THINKING OUT OF THE BOX

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Summary

In search for innovative solutions related to the future air transport system a project was started on behalf of ACARE (the Advisory Council for Aeronautic Research in Europe) to collect and assess new ideas. The results of the project were very promising and plans were made to start a comprehensive process for systematic gathering of novel ideas for the future air transport system.

1. Background

Aviation is in constant change. It was only a little over 100 years ago when the first powered and controlled flight took place. Since then, aviation has known a remarkable development.

It was towards the end of the First World War that commercial air transport started. Flying was still expensive and dangerous in those days.
But commercial aviation has evolved from transport for the happy few into an efficient mode of mass transport. Today, some 75% of all air transport trips are related to leisure. Air travel has become a part of normal life and is not regarded as something special any more.

The development of air transport has been much related to the development of the demand for it. That itself was related to the growth of GDP, to the lower cost of flying even over long distances, to new business models introduced into the market and to an increasing flexibility that was offered to the passenger. Also government interventions had a substantial effect on the development of air transport, both negative and positive.

New options and technologies were offered to air transport operators and passenger constantly. But it were the step changes in the air transport system that made substantial changes of the ATS system possible. These step changes can be identified as follows:

In 1919, new airlines started to offer regular services between major cities in Europe. In that year also the first all metal aircraft, the Junckers F-13, flew for the first time.

The introduction of the all metal DC-2/3 in 1934 was again a step change in civil air transport. The all metal aircraft initially allowed seat mile costs that were 33% lower than the cost of the previous generation of fabric covered airplanes.

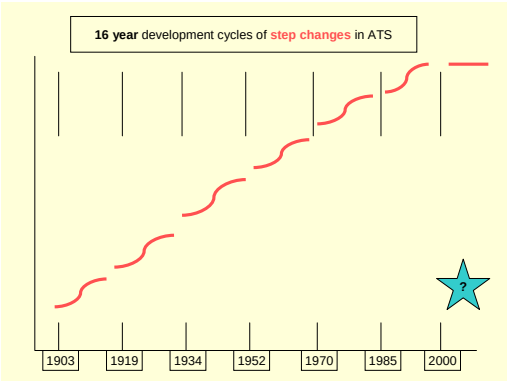
Incremental improvements followed, resulting in even more fuel efficient airplanes like the DC-6, which already had seat mile costs of some 32% lower than the DC-2.
But it was again some 16 years later in 1952 when a next step change occurred as turboprop and jet powered aircraft were introduced in the civil market. Again speed, comfort and capacity increased and cost were lowered over the previous generation of airliners.

The introduction of the first wide body aircraft was the next step change that followed some 16-18 years later. The increased efficiency of wide body aircraft made air transport accessible for mass transport over large distances. At the same time as the B-747 was introduced in the market, the first supersonic airliner, the Concorde, was introduced. The Concorde was a masterpiece of engineering and it was retired from service only recently.

Again some 16 years later, in 1985, another step change occurred with the introduction of ETOPS operations and the introduction of the first all composite aircraft. The Beech Starship and the Piaggio Avanti were the first of a new generation of all composite aircraft.

After each of these step changes occurred, incremental improvements of the new concepts were made. All these changes have made air transport a very efficient way of travel. For example a B-777 consumes only one litre of kerosene every 44 Km at a speed of 800 Km per

hour, which cannot be matched by any mode of ground transport.



If there were to be cycles of step changes, one would have expected a step change again in civil aviation at around the millennium.

Today we see that climate change can become such a force for change, or segmentation in the market, hydrocarbon fuel availability, globalisation or a withdrawal from it, or the pressures of congestion or mass migration. Each of these, either singly or with others, has the power to force a change in context and to provoke a change in the conditions that rule the air transport system. Such a change would require several new concepts to be available.

But such a step change was not very visible at the start of this century. Perhaps the introduction of Very Light Jets for air taxi services will prove to have been a step change in air transportation. Also the introduction of satellite based CNS will prove to have been a step change. However no major breakthroughs are visible in the larger aircraft segment.

Therefore some argue that we are at the end of the development in civil airliners or even in civil aviation. No substantial efficiency improvements over the current very efficient aircraft are feasible, these critics argue. Is it true that we cannot expect another step change in civil air transport?

This question was raised by the European Commission at the start of this century. In Europe no single forum existed where all stakeholders could be confronted with this question.
The air transport system is made up of many subsystems (like airlines, airports, ANSP's, industry, research organisations etc.) that all set their own objectives. They try to optimize their own subsystem, which will not necessarily result in the optimum for the whole system.

Air transport development is not centrally directed and has to rely on a consensus model for decisions between the different stakeholders. So the European Commission launched an important initiative by inviting a group of Personalities in Europe to set some far reaching joint targets for the air transport business in 2020. This group under the leadership of Commissioner Busquin, set challenging goals for air transport development in Europe. These goals are well known today and serve as the guideline for European and national research in the European Memberstates. The group also advised to set up a permanent advisory group involving all stakeholders in Europe. This Advisory Council for Aeronautic Research in Europe (ACARE) made research roadmaps to clarify the research needs to achieve the goals set.

The European Commission also initiated the Single European Sky. This initiative has 3 major elements:

-The functional airspace blocks that will no longer follow national boarders but will be structured according to the traffic flows. The FAB concept may result in a smaller number of airspace sectors which will be cost effective and more efficient.

- The flexible use of airspace. FUA may ultimately result in the simultaneous use of the European airspace by civil and military aircraft. This will enable airliners to use direct routing and access to the large military airspace in Europe. This will not only increase cost effectiveness, but also save fuel as civil airliners will no longer need to use old fashioned airways which were originally based on radio beacons and are situated around blocks of military airspace areas, thereby reducing the impact on the environment substantially.

- Advanced ATM procedures and architectures that will allow the maximum use of the airspace, whilst keeping high safety standards.

The SESAR forum was created that should develop these advanced ATM concepts. These concepts will address the

gate to gate travel, integrating the en-route traffic management with the arrival and departure traffic management and the airport movements. The envisaged ATM concepts should allow Europe to accommodate 3 times more air traffic then today by 2020 and be flexible enough to accommodate the envisaged traffic growth after 2020. The system should introduce a delay free, flexible and very cost effective ATM solution.

It became apparent that the far reaching goals set by the Group of Personalities cannot be met by incremental changes. These incremental changes are very useful but will not be sufficient.

Connections with the past will always remain. The laws of physics will continue to impose their strict discipline on what is possible. The infrastructure of the past will take many generations to replace. The human resources of the global air transport system cannot be changed overnight. New designs take many years to come to fruition. The system has, in the jargon, both a high inertia and a long time constant. So the transition to another era is not sharp and sudden but gradual and progressive.

The European Commission asked for a way to stimulate the next step changes in European air transport which may help to achieve the goals set by the Group of Personalities. Besides, the development of aviation will not stop in 2020 and industries predict a sustained annual growth till 2040 of some 5% per year for passenger transport and even more for freight transport.

As a result the European Commission asked for a think tank approach to stimulate innovative, discontinuous, revolutionary and radical ideas. It asked a few individuals to organize this action, which was to be funded by the European Commission and performed under supervision of the ACARE secretariat, which is called ASTERA.
In this way the idea for a workshop to stimulate Out of the Box thinking was born.

An example of existing Out of the Box thinking is plasma aerodynamics. Rather then trying to optimize the shape of the wing to reduce drag as much as possible, the idea is to change the characteristics of the air in front of the aircraft. Some claim that a 30% reduction of total drag is feasible with this technique, a figure that could never be achieved through traditional incremental improvements to the wing aerodynamics.

2. The OUT of the Box project

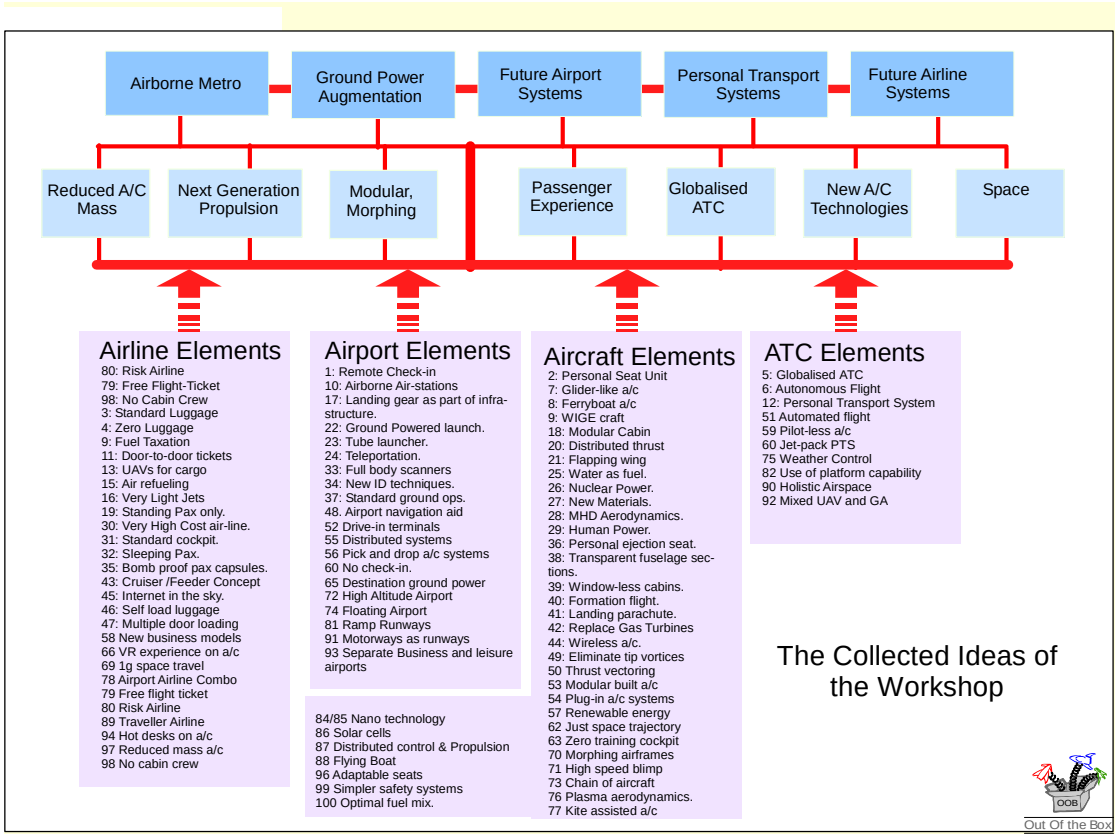
The Out of the Box project was initiated in the second half of 2006 and was conducted in 2 parts due to budget constrains. The first part consisted of a workshop to generate radical ideas. The second part consisted of a workshop to assess the ideas and to select the most promising ones for further study. All ACARE stakeholders were requested to provide delegates to the workshops. Although the participation was limited to 35 people, the whole ACARE stakeholder community was well represented. Furthermore independent experts with a background in economics attended the workshops.

To prepare the participants for the first workshop, reference material was produced, including suggestions that could be seen as Out of the Box thinking as well as an overview of technologies that are already under development and are therefore to be regarded as being already in the box.

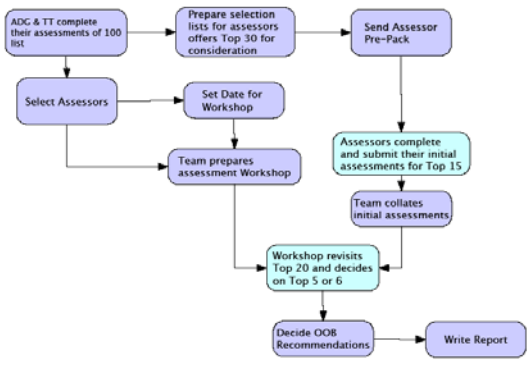
In total some 100 ideas were generated in the first workshop. These ideas were clustered after the workshop into concepts that would have an effect on the total air transport system, concepts that would affect one of the air transport sub-systems primarily and subordinate topics. A report was produced to be able to track the concepts later on.

Although not all ideas generated during the first workshop may to be regarded as totally new, the ideas covered both process and product innovations, like business models for air transport as well as the air transport vehicles and infrastructures development. The ideas would have an impact on improving cost efficiency, time efficiency, environmental impact, safety and security as well as customer choice and satisfaction. The ideas were clustered around 4 elements: airline elements, airport elements, aircraft

elements and air traffic control elements. The chart illustrates the results.



The second part of the project dealt with the assessment of the initial ideas. The chart below illustrates the procedure that was followed.



During the second part of the project, the assessment, the participants were asked to classify the 100 ideas according to feasibility and acceptability in terms of customer acceptance and desirability, in terms of economic and business feasibility and benefits and in terms of radical content and technical feasibility. It was recognised that some technical concepts would need the development of emerging technologies. The feasibility that these technologies would mature in a reasonable time from very low technology readiness levels (TRL1 and 2) into higher readiness levels was also assessed.

Based on the initial assessment, a group of 23 initial ideas were further assessed and a group of 11 ideas was identified as having the best potential in view of public, political, technological and competitive merits.

These concepts were:

- An examination of new primary energy sources for propulsive power
- Distributed propulsive power and control functions
- Glider like aircraft with low power consumption
- Formation flight for power reduction

- Connecting the passenger to the aircraft as a process
- Door to door journey ticketing
- Personal air transport systems
- Global, seamless and automated ATC
- Cruiser/ feeder concept
- Ground assisted take off and landing
- Off-shore airports and flying boats

Although all these ideas were regarded as being very interesting and would be worthwhile to give further attention, a further down selection process was performed based on innovative characteristics that resulted in the 6 most favoured concepts. These concepts will be discussed below.

3. Primary energy sources for productive power.

Today much emphasis is placed on the development of alternative fuels. A likely candidate for jet fuel replacement is synthetic fuel made from coal, natural gas or other hydrocarbon feedstock. On the longer run bio-fuel and hydrogen may have a potential. The use of solar cells and fuel cells for secondary power is also already under investigation.

The issue addressed in the Out of the Box exercise was the replacement of the traditional gas turbine in its present advanced and fairly mature form. It would be desirable that energy could be transformed directly into forward motion without intermediate devices like a jet engine. Also hybrid forms of energy systems could be envisaged. The analysis should include the aerodynamics, thermodynamics, material sciences and storage and distribution of new energy sources. Conversion devices might involve mechanical and electrical design that could be related to power by beams of space energy, MHD or nuclear energy and the resulting designs would need to be considered for their integration into the aircraft structure.

4. Global, seamless and automated ATS.

The future air transport system would benefit from a single seamless Air Traffic Management system that would replace the diverse systems used today.

A future system would allow individual aircraft to find their way based on a high level of autonomy. Aircraft would become autonomous in what is now called both controlled and uncontrolled airspace.

The ultimate aim of such a system would be that both manned and unmanned air vehicles would be able to fly safely and securely through the airspace world wide. Although some elements of such a system approach are already under development, fully automated trajectory planning, sense and avoid and anti CFIT and GPWS functions would need to be integrated.
Such an approach would require a big scale framework to operate and the key obstacles need to be investigated. How much autonomy over the system can be delegated is another issue and the question remains what kind of manual override possibilities should be built in.

5. The cruiser/ feeder concept

It can be envisaged that airport capacity becomes a real problem in the not too far future. Most HUB airports are already saturated and the public acceptance of noise and pollution by those living near the airports is being reduced.
One possible concept could be to develop very large aircraft that would circle the world. Initially these large aircraft could be used as aerial tankers, which would allow the operators on long haul flights to use more efficient smaller aircraft with a limited fuel capacity.

These large aircraft could ultimately be developed into flying airports that would circle the world on a permanent basis, being powered by nuclear propulsion units. Passengers would be brought up to the cruiser at their departure point by feeder aircraft that would be able to provide near door to door service.

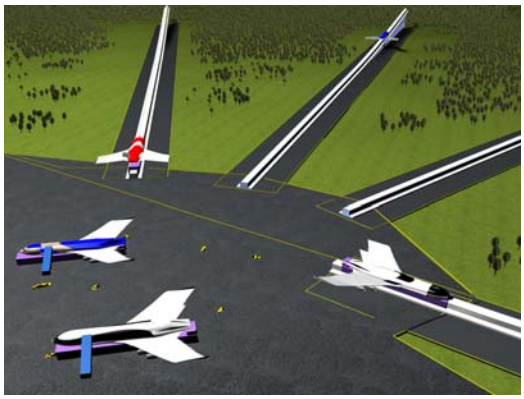
At their destination feeder aircraft would collect passengers and fly them to their ultimate destination. The introduction of such a solution would not only require research into the technical feasibility but also on the business and logistic models that would need to be used. It would involve a total systems approach.

There are many questions to be answered like the construction of the cruiser airplane, how it would take off and land for maintenance, what on-board maintenance would be needed and how the feeders should look like. The docking procedure for the feeder aircraft is another important issue. Also the operational concept, the flexibility, the preferred routes, the number of cruisers, the human factor issue and the environmental impact needs to be investigated. The consequences for security, safety and evacuation need also to be looked into.

6. Ground powered take off and ground assisted landings

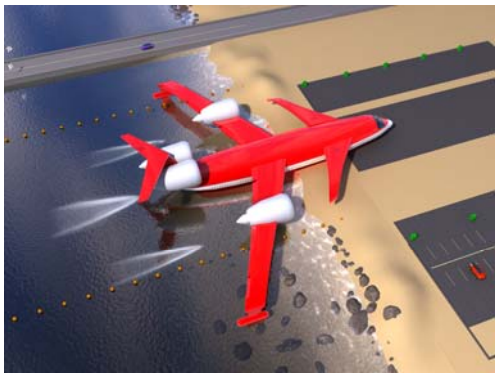
The idea behind using ground power is to reduce the installed aircraft power requirements and eliminate the need for an undercarriage which would reduce aircraft weight and drag and thus make airplanes more energy efficient. Other benefits might include the use of smaller airports, noise reduction and other environmental gains.

For take off assistance, electrical, steam or magnetic devices could be used. These could rely on oil based, nuclear or solar energy sources. One issue to be looked into is the energy storage.
To launch airplanes ramps, MAGLEV or catapults could be used, that might be augmented by short take of rocket power.



Research would be needed into the aircraft design adaptations, the energy needs as well as the safety of the system.

For landing the idea is to reduce aircraft weight by eliminating the undercarriage. Some alternatives should looked into like landing on water, landing on small cars that could be using electro magnetic fields to position the aircraft, para-foil landings etc.



7. Personal air transport

The idea of personal air transport is not new. In the past many have tried to come up with ideas to enable personal transport vehicles. Most failed as the technology was not advanced enough and business models for personal air transport were lacking. In more recent years NASA has investigated concepts for personal air transport vehicles and their operational environment. This was coupled to the policy to revitalize the small aircraft production in the United States.
Recently new small aircraft were developed that can be used as a new form of air transport creating a new air taxi business. This is completely different than the business aviation that is already well established. Many designs are on offer for very light jets, some originating from European companies like Grob and Diamond.
Ideas exist to enable individual air transport in order to avoid the ever increasing congestion on European roads and to offer an alternative for the current transport system in new European Member States.

A first issue that needs sufficient attention is the operational concept. Where can individual aircraft take off and land, what is the environmental impact, what about certification, maintenance, training and what about ownership models, liability issues and infrastructures requirements?

The second issue that needs attention are the vehicle technologies. Safety will be of utmost importance. Guidance and control is another important topic. Should these aircraft be able to operate fully autonomous or not? What about collision avoidance in the air, obstacle avoidance and loss of situational awareness of the operator? In short, the concept of personal transport seems very attractive but both operational and technical concepts still need further research before the concept can be introduced.

8. Passenger pleasing air transport

The topic concerns the system used to process passengers and their luggage from arrival at an airport to being seated in the aircraft ready for departure and from arrival to leaving the airport. The usual experience of the passenger now is to go from one process to another, from check in to baggage deposit to emigration to security and so on in ways that do not appear to be connected and integrated. Queues form and reform at intervals through these multiple processes and the whole procedure take considerable time and involves a lot of walking.
The focus of the Out of the Box topic is to design a single seamless process with multiple outcomes.

One option is to look into the airport of the future that should be part of a multi modal transport system. One could think of multi modal passenger and freight transport units that can be used by different transport modes including aircraft. This would call for a complete aircraft redesign. There could be modular aircraft and designs that could quickly take modular, preloaded, units onboard. This would call for a multi-system management system.

Another option is to improve logistics inside the airport. Passengers could be served by advanced IT systems that would provide them with all relevant information on the flights, routing and luggage status. Passengers could be tracked to avoid delays at boarding. It would be interesting to see if the idea of a chipped passenger that would have priority over the non chipped passenger could be a feasible concept.
The passenger-IT systems could be integrated into a networked centric information system that would provide information on all transport modes to facilitate door to door transport.
Special attention should be given to security systems used at airports. These are not designed to handle large numbers of passengers and completely new

solutions are called for. Advanced scanners could be integrated to form a security check corridor where passengers can walk through without the sometimes humiliating checks they have to accept today. The ACARE target is to enable a 15 minute journey from the airport kerb to the gate for those who do not want to enjoy the shopping malls that are available at airports today.

9 Next Steps

The results of the Out of the Box project were offered to the European Commission. Some of the ideas developed in the Out of the Box project will be included in the work-program of the 7th Framework program for RTD support of the Commission.

The Commission has been supporting aeronautical research and technology since the second EU Framework program and since then these Framework activities have been very instrumental in supporting aeronautical RTD.
The focus of the Framework programs has shifted over the years. In Framework program 5 the opportunity was created to embark on so called Integrated Project that were larger than the traditional research projects. The focus of the IP's was the integration and validation of technologies. In the 7th framework program a new instrument, the Joint Technology Initiative, was added. The objective of the JTI is to enable demonstration activities on a European scale.
This illustrates that the Framework programs are in danger to focus more and more on near market research that will deliver results within a relative short time period. The Commission has also realized that the long term innovative research may become a victim of the shorter term research and has called for break-through technologies in its new Framework program. The results of the Out of the Box project will help the Commission to define topics for this long term research in its aeronautics and air transport work program of FP7.

10 The future

It was realised during the Out of the Box activity that initiatives to seek innovative solutions for the future air transport system should not be confined to a single event.
The idea was launched to set up a comprehensive process for a more systematic approach for creative, innovative thinking.

It was also realised that innovative solutions will not only come from the aeronautics sector. In the first Strategic Research Agenda of ACARE the idea to start a technology watch activity was already mentioned. The purpose of the technology watch is to identify promising developments outside the aeronautics domain that could have relevance for the air transport sector.

It is also felt that continuation of the Out of the Box workshops involving other participants including people with a background in sociology and economics would be beneficial. But innovative ideas will not be generated in these workshops alone. It is expected that innovative ideas will also be generated in Stakeholder organisations. If a platform would exist to exchange these ideas within Europe, the whole European air transport sector would benefit from these.

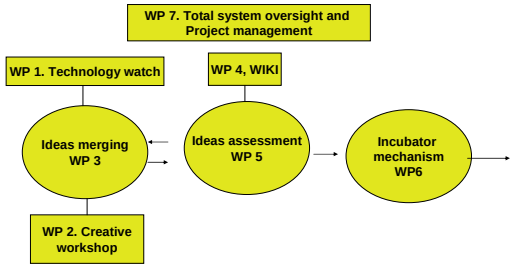
So the idea was launched to create a specific WIKI-pedia type of website where ideas can be exposed. Such a website-,called INNO-pedia, would help to gather all kinds of ideas in Europe.

These ideas would need to be assessed to select the most promising ones. The ideas that hold the best promise for Europe should then be supported by funding research into them. However funding of long term, sometimes wild ideas calls for a special mechanism.

That is why the idea of an incubator mechanism was launched. The incubator would enable new ideas to be developed outside the competition with short term market driven research.

A European incubator mechanism would not be a single organisation. It would be a mechanism that would involve many different organisations like universities, research organisations and industrial laboratories. These could form virtual working teams to perform research on selected ideas. This could even stimulate the establishment of Centres of Excellence in particular domains of air transport and aeronautics in Europe.
Funding for the work can come from European as well as national resources.

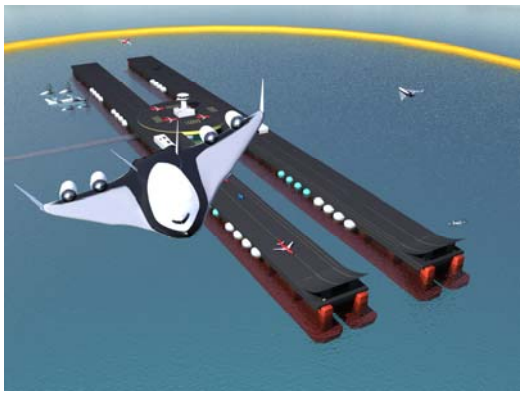
In Europe the Commission has not only the traditional Framework instruments but has recently also enabled the European Research Council to stimulate emerging technologies.



The set up of such a comprehensive activity has recently been proposed to the European Union for funding. This could provide the start of an initial activity that later could become a comprehensive process in which all European stakeholders in air transport could participate.

11. Conclusion

The Out of the Box activity has been a successful attempt to mobilize European stakeholders to think about creative solutions for the longer term future of air transport.
The workshops have been very appreciated by all who participated in them.
New ideas were generated in an open and positive atmosphere.



During the second phase of the project, the most promising ideas were further analysed and recommended for new research to ACARE and the European Union.

It is generally believed that these ideas could contribute to master the challenges that the air transport system may face in the future.
The workshops have shown that the aviation sector is still very creative and that the development of air transport and aeronautical technologies is far from being mature.
Exiting new ideas will prove to be a challenge for future generations of aeronautical engineers.