up the data and in using it to protect the system. Safeguards are necessary for the use of the data, even those concerned with some part of the data may not be able to access all of it. The use of the data for legal or criminal action may need to be internationally defined and protected. Passenger baggage is also a potent vehicle for carrying harmful substances into the system, with or without the consent of the passenger. Baggage must therefore be subject to positive and varied screening.

The risk is not confined to that from passengers. Staff members of many kinds will each have a potential risk associated with their duties that take them into contact with aircraft, its supporting systems, passengers or the ATC system. Each member of staff requires vetting, at least to some degree, and be prevented from working in areas outside the needs of their job. They must also be identifiable as who they say they are. This must apply also to their tools and equipment so unidentified articles may not be carried into the system and left there.

Other risks are more removed from the travel operations themselves; the direct attack on an airliner from outside the airport perimeter or the contamination of food that uses the air system for its deliver.

In the event of an attack on an aircraft the first protection for the aircraft is that the cabin must be inviolable. The last protection must be that at some stage of an incident control of the aircraft and its return to a safe haven must be taken over by the ground ATM system. Thereafter the crew would be powerless to steer the aircraft or influence its behaviour in any way. Between these two lay a number of measures that are discussed below.

All of these systemic measures need regulation and agreement, desirably internationally. They need processes to make them available, training to make people competent to use them, and investment to sustain them.

Below the system level there are numerous matters that fall appropriately into one of the main participants.

Airlines

For the airlines the Ultra Secure ATS represents considerable change. Although airlines try to minimise the imposition of security on passenger convenience there is no denying that the Ultra Secure system is pervasive and represents a higher level of imposition on passengers and freight. Some value is seen by airlines in sustaining a highly visible security system.

The aircraft are more secure than ever before and passengers are only permitted to designated parts of the aircraft – and certainly not to any part of the flight deck. Passenger baggage is reduced by constant efforts by the airports and the airlines to reduce hand baggage on the aircraft.

Unseen by passengers the aircraft is fitted with auto-recovery systems that not only allow the ground controllers to take charge of the aircraft but, if the route deviation is extensive, require them to do so by removing the control from the aircraft captain.

The aircraft is known to be vulnerable to short-range ground launched missiles and passengers are re-assured by the anti-missile systems fitted to most modern aircraft. Development of secure, reliable and affordable systems will be in association with military systems companies and will rely on much military technology.

Airlines, in co-operation with the ATM and airport systems routinely operate high security approaches and departure flight profiles to make the terrorist task more difficult.

Airlines continue to have maximum difficulty in clearing passengers for flight who have no record of previous flights or any satisfactory biometric chip or ID. These passengers are warned to allow extensive periods for security checking.

Airports

Security of the Airport focuses on the following :

- Check-in
- On route to aircraft
- Airport infrastructure and campus
- Peripheral areas next to airports

Passengers are subject to a series of biometric checks to establish their identities and these are compared with any information held on the passenger databases. This can be undertaken remotely in an outer-portal restricted to passengers that is then sent via secure means to the inner-portal from where they depart within a short space of time. Passengers are separated at this point from non-passengers.

Passenger luggage (including hand luggage) is separated from them at check-in and goes though a series of remote checks. This sometimes involves a process where suspect luggage is constrained to detonate in a safe but contained environment. All luggage processes are automated with active tags assigned for easy identification and tampering detection. Luggage is boarded automatically in explosion proof containers. Reconciliation of passenger and hand baggage are again undertaken at the aircraft. Luggage by necessity needs to be of standard dimension and non-customisable (in design or material).

Air traffic control is undertaken from a virtual airport tower which may be located at a remote highly secure facility operated by National Authority staff who had also been through robust checks. Such a tower could well control a cluster of airports. Intrusion detection systems have been installed for the ATM locations, airfield and associated areas. Only companies and staff that have gone through company, regional, national and international checks, including criminal and health records carry out aircraft services. These service "airports" might increasingly be remote from passenger airports.

An inventory management system is in place to ensure no hazardous items are left airside, which if used directly or in combination with other materials could be combined to produce weapons. Ground movement of all vehicles is logged and analysed in real time to ensure no unauthorised vehicles go near the aircraft either as result of harmful intent or unintended approach due to weather re-direction. The airport external perimeter area is monitored to prevent attacks on the aircraft from ground-launched missiles.

Overarching intelligence data management system between airport, police forces and medical records allow airports to operate safely and securely.

In the airport peripheral areas surveys of risk are carried out to identify those locations from which aircraft can be attacked directly from public areas adjacent to the airport and its runway system. In extreme cases alternative measures have been considered including compulsory land purchase, re-routing taxiways and additional screening inside the airport perimeter. The objective has been to make it impossible to mount an attack on an aircraft directly from a public area by any conceivable terrorist weapon.

In managing passengers the airport also implements heightened security over its own employees and those of airlines, suppliers and servicing agents. Airport employees are separated from passengers in all but essential duties. The objective is, as far as practicable, to confine staff members to their essential duty stations, to limit mixing between staff and passengers, to vet staff members and to limit access only to approved members of staff.

The airport security management system co-ordinates all the necessary components safely and securely.

Aircraft

Security of the Air Vehicle focuses on the following:

- The design and implementation of new types of flight deck and cabin allowing the neutralisation of terrorists including the utilisation of non lethal devices, preserving passengers' lives whilst immobilising terrorists.
- The design and implementation of a secured cockpit with biometric controls preventing control by unauthorised pilots or other staff, detecting abnormal attitude and able to engage an automatic pilot to fly safely to a designated airport.
- Installing on board video monitoring system with identification capabilities, able to detect hazardous attitudes (anxiety, feverishness, nervous stress etc) among travellers or staff.
- Protecting the aircraft against electromagnetic threats and prevention of unauthorised access or interference with the infrastructure

SECTION 3

for navigation, communication or data links. The system also assures continuous transmission of a transponder signal.

- Systems that automatically detect deviations from the authorised flight plan, exclude access to restricted airspace and prevent impact with fixed obstacles and sites as well as collision with other aircraft. These automatically return the aircraft safely to the ground at a designated airport.
- Protecting aircraft against short-range missile attacks. This includes changes to engines to mix hot exhaust with cool by-pass flows to reduce heat signatures as well as fitting detection and jamming facilities to the aircraft.
- Defining and implementing security clearances for all crewmembers with a definition of the classified information set, as well as procedures to control identification and access of all personnel to the flight deck.
- All stakeholders (airlines, manufacturing industry, unions, and Governmental bodies) have redesigned their security processes to allow the possible implementation of additional defensive capabilities to address newly-identified threats, and provide security training to all crewmembers.

Air Traffic Management

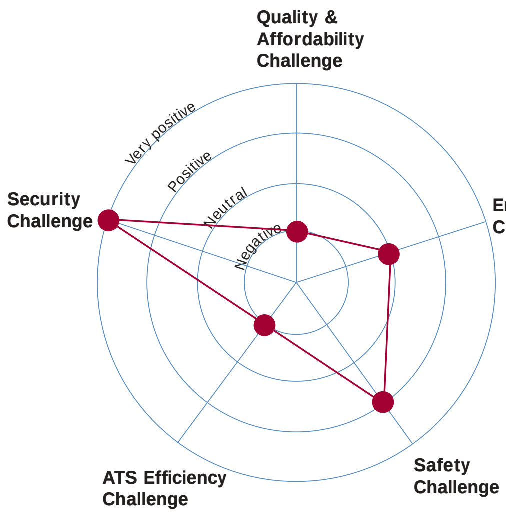
The Airspace is designed to channel air traffic in “secured areas”. These zones are secured from ground attacks, and are sufficiently isolated from “sensitive” zones, such as major cities or power plants. A ground surveillance system enables aircraft-independent surveillance, and detects any infringement of airspace boundaries.

The basis for the ultra secure ATM is a filed 4D trajectory “contract” between the aircraft operator and the ATM infrastructure. This 4D contract is updated between the ground system and the cockpit according to changes in the situation of the flight. Sometimes the 4D information is not sufficiently precise, at least in some portions of the airspace, to ensure completely de-conflicted trajectories. It is therefore be complemented by manual, ‘conventional’ ATM functions, possibly delegated to the cockpit, using Airborne Separation Assurance capabilities.

The integrated (air / ground) 4D trajectory management system is ultra secured, in order to prevent any intrusion in the definition and negotiation of trajectories.

Trajectories close to the airports are the most security sensitive, because of their proximity to cities and the ground. Secured trajectories are therefore defined and strictly respected by the aircraft. Any deviation from the defined trajectory is immediately detected, and given the ground proximity of the aircraft and the impossibility to launch interception actions, the ground system takes over the control of the aircraft in order to put it back on its planned trajectory.

Links to SRA-1 Challenges and Goals



Ultra Secure

Emphasises all aspects of providing a more secure system and is willing to trade off considerations of environment and efficiency.

Research Infrastructure

Delivering the new systems to enable parts of an Ultra Secure HLTC to be delivered will require a number of technologies. These will need to be validated in large scale systems as Technology Integration Platforms and will include:

- Manager of Aircraft Trajectory
- The Vision Airport Tower
- Trajectory Protection & Recovery
- Secured Airport Demonstrator
- Cabin Mock-up Demonstrator
- Air Traffic Control Centre

Enablers

Certification and Qualification

In addition to traditional certification and qualification [C&Q] processes the Ultra Secure HLTC will require a better understanding of combined C&Q criteria as Air Vehicle, Air Traffic Management and Airport operate together to produce a secure environment. Additional and better International standards will be needed to make the whole air system coherent in operation.

Certification of integrated and / or massive database systems for security will present special challenges. The history of large data-bases, especially those having inputs from many sources of unproved reliability, is not conducive to ready acceptance that any new large database will be sufficiently secure for this purpose. The C&Q aspects of such central systems need to be researched in parallel with the development of the technology for the system. These arguments apply equally to those systems that integrate the operations of several agencies using data supplied by them all.

The certification of anti-missile systems will be a new area for most civil airlines and one that will stretch the regulatory authorities. The enabling technology will essentially be provided by military systems companies but the certification will remain with the civil authorities. This new relationship will require to be developed.

Simulation

New and extended Simulation and Crisis Management tools will be vital both to understand, explore and test situations by simulation.

Public Acceptance

The broader question of public acceptability of personal security IDs or implanted chips and national differences in their application will be a powerful regulator of progress in this area. The relative progress of national, regional and international agencies in seeking and getting agreement to implement such measures will apply far outside the ATS but will govern its progress.

Operational Liability

The management of the operational and liability issues that would follow from the ATM system taking command of an aircraft in flight need international policy, standards and regulatory support to be put in place.

Other key enablers are addressed in the Integration Section.

Towards the future – an assessment of long-term possibilities

Looking beyond 2020

Looking at the technologies needed to deliver the air transport system of 2020 has its own challenges but is also constrained. Many of the technologies are with us already, others will need to be developed in the short term if they are to be delivering benefits by 2020. On the whole, therefore, the technologies discussed in the other HLTC's are mainly evolutionary developments. But ACARE wants also to look further ahead, to the middle of the century and beyond. It wants to explore and pioneer the more radical, revolutionary and innovative combinations of technology that might have the power to cause a radical step change in air transport in answer to the long term challenges and design imperatives.

This section of the Agenda takes a deliberately long-range view of technologies and examines some of the possibilities whilst trying to avoid falling into the quicksand of predicting solutions so far ahead. Perhaps only some of the technologies listed here will have a major impact, but work on all of them needs to be kept going in the meantime to prepare and explore for the possibilities that they may offer.

Predicting any aspect of the future more than 50 years hence is fraught with dangers for the prophet. Historically such predictions have been wildly wrong, although some grains of truth may be found in them. Without predicting the future some of the factors that will condition it may, however, be set out. We can expect mobility and globalisation to grow, and electronics computers and the like to increase massively in power and reduce in size; for micro-machines to be made practical; for leisure to increase; for fossil fuels to be more difficult to raise and more expensive.

We can expect world population to rise further but perhaps to level off at about 10 billion people. Life expectancy will rise although it will remain very uneven.

The detail of how these and other factors will influence the world of air travel is unknown. However it is reasonable to assume that Air Traffic will continue to grow in the next decades well beyond the 3-fold factor predicted for the year 2020. We know from the past that unless we continue to work on new technologies and apply these in a new generation air transport system, the future will be poorer and our place in it more limited.

The technologies for change

Figure 6 sets out some of the key technologies for change and their possible relationships.

The change making technologies for the air vehicle might lie in the following:

Propulsion

Creating propulsive power from new forms of energy; Solar Power, Nuclear Energy, Hydrogen from the sea, Beamed Energy devices using laser or micro-wave and ground-powered energy forms. Each of these has their own links with other aspects of the air transport world and their own implications for ground equipment, production and the sustainability of the energy. The prize in this area is a sustainable, affordable, practical form of energy to complement fossil fuels which will likely still be used for several more decades.

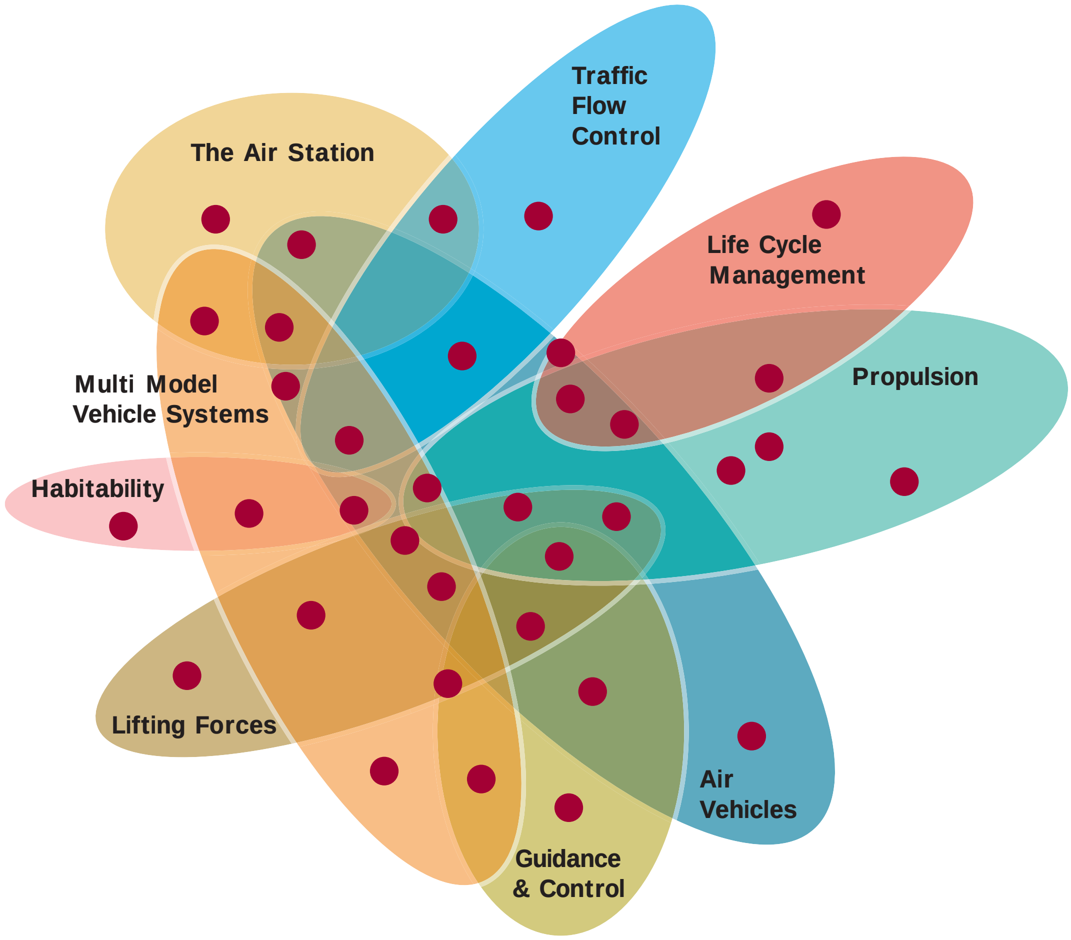


Figure 6: Schematic diagram showing the interplay of technologies and change areas

Lifting Forces

New technologies will not alter the laws of physics but new approaches may give new insights into ways of harnessing forces for lifting. Among these may be ways of morphing the aircraft structure into different shapes or aerodynamic forms under computer control. Thrust may be vectored to give directional or lift control. Plasma jets may replace the burnt fuel exhaust as the means of delivering thrust. Lift mechanisms may use alternative forces to fluid dynamics to derive the vehicle lift.

Guidance & Control

There may well be an approach to 'total automation' where on-board computers manage the whole flight, the lifting forces and speed of the air vehicle. The power of computers will be greatly enhanced and capable of centralised or dispersed operation. This will allow robotic technologies to be embodied in 'independent' robots for specific tasks. The location of aircraft control will be possible equally by ground operators and on-board crew. Pilot-free aircraft may be approved for certain roles.

Habitability

The environment of the air vehicle may be capable of being controlled in ways unfamiliar today. Technologies from the world of leisure and entertainment may contribute the means to create virtual environments at will and these virtual sensed environments may be common.

Life Cycle

The processes of design and manufacture will be increasingly automated with assembly increasingly featuring standard modules. The air vehicles of the future are likely to require very little or no maintenance of a routine kind and will have monitors of condition built into all the principal systems. At the end of their life they will be totally re-cycled or re-used.

The Air Transport System

Whilst there will be great changes to the air vehicle, possibly along the directions above, it is probable that new approaches to the air system will also be developing. The concept of an airport of the form established in the mid-20th Century may be challenged in the latter half of the 21st Century. Air-stations may be commonly located in the off-shore littoral zone around the shores of the world. The fundamentals of passengers and their baggage travelling together at all times may be reviewed and different modules may be used for assembling collections of passengers, baggage and freight. These modules may be handled by air-stations in quite different ways and interface differently with the air vehicles.

What is known as ‘general aviation’ may expand with the use of simple-to-fly personal air machines that are subject to a high level of automated control but use the air space above and around cities to expand the sphere of personal transport.

The air system will continue to address ways of aggregating passengers into different traffic flows and re-assembling them from flow to flow. The ways of doing this may be radically different and new approaches should be explored in simulations of new concepts.

The interface between the flight vehicle and the station may be subject to fundamental review. The concepts of docking rather than parking may enter the picture and this docking may be on the ground, on the sea or in the air to conduct the transfer of passengers or baggage / freight. The management of the docking operation will probably be automated and the docking position may feature means to move multi-modal elements from the flight vehicle to the station or to other vehicles.

Enabling the future

If the new technologies, and most importantly the new thinking and new solutions, that ACARE believes are both possible and necessary for the latter part of this century are to be realized they will need the support of new unconstrained thinking in the much shorter term. The following are some of the enabling activities that will be needed for its encouragement:

- The stimulation of creativity in the European university community running against the current trend of short-term technology application. Students should be encouraged to think of new solutions even where the technologies are not yet fully developed. Their results should be widely disseminated.
- A ‘technology watch’ mechanism to monitor progress in other sectors and to spot new technologies that, in combination with more familiar ones, will make for new solutions.
- Mechanisms that link creative thinking to the external world of air transport. This will require that potential solutions are realistically

capable of being introduced and have an identified benefit for air transport. The study of these technologies and their selective exploration is in the nature of an "incubator" of novel and radical ideas that have the potential to breakout from the traditions of the past.

- Creation of a European model of the USA's DARPA (Defense Advanced Research Project Agency) for aeronautics with the ability to seek new and radical solutions from any sector of business and with highly respected individuals to stimulate revolutionary ideas. These individuals should not be from established and traditional disciplines alone but should include a variety of experiences to challenge current thinking.

- Mechanisms to reward contributions from Industry should be introduced, certainly to grant some protection to their ideas but also to fund promising ideas to explore their potential.

Section 4

- An Air Transport System overview
- Institutional enablers of the agenda
- Resources and efficiency

An Air Transport System overview

Introduction

The purpose of this section is to draw attention to, and in some instances expand upon, those common issues of importance mentioned within the Agenda. For ease of readability they have been grouped into business, policy, process and technical issues.

Business issues

Across the HLTC's are references to the relationships between the major actors and threaded through these is the importance of the 'business models' that form them. However the technologies of the HLTCs are deployed, and however much institutional support materialises, the business relationship between the airlines and the airports will define the type of air transport system for the future. Their operators (who will increasingly be in the private sector) will adopt normal business approaches – seeking as much independence as possible whilst enjoying the fruits of collaboration only where necessary or desirable.

Specifically ACARE sees changes in the European system of slot assignment, ownership and management. Airports will need to address the needs of a wider set of airlines in a field where the number of airlines will be shrinking. Rules governing the ownership and operation of airlines will change to the benefit of some and the removal of protection for many. Airlines and airports will tend towards a set of niche markets that they serve with efficiency. The deregulation of airline and airport operations, and in some areas of ATC too, will be a major factor in prompting market forces to apply to all the players with great benefits to the consumer.

In considering the future of the EU ACARE has recalled that the air transport market is a global one. EU suppliers serve global customers for goods and services and part of the EU's economic benefit comes from this global view. In considering the growth of the market ACARE has, therefore, considered not only the growth in EU based traffic but also the worldwide picture. This growth in traffic will follow the growth in wealth creation not just population growth and the G7 countries seem likely to continue their importance for some time. Nevertheless new commercial powers will arise and will create a rapid growth in air travel – albeit from a lower base. At the same time other factors, the reduction of noise and pollution around airports will be centred on European considerations firstly but recognising that any technologies that are applicable in the EU will also be transportable to other areas where similar problems arise.

Policy issues

One of the frequent references in this Agenda is to the importance of runway capacity. It is facile to suggest that the response to this must be to build more since opposition to new airports will be severe – especially in Europe. Nor will extending their operating hours be acceptable unless there are major advances in noise control and in reducing the pollution that presently besets major airports. A combined approach will be needed in which every airport in a densely populated area is enabled to work to its capacity: by increasing the concurrent use of multiple runways, by extending hours of use, by increasing the efficiency of their use, by increasing the average size of aircraft, by limiting their use by small or lightly loaded aircraft, and taking major steps in the reduction of noise and pollution for those who live nearby. Nor is this only a problem for airports to solve. Airlines have a role to play in the aircraft they use and the way in which they manage them and train their crews. Local government agencies have a role to limit, and turn back, the approval of building up to the airport fence. Only by a case-by-case, combined stakeholder approach can some of the world's largest and most important airports be sustained and fully exploited.

It is clear today, and even clearer in considering the future, that the issues of getting people to the airport and transferring them to aircraft will only be improved by a system-wide consideration that encompasses the whole journey. This Agenda does not attempt that study but ACARE wishes to stress that the development of ground transport in harmony with airport development will be a vital factor. Crucial to the successful meeting of these areas will be inter-modal transfer arrangements – between train and aircraft, between aircraft and, between aircraft and car. The infrastructure implications for well developed and efficient inter-modal operations will depend upon stable policies being developed early in the planning and for these to be supported by the final design of the structures and processes. ACARE favours, as far as practicable, that the Class 1 Airports – the major hubs of the world – should be served solely by low emission high capacity trains contributing to a better environment around the airport. In smaller airports and those with less intense pressure from passenger numbers or from dense building near to the airport, mixed transport systems could be expected although planning ahead for growth will remain important.

The use and benefits of technology are clearly not only about the technical achievements of scientists and engineers. Some of the technologies and concepts of operation in this Agenda will also require a progressive level of public acceptance before they can be fully realised. The concept of un-manned freight or passenger aircraft and single pilot aircraft are, for example, less daunting technically than they are for presentation and for gaining and keeping public confidence. Part of the Agenda must therefore be to address, develop and manage these aspects alongside the technical developments. They must be explained, demonstrated and tested to the very high level that the public will require if the same public is to enjoy their benefits.

The Agenda assumes that part of increased security, whether in the Ultra Secure HLTC or as part of other futures will depend upon personal ID using modern technology. The technologies for this are available today although not in an integrated form. What is far from clear is whether the communities that these ideas serve are as prepared in their thinking as is the technology. More work is needed by people outside the aviation community to examine the preparedness of different cultural societies to adopt or to submit to biometric ID whether by personal chips or as documents. In developing the integrated form of new security measure the ACARE community needs to understand the pattern of preparedness of the travelling public and those who work in the aviation world.

It is clear to all participants in ACARE that the industries in the large community that serves the air transport system will benefit from a stable air transport policy. ACARE understands how difficult this is to achieve but continues to advocate work towards it. At the level of Member States ACARE believes that they appreciate the reality that places nations in competition with each other. The success of companies in the separate nations will be determined not only by their own efforts – although these will continue to be an important competitive measure – but will be heavily influenced by their national and, for the EU, by European policies. Those nations that have a clear position on the air transport future, and a clear view of where they want their aeronautic industries to succeed, have selected realistic areas to support in their industries and have earmarked the funds to do so will do relatively better than those with a laisse faire approach to these matters. It is not for ACARE to suggest the level of support that each nation should give but to highlight the importance to the outcome of governmental positions, whether national or EU.

Throughout the early period covered by this Agenda EASA will be in development. ACARE expects that EASA will find gaps in the systems of certification and in the readiness of the safety system to absorb the changes that this Agenda emphasises. It is recommended by ACARE that EASA should progressively take control of a broader span of safety related matters including EU-level facilities that have major roles to play such as the proposed Centre of Competence for safety research.

Process issues

The business of managing effective research consists of much more than the actual 'bench' work of looking at technologies. The primary need is for a sense of purpose expressed as a set of priorities of achievement or action agreed with the 'end users'. From these it will be possible to construct rational and focused programmes of work to deliver the results needed. The involvement of the relevant stakeholders in this is vital if the research results are to be applied.

In surveying the technologies that will or may be needed ACARE recognises that choice will be necessary. It has used the concepts of scenarios and HLTCs to inform those choices. In examining each technology area the Agenda sets out whether it is Base, Key, Pacing or Emerging[1] and this combined with the time based assessment of their need gives a very good basis for making these choices as well as guiding those actually constructing research programmes.

It is a foundation point for ACARE that this Agenda should be advisory and informative. ACARE understands that the Agenda will not be delivered by means of the prescriptions of a single programme. In reality the Agenda will make its contribution by influencing the formation of many different research programmes. Whilst ACARE may hope that the totality of these programmes covers neither more nor less than the Agenda this is unlikely to be the case without frequent review and monitoring. Already a number of agencies are using the Agenda to guide their work programmes and more will, no doubt, follow suit. But since individual agencies cannot take an integrated view ACARE expects that such a view needs to be taken to avoid holes or duplication in implementing the Agenda and the need for any adjustments to be brought to the attention of the governments, institutions and firms within the EU. This monitoring will be a matter of continuing attention in parallel with the focused work of developing the new technologies.

Technology issues

It is unfair, however, to portray most of the issues as ones of presentation. There are also serious, challenging and intractable technical and managerial issues mentioned. First among these is the implied dependence of the ATS upon critically important and large integrated ICT systems – for example for passenger security, for ATM and for airport tracking systems.

The importance of large ICT systems is well recognised – in the US it has been summed up neatly as: "Technologies for gathering, storing, processing, displaying, using, communicating, and managing information – sensory, temporal, geographic, environmental, situational, status – are becoming pervasive and are revolutionizing transportation. All facets of transportation – vehicles and infrastructure – are incorporating

1) See Volume 2 introduction for technology classifaction definitions.

information technology in their design, development, operations and use, not only making individual modes more efficient but also improving the efficiency of the system as a whole."

Experience to date in the development of these has been frequently disappointing. It is not appropriate to discuss here the reasons for these failures to deliver expected results. It is, however, a point of some importance that if the ATS is to depend on them then simultaneous development of the processes of creating them needs to go on in the ICT community. It is also the case that the ATS will actually need to consist of several 'systems' running in parallel and this needs to be taken into account at all times. This arises from two factors, backwards compatibility with existing systems to cater for the extended timescales of introduction and the need for flexibility to deal with a huge variety of abnormal situations.

The technologies for the ICT systems that need to be integrated together to make the system work must also cater for varying levels of progress around the nations; different sources of data (i.e. individuals, agencies, governments); varying levels of data protection laws; as well as establishing clear liabilities for mis-use of the information, corrupting the information and areas of permission to use the information for the purposes of the air transport system. These will represent considerable challenges and will need large validation projects to secure them. A list of possible Technology Integration Platforms is given in figure 7.

The variation over major players across the ATS is enormous. The span of airlines, airports, aircraft, and passengers are all massive in scale. The difference between a Euro-centric view of an experienced, biometrically chipped passenger waiting at a modern airport for a modern airliner run by a modern airline is at one extreme. Vastly different is a first time traveller in the developing world with no knowledge of biometric checking waiting at a regional airport to board a regional aircraft bound for a connecting international flight. Our vision of the ATS of the future must cope with all kinds of variability in progress. There will also be various kinds of 'abnormal' situations. These can vary from a suddenly defective engine, to a passenger taken ill, to an outbreak of food poisoning at an airport. These and many other variations from the normal will tax the management systems that control the ATS. The ability of the systems to absorb abnormal situations will be best achieved if they can be anticipated in the systems' development. To facilitate this a number of airport studies aimed at system optimisation are proposed.

The issue of Personal Transport Systems – personal air-vehicles – in the ATS is not exhaustively dealt with here. ACARE does not judge them to be a major traffic controlling factor for Europe within the 2020 timeframe. It is acknowledged however that within the European supply chain there are a number of companies in the old and also new Member States which create significant value for Europe from this segment. ACARE expects them to continue to have an important role in providing the necessary products to parts of the USA or other wealthy, spacious and economically advanced countries. Personal air vehicles do not, however, represent a major opportunity or threat to the European ATS concepts outlined here. The potential issues of dealing with them in great numbers is not therefore addressed in any detail.

ACARE also recognises that the development of, and preparation for new technologies is itself only a part of the process of developing the air transport system. The installations, aircraft and systems to be purchased will cost far more than the development of the technologies. No estimates of the delivery cost are made in this Agenda although ACARE is conscious that the value of its work is, in the final analysis, only made good by the delivery of new capabilities and products from which flow the economic and social benefits. These costs should be anticipated and it should, in ACARE's view, be a matter for regional and international forward planning to anticipate some of these changes and to plan how the funds for their purchase, whether nationally or regionally, should be provided.

An aspect of technological cost that has often been identified, and too often ignored, is the **provision of the essential demonstration and validation systems.** As the air transport system moves to larger and more integrated systems these will require to be supported by large-scale Technology Integration Platforms. These are identified in this Agenda and summarised in figure 7. Their provision is essential if the resultant systems are to provide reliable and robust systems for the longer term. Their cost is a significant part of the research programme. Some of these systems will be focused on societal and regulatory areas such as environmental control, safety, security and the like where changes to the regulations applying will imply major changes in investment patterns across the airline and airport industry, and changes to design briefs in the aircraft industry. These issues therefore need to be considered very carefully and ACARE submits that they need to be tested out in large-scale representations of the air transport system if all their ramifications are to be explored before decisions on introduction are made.

Technology programmes alone however do not change anything. At best they make possible changes that people have been waiting to make or create new opportunities for creative minds to offer new solutions. The issues facing the ATS are as much concerned with identifying the problems, and selecting the most urgent of these as they are with solving technical issues. An important product of this Agenda will be to use it to test the nature of the problems and solutions outlined and to assemble the priorities of those who will deliver, fund or benefit from them.

Figure 8 provides one indication of the spread of engagement in technologies across the HLTCs. It gives a sense of the likely intensity of effort needed in individual technology areas and thus some idea of the relative resources needed. What it cannot show, in this form anyway, is the inter-locking nature of systems development or the relative difficulty of the separate technologies. The Agenda's realisation depends upon systems being advanced and this will require the work on many individual technologies to be linked. Doing this requires a strong community of engineers and researchers having multiple skills and able to integrate the work of different specialists.

- The Visual Cockpit
- Atmospheric Hazards Prevention
- Manager of Aircraft Trajectory
- Enhanced Navigation, Guidance & Control System for A/C Trajectory Protection and Recovery
- The Vision Airport Tower
- Human centred Analysis and Demonstration for Integrated Air Transport
- Integrated platform for system Development
- Safety analysis & Certification
- Secured Airport Demonstrators
- Knowledge Management System for Human Factors Integration
- En-route Approach
- Airport Approach and TMA
- Airport Terminal – landside and airside
- Aircraft in the Managed Airspace
- The Environmentally Friendly Aircraft
- Environmentally friendly Rotorcraft
- Trajectory Protection & Recovery
- Cabin Mock-up Demonstrator
- Air Traffic Control Centre
- Autonomous flight operations (single / no pilot)
- Large scale ATC tracking for autonomous operations
- Networked flight or mission simulators
- Generic ground environment test and training facilities

Figure 7: Example of Technology Integration Platforms (TIPs)

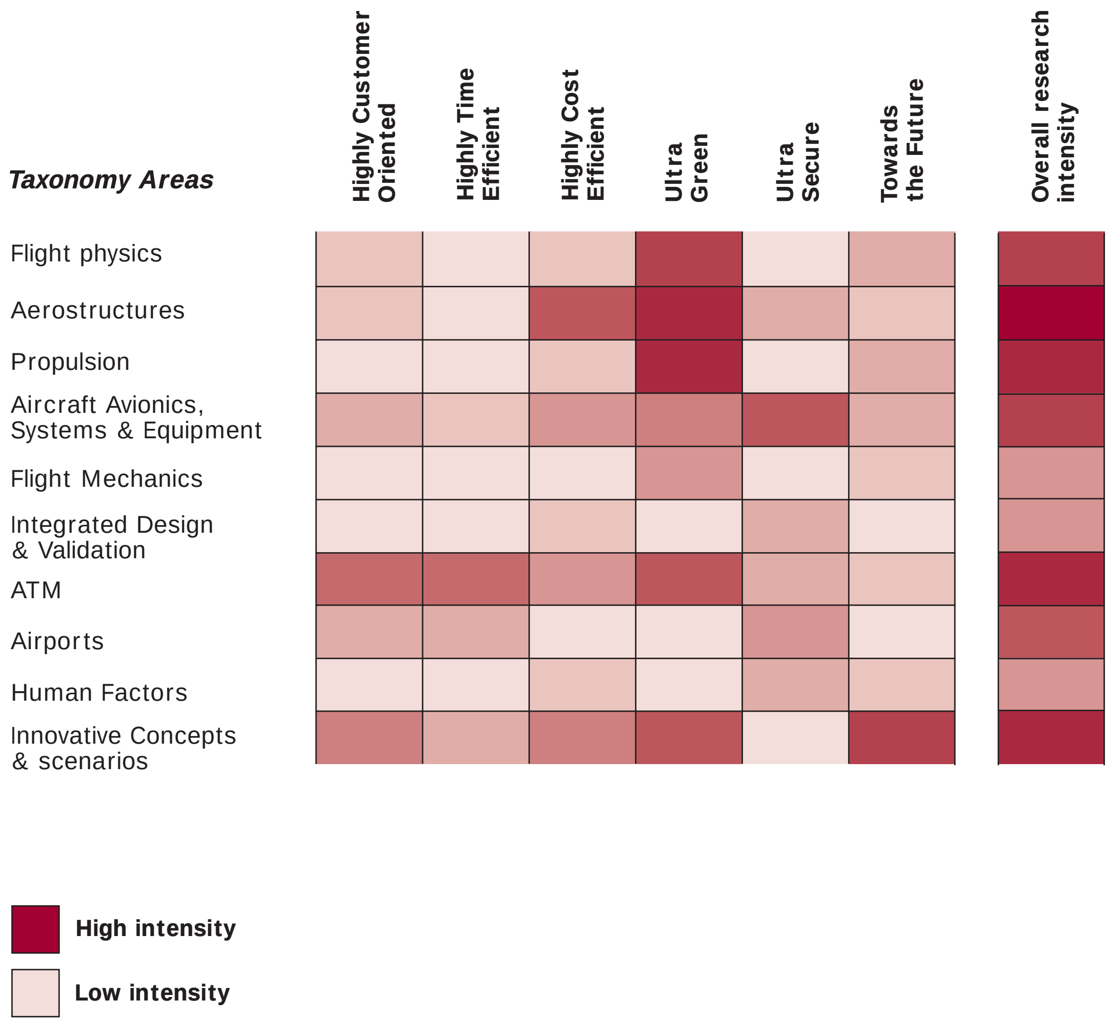


Figure 8: Table of indicative research intensity by technology area and HLTC

Institutional enablers of the agenda

Introduction

A key pre-requisite for the prosperous development of Aeronautics in Europe is an appropriate education system providing the necessary qualified workforce. This workforce needs a research infrastructure with leading edge test and research facilities, adequate RTD support mechanisms, certification and qualification procedures respecting society's requirements and the progress in technologies as well as an optimised technology and production supply chain.

In the first issue of the Strategic Research Agenda, ACARE identified that to support the research intention and enable it to function a number of actions would be needed by the institutions of Europe including their governments. This section of the second issue updates and expands on a number of these that have been selected for special study in the interval.

The research infrastructure

Within the ACARE process it was agreed from the outset that a world-class and efficient research infrastructure is a strategic enabling mechanism to meet the SRA top level objectives. This should include research capabilities at Universities, at Research Establishments and in industry coupled with shared arrangements for large scale simulation and validation facilities, research facilities for structural, aerodynamic and engine testing and also for high performance computing and flying test-beds as well as other large scale validation infrastructure.

These facilities are often found in those countries that already have significant aerospace industries, both civil and military, some of which are in the new Member states. Most of these facilities were established against the national needs of the day. The few exceptions include the German-Dutch Wind Tunnel (DNW-LLF) and the European Transonic Wind Tunnel (ETW), where international co-operation has been a leading principle from the outset.

Europe is left with over-capacity in certain fields and under-capacity in others. Whilst some progress on consolidation has been made, further work is needed. This further consolidation should lead to the creation of a network of research centres to make more efficient and effective use of limited resources. A similar process has started in industrial research centres.

ACARE sees the need to address this issue by forming a cross-stakeholder group that should take the requirements outlined in this Agenda and consider what facilities are needed and which are already available.

These facilities are likely to fall into three main categories:

- **Strategic Facilities:** Existing facilities that give competitive advantage to the European civil aircraft industry and which need to be ring fenced to ensure their long term survival. Whilst operating these facilities on a commercial basis, there will be no guarantee that a financially self-supporting operation based on a full workload can be achieved and European funding should be used to avoid closures and bridging these gaps.

- **Common Facilities:** Each of these facilities will differ in respect of specifications and ability. Creating a European list of preferred facilities would allow these to be favoured for new investment / upgrading by the cross-stakeholder group. Use of these facilities would be subject to incentives (such as a European voucher system) that offered encouragement to users in preference to other facilities.

- **New Facilities:** The cross stakeholder group would also determine which new facilities would be needed. Innovative Public-Private-Partnerships (PPP) should be established for these facilities to ensure that each stakeholder has a financial incentive to use the facility which would be designed on the "fit for purpose" principle and taking a prudent view of the need for additional features.

Certification and qualification

Aviation is necessarily a regulated system. Safety demands that products on which many lives depend are designed and made to exacting standards and deliver predictable and reliable performance. Certification and qualification are among the means used to ensure this. As systems become more complex and technology is able to provide new solutions the needs of safety and security remain vital and the idea of re-producing these across the separate states of Europe progressively less sustainable.

New approaches to certification and qualification will be required that enable advances in technology and design to be deployed in a safe, timely and cost-effective manner into products that will lead to the changed experience of travellers, customers and citizens.

Within Europe the European Aviation Safety Agency (EASA) is now established, although its scope is currently limited. Allowing for the increased scope already outlined in the EASA documents, there are likely to be new certification needs identified as we move towards certifying the 'systems of systems' that will become even more evident, as we move towards the implementation of the Single European Sky.

These 'systems of systems', as the HLTCs have highlighted, arise from the need to see air transport as an integrated whole. While some subsystems have sophisticated regulation (often based on extensive data analysis) in others regulations and oversight is lacking, most notably in the interfaces between subsystems. Safety will become a more critical factor, as we reach out for the SRA goal of 80% reduction in accident rates by 2020 relative to 2000[2], a stronger and more technological European approach towards safety and regulation must be taken. It is proposed that two separate actions are taken:

- Harmonisation, co-operation and co-ordination between national authorities in specific areas like safety through the use of dedicated mechanisms, building on the ERA-Net concept. The purpose of such a mechanism would be to establish, within the framework of the SRA, a European safety and certification roadmap.

- Setting up a virtual European Safety Centre of Competence. Although several public and private organisations in Europe perform research aimed at supporting safety and regulation in Member States a European Centre of Competence would combine these capabilities and create a critical mass. In this way, Europe would benefit from the same capability that exists in the USA (FAA laboratory, NASA

2) Similar, but even more challenging than FAA's goal of 80% reduction by 2007 compared to 1996 and Universities). The Centre should work along a commonly agreed research agenda. Relevant stakeholders (Member States, EASA, JAA, EUROCONTROL, EREA, Universities as well as the manufacturing industry, pilot / controller organisations, airlines and airports) should participate in supervisory and advisory bodies of the Centre of Competence and ultimately co-ordinate the supporting research activities in the public domain.

The purpose of the European initiative would be two-fold: to ensure that safety regulation exists for air transport as an integrated system of systems, and to ensure that simplified regulation encourages rather than hinders the development and implementation of new technologies and changes in the system. Traditionally, regulatory requirements are one step behind – or at best just in pace with – developments in the air transport system and industry. The current initiative should ensure that the development of new regulation goes hand in hand through interaction with the developments in air transport. The start-up of the European Safety Centre should be supported through European funding, whilst the follow-on should be supported by EASA. This will create momentum and enable Europe to become a leader rather than follower in regulation and its safety research.

Education

Education has to follow society's changes and needs. It is at one and the same time a self-organising process with many independent participants, an essentially national process, and multi-sector in its influence. It serves the interests of the national and European community and those of the many individuals who must pass through it. So the ACARE interest in education must be partisan and selective. Partisan because ACARE's interest is in the future of aeronautics and selective firstly because it cannot influence individual national education policies but might influence European or collaborative initiatives and, secondly, because some aspects are more important to aviation than others.

For the world of aeronautics, as for every other sector, Europe needs a sustained flow of competent, trained and motivated employees if the future vision is to be realised. There is a perception that not enough graduates are entering the aeronautic technology supply chain. The reasons for this need to be understood.

ACARE launched an exhaustive 8 month "education study", canvassing opinion from both the demand side (employers) and supply side (universities). The following bullets outline the main conclusions:

- A solid education in both fundamental and aeronautical engineering core disciplines is indispensable.
- Aerospace remains a challenging sector and must ensure that the increasing demand for specialists in aerospace engineering can be met – especially as there is a general trend that fewer under-graduates are choosing an education in Science and Technology.
- Most entering and graduating are male with a decreasing number of these being recruited by the technology supply chain.
- There is generally a strong alignment between the curriculum offered by Universities and aerospace employers needs.

Mechanisms to improve the situation

Improving university curricula

Whilst the alignment of the curricula and employers need is strong it is felt that it would be benefit from greater emphasis on maintenance, repair and overhaul (MRO) as a consequence of ageing airline fleets. In addition employers increasingly see focussing on 'soft skills' within the curriculum as contributing essential factors that differentiate graduates. Basic knowledge is taken as a pre-requisite. In summary therefore the sector will increasingly demand more multi-disciplined people that are solution (result) oriented, well acquainted with IT-technologies, possess excellent communication skills and are experienced in multicultural team working.

Universities should also be encouraged to keep their basic research programmes in balance with the amount of contract research that they undertake. Too much of the latter will be at the expense of the former.

Improving the mobility of graduates

Whilst the sector's needs are part of a larger debate the sector is taking steps to facilitate the movement of employees across Europe by accrediting the quality of degree awarded. Numerous initiatives, like those within PEGASUS and the European Credit Transfer System (ECTS) have been adopted to compare education standards in different places. A European education accreditation system with legal status still appears a long way off. ACARE meanwhile recommends a voluntary accreditation system for aeronautical education recognising the diversity of the national education systems. The specific criteria for such a voluntary accreditation could be developed in co-operation between universities and aeronautical societies and organisations (CEAS members, ASD, EREA, PEGASUS, EASN, etc.).

Improved co-operation and co-ordination of long term innovative research

Improvements should be channelled first and foremost into the establishment of an organisation that would bring together expert groups from academia and research organisations, building on the European Area Science Network (EASN) initiative, to co-ordinate long-term research plans. Such an organisation should be supported through the creation of an Association for Universities similar to EREA (REs) and ASD (Industry) and the set-up of Centres of Excellence in selected technology domains aligned to the ACARE taxonomy. Long-term innovative research in these areas should then be adequately funded. On top of the National funding, which itself needs to be better co-ordinated, European funds should be brought to bear to support an adequately innovative research programme. Where European funds are involved they should only be released after going through a tailored evaluation process and then should fully support (to 100%) the research work to be undertaken.

Improving young people's perception of aeronautics and air transport

ACARE's principal recommendation is to attract more people into Science & Technology and consequently aeronautics, by offering challenging and rewarding career opportunities. Such opportunities should feature in primary school education and continue through to university education by utilising school-labs, EUROAVIA, Akaflieg and other such organisations. Furthermore research should become a challenging item in TV by, for example, the creation of interesting documentaries. Air shows should be used to advertise the benefits of an aeronautical education whilst awards for excellence in education should be created and be given adequate press coverage. All relevant communication channels should be used to improve the image of an aeronautical career by displaying the advantages in professional life.

Stimulating the improved relationship and interaction between the market and education

As a first step this could be achieved by providing multicultural team experience during the post initial study period, for example through design team exercises at universities. One possible solution could be to extend the 'ECATA' programmes or set up a "European academy" as a joint partnership between the employers and education establishments to give students design experience and stimulate creativity as a team process.

Additionally steps should be taken to create a permanent platform where university representatives (e.g. PEGASUS and a representation of universities not involved in PEGASUS but part of EASN) and the demand side (e.g. ASD, EREA) should meet at regular intervals to exchange views on the requested developments of the curricula at universities. In particular this body would act to inform the universities of the changing needs of the industry. Public seed funding for the initiative would be a key enabler.

Supply chains

The business of aeronautics occupies not only the small number of very large companies that are household names but tens of thousands of smaller, specialist companies. These may also have other markets but their expertise is vital to the whole. Two approaches are necessary: firstly to map and make more visible these areas of expertise and secondly to create processes for their improved co-ordination. These aspects are dealt with respectively in this section and the next.

First we should state whether any of the measures proposed in SRA-1 have progressed... and they have.

- A network of Aeronautical national contact points, across the entire enlarged Union, is now working and has been central to data capture for the baseline study.
- There is a web portal[3] where SMEs can showcase their capabilities and prime contractors can engage with them to collaborate on a particular project. Success is proven by the increase of the SME participation in the aeronautics research of the EU Framework Programmes leading nearly to a doubling between FP5 and FP6. This is now being expanded to other elements of the supply chain. Such expansion will be much easier and more effective if it becomes the sole aeronautics database for Europe.
- ACARE launched an exhaustive 7 month "Base Line study" involving 18 countries

Main findings of this Base Line study are

Location of research capabilities: The high concentration of both the industry and the research capability in the same small number of countries is confirmed. There is, however, a large and diverse capability spread throughout the Member States (now "visible" as a result of this study). These are often in small, specialised organisations, and as in larger organisations, increasingly focussed on new and emerging research disciplines such as Human Factors, Airport and Air Traffic Management.

Public RTD Funding: Aeronautics is not spread evenly throughout the EU and neither is its funding. 9 out of the 18 states surveyed have a publicly funded aeronautics programme and in 6 of these civil aeronautics is an explicit priority. The EU's Framework programmes are seen as essential to support national programmes and regional aspirations and vice versa.

3) *www.aerosme.com*

In summary, this report, found:

- National and EU support in research is mandatory and will continue to be in the future.
- That large companies have a clear role as integrators at the top of the supply chain. They are coming under increasing pressure to purchase from global suppliers.
- Only the most competitive of smaller companies can hope to move up the supply chain. The companies that will do best are those with clear skills in specialist technologies and / or domains, especially, if these are leveraged by industrial alliances and globally competitive business processes.
- Gaining economic benefit from research is not easy and needs to be combined with other factors. Firstly the interests of national enterprises will always be helped if their national government has a clear support strategy and accompanying policies, especially at the research level, and funds these appropriately. Secondly national companies will benefit from encouragement and assistance to share down-stream risks with customers.
- Throughout the supply chain, measures to increase the visibility, knowledge and confidence of primes and other upper-tier customers in supplier companies will be especially useful.

Trans-European synergy

A good basis for comparison of technologies (taxonomy) and programmes (SRA) has been created that is structuring public and private research programmes and facilitating comparison both within and between parties. The process, whereby stakeholders have adopted the SRA as the baseline for their own research and development programmes, should be strengthened. The aim is to have all stakeholders adopt this position so that all of the specific requirements of the SRA can be met.

All programmes will contain a combination of societal and competitiveness issues and self-interest will militate against nations and regions sharing those programme details that deal with issues of local competitive importance. Each company, research institution, region and Member State has such issues of self-interest and each must be in a position to further its own position by enhancing its local capability and related expertise. This may involve assisting suppliers reach a higher level in the value chain and supporting businesses entering into global aeronautical supply chains. It could include the development of specialised niche areas, clusters and strategic alliances between functional specialists across national / regional borders. This mixture of independence and alliances may allow continuing duplication. Some duplication can be fruitful, necessary and appropriate in fostering improved performance and innovation through Intra-European competition.

However, at a European scale both money and numbers of researchers are limited and if we are to achieve more of our goals we need to balance self-interest with more co-ordinated planning. The macro objective is the appropriate and efficient use of scarce financial and human resources as well as bringing the most appropriate expertise to bear on a particular technology area. The best overall return on investment will come from a set of flexible and adaptive measures that allows both competition and collaboration to co-exist in a balanced and selected manner. Aside from conscious competition the unnecessary duplication of RTD effort must be avoided. One of the key measures open to Member States is to adopt the Strategic Research Agenda as the best available expression of the joint way forward and to encourage its use to inform national plans. This eventually requires reporting and monitoring.

These measures need to be both effective and transparent. There may be a need to improve current mechanisms or develop new ones to ensure that the intended level of co-operation happens and works effectively.

The industrial and research communities have a critical role to play, together with National public authorities, in clarifying where "protection" of supporting competing activities is needed and where an opening-up of funding programmes could be achieved. A dedicated mechanism building on the ERA-Net concept could provide the necessary discipline to deliver results of this kind in the near future. Such a mechanism could usefully start with identifying areas of common interest such as environment, safety and security.

A further mechanism, the **Observation Platform,** should be introduced to assess the rate and depth of the SRA implementation. It will guide and inform the co-ordination / construction of future programmes. Main actors need to identify any gaps and stimulate the appropriate funding mechanisms and ensure that the different R&TD activities are complementary. In parallel it is recommended that it should also perform a Technology Watch function; identifying those technologies used in other sectors which could be usefully adopted in the Agenda.

International collaboration

The Top-level objectives identified by European Aeronautics a Vision for 2020, are "Meeting Society's needs and winning global leadership". The SRA defines what Europe should do to create the technologies that will support these objectives. Whilst the term "Global leadership" reflects the reality of global competition this necessary competitive dimension by no means excludes co-operation in a market also determined by common influences. These common features are often regulated in common ways and by reference to commonly accessible technology that allows the needs of society to be met around the world.

The USA and Europe are the major forces in the market, although it is expected that the Pacific Rim countries, most notably China and Japan, will progressively become a force to be reckoned with in the mid- to long-term. In the short term it is therefore inevitable, and desirable, that consideration should be given to the relationship between Europe and America on these common issues seeking to realise those benefits that are possible from collaborative pressure on them. The challenge is, therefore, to accept the areas of independent, competitive action on technology with co-operative action in areas of common concern and common influence upon the global market and the world's communities.

Whilst Europe must look first to identify what must be done in Europe the essential character of the market is global and much of what is needed in Europe will be common to the world market.

These common issues can be split into two categories.

- Firstly, there is work that will be generally beneficial by improving customer service and confidence or increasing society acceptance. Typical examples include areas such as safety, security and the environment together with areas where it is necessary to have homogeneously inter-operable air transport systems where international standards are necessary e.g. in avionics and air traffic management. This could be termed **"Context Collaboration".**
- Secondly, collaboration may be fruitful at each level in the technology supply chain (i.e. from Universities through Research Establishments to Industry) who can see that their competitive market position may be improved by joining forces. This could be termed **"Commercial Collaboration".**

Collaboration cannot be imposed upon participants but creating plans and enabling mechanisms for

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context collaboration must be a development activity. These can be summarised as:

- Opening dialogue with the USA to establish a common perspective.
- Developing a tentative road map of beneficial collaborative areas with underpinning justifications and definitions of the scope of possible projects.
- Consulting within the aviation community in Europe about the areas where collaboration would most likely find willing participants.
- Establishing between the EU and national governments that any obstacles to fair and equal collaborative participation can be removed.

It seems unlikely that areas for **Commercial Collaboration** can be usefully defined. They will depend upon the views of participants and the arrangements that each can agree. The planning that would be useful is probably confined to establishing that the principles of fair and equal treatment across the Atlantic can be implemented.

Recommendations

General

Member States should designate the Air Transportation System and the relevant industry and research institutions as a distinct national priority and / or enabler for economic growth.

All stakeholders should adopt the SRA as basis for their individual programmes.

All stakeholders must ensure the appropriate and efficient use of scarce financial resources and that unnecessary duplications of RTD effort is avoided.

Each Member State should review how its own industry can be facilitated to develop to its full potential.

Research infrastructure

- Industry, Research Establishments and Academia should establish a cross stakeholder group to define Europe's research infrastructure requirements and preservation based on those laid down in the SRA. The group should (a) designate strategic facilities and support them; (b) designate preferred facilities and create incentives for their use (e.g. a European voucher system) and (c) identify the need for new facilities.
- Member States and the EC should establish co-ordination mechanisms (similar in concept to an ERA-Net) for the encouragement of collaboration between national authorities in specific public interest areas e.g. safety. Virtual Centres of Competence that are responsible for conducting the research should support them.
- The EU should continue the Framework Programmes as being essential to support the ambitions of the supply chain to develop. For future Framework Programmes, measures are recommended to continue and further develop the positive system of transparency and accessibility to ensure that the full benefit of the untapped potential is made available as necessary.
- Stakeholders should organise themselves, e.g. through a network of Centres of Excellence, to stimulate and co-ordinate innovative, targeted long term research (which should be fully funded). Universities should create an Association similar to EREA (Research Establishments) and ASD (Industry).

Education

- Industry, research institutions and academia should create a permanent forum for dialogue between the supply side (academia) and the demand side (the industry) to develop appropriate mixtures of curricula for European aeronautics education and assure quality and quantity of scientists and engineers.

- Academia should implement a voluntary system of accreditation in aeronautical disciplines to verify the quality of degrees awarded. To facilitate the mobility of employees across Europe, a Pan-European system of accreditation would be a natural extension.

Implementation

- EU and Member States should implement programmes that not only support research by national and regional industry but also other activities. These might include e.g. enterprises becoming risk sharing partners; the development of skills in new research areas such as human factors etc; the formation of strategic, industrial partnerships; and the development of modern business practice.

- The EC should organise regular workshops where bodies dealing with future air transport research, such as ACARE in Europe and Blue Ribbon in the US, are invited to share their views. As a first step this could be to compare and contrast strategies and perhaps thereafter to identify those common perspectives which could perhaps be tackled jointly.

- All Stakeholders should continue to use the Observation Platform of ACARE to monitor the progress being made in meeting the SRA goals. In parallel it is recommended that it should also perform a Technology Watch function; identifying those technologies used in other sectors which could be usefully adopted in the Agenda.

- All ACARE stakeholders, most notably National governments and the EC, should aim to establish co-ordination mechanisms, to improve synergies in the implementation of their respective research programmes, in particular in those areas where European added value is more evident.

Resources and efficiency

Whilst ACARE believes that more research is essential if the Top Level Objectives are to be realised and that this will need more funding to be deployed it is also sure that the efficiency of the research done also needs to be improved. This is the same message that was given in SRA-1.

Increasing the research output will require both financial and human capital to be increased and to obtain more output per unit of each than we do today. The financial capital can come from public and private sources but the human capital for aeronautics is a resource in competitive demand by many other sectors.

Increasing the efficiency of research

The first step in increasing efficiency is to establish an agreed and generally utilised SRA that will be used to construct research programmes. The implementation of this SRA will then need to be monitored to ensure that implementation progress in areas of common interest is properly co-ordinated.

Making research transparent will encourage the formation of both new collaborative research associations and access to the wide range of research programmes fitting under the umbrella of the Agenda.

Within this more collaborative context creating Centres of Excellence that allow more enterprises to benefit from the best research products of Europe in areas of common concern will be a further important step.

For those research facilities outside the Centres of Excellence it will be desirable to create incentives to use selected research facilities so that Europe can progress towards a non duplicative set of key and common research facilities in these areas.

More money

The estimate of the future funding required to meet the ambitious SRA goals represents a **65% increase on current expenditure** over and above inflation. This amount accords with the investment aims laid out at the Barcelona European Council and will need to be met by public and private sources in a ratio close to two thirds private and one third public.

Securing this level of investment is essential for Europe's competitiveness and productivity if it is going to continue to close, and ideally match, those of USA and Japan. On top of this industry will need to invest substantial amounts of capital to bring the products to market through expenditure on design, development and manufacture.

European FP's are having a catalytic effect and their budgets have increased over the last decade whilst national budgets have not. If the ambitious goals are to be reached this will need to be addressed. Given that today shows that private investment in Civil Aeronautics Research is broadly equivalent in the EU and in the USA but public investment in Europe is only a quarter of that in the USA ACARE expects the bigger challenge to come in the public sector and in particular from the Member States.

Air transport is, however, well positioned in the wider debate on resources. Air Transport is a strong component of Europe's intention to concentrate on high technology sectors embedding high levels of knowledge into products and services. Europe sees these as the vehicles for sustainable competitive advantage through a highly skilled workforce. Within this context the air transport sector is a key sector.

Policy support

More money and more efficiency will however, even together, not be enough to realise the objectives. It will also be essential to recognise with specific policies the importance of creating the correct environment. This must encourage and reward companies that undertake their research in Europe. It must persuade them to stay here through a range of policies that address matters from low corporation tax rates, R&D tax credits, export credit guarantee schemes, risk-sharing equity funds, and the level and quality of publicly funded research.

Finally the whole will depend, as ever, on people. The great opportunities and the great needs of the new century will demand educated and trained people who can bring both vision and competence to bear on these exciting challenges. It is clear that more human resources will be needed, ACARE considers that an additional 50,000 researchers will be required over the period in question. Whilst some of this increase can be met through Europe's education system, steps to reverse the trend of exporting Europe's research 'means of production', and then importing the output of their research, should be taken. Fostering a receptive research environment is fundamental to this reversal as it will also encourage "external" researchers to conduct their research in Europe.

Section 5

- Key findings of SRA-2

Key findings of SRA-2

Introduction

The Strategic Research Agenda is a process. This edition of the Agenda builds on and extends the work of the former, and first, edition. It is not surprising, therefore, that in this section of SRA-2 many of the key findings should be similar to those of SRA-1. The benefit of the 2 years interval has been to explore some of the issues in more depth and to recognise a wider set of opportunities and possibilities. So the Findings are also susceptible to amendment.

The findings

1. SRA-1 has been a success and this has contributed to SRA-2, not only in the confidence that ACARE has had in extending the scope but in the feedback that ACARE has had from SRA-1. SRA-1 has been adopted as **the** reference for a number of national and institutional bodies that have established their research programme using it as a guide e.g. FP6, French and German National Programmes, EUROCONTROL and an increasing number of industry stakeholders. This is helping with the transparency of programmes and with collaboration. As this process develops we expect to move on to using the Agenda to improve the efficiency of the research process and to highlight those activities that are most value-adding and also those which are duplicative for no good reason. The Agenda will give a strong, common background for this.

2. Wealth generator – Air transport is in itself a significant contributor to European wealth. The resultant benefit is spread across all Member States, either as a result of its direct contribution (2.6% GDP and 3 million jobs) or, even more importantly, as a consequence of its lubrication effect on all modern economies enabling our life-style and the way we do business. Its total contribution to the economy is estimated in excess of 10% of GDP.

3. The Agenda is more robust – This edition of the Agenda reflects alternative socio-economic scenarios and their associated technologies in the holistic approach advocated by ACARE and it is thus more robust than SRA-1. It also provides an indication as to the importance of each separate technology and the timescale of its importance. It presents important new planning aids to research programmers.

4. European research needs more money – re-analysis has shown that, taking an encompassing view of the research needed and the necessarily associated facilities and demonstrators, about 65% more funding is now required over the 20 year forward view than is presently being invested. Whilst this expenditure is not evenly paced there is clearly an urgent need to see a reversal in the trend to decreasing amounts of research funding assigned to air transport research at national level.

5. European research needs more people – The Industry may face a shortage of skilled young people in the future, partly due to demographics and partly due to the reduced attractiveness of the aerospace business as it may be perceived by young people. Future graduates will need additional skill sets most notably in multi-disciplinary approach, excellent communication skills, open mindedness and cultural awareness.

6. Research needs to be more efficient: The research funds used across Europe must be better co-ordinated with less duplication of work that has no justification for being conducted.

This could perhaps start with areas of common societal interest (safety, security, environment, ATM). Some examples of progress are already evident such as the joint action between EUROCONTROL and the EC.

7. Implementation monitoring: The Observation Platform is launched – it will provide a snapshot of current status, trend over time and together will guide and inform future research programmes and will facilitate better co-ordination.

8. Money alone is not enough: The creation and funding of research programmes will be to no avail unless European companies are encouraged to retain their European bases and to conduct their own research in Europe. In addition to the work outlined in the Agenda a number of policy actions are needed to ensure that the entire community involved in the aircraft and air transport sectors sustain a coherent and stable future. Part of this policy challenge is to ensure that the competition between major regions is recognised as a major factor in the development of industrial plans. Stability will be encouraged by equality of treatment both inside and outside of Europe.

9. Action is required by each Member State if the full contribution of their own industry is to be fully exploited.

Next steps

Many of the actions expressed in this Agenda need to be monitored and encouraged among the nations and the other stakeholders of the EU. ACARE will continue to act as the disseminator, proposer and general promoter of the Agenda as the standard point of reference for all aeronautically related research work across the Community. These actions for ACARE are almost self-evident in its role.

There is, however, a set of even more challenging actions that ACARE wishes to accept and to meet. ACARE perceives that important actions need to be addressed during the next 2-3 years in the following areas:

- Member States should designate the Air Transportation System and the relevant industry and research institutions as a distinct national priority and / or enabler for economic growth.
- Encouraging more debate, and research, about the impact of aviation on the atmosphere and to plan the environmental controls of the long-range future.
- Pressing the nations, the EU, airports, airlines and the ATM community to address the new business models that will be necessary in the future.
- Promoting more international debate about the long-term consequences for and of the aviation transport world.
- Facilitating links between the Member States and their collaboration on matters of aviation research within the framework of the Agenda.
- Proposing actions that will lead to the establishment of a European repository of aviation knowledge and act as a centre for new studies of the issues that are outlined in the Agenda.
- Integrating representatives from the new Member States into the framework of ACARE and together with them strengthening the Agenda with their new knowledge, experience and capabilities.
- Each Member State should review how its own industry can be facilitated to develop to its full potential.

Only with ACARE taking an active, unified role within the wider community can the benefits of the research programme outlined in this Agenda be brought to deliver the Top Level Objectives of Vision 2020.

Glossary

A/C	Aircraft
A/P	Airport
AA	Airport Approach
ACARE	Advisory Council for Aeronautics Research in Europe
ACAS	Airborne Collision Avoidance System
AMA	Aircraft in the Managed Airspace
AMP	Atmospheric Hazard Prevention
ANSP	Air Navigation Service Provider
APU	Auxiliary Power Unit
ASD	AeroSpace and Defence Industries Association of Europe
ASMGCS	Advanced Surface Movement Guidance and Control System
AT	Air Traffic
AT	Airport Terminal
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATM	Air Traffic Management
ATS	Air Transport System
C&Q	Certification and Qualification
CAA	Civil Aviation Authority
CAD	Cabin mock-up Demonstrator
CEAS	Confederation of European Aerospace Societies
CFD	Computational Fluid Dynamics
CFIT	Controlled Flight Into Terrain
CO_2	Carbon Dioxide
COE	Centre Of Excellence
DARPA	Defence Advanced Research Project Agency
DLR	Deutschen Zentrum für Luft- und Raumfahrt
DNW-LLF	German-Dutch Wind Tunnel
EASA	European Aviation Safety Agency
EASN	European Aeronautics Science Network
EC	European Commission
ECATA	European Consortium for Advanced Training in Aerospace
ECTS	European Credit Transfer System
EFA	Environmentally Friendly Aircraft
EFR	Environmentally Friendly Rotorcraft
EGPWS	Enhanced Ground Proximity Warning System
ERA	En-Route Approach
ERA	European Research Area
ERA-NET	European Research Area Network
EREA	European Research Establishments Association
ETW	European Transonic Wind Tunnel
FAA	Federal Aviation Administration
FMS	Flight Management System
FP5	Frame Work Programme 5 (1998 – 2002)

FP6	Frame Work Programme 6 (2002 – 2006)
GDP	Gross Domestic Product
H_2	Molecular Hydrogen
HCAD	Human Centered Analysis and Demonstration
HCE	Highly Cost Efficient
HCO	Highly Customer Oriented
HIDP	Highly Interactive Dynamic Planner
HTE	Highly Time Efficient
ICAO	International Civil Aviation Organization
ICT	Information and Communication Technologies
IFR	Instrument Flight Rules
IP	Integrated Program
JAA	Joint Aviation Authorities
KMSH	Knowledge Management System for Human Factors Integration
LNG	Liquid Natural Gas
MAT	Manager of Aircraft Trajectory
MRO	Maintenace Repair and Overhaul
NASA	National Aeronautics and Space Administration
NOx	Nitrous Oxides
PEGASUS	Partnership of a European Group of Aeronautics and Space UniversitieS
PHMS	Passenger Health Monitoring System
PPP	Public Private Partenrship
PSAC	Platform for Safety Analysis and Certification
R&D	Research and Development
R&T	Research and Technology
RE	Research Establishment
RF	Radio Frequency
RPK	Revenue Passenger Kilometer
RTD	Research and Technology Development
RTK	Revenue Tonne Kilometer
S&T	Science and Technology
SAD	Secured Airport Demonstrator
SARS	Severe Acute Respiratory Syndrome
SME	Small Medium Enterprise
SRA	Strategic Research Agenda
STREP	Specific Targeted Research Project
TCAS	Traffic Alert and Collision Avoidance System
TIP	Technology Integration Platform
TMA	Terminal Management Area
TPR	Trajectory Protection and Recovery
UG	Ultra Green
UHBR	Ultra High Bypass Ratio
US	Ultra Secure
VAT	Vision Airport Tower
VC	Visual Cockpit
VTOL	Vertical Take Off and Landing

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Manufacturing industry	Frieder Beyer Christian Mari Jerry Haller Terry Knibb François Quentin Mario Pellerei Raymond Pellichero Philip Ruffles Dieter Schmitt Jean-Marc Thomas	Liebherr-Aerospace Lindenberg GmbH SNECMA Smiths Aerospace BAE SYSTEMS THALES Agusta Westland S.p.A. SABCA Rolls-Royce plc AIRBUS S.A.S. EADS
Airlines	Jouko Malen Cees Gresnigt	AEA (Association of European Airlines) IATA (International Air Transport Association)
Airports	Philippe Joppart	ACI Europe
Regulators	Klaus Koplin	JAA (Joint Aviation Authorities)
EUROCONTROL	Jean-Marc Garot	EUROCONTROL
Academia	Billy Fredriksson	Linköping University