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Foreword

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Formidable challenges face all industries in the coming decades. Customers will be demanding and expecting improvements to continue but for aviation this delivery of more for less will be accompanied with a second challenge – doing it sustainably. For of all aspects of the future, perhaps the most serious challenge will be to eliminate fossil fuels and to re-engineer a world that is sustainable for future generations.

Aviation has a unique role in bringing people from all cultures and businesses together physically. It is an essential part of a shrinking world and an aid to enhancing peaceful coexistence: although the internet is also good at doing these things, it lacks the truly human-to-human dimension that world travel provides.

As the BRIC[1] economies forge ahead, demand for business air travel will increase and the wealth thus created will fuel demand for more leisure travel. Other countries and blocks will likely join the BRIC group (e.g. South Africa, Indonesia, Mexico ...). Many of these emerging Tiger economies will have a fast growing young demographic, so these new passengers will be expecting an exciting journey to fashionable destinations.

In contrast, in the developed world, an increasing older population with longer retirements will have a desire to see the world and its cultures, cities and scenery but with a need for more support and comfort that comes with age. Many travellers will however, have less to spend because the fruits of economic growth will be spent on re-engineering the planet and repaying debt. Taxation on travel will rise as authorities will be seeking many ways to raise revenue to pay for the demographic time-bomb and deal with the challenges of climate change.

It is forecast that in the next 50 years world population will rise by 50% and it is also forecast that many people will be living healthy lives to 100+ (perhaps even to 150years!).

Fortunately for engineers and technologists at Airbus, their 4 decades of innovation is set to continue and to accelerate as scientific research underway today bears fruit. We can expect to gradually solve the challenges that sustainability requires and by designing our way into a better future we should also be able to delight customers and enhance business as well.

Research in nanotechnology, biotechnology, information technology and cognitive science[2] are providing a growing set of opportunities. Some examples include; new light and strong composite materials, electronic plastics, fuels created directly from growing plants (that are effectively scrubbing the atmosphere of unwanted carbon), smarter computer and avionics systems and transport informatics.

A key challenge will be to bring the futures of new technology, of good design and innovative business together. For example; a future aircraft will need to be much more fuel efficient and need radical approaches to engines, airframe and avionics. The needs of passengers will require inspired

[1] Brazil, Russia, India and China
[2] Known as NBIC

cabin designs with the latest display and entertainment systems and new efficient boarding methods will be needed to help older passengers. The current businesses of airlines could change to be fully integrated with other parts of the transport system to minimise delays and hassle and maximise efficiency. Passengers will demand flexibility and an end to the hassles associated with flying.

Intelligent transportation systems could organise optimal journeys so that all waste, error and delay are accounted for so that the traveller need only follow real time instructions (delivered by a personal wireless communications device that allows detailed tracking).

Airports are travel bottlenecks so a future challenge will be to find innovations to streamline the part airports and aeroplanes play in multimodal travel. People do not want endless concrete, endless traffic queues, overcrowded rail journeys and endless delays, queues and the hauling of luggage.

Self guided and remotely piloted aircraft are currently being pioneered by the military so perhaps the current model of human pilot and human air-traffic controllers may be redesigned. It seems unlikely that a passenger plane would have no pilot but a freight plane could be a candidate. Certainly if the demand for travel increases and the skies are hugely crowded, then radical new approaches to safe control and guidance will be needed. Many advances in navigation, wireless and sensor technology are predicted and research into machine learning and cognitive sciences are suggesting that in 40 years, there may be few human tasks that could not be performed by a machine.

The goal of sustainability will need new approaches to materials, recycling and manufacturing. As well as fuel efficiency, all parts of the lifecycle of aircraft will need to take account of their environmental impact. Recycling and re-engineering may be as important as the initial manufacturing processes.

Looking to the future we can learn many lessons from nature. Biomimicry inspired mankind to follow birds into the skies and it is likely that we can copy many other tricks that nature has evolved.

Smart new materials should enable designers to create airframes that are as light as possible. Smart on the outside to aid aerodynamic and operational efficiency and smart on the inside to maximise passenger comfort and enjoyment. Electronics and computing will be integrated into the designs and it can be envisaged that computer chips will be everywhere and in almost everything[3].

Looking back at aviation in the 1960s one could conclude that change has been rapid in some areas but slow in others. The next 40 or so years are likely to see greater changes as the challenges have increased. A less conservative approach will probably be needed with radical new designs, using new and converging NBIC technologies and many business innovations.

[3] This concept is sometimes know as “The Internet of Things”

Introduction

In 40 or 50 years time, will the world be very different from today? Will we have breached new frontiers in space: walked on Mars, perhaps found life on Jupiter? What will have changed on our planet and can we predict this future?

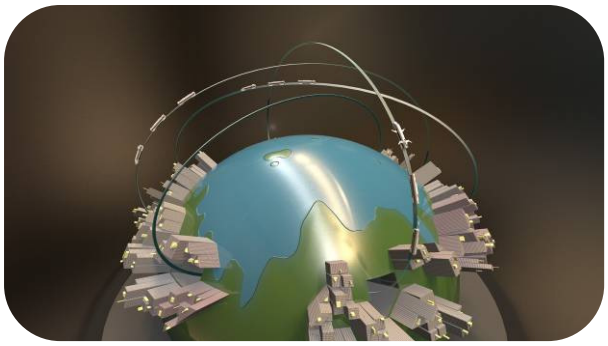
Before we try, let's ask the question: What DO we know?

We know that in 50 years time the last oil resources will be both rare and expensive. We know that with the depletion of fossil fuels, the growing scarcity of non-renewable raw materials, the urgent need to limit the emission of greenhouse gases and issues like food or water security resulting from the growing loss of biodiversity, our whole way of living will be called into question.

We know that aviation is currently responsible for 2% of all man-made emissions but also it is important to know that even with predicted growth rates of almost 5% per year, the industry has set itself a clear and ambitious aim: to halve its net carbon emissions by 2050.

And we know that a thriving global economy, wider social equality and a healthy environment are essential ingredients for a safe, secure and prosperous future. Better connectivity stimulates economic and social development. That's why people and goods, need and want to travel, with over 2 billion passengers and 35% of global trade by value moving by air each year, generating nearly 8% of world GDP and supporting millions of jobs in dependent industries such as tourism and agricultural export.

The world population will have nearly doubled by 2050; that means roughly 9 billion people will need and want to travel. But they will also need and want to protect our planet.



Right now, air travel accounts for just 7% of the population being affected by noise from transport, which will continue to drop steadily as newer, quieter aircraft enter service replacing older, noisier models. And while just 1% of all land use by transport is for the purpose of air travel, this infrastructure is also paid for by the industry itself, rather than by taxpayers.

So is laying thousands of miles of rail track or building more roads the best way forward? What will the impact be on land use for housing, agriculture or biodiversity? Where will the power come from for all those trains and cars? Before investing billions in new infrastructure that will reshape our landscapes and our lives forever, has there really been enough investment in independent studies to understand the full lifecycle benefits of all modes of transport?

In developing a fully integrated, global transport system to serve the needs of a growing population, shrinking land availability and an increasingly fragile environment, we need to push the performance and capabilities of each. We must ensure that we can select the most appropriate form of transport for each need and provide seamless integration for the end user.

So what will the world of air travel look like in the future?

Already celebrating 40 years of Innovation, Airbus also looks forward more than 40 years to 2050 and beyond, anticipating the global needs of a better connected and more sustainable world.

Airbus believes that the future of aviation, must take into account not only technological advances but also passenger and market demands, the growing population and its demographic profile and respect for all aspects of the environment.

In the last 40 years aircraft fuel burn and emissions have been reduced by 70% and noise by 75%, thanks to advances in technology. But at the same time 72% of air traffic operates through 114 airports that are already congested and have no capacity for expansion in the near future – an increase of 8% traffic and 21 airports in less than two years. So even though air traffic will double in the next 15 years, airport capacity will not.

Which means, that as demand for air transport continues to grow, we need huge step changes in aircraft design, operations and energy management to keep air travel comfortable, affordable and eco-efficient. All this, whilst still achieving the aviation sector's goal of halving its net carbon emissions by 2050.

That's why, working in consultation with industry stakeholders and experts, Airbus is taking a flight into the future, to better understand the needs and expectations of tomorrow's air travellers and global markets. What does a more connected world look like? What direct benefits will it bring? And most importantly of all, what do the passengers, operators, scientists, engineers and decision makers of tomorrow think?

Welcome to **The Future**, by Airbus. It is intended to spark debate, launch arguments and open the path for everyone to have a say in what they want from the future of air transport.

Join the debate. Contact us at: thefuture@airbus.com.

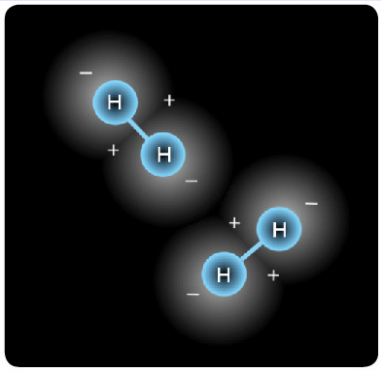
Future Energy Sources

The immediate challenge for aviation is the environment. Since the 1960s, commercial airliners have cut their fuel consumption and, therefore, their CO_2 emissions by 70%. Today, a passenger on board an Airbus A380 only uses 3 litres of fuel per 100 kilometres. But there's always room for improvement. And as the affect carbon emissions have on our planet becomes increasingly important, it is essential for the aviation industry to continue to find even more solutions.

The coming generations of aircraft will have to save every drop of fuel, before eventually giving up on fossil fuels altogether and moving onto new ecologically sound alternatives.

Airbus was one of the first companies in the aviation industry that saw a need for action in the development of alternative fuels and defined a strategy, involving major research programmes and test flights. This strategy is unique in that it takes a truly holistic, lifecycle approach, the same as for the company's lifecycle approach to environmental management, looking at every aspect from initial conception and production as well as land use and social, economic, geographic, cultural and resource issues.

And so to some of these alternative fuels of the future…



Hydrogen

The 'Cryoplane', fuelled by hydrogen, is a potential aircraft of the future.

Hydrogen is not a new fuel. It is a storage means for energy. The use of hydrogen is environmentally friendly because its only exhaust product is water.

We already know that aircraft can fly with hydrogen. The problem today's engineers face is that it is too voluminous, and above all, does not exist on earth in a pure form, so a lot of energy would have to be wasted to produce it. Fuel cells that use hydrogen and oxygen from the air to make electricity, sadly would not work for an aircraft. However, because they are quieter and non-polluting, they may replace batteries and power generators in the future.

In the long term hydrogen may not be the solution, but nuclear fusion, or perhaps superconductivity, could give us limitless environmentally friendly energy production.

Energy harvesting

Energy harvesting is another option for the future. We will no longer need to use energy that has been 'produced', rather it will be energy that has been 'harvested' from, for example, the heat your body gives the seat or bed in your cabin.

Solar power

Solar power is the epitome of renewable energy.

Just recently, The Solar Impulse aircraft, powered only by solar energy, triumphantly completed its first night and day flight. The ultra light aircraft was airborne for a total of 26 hours, fuelled entirely by solar energy.

But there is a limit to solar energy. And the question that leaves engineers scratching their heads now, is how to make that leap from the light aircraft we've seen make a major technological breakthrough today, to fuelling the passenger airliners of tomorrow?

If an entire aircraft were to be covered with 100 percent efficient solar panels, it would still not be enough to sufficiently propel a large aircraft. Even greatly increasing the output of photovoltaic cells wouldn't make an airliner fly. In the more immediate future solar power could provide electricity on board the aircraft once it has reached altitude.

But who knows what the future will bring!

Biofuels

It is biofuel that is currently being heralded as the fuel that will replace fossil fuels. Biofuels are any kind of fuel made from living things or the waste they produce, such as wood or straw**,** but in recent years, biofuel came to mean fuel made from crops.

Airbus believes that it is neither responsible nor sustainable to develop biofuels that compete with food resources, so our attention has turned to a second generation of biofuels known as **biomass**.

There are some 200,000 species of algae available for research into aviation biofuels. If you give certain algae seawater, sun and carbon (the same carbon we are trying to get rid of), they start growing and become a 'biomass' plant. The fact that a biomass plant thrives on CO_2 thereby reduces its carbon footprint during its lifecycle of growth. Biomass plants give out oil from which we can make a fuel very similar to present day kerosene. As they don't require fresh water or land used by agriculture, these biofuels – made from biomass – could well be one of the future possibilities for aviation.

Whilst it recognises that it won't be possible to produce significant quantities in the next decade, Airbus believes that biomass fuels could provide up to 30% of all commercial aviation jet fuel by 2030.

Unless of course a major scientific discovery comes along in the meantime and, once more, revolutionises our way of living and travelling!

Unlocking Transport Congestion

By 2050, on a far more densely populated Earth than today, there will be 4 or 5 times more aircraft in the sky. So, what good is designing aircraft that use less fuel, if we keep them flying round and round overloaded airports waiting to land?

Today, certain distances are maintained between aircraft for safety reasons. Tomorrow, thanks to the progress of navigation, surveillance and communication technologies, these distances could be greatly reduced. Aircraft could follow each other far more closely. They could even fly in formations, like migrating birds, in a sky managed harmoniously on a worldwide scale. Imagine the skylines of the future with V-formation flocks of aircraft flying silently, flying faster, but using less fuel!

But what good are more comfortable, eco-efficient aircraft if the passengers have to waste hours on end in crowded airports? The airports of the future will have to be much more practical than today…

Taking a plane could be as simple as taking the underground, with planes parking alongside a loading bay on which passengers are waiting, similar to a subway.

Alternatively passengers could be calmly pre-seated in modules (or capsule compartments) before the plane actually arrives. These compartments would be loaded onto the plane as it lands. Airbus engineers describe this as the 'Aircraft Pod Concept'.

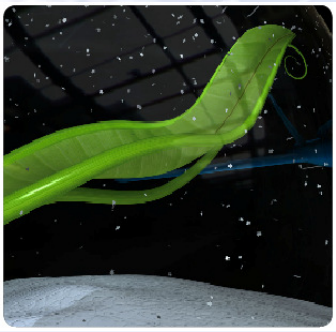
In fact, why should there be a distinction between aircraft and airport at all, because they are all part of an ensemble that transports people and goods?

New Cabins

The aircraft cabins of the future will be made up of components that could have several different states. Materials that can alter to suit the user on demand!

Just some of the options include:

Opaque or transparent walls
Materials of the future can include additional functionality that provides transparency ***on*** command, negating the need for windows. This smarter structure would help to make the aircraft lighter and more cost-efficient while giving the passenger 360 degree views of the skies. The planes of the future will offer an unparalleled, unobstructed view of the wonders of the five continents – where you will be able see the pyramids or the Eiffel Tower through the transparent floor of the aircraft.



Ecological materials

The future passenger cabin will of course be ecological. No more non-renewable materials like metal and plastic, but plant fibres, fully recyclable, that can be grown to the desired shape from responsible, sustainable resources.

Self-cleaning

Materials will be self-cleaning. Think of the leaves of a lotus plant, which water rolls off in beads, taking contaminants with it. Today this is already used on the surfaces of cabin bathrooms. In the future this will be found on the fabric of seats and the carpets on which we walk.

Changing shape

Materials that change shape and return to their initial shape, like the organs of living creatures, are a very real possibility. Such materials might be metals that have a 'memory'; or are covered with a 'skin' of material that carries a system that will instigate a shape change. A memory is created by providing materials with a certain level of intelligence. This means the ability to 'control', so a sensor system and an activator system exist within the material.

Self-repairing

These intelligence materials could well be self-repairing. Self-repair of this kind is already used today in surface protection. Certain paints can seal a scratch just as the human skin heals itself when scratched.

Composite materials

Future materials may not even be the materials we see and use today. 'Composite' materials will be used – which means something made of a combination of different materials. In the future materials may not event take a solid state, but could be a composition of fluid and gas for example.

Holographic technology

Perhaps you would prefer a private cabin… that can turn into an office… or a bedroom… or a zen garden? Or anything else you like, thanks to the projection of virtual decors. Holographic technology will have advanced to such a degree that the virtual world will be indistinguishable from the real.

So imagine, if you will, stepping in to your pre-selected themed cabin, relaxing into a perfectly clean, ecologically grown seat that changes shape to suit you and looking up through the transparent ceiling at the Milky Way in all its glory, at an altitude of 10,000 metres.

Biomimicry

In addressing the challenges of both the needs of a growing population and the needs of an increasingly fragile environment, nature itself might just hold some of the answers. Aeronautics engineers have been inspired by nature since Leonardo de Vinci first started drawing flying machines some 500 years ago. '***Biomimicry***' – the study and imitation of nature's best ideas to solve human problems – is still used today by engineers devoted to researching eco-efficient solutions to flight. A few have already been outlined in the previous pages, such as formation flying, the lotus effect or self healing skin, but there are many more beside and many more as yet undiscovered.

So the next huge step change in aviation might just come from caterpillars in someone's garden, the fly in their coffee cup or the plant in their local park. Unfortunately, it may also lie in a piece of rainforest about to be turned into a palm oil plantation, an area of ocean being damaged by pollution or a species being lost to hunting or alien predators. With 30% of known species currently under threat, we run the risk of destroying the answers that we are searching so hard to find.

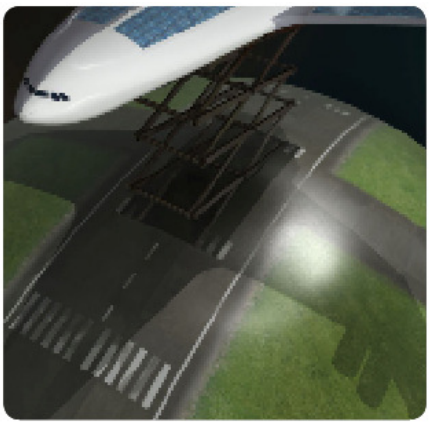
Flexibility – Travel to Suit You

The motto of tomorrow will be flexibility. In the future there will be so many different ways to fly.

For your personal travel, not far from home, you'd choose your own vehicle – perhaps the much-vaunted 'flying car'. But as soon as you want something more economical or faster for longer distances you'd need something else that allows for mass transportation. So your 'car' of the future could be a capsule you keep in your garage, then drive or fly to dock onto an enormous 'mother ship' that takes you to your final destination.

But what about ground-space? How do we avoid sprawling airports and extending runways?

Vertical take-off would be one way of gaining space in cities.



We could have flying aircraft carriers for our long distance flights, which circle the globe and on which small aircraft can dock.

In the middle of this century, telecommunications will be so perfect that we will have to travel far less for our work. On the other hand, it will be easy to work… as we travel! Communication technology will be as accessible on a plane as it is in an office. But it still won't replace the benefits of face-to-face meetings, the sensation of holding a new grandchild or the excitement of visiting a new country for the first time. Telecommunications will never replace the sights and sounds of real travel.

We will want to arrive at our destination in ever shorter time frames, whatever the distance: so will anyone bring back 'The Supersonic Plane'? Or perhaps we'll see the 'Hypersonic Plane', which would travel above the atmosphere and reach Australia, for example, in just two to three hours.

Unless we decide to take our time and enjoy a trip with every comfort: swimming pools, spas, tennis courts etc. The next generation of air tourism will be 'cruise ships of the sky' with packages to suit the individual. And on these flying palaces, that will make their money from casino takings, restaurants and other attractions, the ticket may even be for free!

Travel in the future will be about choice. You will be able to choose if you want fast travel, luxury travel or basic leisure travel. To make this choice you could be assisted by a personal cyber assistant that is always around you, knows what you want and what you feel and will make the travel booking according to your personal preference.

The final frontier will be space. We are already seeing the first serious steps towards space tourism today, but an orbital space station could become the ultimate holiday destination. Experience the joys of weightlessness… and the unrivalled view of our very own Earth, the planet that we have been able to preserve in all its splendid diversity.

The Airbus Concept Plane

We've looked at a multitude of visions: the Supersonic Plane, the Hypersonic Plane the Cryoplane and the Cruise Ship of the Sky, to mention but a few.

But Airbus' experts in aircraft materials, aerodynamics, cabins and engines have also come up with the design that is an 'engineer's dream', to meet the expectations of the passengers of the future. More than a flight of pure fantasy, The Airbus Concept Plane illustrates what air transport could look like in 2050 – even 2030 if advancements in existing technologies continue apace. Ultra long and slim wings, semi-embedded engines, a U-shaped tail and lightweight intelligent body all feature to further improve environmental performance or 'eco-efficiency'. The result: lower fuel burn, a significant cut in emissions, less noise and greater comfort.

It's not a real aircraft and all of the technologies it features, though feasible, are not likely to come together in the same manner. It is designed to stretch engineers and push thinking beyond the usual boundaries. The Airbus Concept plane includes the following technological advances:

- ***Longer and slimmer wingspan*** - It is configured with high aspect-ratio wings (ultra long and thing) to better glide through the air. They also improve fuel efficiency and the flow of air over the surface of the wing to reduce drag and fuel burn.

- ***Intelligent materials*** – It is built using new lightweight 'smart' materials that sense the load they are under. This will make a lighter aircraft and reduce both fuel burn and emissions.

- ***Manufacturing methods*** - New manufacturing methods will reduce the cost of building the aircraft in spite of the new advance materials and complex shapes.

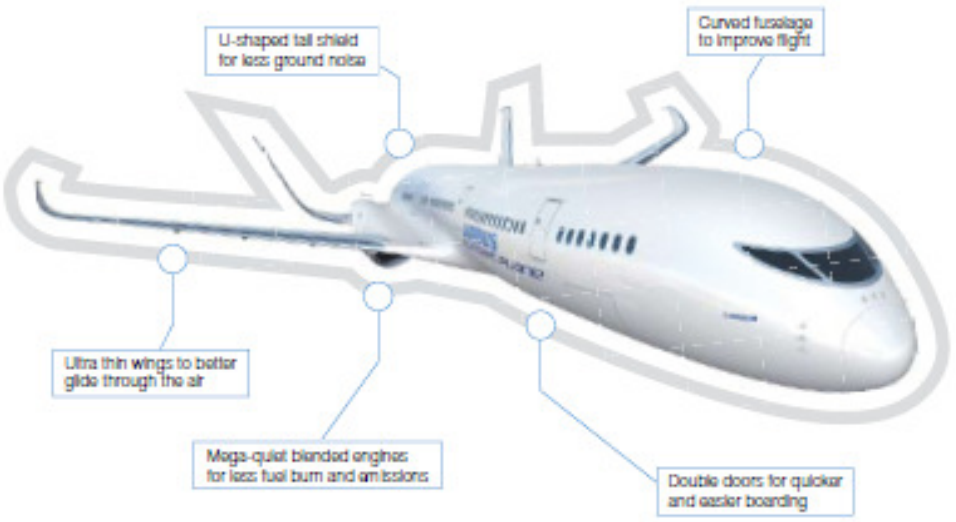
- ***Engines*** – The engines will be more reliable, quieter and fuel-efficient. They are installed at the rear of the aircraft, far from the cabin, which increases cabin comfort (lower noise levels). It is also more quiet externally thanks to the shielding from the empennage (tail surfaces). The positioning of the engines, at the rear and semi-embedded, fully optimises the aircraft for lower fuel burn. They can be semi-embedded because advances will have reached such a level that engine reliability will diminish the need for easy access.

- ***Fuselage*** (central body of the aircraft) – The fuselage of the concept plane is not a simple tube, but is curved and shaped to provide more space inside for new cabin configurations in specific areas, with better aerodynamics outside to improve flight. It would be an all-composite aircraft to take advantage of composite's ability to be shaped efficiently during manufacture.

- ***Doors*** – The entrance doorways will be built as double doors, for faster access to ensure quick and easy boarding.

- ***Empennage*** (tail section of the aircraft) – The aircraft has a U-shaped tail that acts as a shield to reduce noise. The concept plane does not include a vertical tail, as seen on the planes of today - required because engines are installed on the wings, so it is needed for directional stability in case of engine failure. The engines of the future will have no risk of failure, so can be placed at the rear and remove the need for a vertical tail.

- ***Electrical systems*** –The aircraft will continuously monitor its own state of health, predict any need for maintenance and automatically schedule this well in advance. The electronics and other systems on board will be very reliable, needing minimum or zero maintenance.



Conclusion

Inspiration in our industry is a two-way affair. Engineering concepts such as these are developed as part of Airbus' ambition to help inspire future generations to fall in love with the world flight can unlock. But Airbus is also looking to young people – to the passengers, crews, engineers, scientists and decision makers of the future - to inspire them; taking their vision of the future of air travel and making it come true.

Over the next 40 or 50 years air travel will continue to facilitate social and economic growth, creating jobs, driving investment, productivity, cultural exchange, social development and economic enrichment. It must do all of this however whilst still contributing to a more sustainable world.

Air travel, Airbus and the aerospace industry has an exciting future ahead of it. Unlocking this future will require new levels of inspiration, innovation and investment. Above all it will require a shared vision of the future, so that the next 40 years sees everybody working together towards a better, more connected and more sustainable world for all.