ACARE

2008 Addendum

to the

Strategic Research Agenda

Advisory Council for Aeronautics Research in Europe

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Foreword

Europe has a strong role on global air transport – a large, complex and highly technological system. This 2008 Addendum to the ACARE Strategic Research Agenda reinforces the importance of a coherent roadmap for aeronautical technology development, recognising the inherent need to periodically update some of its forecasts and assumptions.

The original ACARE aspirations are for better technology linked to social aspirations (cleaner environment, safer travel and more security) as well as the benefits of a more competitive Europe. These seem all the more prophetic today, just a few years from the previous Strategic Research Agenda in 2004 and at the same time so far away in terms of changed landscape. A few examples will prove the argument.

Two very large initiatives have been launched since the last SRA and are now on their way: "Clean Sky", an ambitious research project with demonstrators, that will improve the impact of aviation on the environment, and "SESAR", which will develop and deploy the future Air Traffic Management system at a pan European level taking stock of the most off the shelf technologies. A number of large demonstration programmes and a range of applied research programmes have been launched through the EU Framework programme and national programmes.

The international scientific community now clearly points to the need to urgently act to fight climate change. A consequence was the introduction of air transport in the European Union's Emission Trading Scheme, a fact surely not foreseen in 2004.

And who could have predicted the rise of oil price from $30 to over $100 per barrel and the implications for our industry? Not to mention the Euro-Dollar exchange rates and the associated risks for European competitiveness.

These facts seem to show us that the natural course of events pays little attention to our forecasts, no matter how careful they seemed to be when they were formulated. We need to accept this situation and review our plans from time to time.

This is what ACARE tried to do with the present 2008 Addendum, highlighting the changed circumstances and giving recommendations to steer the technology and institutional roadmaps back on track; because the conditions may change but our goals of a sustainable and efficient air transport remain the same.

The present document is significant also because it will serve as a stepping stone along the path to a new Vision of Air Transport stretching well beyond the 2020 horizon. It is a milestone in the roadmap which will culminate with a third edition of the Strategic Research Agenda.

This 2008 Addendum is the result of an open process based on consensus, where all stakeholders of the ACARE community provided their views. We would like to thank all the numerous contributors from different ACARE working groups for the time and attention they have devoted to this exercise.

François QUENTIN and Joachim SZODRUCH
ACARE co-Chairmen

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Introduction

The context in which aviation is operated is changing rapidly. This context embraces not only technical change and the development of economies and businesses but also the growing realisation that some important world resources are limited and our climate is changing in ways that must be mitigated.

It is four years since the last Strategic Research Agenda was published and it is timely to look at the nature of these changes and to determine what changes may be necessary to the priorities, pace or content of the SRA. The review was undertaken by the Strategic Review Group within ACARE.

This Addendum is intended to bridge the time between the last SRA and a full review of aviation, its direction and the technologies necessary to support it. This full review is presently expected in 2010.

Progress on the Agenda

Progress on the technical topics of the Agenda has been generally good but with less headway being possible on institutional topics the pace of which is limited by governments. Less funding has been available for research than had been considered necessary and some items have therefore been given a lower priority. About 200 projects have been launched from the European Commissions Framework Programmes in this field worth about 2 B€.

Two very large Joint Undertakings have been started since the last SRA: "Clean Sky" a project devoted to technologies that will improve the impact aviation has on the environment and "SESAR" the comprehensive change in European ATM.

Technical Issues

Three important areas have been identified for increased priority: The Environment, Alternative fuels and Security.

The Environment

Aviation is a component of environmental impact, albeit presently a small one. However, it is growing and it becomes urgent that the aviation community should address the challenge to a sustainable aviation system. The challenge is in two parts: both global climate change and local noise and air quality. Much the more important is addressing climate change although local conditions are meeting a declining level of tolerance around airports and this too is an urgent matter.

Three main factors arise in considering climate change: the scientific understanding, the funding and the technologies. The findings of the IPCC point very clearly to the need to do something but there are areas of detail where more understanding is needed. Increased funding is vital if the evolutionary and breakthrough technologies are to be developed. Technologies are at the heart of the matter and breakthroughs are required to approach a state where aviation can reduce its impact on the environment as fast as its growth rate is adding to it.

Local air and noise performance needs to address many of the same issues of CO_2, NO_X, and particulates, including noise. Public tolerance appears to be reducing and visibility of new targets for the future as well as an independent approach is therefore needed. Solutions must include ATM components as well as aircraft components.

Key Recommendations for the Environment

- **Global climate change** is the most serious environmental issue which needs to be considered globally with Europe pressing for common actions
- **More investment is needed** involving both public and private capital.
- The application of new **and advanced technologies** is required in the field of aircraft but also in the important area of ATM.

- The technical agenda should remain unchanged for incremental improvements and be **accelerated** towards breakthrough and contributing technologies whether these address reductions in CO_2, NO_x particles, contrails etc. on local or global levels.
- The **phenomena and data** relevant to aircraft emissions should be better understood and collected respectively.
- **New concepts for the long term** future should be encouraged by support to innovative research.

Alternative Fuels

The world's fossil reserves of oil are declining as consumption rises. Peak oil production may already have occurred. The adaptation of aviation to other fuels is not yet a necessity but its possibility is certainly now a matter of concern. Current fuels have high energy density and their systems have been refined to deal with their particular burning and ignition characteristics. Replacing these fuels will be cheaper and easier if the new fuels are "drop-in" rather than completely or partially novel in their characteristics of use. A number of drop-in fuels are potentially possible from coal, coal tar, or biomass etc. Alternative fuels might include liquid hydrogen, liquid methane, nuclear power etc.

The whole life environmental impact of fuel candidates in their production, refinement, storage and use needs to be studied carefully for every candidate drop-in or new fuel.

Key Alternative Fuel Recommendations

- **The technological option**s offered by different alternative fuels need to be studied in detail along with the related environmental ("well-to-wake") and economic aspects.
- **International co-operation** on these issues will probably be necessary.
- Two parallel **research efforts** are needed focusing (a) on drop-in alternatives to crude-based kerosene fuel, within current basic jet engine technologies and (b) on 'revolutionary' aircraft power systems.

The Security Challenge

Security threats have increased since the publication of the last Agenda. The impact of these threats has been the imposition of increased security measures at airports resulting in delays for passengers increasing and not decreasing as planned. Passengers see the responses to threats being applied piecemeal and often not corresponding to the current threat assessment. Whilst the systems in use have individually become more capable they are being integrated incoherently and unresponsively and this needs to change.

In airborne security the favoured approach is to work towards a system wherein the aircraft can be controlled from the ground in an emergency.

Key Security Challenge Recommendations

- The system by which security requirements are established should be reviewed with a closer look at the causes of **inconsistencies and changes** which rest mainly with regulatory and political networks.
- More capable, wider scope and l**ess intrusive systems** at the level of both deterrence and detection should be developed.
- **Variable** performance capabilities should be investigated to relate to a variable threat scenario.
- Security **research** will need to be focused towards a number of specific solutions at system-level.

Most of the topics above are already contained in the SRAs, which supports the robustness of the Agenda. However, what has changed is the increased emphasis on a more "**systemic view"** and the need for rapid variation in threat.

Institutional Issues

Business Models

New business models are constantly under consideration and this will not change. The technologies necessary to deliver a new business model and the market for that model must clearly go hand in hand if the resultant business is to prosper. Many new models will arise to exploit new technologies and these are in the hands of the business corporations that will make the new technologies serve a business end. However, it is also the case that technologies might be encouraged with greater knowledge of the business aims that are unfulfilled in their absence. External factors such as fluctuations in exchange rates effect business models and the technological solutions required. Business models are also much influenced by regulation changes. The Group concludes that ACARE should cultivate a greater engagement with the business and regulatory world to ensure that technological outlets in new business streams are being adequately factored into the technical research programme.

International Collaboration

There is a pressing need for international collaboration in the aviation community on issues of standardisation and alignment of processes, materials, fuels, procedures and protocols, climate and environmental impact and of regulation in these areas. The Group understands this as **strategic collaboration.** But Europe is not presently having the impact on these strategic international matters that it should. The Group recommends renewed engagement with these areas of international concern. For this to be effective it will be necessary that Europe equips itself better for the discussions and negotiations with prepared data and a strategic plan for their presentation before international fora.

Another sort of international collaboration is commodity or **commercial** collaboration. This is undertaken by companies for their own ends and has very little relevance to initiation by ACARE, or by national or European governments.

Key International Collaboration Recommendations

Strategic collaboration should enable the European air transport sector to benefit from the increasing worldwide demand for air transport, both in terms of providing services and in terms of developing and selling products. The prime issue for strategic collaboration is setting and applying **worldwide standards** for aviation and European industry must be as active as its American competitors in the standardisation arena.

Commodity cooperation must be initiated by the interests of the **parties concerned** in making the particular collaboration effective in their context. There will continue to be opportunities for collaboration in basic research but the balance of gain and loss should be carefully considered before embarking on such collaboration.

Infrastructure and Education

ACARE has been working hard to advance the causes of a more integrated and appropriate infrastructure. Numerous changes to establish harmonised education and training systems with voluntary accreditation systems with more Industry-Academia partnerships will all increase educational coherence, helping to ensure a supply of trained, adaptable and mobile people attuned to the needs of the future. The focus on maintaining and upgrading 'Key Facilities' should be continued. Some advances have been possible but in general progress has been slower than hoped because many of the changes being promoted require one or more governments to act in their support and this has not happened at nearly the rate that is required. ACARE is encouraged to renew its communication with national governments to press for action in these areas in the interests of a more effective and more cost-efficient research community.

Conclusions and Recommendations

Overall the Group found that the current Agenda is correct in its direction and content. Relatively few but important adjustments are now indicated. The dominating issue for aviation in the immediate future is reconciling the pressure for reduced climate change impact with the growth in aviation that brings enormous economic benefits. Further downstream we expect the aviation community to become involved in new challenges as the effects of climate change, reduced resources of oil water and land change the nature of the world. With some of these issues remaining to be drawn into the review expected in 2010 the Group's principal conclusions were:

- The present Agenda is endorsed in its essential direction and content.
- Adjustments and accelerations are recommended in the area of environmental technology development, action on alternative fuel, and on security systems.
- Revitalised action is indicated to encourage faster and effective progress on the supporting mechanisms that will make increased technological progress and effectiveness possible, economic and useful.
- A new effort is recommended for international collaboration that emphasises the European contribution to globally relevant solutions for aviation.
- ACARE should develop engagement with policymakers and industrial leaders as an essential part of its understanding of the contributions of the technologies that it supervises.
- The importance of the long-term is re-emphasised.

THE 2008 ADDENDUM

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Introduction

The world is in constant change and its rate of change has been accelerating. At the same time the exploration, development and exploitation of the complex systems of technology used in aviation take many years. This creates a tension that needs to be constantly monitored between the rate of change and the rate of progress to ensure that aims are still valid, that progress is still adequate, that targets are still relevant.

The main body of Vision 2020 and of the Strategic Research Agenda were developed in the years 2000-2004 and it is appropriate to revisit both documents and to carry out a review now to see whether areas of the Agenda need to be changed in direction, pace or content.

This awareness of change is also reflected in the USA where the US National Plan for Aeronautics R&D has been published. Whilst these two documents have been prepared in quite different ways the focus of their impact is unsurprisingly similar.

The life of this Addendum will be finite. It is a mid-term review against the intention that in 2010 there should be a thorough reconsideration of the challenges facing aviation and this will allow the preparation of a new Strategic Agenda in early 2012.

Even in this short span of years there has been significant change in the context in which aviation operates. One needs only to think of the international security consequences that followed the attack on New York in September 2001, the still continuing hostilities in Afghanistan and Iraq, the rise in awareness of the issues around global warming and the rate of change in the natural world that is resulting. Enlargement in Europe has brought more attention to the technologies in General Aviation. Long term prospects for autonomous air vehicles are continuing to emerge. Very recently we have seen the global financial downturn and do not yet know its implications. Furthermore the steep decline in strength of the $ against the € over the past two years has eroded the competitiveness of Europe in the global aeronautical market.

Looking to the slightly longer time frame new estimates of total fuel reserves show that we are living on declining natural assets with no truly sustainable solutions yet in sight. Alongside these grim projections the two potentially huge economies of China and India have got into their stride and are developing fast with attendant increases in their demands for power and water. Forecasts of the global requirements for food, water and power give little scope for optimistic or *laissez faire* attitudes.

Economic development produces demands for both freight and passengers. Despite 9/11 air travel continues to grow at about 5% annually, although this growth is not evenly distributed. The short term pressures for the delivery of a range of technological advances continue but with some changes to priorities that are addressed later. At the passenger level we note that real whole journey times are increasing rather than reducing under the pressures of growth, congestion and variable security needs. For the longer term a start has been made to identify radical new technologies and concepts that would enable transformational change to take place.

With these factors in mind the Group has reviewed the Strategic Research Agenda and proposes the amendments set out in this Addendum.

Many readers will be familiar with the content of SRA-1 and SRA-2 but for those without this awareness a short introduction to the background is included in the next section.

Progress on the Agenda

The Agenda describes a vast range of technologies that are to be developed; the technology map for the Agenda describes about 350 primary technologies. Taking their lead from this Agenda are the enormous investments being made by

Europe's aeronautic research teams; in industry, in R&D institutions and in academia. This investment, large though it may seem, is less than the Agenda considered necessary to achieve the High Level Objectives. It is natural to monitor progress on any major project and ACARE has a project (AGAPE) under the auspices of the European Commission that will rigorously and objectively examine progress in the research areas of the Agenda. This will be completed in good time before the preparation of the next overall vision statement and the subsequent Strategic Research Agenda.

Overall, the technical progress is good but with such a large programme is would be strange if everything were to be unchanged. In the five main challenge areas of Environment, Cost, Safety, Security, and Affordability we see two main forces influencing progress towards the objectives. Firstly, the investment resources being applied to aeronautic and Air Transport System (ATS) related research have not grown to the extent and at the rate that was advocated in SRA-1 and so some lower priority areas of work are therefore making less progress than planned. Secondly, we see that the relative emphasis being placed upon different topics is changing. Environmental protection, for example, has certainly moved up the priority list and this has the effect of moving other work down. Expectations and demands continue to adapt to world conditions. Those that are growing imply that harder targets should be set, or greater achievements made. This particularly applies to environmental matters including local noise where the levels of acceptability appear to be dropping over time. In contrast 2007 was a year of record achievement for aviation safety and there has, consequently, been rather little public debate about air safety although we believe that the objectives outlined by Vision 2020 are still relevant.

Despite these changes much has been achieved. The intermediate need for acceleration in the aviation community response to the environmental challenge has been firmly responded to by the large technological programme under the JTI[1] umbrella "Clean Sky". This is a large new and multi-faceted programme, wholly created since the last SRA, which is looking at ways to demonstrate and validate the technology breakthroughs that are necessary to make major steps towards the environmental goals. Such programmes, aimed at higher technology readiness, have an increasingly important role to play in shortening the time to market for new solutions tested on full scale demonstrations.

SESAR, the major EU-EUROCONTROL-sponsored programme for ATM research towards implementation of the Single European Sky concept, has now completed its definition phase and has produced an ATM Master Plan. This ATM Master Plan, whose execution will be overseen by the SESAR Joint Undertaking, defines the route to be taken to implementation of the SESAR Target Concept for the 2020 ATM system. The development phase of SESAR will progress through to 2016. The SESAR JU is responsible for all ATM-related RTD in EUROCONTROL and in EU Framework 7, including long term research and the TEN-T ATM funds and contributions of its members from industry.

In the research programmes some 150 new aeronautic research projects have been approved by the Commission for funding under Framework Programme 6 and nearly 40 more from the first Call for Proposals in Framework Programme 7. They will account for a total expenditure, by the Commission and Industry together of some € 2 Billion. Alongside these projects funded by the EU, there are a number of large and important research efforts under the control of individual firms and laboratories where the scale of investment and the details of the work being done are less accessible. There continue to be important links between military research and civil oriented aeronautic research. In many fields the scientific work is common to both. This gives the opportunity to make use of advances in one area in the other, and that process continues to deliver overall benefits to the civil aeronautics programme.

Progress has also been made in the area of the far future and it has been possible to complete a prototype project looking at some of the issues of the years after 2050. This "Out of the Box" project has examined 100 new and often radical possibilities from which it selected 6 to recommend for immediate consideration for incubator fund-

[1] Joint Technology Initiative

ing. The success of this project has also allowed a more comprehensive project to be prepared and funded for establishing a system for the support of innovation in aviation under the CREATE title within Framework 7.

Institutional Issues

In the area of policy, managerial, institutional, educational and other mechanisms that are necessary or desirable for the future of aviation the picture is less encouraging. SRA-1 and SRA-2 both emphasised the need for advances in these non-technical areas if the benefits of the technologies and opportunities being created are to find expression in new products and services that better meet European aspirations.

In the educational areas identified where new mechanisms are needed there has been disappointingly little progress in the last 5 years despite great efforts by ACARE to make progress. There is still a need for education in aviation related subjects to be more transferable around Europe, and this would contribute substantially to increasing the exploitation of Trans-European research synergies. Harmonised education, better and consistent accreditation schemes, more soft skills training, are all steps that have previously been identified and need to be taken forward. Research must remain connected to the upstream –education – and downstream - innovation - elements if researchers are to be attracted and effective.

In the infrastructures necessary for better research effectiveness there has also been disappointing progress. Improved supply chain mechanisms and improvements to certification and qualification processes are both aspects that need more progress. In addition the whole physical infrastructure of test beds, wind tunnels, and electromagnetic facilities still need to be rationalised and taken forward as new investment decisions present opportunities for equipping research with the competitive tools it needs. In both of these areas research education and research infrastructures better progress needs to be made and this will need the engagement of national governments to ease the obstacles to co-operation, accreditation, investment and the like.

THE SRA REVIEW

Review Process Employed

The Review was undertaken by the Strategic Review Group SRG a specially assembled, balanced and active (and well attended) group within ACARE and working to agreed Terms of Reference.

It identified the main areas where change has occurred in the context of the Air Transport System since the publication of SRA 2. In particular, it identified changes in the overall market demand and selected the priority areas identified in a following section.

Sub-Groups were chosen for each area, which produced 'straw-man' papers collecting a wide range of inputs.

A consultative workshop was held with over 70 expert attendees, who refined the output as a basis for the preparation of this SRA Addendum relevant to the Vision 2020, along with an action plan for ACARE intermediate-term activities.

Topic Areas selected for review

On the basis of the above deliberations, it was agreed that the Review should be arranged as follows:

Under Technical Issues
- Environmental Considerations
- Alternative Fuels
- Security

Under Institutional Issues
- Business Models
- International Collaboration
- Infrastructure
- Education

RECALLING THE STRATEGIC RESEARCH AGENDA

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ACARE and the Research Agenda

The ‘Group of Personalities’ from the Aeronautics Community was convened by Philippe Busquin (then European Commissioner for Research) to produce a vision for aeronautics in the year 2020. The aims were better to serve European society’s needs while remaining a global leader in the field of aeronautics.

In its January 2001 report “European Aeronautics: A Vision for 2020”, the GoP defined a broad and comprehensive vision for the European air transport industry in the global marketplace of 2020. Among its conclusions, the GoP stressed the need for a new Advisory Council for Aeronautics Research in Europe (ACARE) whose aim would be to develop and maintain a Strategic Research Agenda (SRA) for aeronautics in Europe.

Launched at the Paris Air Show in June 2001, ACARE comprises 39 members with clearly defined and agreed terms of reference, including representation from the Member States, the Commission and various stakeholders, including manufacturing industry, airlines, airports, service providers, regulators, the research establishments and academia.

ACARE’s main focus is to establish and carry forward a Strategic Research Agenda (SRA) for aeronautics research that will influence all European stakeholders in the planning of research programmes, particularly national and EU, in line with the Vision 2020 and the goals it identifies.

The scope of the Research Agenda was defined in 2002 to include

- All technologies necessary to secure continuous progress in aeronautics, air transport operations and air travel security.
- All aspects of the Air Transport System excluding non-flying activities of retail sales, leisure etc within a kerbside-to-kerbside boundary.

To this end ACARE seeks to

- Launch and approve the SRA and update it periodically;
- Make strategic and operational recommendations as well as commission studies for implementing the SRA and achieving the 2020 Vision;
- Evaluate the overall results and benefits of the SRA for Member States, the Commission and stakeholder groups;
- Recommend measures for optimising the use of existing research infrastructures and achieving cost-effective investments;
- Recommend measures for improving educational policies to attract the scientists, engineers and other skills that the sector needs;
- Develop and implement a communication strategy to promote awareness of the SRA (within the stakeholder community as well as to larger public audiences) and to disseminate information on stakeholders’ research programmes for facilitating consensus on priorities.

SRA 1 and SRA 2 – The Current Agenda

ACARE developed the first 20-year forward view for technical planning in Europe in the form of a Strategic Research Agenda for Aeronautics Research, which has been reviewed periodically.

SRA-1

The first edition of the Agenda, published in October 2002 focuses on five identified areas of research called “challenge areas”: Noise and Emissions, Quality and Affordability, Safety, Security and Air Transport System Efficiency. Improvement or breakthroughs in these areas are considered essential in order to meet the objectives of Vision 2020. Under each challenge area, a number of separate goals are identified, along with the technical and institutional enablers required achieve the Vision. SRA1 is perhaps best known for these goals, which are often quoted today.

SRA-2

The second edition, published in October 2004, further developed the first edition by:

- Taking a more comprehensive and holistic view of the air transport system, including the perspective of operators.
- Identifying areas of uncertainty, variance and choice by considering a range of possible future world scenarios.
- Integrating the further work done by all the stakeholders in building up their interpretations of the SRA.
- Taking a longer view beyond 2020.
- Bringing the work on institutional and infrastructure issues closer to the needs of the technologies that they need to support and deliver.
- Improving the presentation of the necessary technologies.

Scenarios

One of the key advances in the strategic perspective between SRA-1 and SRA-2 was the introduction of scenarios. These admitted the possibility that the world might not develop in a fixed direction (the baseline scenario) and that there might be other important outcomes.

The additional scenarios that were developed were:

- "Segmented Business Models" which postulate a strongly globalised and stable world showing high GDP growth.
- Constrained Air Traffic Growth" which described a scenario where concern for the environment might place constraints on energy use including that of aviation.
- "Bloc Building" – which described the possibility that a number of regional blocs might form as tension grow between the blocs and their trade develops internally.

These four are not predictions; they assess a range of possibilities but analyse the aviation consequences of each one. This was illuminating in respect of the different technology demands that each might place and allowed some assessment of the relative utility of technologies in the Agenda e.g. by assessing whether a technology would be equally needed whichever scenario occurs or whether it was specific to a particular outcome.

High Level Target Concepts

One of the development areas of SRA-2 was to establish the sensitivity of the Agenda to alternative views of the future. These future views are characterised by a set of factors (such as GDP growth, demographics, environment, security etc.) that can significantly affect the air transport system. This analysis and subsequent representation is through the use of High Level Target Concepts (HLTCs) that extend thinking to channels for organising focused work towards the SRA1 goals. Each of the five HLTCs takes a moderately extreme view in its own area, without regard to the other areas, in a process to create pools of technology that will be drawn upon according to the scenario that eventuates and the business needs of different parts of the ATS. The five different HLTC directions are: protecting the environment, saving time, improving security, increasing choice and reducing cost.

The technologies embraced by the HLTCs will all need to be developed but at speeds and intensities relevant to the developing world. In the SRA-2, ACARE also wanted to look further ahead, to the middle of the century and beyond to explore and pioneer more radical, revolutionary ideas that might have the power to cause a step change in air transport and a prototype study has been recently been completed.

Aside from the technical domain, ACARE also remarked that a number of actions would be needed by the institutions of Europe including their governments in order to support and exploit the long-term research plan. Key pre-requisites for an effective development of Aeronautics in Europe are, among others: an appropriate education system providing a qualified workforce, world-class test and research facilities, certification and qualification procedures respecting society's requirements as well as the technological progress and an optimised technology and production supply chain.

Vision 2020

Defining the technical challenges that must be overcome to meet the objectives

Quality & Affordability | **The Environment** | **Safety** | **Air Transport System Efficiency** | **Security**

The Challenges
Assessment of the challenges identifies what technical work has to be done

The Strategic Research Agenda

The agenda informs, guides and influences the research work that will be supported by the stakeholders

The Stakeholders

Airlines | Airports | European Commission | Other European Institutions | Regulators and ATM services | Research Institutions + Universities | Member States | Manufacturers

The Agenda is converted into research programmes by the stakeholders who will contribute funds, resources and capability to execute the research guided by the Strategic Research Agenda.

Research Programmes

The research programmes are executed, and technical solutions to the problems identified in the challenges and in the agenda are created as new capabilities for the supply chain to create products, systems and services.

Capabilities

The supply chain creates new products, systems and services for integration into products for a sustainable air transport system — these impact upon the system in a number of ways.

These impacts create the changes that will collectively deliver the Top Level Objectives.

Creating Competitive Leadership

Meeting Society's Needs

TECHNICAL ISSUES

TECHNICAL ISSUES

The environment

Changes, new drivers and issues

In a few decades, the sustained impact of about 5% annual growth in air travel has greatly increased numbers of aircraft and the amount of air travel, bringing to society a tremendous increase in mobility and economic benefits. It has also brought challenges not perceived decades ago. In some areas e.g. fuel economy, noise, and cost of operations the industry has made steady progress. Today's typical air operations, whilst recognisable to our forefathers, have immensely greater capability.

What has changed, and continues to absorb an increasing proportion of the attention of policy-makers the world over is the recognition of Global Warming and the associated climate changes. Certainly in former times this was not a main part of the aviation community's agenda. Now it is, even if this sector accounts for about 2% of the man-generated CO_2 emissions world-wide.

These issues of environment, global warming, reduction of anthropogenic greenhouse gas emissions, and sustainable development have become, especially in the last year or so, an increasingly important public and political concern, which has economical, political, psychological and societal effects. The STERN report (2006), the Al Gore movie and the IPCC[2] reports play important roles in this picture. The public, as well as decision makers and trendsetters increasingly realise the importance of these subjects, which have become a highly ranked priority in their actions and behaviours.

During the UN Climate Change Conference in BALI in December 2007, the World's governments were acutely aware of the challenge ahead and the necessity to act and to put in place concrete measures to combat climate change.

These large scale climate influencing effects are not the only environmental concerns, although they may be the most serious. At the local level citizens are becoming less tolerant of noise and emissions associated with airports and these effects are also requiring increasing attention.

As the world's governments wrestle with their individual and collective ability to act rather than just talk the industry needs to review its position on environmental matters.

The image of Air Transport and Climate Change

Every aspect of environmental protection has become loaded with political overtones as nations, industries, individuals and action groups seek to preserve or extend their own benefits in relation to others as well as taking positive measures to sustain the planet.

Air Transport is no exception, and its impact on climate change is being increasingly challenged by comparisons, sometimes inaccurate or deliberately biased, with other transport modes. There is a danger of this entrenching a globally false and degraded public stereotype of Air Transport emphasising it as a serious contributor to global warming rather than a facilitator for mobility and economic activity.

The record of European aeronautics manufacturers in improving fuel efficiencies and CO_2 emissions by about 70% in the last 50 years is important and creditable but inevitably is largely ignored in the present debate. What matters now are the present fuel performance and the outlook for the future.

Today, an aircraft can transport 550 passengers at around 1000 km/h on 15,000 km routes, consuming from 2 to 3 litres of fuel per passenger per 100 km. which is comparable with other forms of transport. In total aviation today consumes about 160 million tonnes of oil annually (2002 data) but this has a finite supply and must be shared with all other users. The burden of cost and difficulty of using different fuels upon different users will, of course, vary. It does, however, seem

[2] IPCC: Intergovernmental Panel on Climate Change

likely that the implications of both will be the most serious for aviation.

The challenges to aviation are, however, not just in comparative terms. In absolute terms it is clear that aviation will be a significant contributor to global warming (a) because it is producing about 2% of man-made CO_2 emissions today (b) because it is growing at a rate of about 5% per annum and (c) because the IPCC indications are that emissions at altitude have an effect on climate change greater than that suggested by the industry's CO_2 emissions alone. The effect of aircraft emissions on the environment is complex and is not fully understood. For these reasons the present emphasis being given to the environment is justified even if some of the comparisons are not.

The sector of Air Transport and aeronautics sectors need to respond to two increasingly stringent environment and resource related challenges:

- Further improve air transport fuel-efficiency and environmental performance with the aim of neutralising (or better) the effect of forecast air traffic growth;
- Increase the technological research efforts on future aviation fuels and energies in order to address the depletion of non-renewable fossil fuel resources which will soon become increasingly scarce and even more expensive.

The issues of alternative fuels are dealt with separately below.

What does the current SRA say?

Vision-2020

From Vision-2020 (Jan. 2001) onwards the environment has been recognised as a major challenge for Aeronautics and Air Transport: The Vision 2020 report recommended the total commitment that the industry is delivering in the task of studying and minimising the industry's impact on the global environment.

The environment was also identified as major issue by ACARE in its Strategic Research Agenda. Below is a synthesis of the "Environment" Chapters in SRA-1 (October 2002) and SRA-2 (October 2004):

Environment in SRA1

For SRA-1 the "Challenge of Environment" for the Air Transport System was considered by ACARE, based on the Vision 2020 recommendations: The challenge of meeting continually rising demand whilst demonstrating a sensitivity to society's needs by reducing the environmental impact of manufacturing, operating, maintaining and disposing aircraft and associated systems.

It was recognised that the introduction of high bypass-ratio turbofan engines in the 1970s and then increasing cycle pressure ratio had contributed importantly to reducing noise and fuel consumption. At the same time while efforts to reduce NO_X emissions have been made, more research is needed in engine combustors to further reduce NO_X emissions. Important breakthroughs, both in technology and in concepts of operation, are said to be needed in order to reach the 2020 targets. SRA 1 environmental objectives are:

- Reduce CO_2 by 50% per passenger kilometre (assuming kerosene remains the main fuel in use)
    - Airframe contribution: 20 to 25%
    - Engine contribution: 15 to 20% (of SFC decrease)
    - ATM contribution: 5 to 10%
- Reduce perceived noise to one half of current average levels
- Reduce NO_X emissions by 80%
- Reduce other emissions: soot, CO, UHC, SO_X, particulates, etc.
- Minimize the industry impact on the global environment, including substantial progress toward 'Green-MMD' (Manufacturing, Maintenance and Disposal).

Goals, leading concepts, solutions and technology enablers were derived from these objectives.

The main SRA1 conclusions and recommendations regarding environment were the following:

- Vision 2020 goals were seen to be achievable but only with the introduction of radically new technologies

- An air transport system model was seen to be necessary for the assessment of the environmental impact of changes of aircraft and the infrastructure
- Closer cooperation was needed between aircraft designers, ATM authorities and climatic researchers;
- A study was needed to establish the best options for future aircraft and engine designs and critical technologies.

Environment in SRA2

SRA2 (Oct. 2004) confirmed SRA1 and extended it with a wider systemic approach.

Three issues are embraced by the Agenda: One global - the effect of air travel on the environment -, and two of local importance - local air quality and noise.

The "Ultra Green ATS" HLTC technology pool includes the following objectives:

- Contribution of aircraft (airframe, rotorcraft and engines): aerodynamic improvements, weight reduction, fuel-efficient engines and systems, novel aircraft concepts, configurations, propulsion integration, adaptive structures and other airframe technology breakthroughs, noise-shielding and active noise control techniques, for rotorcraft, adaptive rotor and new turbo-shaft engine architecture.
- Contribution of airlines in terms of choice of aircraft, routes and speed, approach and departure procedures, and use of cleaner products.
- Contribution of airports in terms of construction, de-icing fluids, crisis management, ground vehicles, alternative solutions for aircraft taxiing, refuelling facilities, freight management, building restrictions around airports
- Contribution of ATM in terms of 'green routes', 'green areas' and 4D-trajectories optimised for the environment

Future Trends and Constraints to Progress

A: Climate Change

One of the issues facing ACARE is to avoid having its research programme inappropriately influenced by the sometimes misleading and inaccurate representation of the environmental effects of Air Transport that appears in the popular press. There remains an urgent need for more factual data on the absolute and relative levels of aviation emissions and their effects (even if these are not totally favourable to aviation). It is hoped that this will lead to, or at least enable, a more balanced view of the real contribution of air transport, compared with other sources of emissions, and to a rational technological programme toward their resolution.

However, this in no way denies the real need for further dramatic progress. In meeting the environment challenge, human ingenuity, research and technology (enabled by government funding incentives) will, we are confident, do the job much more efficiently than draconian regulations or drastic disincentives for air travel.

It is likely that in two to three decades, ***intensified*** research & technology could bring to the market the revolutionary solutions needed to achieve the 'Green revolution' of the Air Transport System in the first half of this 21st Century. Smaller efforts will only lead to incremental progress insufficient to meet ACARE's more radical and ambitious targets.

There is no universally applicable single solution to our problem. Solutions will require imagination and innovation, working on as many fronts as possible, incubating innovative ideas, anticipating new concepts, systems of systems, preparing further step changes in the systems' architecture and integration, radical breakthroughs, and bringing these future technology leaps to reality by thorough validation and demonstration.

The technology prospects are numerous and promising, and will undoubtedly lead to a fresh set of unexpected 'Ultra-Green' solutions. However, neither we nor the public should underestimate the efforts needed.

Today (2008) the challenge can be represented by the following statistics:

Air traffic 2007	2 billion passengers per year
Air traffic growth	4 – 5% p.a.
Aviation contribution to CO_2 emissions 2007	2%
"State of the Art" technology CO_2 emissions	50-75 g CO_2/RPK

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Extracting indications from a recent report[3] to IPCC and taking a reasonably likely combination of improved technology, incentives and projected traffic growth it appears likely that overall carbon emissions from aviation could rise by a factor of only about 2.2x between 2002 and 2030 whilst seat distances (SKO) rise by around 3.3x .

The issues at a global level concern CO_2, NO_X, soot/particulates, and water vapour. The problems of CO_2 are relatively well publicised. NO_X is also a significant contributor to climate change forcing e.g. through modifying the O3 component. Water vapour and the impact of vapour trails is not yet well understood and the possibilities that all forms of emission may have a greater effect at high altitude also need more work. Indeed, there is an urgent demand for a better understanding of the precise mechanisms by which all aviation emissions cause climate impacts. Current ***incremental*** technology improvements are allowing compensating savings for about a third of the extra CO_2 attributable to traffic growth alone. Therefore, ATS stakeholders need to define global objectives (whether stabilisation, or even a reduction) for emissions, with the ambition of stabilising the global environmental impact of aviation in relation to other uses, or in absolute measures. This further emphasises the importance of continued work on breakthrough technologies. Progress at today's rate and along present lines will produce insufficient change to bring about sustainability in the face of expected traffic growth.

B: Local Environment

The sensitivity of populations who live around airports appears to be increasing and both noise and air quality issues are becoming more stridently represented. The threshold of "nuisance" when applied to noise or air quality appears to be falling and attempts to satisfy the needs of these populations are meeting challenges made worse by these effects and by the increase of traffic.

Some partial solutions are not dependent on technology and, for example, re-routing approach and departures can have beneficial effects on the more heavily populated areas. What is clear is that achieving an adequate reduction in nuisance still represents a major challenge in both noise and separately in emissions.

The medium-term objectives and progress

Both categories of environmental impact still need to be addressed and separately:

- Global impact (green house effect, climate change, CO_2 and NO_X emissions, but also soot, particulate, water vapour, contrails, etc.): further work is needed to better understand the mechanisms of climate change, and the impact of aviation on it.
- Local impact: noise, and local air quality, NO_X, unburned fuel in the vicinity of airports.

Progress assessed against SRA-2 objectives is generally satisfactory on all fronts. However, as noted, the objectives are changing in either degree or pace and the aviation community fully recognises the **extra impetus** that needs to be created. Furthermore the impact of effective Emissions Trading Schemes (ETS) will need to be taken into account in planning the technology programme and these are likely to emphasise (as they are intended to do) the technologies directed to cleaner flight. ACARE's position with respect to the ETS[4] is an integrated multidisciplinary one and recommends comprehensive actions for responding to it.

Mapping precise expectations and objectives for future achievement is particularly difficult in the environmental area. This is because:

- The technical components are to some extent inter-applicable i.e. they can be traded off against each other. So the absolute performance in, say, noise will be dependent on the trade-off positions selected with reference to CO_2 or NO_X.
- The overall emissions of the aviation sector are made up from ground-side and air-side operations and these may interact in the eventual solutions.
- The targets for specific achievements are formed in part from levels of public acceptance, especially with respect to local noise, and night flights. It is likely that these levels of acceptance are continuing to fall over time with the public less tolerant of previous levels of noise.

[3] DTI Ref 06/2178

[4] Position Paper Nov 2007

- The regulatory regime changes from time to time (always to improved performance) although it is difficult to anticipate accurately the timing and levels of future regulations.

Notwithstanding these challenges it is clear that more effort is needed in all the principal areas of environmental performance separately and interdependently. An important question is how the necessary investments can be funded.

Simple market forces will not produce the required or desired improvements. Manufacturers need only to stay ahead of their competitors and customers, both operators and passengers will continue to seek price benefits in comparing improvements. Greener aviation produces nowhere near the additional income to pay for these investments and market forces alone are a totally inadequate means for justifying them. To some extent, although it is clearly difficult to say by what extent, protecting the environment is a necessary public good. As such it is appropriate, and is the practice, for public funds to play a part in making the necessary improvements. The attachments of values to both CO_2 (through emissions trading) and noise (e.g. the Schipol review) are important contributions to these issues at both global and local levels. Whatever progress is possible within the composite funds available needs to be maximised and a number of measures have been taken to optimise the output of useful and relevant technologies from the funds expended. “Clean Sky” is a massive collaborative effort allowing the contributions of all members to be used across Europe. The public funds applied through the Commission Framework and national programmes are always collaborative, and are carefully balanced against the priorities of the period.

Set against these efforts to maximise the product of the research programme attempts by governments to tax aviation into better environmental performance present serious difficulties by reducing the funding likely to be available to create solutions. Indiscriminate taxation provides little incentive to provide greener solutions. Taxation will also always suffer from the suspicion that it is part of revenue raising and not a genuine commitment to improving the environment. Mechanisms to channel the funds raised back into green research certainly exist and would need to be explored if the taxation route is followed.

In all of the above the emphasis has been on the complexity and challenge of finding solutions to both the global and local environmental challenges. By these means the interests of European society can be met and Europe can make its appropriate contribution to world environmental progress. But the High Level Objectives of the Strategic Research Agenda also include sustaining Europe as a world leader in aviation. It is therefore also an economic imperative that our progress should be constantly assessed in relation to our major competitors.

In the Longer-term

The potential in the longer-term is for entirely new technologies that will take us much closer, or even to exceed, the target of neutrally sustainable growth. This will only come from sustained public and private investment in carefully selected and controlled projects.

Review Recommendations

- The most serious **environment issue is global climate change** and this needs to be considered globally. This implies at least that if sharing of data and approaches with e.g. ICAO/CAEP, USA, etc is to be continued, Europe should press for appropriate and timely decisions about common actions.
- **More investment is needed** and this must continue to involve public and private capital.
- The application of new and **advanced technologies** is required not only in the field of aircraft but also in the important area of ATM where significant environmental contributions can be generated.
- The technical agenda for incremental improvements should remain unchanged but be **accelerated** where possible both in breakthrough and contributing technologies.
- The search for the necessary breakthrough technologies **must be accelerated.** These should be regarded as equally relevant whether they address reductions in CO_2, NO_x particles, contrails etc. on a local level (noise / air quality) or a global one (climate).
- Establish a **factual, authoritative, independent database** of aircraft performance both current and of future trends that allows calculations of the environmental impact of aviation to be more readily based on agreed data.
- Increase efforts to **understand the phenomena of altitude related** effects and the consequences for the global environment.
- **Exploit the available technologies** for climate protection through all appropriate mechanisms including the JTI project "Clean Sky" and SESAR
- Continue to encourage the creation, assessment and development of a range of possible **new concepts for the long term** future through support to innovative research.

Alternative Fuels

Changes, new drivers and topics

The general background to the rising concern with environmental matters is set out above. One of the areas identified is the position of aviation with respect to the limited reserves of hydrocarbon fuels.

Total energy demand will increase significantly in the next decades due to population growth and developing economies. Hydrocarbons will remain an important basis of the energy supply even though the age of "easy" oil is over. Crude oil supply will diminish in the mid- to long-term future. According to various forecasts the average estimate for the production peak for conventional oil will occur around 2030 i.e. in about 25 years time although these estimates vary widely and peak production may already have happened. What is more certain is that the cost of crude oil will continue to increase. Already the current $100 or so per barrel seems very high from the $30 perspective of SRA-1.

In the face of these pressures the USA has established the Commercial Aviation Alternate Fuels Initiative (CAAFI) to consider the alternative fuels possibly available over time and their benefits and disadvantages. One of the issues for Europe, besides the technical search for alternative fuels, is whether a global standard can be established. The US have also made several attempts to introduce legislation that funds a coal-based alternative transportation fuel. Europe needs to be alive to the possible risks of an international standard being built around a specific route.

The use, sale and availability of sustainable energy sources is therefore an important issue for aviation and the Air Transport System of the future, most especially since the entire ATS is currently operated on an assumption of continued supplies. Geopolitical developments will determine the availability and sustainability of existing and new energy sources that can be used for aviation. The environmental issues associated with traditional hydrocarbon fuels are dealt with above but those associated with alternative fuels need to be recognised.

What does the current SRA say?

Although mentioned in Vision 2020 and the ACARE Strategic Research Agenda 2 through the Environmental "Ultra Green" High Level Target Concept and as specific technologies the need for alternative fuels was not identified as a major challenge for the Air Transport System within the 2020 threshold. Cryogenic fuels like hydrogen, fuel additives and generally speaking cleaner and alternative fuels to reduce harmful emissions were cited at that time. Political and public debate on the issue was less intensive and the introduction of aviation emissions in the EU emission trading scheme less imminent.

SRA-2 addressed a large number of evolutionary or revolutionary technologies but without specifying technology readiness levels (TRL) for each technology. It mentioned liquid H2, biofuels, synthetic fuels, LNG, alternative power sources (e.g. fuel cells) as well revolutionary energy sources for aviation like Solar Power, Nuclear Energy, Hydrogen from the Sea and Beamed Energy devices using laser or micro-wave and ground-powered energy. The technical readiness of different alternative fuels will vary. Those that have the opportunity to meet the mid-term environmental challenges of aviation will be those capable of being brought to deployment in that timeframe. Other energy users, not aviation, may be the primary drivers for the options.

Future Trends and Constraints to Progress

The most significant property of existing aviation fuels is their high energy density although they also have several other important properties to which current aviation is very well tuned. Alternative fuels for aviation therefore fall into two main camps: "drop-in" fuels with substantially similar properties and alternative fuels where some different properties are demonstrated. Both have been investigated for quite a time but significant aviation-specific research is needed to identify realistic and practical options for implementing future alternative aviation fuels for 2020 and the decades beyond. To meet near, mid and long term solutions for possible replacement(s) significant challenges (technical and non technical) have to be met with almost all alternative fuel options. It is essential to find an economically viable solution that also offers a manageable transition from conventional to alternative fuels. A coherent aviation point of view on the issue needs to be investigated in detail taking into account the following factors:

- Aviation constraints and specifications for fuels.
- Environmental impact of alternative fuels for aviation from source to usage.
- Availability and environmental implications of alternative energy options.
- Security of supply, with aviation as a part of the total energy system and its economy.

Several prospects for new fuels have been aired. One is for a new fuel that may not require fossil fuel inputs at all. Such a prospect was outlined recently in which a new genus of microbe might be developed through DNA engineering with the ability to produce bio-fuel from sugars and cellulose. More promising, perhaps is fuel from biomass or algae as fuels from sugars are likely to be alcohols which have a variety of problems as fuels. However, for the time being we shall be dependent on alternatives such as those already identified.

The European Commission has responded to these concerns and has published (Dec 2006) a communication setting a target for the European Emissions Trading Scheme (ETS) to include aviation to and from the EU by 2012. The European Council also made a commitment to reduce greenhouse gas emissions to 80% of 1990 levels by 2020.

Aviation constraints and specifications for drop-in fuels

The technical challenges for alternative fuels are very demanding with significant aviation specific constraints. Avoiding totally new fuel infrastructure, engine and aircraft design developments, the starting point must use the existing kerosene fuel parameters e.g. energy density (43 MJ / kg) and freeze point. Generally speaking current parameters that need to be fulfilled for any aircraft fuel are 'fitness for purpose' properties, safety, performance, operability, emissions, handling etc.

Whilst equivalent specifications may be a starting point the possibility of extension or relaxation in some of the current specification parameters should to be investigated during the research as well as the possibility of developing multiple new fuel specifications.

Environmental impact of alternative fuels from production to usage

Alternative fuels might contribute significantly to lowering the aviation environmental impact (local, regional, global). The ideal would be to get a carbon neutral fuel in the long term and aiming at a "zero emission aircraft".

The environmental impact of a specific fuel needs a **life cycle analysis** of the fuel in terms of total emissions from the ground to the air. It starts at the extraction of the energy source going through the processing and production of the fuel followed by the transportation and storage and finally the usage in the aircraft during the mission from gate to gate. For example the production of Coal to Liquid fuels is CO_2 intensive and would therefore only be useful if accompanied by sequestration of the CO_2 that occurs during the processing. This total analysis is known as "Well-to-Wake".

In terms of comparison with existing conventional kerosene an alternative fuel is only greener if its overall life cycle emissions (CO_2, CH_4, CO, NO_x, SO_x, UHC, soot…) balance would be better than kerosene. These comparisons would also need to be set alongside possible solutions for all other major fuel uses so that intelligent decisions could be made about allocation and selective choices. It is also important that the overall sum of the energy required to produce the fuel and the total greenhouse emissions liberated is fully understood.

Specific aviation impacts on the climate need to be considered when considering alternative fuels e.g. the increase in contrails inducing cirrus cloud formation when assessing hydrogen as a fuel.

Availability and environmental implications of alternative energy options from the aviation point of view

Fuel prices including kerosene have been increasing constantly over the last two decades. Alternative fuels can be an economic replacement option for conventional oil based aviation fuels in the near-to-long term.

A near-to-mid term solution could be the production of synthetic drop-in fuels. They have the advantage of producing less emission in terms of CO_2, particulates, (no) sulphur, (no) aromatics and have a better thermal stability which could allow engines to run hotter and thus reduce fuel burn. However, they can be expected to produce more water vapour which might bring its own problems. Synthetic fuels produced through the “Fischer Tropsch” process can be produced from gas, coal, oil sands or biomass with the advantage of being able to produce identical final products regardless of the initial feedstock. This process of Anything-to-Liquid “XTL” (gas, biomass, coal, other to fuel) has the potential advantage of producing synthetic kerosene that can be used in existing engines as “drop in fuels” without having to change significantly existing engine or aircraft technologies. At present they cause a number of factors (e.g. ignition, altitude relight) to be compromised and more work will be needed if they are to be effective.

Biomass has a great potential as a feedstock for synthetic fuels (e.g. lignocellulose, starches, vegetable oils, terpenes, algae) but with varying qualities in terms of biomass production rate (e.g. algae has the best production yield). World potential for biomass production would need to be taken into account if many large fuel consuming sectors identify this as a fuel resource (see below).

Other long term options to be investigated for aviation are e.g. liquid hydrogen LH2, liquid natural gas, liquid methane, nuclear energy or other revolutionary options. These would not be drop-in solutions as they would demand new technologies for the aircraft, engines and infrastructure. Independent power units might use the same kerosene fuel as the main engines but do so in a fuel cell which would enable higher efficiencies to be obtained.

In general it is important to consider these alternative fuel options from the source, through the production process to the final product analysing the impact on aircraft and engine technologies as well as the necessary infrastructure.

Security of supply, aviation as a part in the total energy production and economical aspects

The whole future world aircraft fleet fuel demand needs to be assured taking into account the projected air traffic growth per annum of about 5%. Therefore **fuel availability** in sufficient quantities is an important issue for existing conventional and alternative aviation fuels like biofuels. The issue of available land for enough biomass production for aviation biofuels needs to be analysed as well as the possibility of price increase of crops. It would not, for example, be useful for the world CO_2 balance to cut down rain forest areas in order to establish monoculture plantations for biomass production although these issues are far from simple, or their analysis agreed.

Production, transport, storage and supply fuel infrastructures need to be continuously available worldwide without a break. The migration from one fuel regime to another needs careful consideration so that all aviation users can have a seamless transition to their new fuel type including all the stages from production to emissions or “well-to-wake”.

In a parallel with studying the environmental impact of alternative fuels for aviation a life-cycle Economical Cost Benefit Analysis addressing aspects like, Research & Technology, production, operation, transport, supply and maintenance costs also needs to be done to assess the possibilities for an economical viable alternative fuel solution for aviation and the transitional replacement of conventional fuels. This is necessary in order to maintain Europe’s competitiveness and leadership in civil aeronautics and has also to be seen in relation to the fact that the fuel production for aviation represents only a small part of the total fuel production in the world. Difficult political decisions will be faced when new solutions are being considered for aviation and for many other users. For this reason it will be important that different fuel users have analyses of their own economic and environmental costs on properly comparable bases. The environmental, political and economic effects of these fuel allocation agreements will surely make the trials of getting action from the Bali Conference seem small in comparison.

Review Recommendations

In the coming decades, fossil fuels for all users will become increasingly scarce, expensive and protected. In order to tackle this problem and lower the air transport environmental impact the potential options for alternative fuels for aviation need to be investigated through appropriate research effort defining a clear aviation point of view on the issue. Alternative fuels are certainly possible, the issues are which of the possibilities represent the most practical answer to the complex of requirements placed upon them.

ACARE recommends dedicated research activities in order to analyse in details the aviation-specific implications of the usage of alternative fuels through near-, mid- and long-term technological options and the related economic aspects for the future air transport system comprising the following points. International co-operation on these issues may be necessary considering that alternative aviation fuels will be used on the world-wide market.

- Detailed "well to wake" life cycle analysis of all alternative fuel options for aviation in terms of environmental impact through scenario analysis (CO_2 and non CO_2 emissions on the local, regional, global level) including attention to biofuels.
- Economic cost-benefit life cycle analysis and scenario for implementation of drop-in fuels
- Two parallel research efforts
- One focusing on drop-in alternatives to crude-based kerosene fuel, within current basic jet engine technologies.
- The second focusing on new 'revolutionary' aircraft power systems: alternative & renewable energy with sustainable technology, including scenario analysis for environmental and economical impact.

The Security Challenge

Changes, new drivers and topics

When ACARE prepared SRA-1 it was just after Sept 11 and there was no prepared security programme. Today, in comparison, it is of paramount importance to adopt a strategic view. Now there are FP7 Security, SESAR, GMES, GALILEO programmes all having security implications whose existence and contribution we must recognise.

Importantly, ACARE must ensure that the SRA Security issue will be addressed. It has to be remarked that the SRA has also a time-line associated with it, dictated partly by the market. The needs and market have to be consistent, and this is where the initiatives mentioned above have a role to play.

Some SRA assumptions have been challenged since SRA-2 publication in 2004. Security threats have increased to the point where they are becoming an issue of passenger convenience; e.g. the goal of 15 min transit time in the airport for short haul flights is unachievable in today's context and indeed in practical experience is becoming worse. The 15 min is unachievable also because airports have different rules, and different business models, and suffer from a rapidly changeable threat situation.

What does the current SRA say?

Security is a two-fold problem: technological and political. The SRA-1 & 2 developed the technological roadmap to a good extent, but the emergent priority is to provide enablers and instruments for the political process.

A common view of safety and security issues is shared among alternative scenarios of SRA-2 where it is envisages that streamlined airport security measures will enable a rapid "hassle free" throughput of passengers throughput of passengers.

Future Trends and Constraints to Progress

The travelling public – especially in business – has high expectations and needs for punctuality and reliability and increasing responsibility is put on airlines for delayed flights. Travel for many people is measured by the time they must leave home or office to the time they need to be at their destination. These times are rising, not falling, and lack of technology is not the only cause.

Air traffic has increased and infrastructures are quite close to their capacity limits, so accessing them is more difficult. Additionally security checks are being heightened to counteract growing and changeable threats of terrorism, and consequently everything slows even further. Allied to this the business models of many airports are not conducive to streamlined and consistent security processes. It is, in part, the inconsistency of security and check-in process performance that demands that passengers are advised to arrive earlier and earlier for their flights. Greater consistency could be achieved with greater investment but this carries a penalty if much of this investment is unused for portions of the day.

The technical advances in the security world are now very dispersed and appropriate technologies for aviation security can be found in a wider variety of places. The fundamental aim of effective, affordable and streamlined systems certainly seems attainable from this abundance of technological effort. Less progress has been made on the formation of requirements. The most important factor is, naturally, the changing security threat. This has not always had a globally consistent character. So the rise and fall of threat assessments in different places and in variable patterns poses special challenges to regulators and operators everywhere. The ability of regulators to keep up with these changes is also a real problem and in several cases new regimes have been introduced more or less at the time that the threat has once more changed. In short the ability of the system to implement rapid, effective and appropriate changes is deficient against both the moving threat and the demands of passengers.

Highly automated, intelligent systems are envisaged as possible complementary systems to augment and adjust fixed systems by the automatic detection and assessment of threatening events and critical situations. This will allow security systems to be responsive to the threat. For example future security systems are foreseen to provide some "behaviour prediction" ability through modelling and simulation to support "what-if" analysis in this intelligent decision making process and to assist security managers. Different security situations could be "dialled-in" to adjust the sensor responses appropriately. These sophisticated extensions from separate sensor machines into an integrated multi-sensor system would need to be explored, integrated and demonstrated for their effectiveness.

Security, therefore, remains a challenge for the SRA and innovative approaches must be found to face the new and demanding technical and societal needs. Splitting down the security issue of the air transportation system into segments could make it easier to focus on the issues:

- Security of inter-modal structures, ground services, etc.
- Security within air transport infrastructures (people and goods)
- Security while boarding
- Air space security, take-off, en-route, approach and landing subspaces

Looking at the capabilities that will be needed in order to address the above areas, new security-enforcing systems are expected to provide threat detection without requiring people to pass through a gate. The prospective deployment of "virtual" control-gates ("smart corridors") will lead to lighter control procedures and improved, adjustable security and better throughput performance.

Quite apart from the important ground-based security systems there is also the important requirement to protect flights when airborne. Anti-hijack measures for the in-flight phase of the journey are today essentially confined to intruder protection at the flight deck door. Many observers believe that a command and control system needs to be developed in conjunction with the airlines, airports and ATM agencies to permit aircraft command to be sequestered by ground-based managers in the event of a hijack. The principal in-flight control technologies needed are already known although setting up a communications system to link these reliably and securely to ground controllers would require new technological work. Without reliability and security they would actually become prejudicial to travel security. A large effort would also be needed in forging the regulatory and international agreements to make the system operable in context. Here too there has been a changing scene with different agencies applying different standards. It is an important area for international collaboration to introduce more consistent standards and better systems for adapting these to changing threats.

However, this entire subject is not entirely process-driven and nations will continue to take the steps they consider to be essential, sometimes at short notice, in the protection of flights under their control.

Review Recommendations

- The system by which security requirements are established should be reviewed with a closer look at the causes of inconsistencies and changes. The main challenge to better security performance, and the balance between the various aims, rests with regulatory and political networks. This conclusion is supported by findings within ESRAB/ESRIF.
- More capable, wider scope and less intrusive systems at the level of both deterrence and detection should be developed.
- Variable performance capabilities should be investigated to relate to a variable threat scenario.
- Security research will need to be focused towards the following solutions at system-level:
    - Automatic surveillance of close spaces alerting upon critical circumstances.
    - Passenger-centric operations.
    - Deployment of stand-off sensors at unattended aircraft to prevent subtle introduction of lethal substances/explosives aboard.
    - Autonomous flight-management operations to preserve flight security against "unauthorized" manoeuvres.
    - Precise automatic localisation of the aircraft in the airspace.
    - Remote assumption of control of hijacked aircraft.
    - Stand-off sensors to screen people remotely and provide continuous monitoring of areas.
    - Security systems appropriate to the special needs of cargo aircraft.
    - Effective systems for the control and approval of airline and airport authorised workers
    - Integrated technical demonstrator systems will be required to show that integrated multi-sensor solutions can deliver the necessary performance.

Most of the topics above are already contained in the SRAs, which supports the robustness of the Agenda. However, what has changed is the increased emphasis on a more "systemic view" and the need for rapid variation in threat.

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INSTITUTIONAL ISSUES

INSTITUTIONAL ISSUES

Business Models

Changes, new drivers and issues:

It is clear that the entire character of aviation and its use of technologies is realised in the way that it conducts business in what is, for civil aviation, largely a market environment. The use and generation of technology therefore demands an understanding of the way in which technology and business interact. Businesses are driven by two primary forces: the regulatory regime and the need for financial performance. We describe the pattern of selling goods and services within these constraints as the business model, and it characterises each business individually. These models range from full range airlines, through air taxis, budget airlines and airports to service support and maintenance. Business models are enabled by the available technologies. They are chosen by businesses, mostly already aware of the technologies they could use for them. They are also influenced by the customers who want different goods and services, and also different attitudes from businesses that they deal with. An example of this is the attention being paid to "green" marketing whether that means less CO_2, less noise or even less visual impact. The issue for this Addendum is whether investment in identified technologies has the potential to enable, without being able to guarantee, a beneficial and significant change in the business models selected by industry. This contrasts with other sections of the Addendum because, whilst there will be a sustained application of incremental improvements to technologies in existing models, the Group here looks at ways to influence new models.

It is clear that new business models are under active consideration. The increased tendency of the market to fragment into new niches, separating, for example time-limited business travellers from cost limited leisure travel is a clear trend. Regional airlines provide almost half of all flights and the competition they face with High Speed Trains will promote new business models – probably in the context of a more seamless journey experience for travellers. Business and General Aviation is rising rapidly amplifying the demand for small airports. The attention being paid to Unmanned Air Vehicles (UAVs) offers specific benefits in a variety of areas (e.g. freight, crop observation, survey work etc). Various new airline models address the particular demands of new segments of the travelling public. Rotorcraft have the ability to contribute to quicker and more convenient short journey times and their use for non-transport applications also grows steadily. Personal Transport Systems (PTSs) are again in the news as people seek to by-pass congested motorways and urban streets. Airports are developing international ownership models that we can expect to influence their business decisions. Airlines are increasingly turning to aircraft rental models instead of ownership and these now account for more than 60% of aircraft. These new models are clearly also being investigated in the area of manufacturing where increased globalisation brings further pressures for the distribution of work content. Since S.E.Asia will form one of the major markets these new models must address the role of manufacturing in future supply situations.

The picture is even more diverse when we add in the possibility of different scenarios. Changes in international relationships would throw up another set of business models that allow their proponents to prosper in the then perceived economic conditions. If we extend the time horizons to include technologies that will be available longer-term we take into view the possibilities of wholly new models that exploit them.

Many of these new and potential business models are inevitably powered by businesses looking to their own future. Standing above these independent moves are considerations of how and to what extent transport may become more integrated in ways that may be beneficial to all.

In many of these and other potential new business models the technologies that they require will be critical. These critical technologies will not only include those for aircraft application but will, perhaps especially, include meeting the new demands that ATM will face with more and different aircraft using the airspace. The question for us was whether the Agenda addresses the technologies that will be needed, not only in existing models but in new ones.

The short and medium term

The immediately noticeable new business model being applied is the move of both major aircraft companies to that of integrator. This places more research and development upon 1st tier suppliers and brings new challenges to alignment of goals and programmes. The recent dramatic change in exchange rate between the dollar and the euro has put pressure on European manufacturers operating in the global market. Financial and economic measures may evolve but there is more focus on the financial affordability of manufacture and production in Europe and the technologies required to retain high value work in Europe.

Alternatively a substantial increase in fuel efficiency would, perhaps, enable new businesses that could not meet financial viability today to operate profitably. Such businesses might include new areas of passenger of freight movement or the transfer of trade from ships to aircraft. There is little prospect of being specific in this area because increased fuel efficiency will also make existing businesses more effective and no clear break point for the creation of an entirely new business concept is visible.

UAVs are already being generated by existing technology but fitting them into a busy airspace safely and effectively requires resolution of the regulatory and control challenges that they pose, part of which has technical issues. As these solutions are deployed UAVs will form a new growth area. Similar arguments could be brought to focus on the regulatory, ATM and control challenges of the Air Taxi business and of PTSs which may emerge into volume production if they are solved for regional airports and the urban areas where they will be used.

Changes in the regulatory framework could provide a sufficiently large disruption of the business world that new models, with existing or new technology to support them might be brought into operation. But such massive and simultaneous changes would very likely be avoided for the economic damage that they might cause. One can, for example, imagine very large tax changes so upsetting the equilibrium of today's businesses that new models entirely might be generated to live within the new regime. But this is a second-order technology effect only. It would first require a hypothetical change in probable circumstance to initiate.

A change of technology to deliver a more dynamically responsive security system to airports might have the ability to provoke a new airport model by making security delays more controllably related to perceived threat levels. But here too the pressure on airports to use retail malls as a major contribution to airport financial performance requires that large numbers of passengers spend time in the airport and it seems presently unlikely that easing security obstacles will bring about changes to this situation.

Space tourism is a fresh and technologically enabled business opportunity that is presently being addressed. Whether these systems will ever appeal to more than a few thousand people will be determined by both the design and the eventual cost of the space trips as well as by their extent.

The Long-term

The longer-term future holds out much more promise of new technologies becoming available with the possibility of changes to the fundamental business models in use. This is controlled by the rate of progress in the whole suite of technologies that need to be advanced in a holistic and systemic way to demonstrate the advanced systems of the future for timely availability of mature technologies for product application. Whilst a complete survey would not be useful it is possible to see some possibilities in the technologies that will take two or more decades to mature sufficiently for deployment. The area of fossil fuel conservation through the extensive use of ground power would initiate entirely new models by which this capability could be turned into profitable operations. Advanced and extremely challenging concepts such as those outlined in the recent Out of the Box study[5] each have the potential to excite new business approaches whether from new air-stations on the seas, very large cruising aircraft with shuttle docking and air re-fuelling, or the provision of seamless and autonomous global ATC with the capacity for UAVs in considerable numbers such capabilities will demand new business models. The established business structures of airlines, airports and services would need to give way to quite new ones.

Summary

Technology developments continue to be important. There are serious issues that need these new technologies if we are to enjoy sustainable, growing and convenient air travel with the personal, business and economic benefits that accrue. These new technologies will find expression and utility within the hundreds of different business models in current use across the world. New models are encouraged by changes in regulation, by the ability of firms to make successful business, or by the normal considerations of competition and market forces that apply. Each of these has technological needs and new technologies create new opportunities. These technical advances may be diverse, in the effectiveness of ATM systems, in manufacturing complex systems in an internationally collaborative project, in flight control systems with secure links to ground-based data, in the application and source of fundamental power for flight or many others. Each has enormous potential to influence the businesses that can exploit them.

When we consider radically new technologies, far removed from being incremental improvements of existing patterns, we see further scope for wholly new businesses to be created. Recent studies into possible future technology have begun to examine radically different approaches to the long term future. Many of these would demand new business models for their exploitation. In general these new businesses will respond to the availability of the new technology and at least a reasonable expectation that the regulatory and economic system will be, or can be, adapted to it since businesses generally start up only when they can see the route to success in front of them.

Business continues to drive aviation and it is entirely appropriate that business and the business models that will succeed when enabled by new technologies should be a clear part of the Agenda. However, new aviation business is subject to increasing challenges due to the ever increasing public and political concerns about the industry's impact on the environment and society, perhaps going as far as concepts of "visual pollution".

[5] Out of the Box Report Part II – Nov 2007.

International Collaboration

Changes, new drivers and topics

International collaboration is often cited as a way to enhance Europe's position. We need to be very clear on what this entails. This note identifies two main, but very different types of collaboration: strategic/context and commodity/commercial.

In the **commercial area** the demand for air transport and related products is changing under the macro economic changes in the world. GDP growth in the old world is moderate but the growth in China and India is enormous. Chinese investment around the world is increasing. High oil prices are driving investments in the old world from the Middle East countries and from Russia.

As the demand for air transport is linked to the development of GDP, we expect the most substantial growth of air transport to be in the new economies. In the past the European aircraft industries were able to sell moderate numbers of aircraft to the new economies, these now have a strong desire to supply their own – sometimes highly regulated - market with indigenous products.

China and Japan are developing and testing their new regional airliners that were developed in these countries with assistance of Western, Russian and Brazilian experts. The experience in Indonesia has shown that developing aircraft without a proper engineering background is a difficult task. After the economic downturn in Russia, the Russian government has made indigenous aircraft development a political priority again. Therefore the new and resurgent economies look for help in the old world to train their people and to assist in setting up aircraft development and production. They also want to benefit from new technological developments in the European and US aviation sector. In order to serve the growth market and secure their market share, the European and US industries perceive the need to enter into some sort of partnership with companies in the new economies. At the moment these arrangements centre around assembly and production facilities but there is a strong desire in the arising economies to begin their own technology developments that would lead to indigenous product development.

Every aircraft manufacturer in the old world is developing their strategic response to these new realities. Given their high production cost, excellent product quality, managerial skills and technology development are important issues for traditional companies if they are to survive and reposition themselves in the new century and in the new economies. Many leading European companies collaborate with emerging economies and are setting up new supply chains there, but it remains their strong desire to keep ahead in technological knowledge and creativity.

In the **strategic arena** the global nature of air transport means new ATM procedures and equipment need to be standardised. The standards and technologies necessary for the implementation of SESAR could become the world standard (and if they do not, the position of the European equipment industries may be endangered). Safety in aviation is still of paramount importance. The safety record in Europe and the US is good compared with the experience in other parts of the world. As aviation will grow on a worldwide scale, high safety standards need to be introduced all over the world in view of the growth in aviation and the increased use of air transport for leisure, also by European citizens.

Finally; the concern over the contribution of air transport to global warming should be a global concern and measures to reduce the impact of aviation on the environment should be applied globally for the benefit of future generations.

What does the current SRA say?

The current SRA is very much focused on the transatlantic competition between the two major players Airbus and Boeing. Developments in China and Japan were mentioned, but the speed with which new economies are developing and entering into the aviation business may have been underestimated in SRA 2.

The SRA states rightly that Europe "must look first to identify what must be done in Europe", but recognises that the market is global and "much of what is needed in Europe will be common to the world market".

The SRA makes a distinction between "commercial collaboration" and "context collaboration".

Commercial cooperation may be fruitful at each level in the supply chain if joining forces can improve the competitive position of the European industry. The governing principle will be fair and equal treatment of the partners (across the Atlantic). The SRA stressed the principle of reciprocity.

Context collaboration is focused on improving customer service indiscriminately e.g. collaboration on safety, security, standards, environment and inter-operability. It is suggested that a dialogue is opened with the US to develop a roadmap for collaborative efforts in these domains. An example is the dialogue between Eurocontrol and the FAA.

Future Trends and Constraints to Progress

As explained above, the global scene in aviation is changing. The competition between Airbus and Boeing is still the main topic but both companies are faced with the same problem of how to capture future growth markets outside their natural markets by involving foreign organizations in their development and production processes. The next big commercial airliner program is expected to be the successor of the A-320/ B 737 series of aircraft. Russia and China have already announced that they will develop an aircraft in the same category. In order to create a commercial success the number of aircraft types needs to be limited and therefore both Airbus and Boeing are looking for ways to integrate the plans in the new economies with their own. This is partly done by offering co-development and production on their near term products like the A-350 and B 787 and by assisting in the development of smaller aircraft that are outside the product range of both companies.

In view of the geo-political ambitions of the European Commission, the Commission is active in promoting technological cooperation with China, Russia and India. Such a policy must be well coordinated with the private sector in Europe for the commercial decisions involved are business not political ones. In the commercial area the actions by the EU should aim to strengthen the position of the European players and not weaken them. As the priorities for collaboration may change according to the competitive situation, the EU actions should be flexible, targeted and business driven.

ACARE should minimise risks in international collaboration. It should seek opportunities to strengthen Europe by promoting collaboration that will benefit the European citizen, the European aerospace industry and promote efficient international arrangements.

How all of this will play out is uncertain. We may see new and interesting separations between design and manufacture, between location and ownership, and between company registration and operation. We have also seen in recent years that context or strategic collaboration can and should be influenced by national and regional agencies. On the other hand commercial or commodity collaboration can only be identified and entered into by companies where each partner is satisfied that their aims, risks and contributions are properly balanced.

Review Recommendations

ACARE should take a long term view on collaboration. Strategic collaboration should be a significant element in a long term vision of ACARE. Therefore ACARE should make a clear distinction between strategic collaboration and commodity collaboration.

Strategic collaboration should enable the European air transport sector to benefit from the increasing worldwide demand for air transport, both in terms of providing services and in terms of developing and selling products.

- The prime issue for strategic collaboration is setting and applying worldwide standards for aviation. These standards relate to operational as well as industrial topics and include safety, security, alternative fuels, and ATM.
- A global system like air transport cannot be efficient without global standards for Air traffic management. Now that Europe seems in the lead by setting the SESAR operational concept, this should define a globally compatible concept for the next 20 years.
- European industry must be as active as its American competitors in the standardisation arena.
- Europe must be willing to share its technology if it wants to engage new strategic partners. But the aim must be to achieve a “win-win” situation. It is also beneficial to benchmark European technology development against developments elsewhere.

Commodity cooperation

- European engagement with commodity collaboration must be driven by the interests of the parties concerned in making the particular collaboration effective in their context.
- European acquisition within foreign countries will often be helpful to constructive collaboration there if supported by a clear strategy for the region.
- European companies should establish their individual priorities for collaboration and be clear about the benefits that they seek and the technologies and other aspects they wish to share in an effective partnership.
- There will continue to be opportunities for collaboration, mainly in basic research, on selected topics. The balance of gain and loss should also be carefully considered before embarking on any basic research collaboration.

Research Infrastructure

The principal objectives for Research Infrastructures remain as they were in SRA-2. The various aeronautical scientific disciplines as well as the development of parts, components and aeronautical end products will remain associated with extensive design, computation, testing, optimisation and validation activities. This complex process requires the systematic use of various research facilities including research aircraft. At system level, the validation of new ATM operational concepts and of associated technological developments will also require sophisticated infrastructures

These various research / test / evaluation tools and facilities represent a tremendous asset and now mostly serve European interests despite the fact that their existence is the result of national initiatives taken in the past 10 to 50 years. They are more and more often integrated in bipartite or tripartite partnerships.

The sector is currently much more concerned by the regular maintenance and imperative important upgrades (including performance improvements) of existing "Strategic facilities" than by the construction or acquisition of new facilities. Also, operational costs of larger facilities need to be secured at an acceptable level by public and private funding. Specific activities like development tests that would in the end benefit all customers, can be particularly beneficial.

At the same time, the community will have to make further progress in the rationalization process undertaken on a voluntary basis several years ago and which already produced tangible results. Operators, in particular of "Medium-size (Key) facilities", will also have to examine, in relation with national and European public authorities, fair ways and procedures (e.g. voucher system) for fostering the optimal use of existing facilities, reducing existing unnecessary duplications and preventing any risk of generating new duplication involving (National or European) public funds.

Review recommendations

Europe (through the Union and through intergovernmental tools) will have to be increasingly involved in the process of regular important upgrades of strategic aeronautical research facilities.

Europe should also devote a specific effort to address 'Key Aeronautical Facilities" in order to avoid further duplications and foster specializations. This is a matter for all, including companies, research establishments, the European Union, and national governments.

Education

The story here is very much the same as for research infrastructures – ACARE doing what it can but unable to take the decisions that need to be taken by national governments. Positive steps have been taken by holding a number of workshops to examine opportunities between the educational institutions most affected.

The need for harmonised education and training systems to produce the researchers and workforce that the aeronautical sector needs has been recognised. The establishment of a specific and voluntary accreditation system for aerospace engineering studies, assuring quality and common standards through a dialogue between Universities, high aerospace engineering schools, research establishments, and industry is urgent. The accreditation system may be developed and employed by a European organization for Aerospace engineering education Quality Assurance closely linked to ACARE.

The pressing need is for the engagement of national governments to give greater impetus to measures that will increase both, the image of the aeronautics career and also the effectiveness and efficiency of research, not only in aeronautics but across the board. It includes efforts to increase the financial attractiveness of research jobs. In addition, Industry-Academia partnerships should be encouraged to form a solid basis for the researchers' life-long learning and easy adaptation to new working conditions and challenges, in order to maintain a sustainable European leadership at the forefront of technology.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

It is clear that the world has moved on from the situation in the 2002/2004 period when the Research Agenda was initially formulated. On the whole the Agenda has been robust in the face of these changes. Progress has also been good although the specifics of this await the outcome of the AGAPE project. The areas of greatest challenge and the range of matters to be advanced were correctly identified and remain largely unaltered. All in all the Agenda has been a success.

However, the changes that have occurred are significant and some tuning of the Agenda is appropriate in respect of seven main areas:

- On the Agenda, taken in the broad, relatively small changes are generally needed (with the exceptions below) to the technical topics that should be researched and in which new technologies need to be developed together with some changes in priority.
- Increased intensity of work in the area of environmental impact.
- Consider the aviation aspects of new and alternative fuels.
- Increased attention in the security area to hassle-free operation dynamically adaptable security screening.
- Consider the airspace use and ATM aspects of the large scale introduction of the European air taxi and personal air transport business.
- Emphasised development of the mechanisms that support the deployment and exploitation of technology.
- New work in the areas of strategic collaboration, to establish European positions, our strengths and targets for strategic co-operation.

Increased effort in the area of the inter-action of technology and beneficial business models, scenario review and adjustment.

Early consideration of the scope and content of the future Agenda for which work should be started now but the main impact of which will fall to the vision document envisaged for adoption in 2010/2011.

The Technical Agenda

Of the range of changes that have occurred the increased scientific, community and political concern about global warming and climate change must be the largest single factor. Aviation is correctly seen as a contributor to these effects although its contribution is often misunderstood or mis-represented. Aviation is also growing at a steady rate and part of the concern about it is undoubtedly related to expectations for the medium-term future when air traffic volumes may have increased two or three times over today's levels.

The aviation community is fully aware of these dangers and concerns and is responding to them. Its response needs to accelerate further. The highly technical background to aviation gives it an uncommonly rational approach and this should be projected onto the wider community. The issues being raised by the aviation community – e.g. well-to-wake analysis of environmental impact and analysis of overall resources and their allocation – are not raised deliberately to confuse the debate but are real issues that need their parallels in every major energy consumption sector. In addition, in aviation the effects of pollutants on the upper atmosphere are not well understood and need further attention to ensure the aviation emissions research is even better targeted.

At the same time the aviation community has already taken major steps to accelerate the deployment and creation of technologies for change. The "Clean Sky" JTI project will speed up the technological breakthrough developments and shorten the time to market for new solutions tested on full scale demonstrations - whilst the research work already in hand within the Research Agenda continues to make planned progress on each segment of the environmental challenge; global impact, local air quality and local noise including consideration of interdependencies. These research aspects would move forward quicker with more investment. The non-availability of the full funds, identified as necessary in the Research Agenda, is an obstacle to progress.

Additionally this Review identifies the new work that can be accelerated now on alternative fuels which can make an important contribution to the wider fuel-consumption debate.

The area of security is another that has experienced rapid change in the years since the Agenda was formulated. Technical progress is diverse and is being multiplied by the emphasis being placed upon a more passenger-centric, hassle free passenger experience in various sectors. Since not all of the technology is specific to sector there is considerable scope for mutual benefit being gained. The Agenda has adequately identified the main areas in which advances will be needed and work continues to this end.

The major difficulty in this area rests with deployment and uptake of the technologies in a coherent and systematic manner. Both researchers and operators are being confused by the inconsistent nature of the security threat (a deliberate strategy in the field) and a fresh approach to the topic is needed. This may well be the acceptance of a continuously variable threat character that will need to be met by adjustable systems able to re-balance the needs of cost and convenience with security performance in a more dynamic real-time operation. To this end the technical efforts in this sector need to consider the ways in which this might be enabled through appropriate research and technology development.

Supporting Mechanisms

Getting new technologies into service and allowing operators and their passengers or clients to benefit from them certainly requires that the technical effort should be correctly focused if the outcome is to be effective and economic. Achieving this ideal requires that the technical community reach out to discuss these issues with policymakers, operators, customers and all the other stakeholders in technical progress. These links are present but are not adequately effective. Confusions remain between the technology programme and the deployment programme and there are many benefits to be gained from improvements in this area.

Specifically, the practice of technology development and the preparation of research agendas and plans, would benefit from the greater involvement of the ultimate users of the technology. That was the inspiration of the Group of Personalities Vision 2020 but that wider and constructive involvement has not been sustained. Given the absence of the identified and necessary funding to achieve all the objectives of the Agenda it is more than ever necessary that the technology be correctly focused.

Collaboration

Even in an intensely competitive globalised world facing differential resource scarcities there is an increasing scope for collaboration. This will make solutions more efficient, travel safer and more secure, international trade more practical, and the allocation of resources more feasible provided that the collaboration focuses on matters of common interest. Matters of partisan interest between two or several partners are essentially matters for their own determination. In these private arrangements few general rules will apply. The partners will each come to appreciate the balance of compromise and benefit that suits their participation if the collaboration is to move forward. Joining firms together in artificial "alliances of the unwilling" has little prospect of creating enduring or productive relationships.

But there are many challenging, important, and urgent matters of mutual concern and in which agreed interdependent solutions are necessary. These include aspects of ATC, safety and security standards, environmental performance minima, standards for alternative fuels, regulation and certification which all fall within the remit of ICAO acting on behalf of its members. It is for the members to speak with the authority of experience and careful analysis and to compromise on details in the interests of timely and effective solutions. Europe is presently falling short of the authority that it should be exercising in these areas. It needs to identify target areas where results are needed and against each of these to take a rigorous look at its strengths and weaknesses. From these it will need to develop a negotiating position and then exercise this position energetically in the appropriate agencies.

Scope

The defined scope of SRA-2 begins to be a limiting factor to the promotion of technologies that many would consider to be an essential part of the future aviation scene. The rapid adoption of new models for **business aviation** using smaller aircraft must be taken into account, not least for their impact on ATM. The SRG also recommends that any new consideration should examine the role of **rotorcraft** more widely, should take into account the progress made and needed on **UAVs**.

The technologies needed for rotorcraft development are, in many cases, the same as those for the generality of aeronautic studies. There are specific challenges faced by helicopters, hybrid vehicles and other rotorcraft that distinguish the field. The scope of the SRA as being concerned with "air transport" is now an obstacle to incorporating these areas into the main aeronautics programme. The uses of rotorcraft are multiple but many of these are in areas similar to search and rescue, evacuation, emergency flights and the like. They clearly do not form part of the central air transport issues but are nevertheless in a closely adjacent area. It will be for those considering the scope of the next Agenda to decide whether the field describing rotorcraft should be extended.

UAV technology maturity is increasing at a high rate and expectations that both a regulatory framework and the required technologies will be ready in 2015 are now credible. To reach this goal, all stakeholders in charge of the evolution of the aeronautic system have to work on a common objective: provide means to allow all airspace users to share the airspace.

The role of ACARE

The technical agenda, its compilation, review, dissemination and application is the primary purpose of ACARE. But this agenda is inseparable from the development of aviation, the global changes and the competing technologies that will determine whether the aim of European leadership is met. In order to support, justify and advance ACARE's view of the appropriate technical agenda it must develop understanding and participation in these issues. It is clear that such a role must include engagement with the policymakers and industrial leaders who will drive policy and business decisions. ACARE is fortunate in this respect that it has many of these leadership figures easily accessible to it. Only by this closer awareness and engagement can ACARE competently monitor the relevance of its technical advice.

Planning the Future

Major changes are taking place around us. The challenges that they place upon us may not be soluble by the methods of the past. There is no reason to suppose, for example, that leaving climate control to "market forces" will be effective. The rise of S.E.Asia is not a remote technical issue but an economic reality that affects our lives. In the past our only alternative to the market was state intervention. But most individual states are unqualified to deal with these complex issues effectively on their own or in time. If present projections are even more or less right the future of a warmer, more populous, more hostile planet with diminishing fossil resources is immensely challenging.

The aviation system is now one of the primary enablers of most modern economic systems. It is effectively impossible simply to close it down. However, keeping it growing and generating its societal and economic benefits is only conceivable if the solutions chosen for it deploy our full range of energies and abilities. These will include technological development, especially of the radical ideas that may contain the foundations for a future sustainable solution. The development of supporting mechanisms that make technology development efficient and effective needs to be lifted up the Agenda. Other areas will include collaboration on matters that are above competition; regulation, taxation, compatible systems, safety and security, emissions control levels, ATM, resource allocation and many more.

There is much that can be done in the short-term and more that needs to be started now for longer-term realisation. New developments such as air taxi operations flying point-to-point, UAVs and PTSs need to be thoroughly reviewed to ascertain the position that they will occupy in the both the operating and thence the technical agenda. The whole system review planned for 2010 should be much more than another look at the technological programme. It must reconsider the entire scope of what we mean by "aviation". Some of the issues identified, but not resolved, by this Addendum need to be taken into effective action both within the technical community and in the political and business spheres.

The excursion into the priorities for business in this review must be fully considered by the review of aviation and its technologies being postulated for 2010. The issues facing the planet, as well as those facing the air transport system, require that the technical agenda be redefined in terms of its scope, direction, constraints and objectives. None of these can be determined in isolation, most especially in the face of the problems that they most need to address.

Meanwhile the path forward is clear:

- The present Agenda is endorsed in its essential direction and content.
- Adjustments and accelerations are recommended in the area of environmental technology development, action on alternative fuel, and on security systems.
- Revitalised action is indicated to encourage faster and effective progress on the supporting mechanisms that will make increased technological progress and effectiveness possible, economic and useful.
- A new slant is recommended for international collaboration that emphasises the European contribution to globally relevant solutions for aviation. These contributions must balance the need for altruistic willingness to compromise with the real value and importance of placing European strengths and interest alongside those of the other leading regions.
- ACARE should develop engagement with policymakers and industrial leaders as an essential part of its understanding of the contribution and the drivers of the technologies that it supervises.
- The importance of the long-term is re-emphasised. Only if energetic, imaginative and radical research is carried forward now in the best way possible and supported with the resources and funding that is appropriate will we generate the new technologies for deployment beyond 2030. It is on these new technologies that the future of aviation, the future strength of Europe and in no small part the future character of the planet, will depend.

Glossary

ACARE	Advisory Council for Aeronautics Research in Europe
AGAPE	ACARE Goals Progress Evaluation
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Transport System
CAAFI	Commercial Aviation Alternative Fuels Initiative
CAEP	Committee on Aviation Environmental Protection
CH4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CREATE	CREating innovative Air transport Technologies for Europe
DNA	Deoxyribonucleic Acid
EC	European Commission
ESFRI	European Strategy Forum on Research Infrastructures
ESRAB	European Security Research Advisory Board
ESRIF	European Security Research and Innovation Forum
ETS	Emission Trading Schemes
EU	European Union
EUROCONTROL	The European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration
FP7	Seventh Framework Programme
GALILEO	The European Satellite Navigation System
GDP	Gross Domestic Product
GMES	Global Monitoring for Environment and Security
GoP	Group of Personalities
H2	Molecular Hydrogen
HLTC	High Level Target Concept
ICAO	International Civil Aviation Organization
IPCC	Intergovernmental Panel on Climate Change
JTI	Joint Technology Initiative
JU	Joint Undertaking
LH2	Liquid Hydrogen
LNG	Liquid Natural Gas
MJ	Mega Joule
MMD	Manufacturing, Maintenance and Disposal
NO_X	Nitrogen Oxides
O3	Ozone
PTS	Personal Transport System
R&D	Research and Development
RPK	Revenue Passenger Kilometre
RTD	Research and Technology Development
SESAR	Single European Sky ATM Research
SFC	Specific Fuel Consumption
SKO	Seat Kilometres Offered
SOX	Sulphur Oxides
SRA	Strategic Research Agenda
SRG	Strategy Review Group
TEN-T	Trans-European Network for Transport
TRADEOFF	FP5 project on Aircraft Emissions and the Contribution of Different Climate Components to Changes in Radiative Forcing
TRL	Technology Readiness Level
UAV	Unmanned Aerial Vehicle
UHC	Unburned Hydrocarbons
UN	United Nations
XTL	“Anything” to Liquid

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