REVOLUTIONISING AIR TRAFFIC MANAGEMENT

Practical steps to accelerating airspace efficiency in your region

ATAG
AIR TRANSPORT ACTION GROUP

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ACKNOWLEDGEMENTS

WELCOME TO THE FUTURE OF ATM

For the last 80 years, the world's air traffic controllers have been safely guiding our flights through the skies using some fairly familiar tools – radar, radios and little strips of paper to keep track of the flights. The job is a complex and stressful one. It requires the controller to think in three dimensions of space and keep track of aircraft carrying hundreds of people, moving very fast and often in crowded airspace. But over the last few years, there has been a steady evolution in the way we think about air traffic control. And it is allowing more capacity into the airspace, with even safer operations and reduced fuel use.

BY **PAUL STEELE**, EXECUTIVE DIRECTOR OF THE AIR TRANSPORT ACTION GROUP

Since the aviation industry first started needing controllers to track aircraft movements in the early 1930s, the introduction of any new technology or operational procedure has been undertaken in a very systematic way and often quite slowly. Safety is our prime consideration and aviation is a cautious industry. We make changes to our operations carefully and after a lot of testing and consultation. It's one of the reasons why we are the safest form of travel. But we are also a very innovative sector and for the last few decades, the technology developments on board our aircraft have often outpaced those in the air traffic control centres. We are now flying jets produced in the 21st century along routes that were, in some cases, defined by the placement of radar stations in the 1940s and 50s. Automation, which has been in use on aircraft since the 1980s is only now coming into use in air traffic management.

This is leading not only to capacity constraints, but also means that the efficiency of aircraft operations is not as good as it could be. So, around the world, technology, collaboration and innovative new concepts are leading to a shift away from air traffic 'control' to air traffic 'management'. The aircraft – and the people that fly them – are being given more decision-making authority over the speed and exact route of their flight than before. They can use the many new navigation and fuel-saving techniques available to them, while increasing the capacity of the skies. However, such capacities are not yet being fully exploited and much more can be done in this area.

Improving aviation efficiency is no longer an option but an environmental and business

necessity. As fuel now accounts for over one third of the operational costs for the world's airlines and the aviation industry works to find additional ways to reduce its carbon emissions, air traffic management plays an important role. And while new aircraft are becoming ever quieter than their predecessors, new techniques in air traffic management are also allowing for less of a noise impact on the communities around airports.

Air traffic management and planning are not areas in which the industry can act alone. With issues of airspace sovereignty and military restricted airspace, not to mention the fact that most air navigation service providers are state-owned, governments must also play a key role in this evolution. While a lot of the work that the industry can do by itself is technology-related, much of the real change can only occur when the institutional arrangements that govern air traffic control are reformed.

Current governance restrictions and regulatory capabilities are holding back the ability for air navigation service providers

to respond to change. In turn, the ability for aviation to grow and help support national economies is also being constricted. This publication outlines some of the projects in which the industry has been collaborating, to provide an example of what is possible. We then suggest key steps that could be taken to further develop the new paradigm of air traffic management, thereby taking full advantage of the benefits that shift could bring to economies, to the capacity of airspace, safety and the environment. We have carried out a lot of this work within the industry. But there remains a lot of work to be done that is not wholly within our control. Many things we would like to do require government action too. These opportunities are frequently win-win situations, so it is time we grasped them with both hands and made air traffic management as efficient as we know it can be.

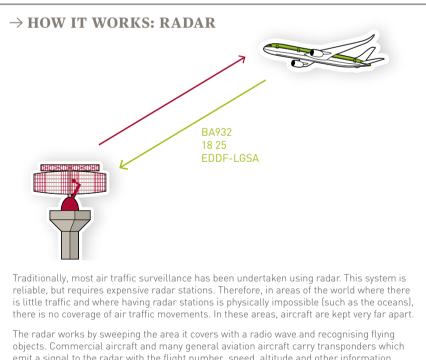Here's how…

AIRSPACE EFFICIENCY 101

Every day, over 100,000 flights take off at airports across the world. Some are short hops to nearby destinations; some flights cross the oceans, but all have to fly in the same sky. It is estimated that up to 8% of all aviation fuel is wasted as a result of inefficient routes that aircraft have to fly. But evolutionary change in the global air navigation services industry, brought about by new technologies and new techniques, which is already having a profound impact on the way increasing numbers of aircraft are handled, more safely, more efficiently and more environmentally-responsibly than in the past.

The industry can only drive this change so far – governments need to reconsider the current State-based approach to air navigation services provision:
• to allow for cross-border arrangements;
• to improve civil-military cooperation for a more flexible use of the airspace; and
• to establish effective regulatory practices that will allow new and more efficient ATM operations to pass the necessary safety assessments.

The vision of seamless and fully-efficient air navigation services will only be achieved if governments take the necessary policy and legislative initiatives to allow the industry's technological and procedural advances to generate meaningful benefits in terms of fuel and CO_2 savings.

Until recently, air traffic has been managed by routing aircraft into narrow, pre-determined routes – much like highways in the sky – originally developed to meet the domestic airspace requirements of countries and often defined by the location of ground-based navigational aids. This has meant that the typical route between two airports has rarely been a truly fuel-efficient path. In fact, it is very unlikely that the global air traffic management system will ever be 100% efficient. True efficiency is a single aircraft being able to take off, climb, cruise, descend and land by using the route that takes the least time. In a zero wind situation, the ideal path is the great circle route, but the atmosphere is composed of many 'rivers' of air that affect the most efficient path. And there will always be elements that get in the way of true efficiency – weather, closed military airspace and the biggest of all – congestion of other traffic.

The Civil Air Navigation Services Organisation (CANSO) estimates that the current air traffic system is operating at 92% to 94% efficiency, on an average global basis (with some significant regional variations). They have set a goal to reach 95% to 98% efficiency by 2050 – the likely limit of possible efficiency due to the factors mentioned above. However, while it appears we are close to the goal now, it must be remembered that each year's growth in air traffic adds to the inefficiency, thus making efficiency gains harder to reach. If we do nothing, in a "business as usual scenario", the system is going to get less and less efficient – this why a revolution in the global air traffic system is needed.

An institutional framework of the 1940s
The current air traffic control structure has its roots in the early days of commercial flight. As more aircraft started sharing the skies, a control mechanism was needed to keep them safely apart. And as these aircraft started flying across borders, controllers were needed around the world. The International Civil Aviation Organisation was formed in 1944 following the signing of the Convention on Civil Aviation (often referred to as The Chicago Convention), which formed the basis for national governments establishing air navigation service providers. Article 28 outlines the obligations:

Each contracting State undertakes, so far as it may find practicable, to:

→ HOW IT WORKS: RADAR

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Traditionally, most air traffic surveillance has been undertaken using radar. This system is reliable, but requires expensive radar stations. Therefore, in areas of the world where there is little traffic and where having radar stations is physically impossible (such as the oceans), there is no coverage of air traffic movements. In these areas, aircraft are kept very far apart.

The radar works by sweeping the area it covers with a radio wave and recognising flying objects. Commercial aircraft and many general aviation aircraft carry transponders which emit a signal to the radar with the flight number, speed, altitude and other information. Today, most long-range radar dishes take 12 seconds to rotate. So, air traffic controllers must wait 12 seconds for aircraft positions to update (near airports, with faster-turning radars, the updates are every 5 seconds). For a normal aircraft, this means the plane can have moved over half a nautical mile each time it is 'pinged' by the radar. To compensate for this time lag, controllers must maintain wider separation between aircraft. This decreases the useable capacity of airspace.

a) Provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention;

b) Adopt and put into operation the appropriate standard systems of communications procedure, codes, markings, signals, lighting and other operational practices and rules which may be recommended or established from time to time, pursuant to this Convention;

c) Collaborate in international measures to secure the publication of aeronautical maps and charts in accordance with standards which may be recommended or established from time to time, pursuant to this Convention.

This system, where each nation provides air traffic control services for its own territory, has served the industry well for many decades. But, as the importance of air transport continues to grow, the system which has provided a reliable and safe service to passengers and airlines will struggle to cope with the increase in traffic and the flexibility required by modern air transport.

The growth challenge

The number of aircraft in service is expected to double by 2030. This growth can only be accommodated safely if the 'control' paradigm evolves into an efficient air traffic 'management' (ATM) system. This requires re-designing the ATM system around the performance of the flight itself, with controllers managing the optimised use of airspace rather than taking 'hands-on' tactical control of each flight. Once implemented worldwide, 21st century aircraft will fly in a 21st century air traffic system, instead of one that has its origins in the 1940s. This will allow controllers to

handle more aircraft at any one time while improving the levels of safety and reducing delays.

There are two mutually-important ways in which air navigation can be made more efficient:

1. Technology and new operational structures that will change the way air navigation service providers interact with the flights they are guiding through the skies.
2. Governance of the air navigation infrastructure itself, away from a State-run service where practicable and towards a liberalised, commercial-oriented service provider run privately or through State operation under strong business-centric management.

Technology and operational efficiency

This publication will be taking a look at some of the technology and operational innovations being deployed in air navigation around the world. They provide a useful picture of what can be achieved when collaboration and the best in technology come together. The case studies in this publication form part of a broader global picture, where ICAO is working with States and the industry to roll-out new technology on a global basis (see 'tying it all together' on page 19). It will go a long way to building the air traffic system of the future.
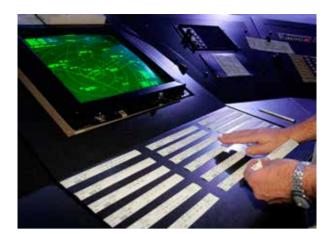
For example, the operational implementation of new technologies based on automated data-links (much like text messages between phones) for communications, navigation and surveillance. These technologies allow the aircraft to fly within a global framework of information systems, rather than relying on voice communications between pilots and air traffic controllers. In this framework, aircraft can dynamically change their direction and altitude to exploit prevailing

weather and traffic conditions, with air traffic controllers undertaking an 'oversight' role, rather than tactically controlling each flight's path through the skies.

It is also vital to treat ATM not as a national but as a global operation, with interoperable automated technologies and procedures, many of them based on satellite data-links. A fragmented airspace is an inefficient airspace; each time an aircraft currently crosses a national boundary, the workload in the flight deck and the control room rapidly increases and the different national zones cannot work as efficiently as a single airspace. The new ATM system will automate many of the current pilot and controller tasks.

States have a vital role to play in supporting the introduction of new technologies and procedures. First, in providing funding for research in new technology. Some States do provide funding (such as SESAR in Europe and NextGen in the USA) but in most countries it is industry that invests and these costs are ultimately passed on the users. Secondly, it is one thing to have the technology, it is quite another to be able to use it. States and their institutions such as ICAO have a role to play in setting standards and in designing and approving the procedures.

Institutional arrangements

While the technologies are currently available for many of these efficiencies to be achieved, there is a major hurdle to their implementation: the governance structures of many air navigation service providers. There are around 200 air navigation service providers (ANSPs) worldwide. Europe has nearly 40 of them alone. Their business model can range from military providers, to government departments and agencies, corporatised (but government-owned) entities, public-private partnerships, and completely private operators. The fragmented, and oftentimes bureaucratic

approach to service provision will not be able to fully realise the efficiencies that are needed from the next generation of air traffic control.

The key step most governments will need to take in the coming years will be to recognise air traffic management for what it is – a service to the world's airspace users, ranging from airlines and their passengers, to air cargo, business aviation, military and general aviation. Air traffic management, as a part of the aviation industry, needs to be seen as a critical enabler of the global economy and should be regarded as a business that needs the freedom to operate. That freedom must come from a more liberalised attitude to ownership and governance arrangements. Consolidation of ANSPs, particularly in areas of crowded airspace such as Europe, Central America and South-East Asia, will be a vital pre-requisite to making the most of the efficiencies that technology can bring. It should also open up access to financing for the deployment of new technology, and investment decisions that are free from political interference.

Traditionally, many ANSPs have been both regulator and service provider. The regulatory oversight function should be separated from service provision and must be independent and transparent. The separation of these two functions is just good governance, after all, the regulated should not regulate themselves. Separation of the two functions is now becoming more commonplace and is now a legal requirement in Europe. And in States where the regulator of civil aviation does not have the expertise or experience to provide oversight (particularly as advanced technology begins to be deployed), new models of industry and government cooperation can be explored, or regional oversight agencies can be established. Experience has shown that separation of an ANSP from the government bureaucracy can enhance ATM performance.

There are excellent examples of corporatised and privatised ANSPs providing real value to their customers – the airlines and other airspace users – and bringing about the innovative approaches needed for today's air traffic management. In cases where the State still performs air traffic control, adoption of a corporatised, business-oriented approach to management has also brought such value.

However, the vision of seamless global airspace is unlikely to be achieved if the proliferation of ANSPs around the world continues. Governments need to take a radical fresh approach to service provision. Instead of each State having its own ANSP, States can delegate service provision to other States and designate a service provider to provide service coverage for a larger airspace. This is not a new concept. In 1959, the Agency for Aerial Navigation Safety in Africa and Madagascar (ASECNA) was formed. This single ANSP provides services to an area covering 17 countries and is over 1.5 times the size of Europe. And, we are starting to see some other States take advantage of the efficiencies and cost savings that such a model can bring. For example, Denmark and Sweden have joined forces to produce one joint airspace.

States can also improve ATM efficiency by reviewing the ways they reserve certain airspace for military use. While recognising a State's military and security needs, huge tracts of airspace are often permanently reserved for the military but remain idle for much of the time. Governments can take steps to allow proper coordination and the flexible use of this airspace, which should be seen as a common and shared resource.

This publication outlines the ATM technologies and operational changes that can have a very real impact on the safety, efficiency, and environmental performance of air transport. However, in order to fully

realise the great benefits that lie ahead, the institutional arrangements for air navigation services provision will also need to change. And for this to happen, governments have to act.

→ **CASE STUDY**

Managing the flow, collaboratively
Airways New Zealand has been using Collaborative Flow Management (CFM) to manage aircraft arrivals at its key international airports. CFM in New Zealand uses ground delays to manage terminal area congestion at the destination airport, similar to the US and Europe. By using the flow management process, aircraft do not leave the departure airport until they have been given an exact time of arrival at the destination airport, therefore allowing flight at the optimum speed and no need to hold before landing. The difference is that in New Zealand the calculated arrival times are used throughout the flight. These times are transmitted to aircraft operating companies between two and three hours prior to departure. The Controlled Time Of Takeoff and Controlled Time of Arrival are established through an online 'reservation' system based on the latest flight plan information as modelled by the ATM system and the declared capacity for the destination airport, as determined by the ANSP. The airline operations team can manipulate their fleet times to prioritise or optimise the management of their network but cannot manipulate other flights without mutual agreement between the operating companies and approval of the CFM coordinator. The optimised departure times are provided to aircrew by their flight operations team using cockpit communications system or pre-departure messages no later than 25 minutes prior to departure but these can be modified and updated prior to take-off. Once the flights are airborne, the aircrew is required to conform as closely as possible to the filed flight plan.

THE COST OF NO ACTION

The need to modernise and streamline the global ATM system is clear. The benefits will be seen in a number of areas: capacity improvements, environmental savings, cost reductions, fewer delays and the continuous improvement of today's renowned safety in air transport. The benefits, however, do not just accrue to the airlines and the people who fly with them. By investing in a solid future for air transportation systems now, governments will be setting course for future growth of the global economy.

Air transport supports nearly 57 million jobs around the world and $2.2 trillion in global economic activity. If it were a country, the aviation sector alone would be the 19th largest economy in the world, around the same size as Switzerland. The trade that aviation supports is valuable and the jobs the sector provides are 3.5 times more productive than average jobs in the economy. It is worthwhile to note that the areas of economic growth that aviation helps drive – high-tech manufacturing, high-value produce and service industries such as tourism – are areas that will continue to provide the stimulus for economic development around the world.

In a recent study for the Air Transport Action Group, Oxford Economics forecast that by 2030, over 82 million jobs and $6.9 trillion in economic activity would be supported by air transport, based on current growth rates. A lot of that growth is taking place in the emerging markets and developing economies of the world. But the growth is not guaranteed. While forecasting such long-term trends is difficult, Oxford

Economics undertook a sensitivity analysis of future growth in passenger and cargo traffic. For example, should growth in passenger and cargo traffic be just one percentage point lower during the period 2010-2030, then in 2030:

• The total number of jobs supported by the air transport sector would be over 14 million lower than the base forecasts.
• The direct, indirect and induced contribution of the air transport sector to world GDP would be $646 billion (2010 prices) lower, with an additional $542 billion lost through lower tourism activity.

While airlines are notoriously susceptible to financial constraints impacting their growth (and bottom line), the lack of capacity in the air traffic management system could impede air traffic growth and its knock-on benefits to the global economy.

Capacity improvements
Air transport and its importance to modern life is growing. From today's 26 million

commercial aircraft movements, it is expected that by 2030 the number of flights will almost double to 48.7 million. In addition, there are general aviation and military movements to consider. Passengers will also be travelling further. In 2010, over 4.8 trillion passenger kilometres were flown by airlines (one passenger flying one kilometre is a 'passenger kilometre'). By 2030, forecasts suggest that 13.5 trillion passenger kilometres will be flown. But the airspace is not getting any bigger and there will not be a huge number of airports built to accommodate this growth, so the system must increase its efficiency to deal with the challenge.

In Europe and North America, congestion has already been causing constraints to growth for a number of years. One of the causes is the need to keep aircraft at sufficiently safe distances from one another due to the lack of accuracy of legacy air navigation technology. The system is very safe, but it is not as efficient as it could be. The impact of congestion is likely to be repeated in developing economies as

their air transport industry grows to meet the demands of burgeoning middle class travellers. The effects are already being felt in the airspace over the Gulf States and the Pearl River Delta. However, a number of these rapidly-developing air transport markets should be able to make the most of early access to new technology, enabling them to see the benefits of more advanced airspace management without having to suffer the economic impact of congested airspace.

Unlike the improvement projects in the United States or Europe, within Asia there is no overarching legislative framework to operate within and drive change. There is, however, a clear vision for a Seamless Asian Sky emerging. This foresees not a single sky as in Europe, but a system of information exchange and coordination between air navigation service providers, which would allow for far greater efficiency. This is particularly critical in a rapidly growing market such as Asia, where a failure to stay in front of the capacity curve will directly impede growth and economic expansion.

Capacity planning on the ground is also a crucial part of the system. Runways and airport congestion can lead to delays in the air as well as on the ground and sufficient planning for new infrastructure is vital. China is leading the way, with 82 airports scheduled for construction between 2011 and 2015 alone[1]. While China is an extreme example, it also points to the necessity of good long-term planning of such infrastructure.

Fewer delays, less lost time, benefiting the entire economy

According to GE Aviation, if a certain landing technique, called required navigation performance or RNP (see page 10), were deployed immediately at 46 mid-size regional airports across the USA, airlines (and, more importantly,

passengers) would benefit from 747 fewer days' worth of flying unnecessarily long landing approaches[2].

In one of the most congested pieces of airspace in the world, the Greater New York area, the total value of the lost time absorbed by the travelling public due to air traffic congestion was estimated to be worth $1.7 billion in 2008 alone[3]. When adding the losses in fuel and staffing costs borne by the airlines, as well as the delays to shipping companies, over $2.6 billion in lost economic activity occurs in one year alone. The Partnership for New York City has projected that the cost of congestion will total some $79 billion between 2008 and 2025. In addition to the losses incurred by those using the system, it is estimated that the knock-on effects on other parts of the economy will result in 5,600 fewer full-time jobs and $16 billion in lost output over the 18 year period.

That was in one metropolitan region. An FAA-sponsored study in 2010 on the impact of air traffic delays across the USA found that in 2007, there was a $32.9 billion cost related to congested airspace, of which $4 billion was in lost economic activity to the wider US economy[4]. In fact, in a 2011 study looking at the benefits of introducing next-generation air traffic management systems around the world, Deloitte found that of the $135 billion annual benefit of moving to better air traffic systems, 30% accrued to the 'overall economy' (with airlines benefiting from 31% of the savings, air navigation service providers (ANSPs) 5% and passengers 34%)[5].

In Europe, too, the Single European Sky is expected to lead to significant and widespread benefits for the European community. The current, fragmented, operation of the European airspace leads to an estimated €5 billion additional cost

to airspace users per annum, as well as around 100 million hours of delay to passengers and 8.1 million tonnes of additional CO_2. Members of the European Parliament voted in favour of a resolution in October 2012 that highlighted, if there is a 'full and timely deployment' of the SESAR technology for the Single European Sky, "there could be a cumulative impact on [European Union] GDP of €419 billion during the period 2013-2030… with 328,000 jobs being created directly or indirectly and a net saving in CO_2 emissions of some 50 million tonnes"[6].

Environmental benefits

It is a clear objective of the aviation industry to reduce its environmental impact. Through the United Nations Framework Convention on Climate Change and the International Civil Aviation Organization (ICAO), governments around the world have committed to reduce carbon dioxide emissions from human activities – and in aviation, there is a direct correlation between saving fuel and reducing emissions. In 2009, the aviation industry agreed a set of ambitious targets to reduce carbon dioxide emissions as part of its commitment to action on climate change. Even though the air transport sector produces 2% of man-made CO_2, it is a rapidly growing industry that recognises that the threat of climate change must be confronted by all industries.

Fuel is also the largest operating cost of airlines, currently totalling over 30%. These two incentives – to reduce CO_2 emissions and reduce fuel consumption – have led to a series of aggressive cross-industry targets. These have gained quick recognition throughout the industry and beyond:

1. To improve fleet fuel efficiency by 1.5% per annum between 2009 and 2020

2. To stabilise net CO_2 emissions from aviation from 2020 through carbon-neutral growth
3. To reduce net CO_2 emissions from aviation by half by 2050, as compared with 2005

The industry is embarking on a four-pillar strategy to achieve these targets through new technology (including the deployment of sustainable aviation biofuels), operational improvements, infrastructure efficiency gains and appropriate market-based measures. There are collaborative projects underway throughout the industry, some of which are outlined in this report, that are helping to meet these targets. However, meeting these targets also requires governments to do their part – through air traffic management improvements and technology and operational measures under their control.

While it will take all available efforts to achieve these goals, it is a waste to have very efficient aircraft technology if the aircraft is then forced to hold above

Expected savings per year if air traffic management systems and technology on board aircraft were optimised

5 million
hours of excess flight time per year based on 30 million flights per year

$1.5 billion
Saved globally if every flight was a minute shorter

9 million
tonnes of fuel per year

28 million
tonnes of avoidable CO_2 emissions per year.

35%
of global flights

✈ 1.8m
⛽ 3m

28%
of global flights

✈ 1.4m
⛽ 3m

1.3m
⛽ 2m

22%
of global flights

2%
of global flights

✈ 0.1m
⛽ 0.2m

✈ 0.4m
⛽ 0.6m

7%
of global flights

✈ Hours of flight saved
⛽ Tonnes of fuel saved

Research conducted by Airbus in 2012 reveals just some of the significant benefits available by modernising the air traffic system.

1977 1992 2007 2022

Global air traffic has doubled in size once every 15 years since 1977 and will continue to do so. This growth occurs despite broader recessionary cycles and helps illustrate how aviation investment can be a key factor supporting economic recovery.

→ **CASE STUDY**

Greener skies over Seattle
Alaska Airlines prides itself on being the leader in fuel efficiency among the 10 largest US air carriers. Working in partnership with the FAA, Boeing, Jeppesen, and the Port of Seattle, Alaska Airlines developed a project in 2009 called 'Greener Skies' to fly new types of Required Navigation Performance approaches into Seattle-Tacoma (Sea-Tac) International Airport. With Boeing and Jeppesen, they designed prototype procedures for shorter continuous descent approaches to Sea-Tac to remove intermediate level-offs and create shorter downwind legs, thus saving several hundred pounds of fuel.

The procedures were first demonstrated in June 2009 on a non-commercial flight. When implemented on commercial flights, they achieved savings of between 90 and 180 kg per flight. Alaska estimates annual savings of almost 6,500 tonnes of fuel and reducing CO_2 emissions of over 22,000 tonnes. In addition to fuel savings, these approaches reduce noise over populated areas during the continuous descent and as the aircraft fly over fewer communities during their shorter approach.

An industry team led by Alaska Airlines recommended that the FAA institute these procedures nationwide. The FAA agreed and 'Greener Skies' became a national initiative in late 2011. Currently, Boeing and industry partners – including Airbus and Quovadis – are working together with the FAA to develop new standards to implement precise RNP procedures for airports with multiple runways, to better manage traffic and capacity in busy airspace, reduce fuel consumption, emissions, and noise for a more efficient and green global airspace.

overcrowded airports or fly circuitous routes because of congestion. The environmental benefits of shifting towards a more efficient air traffic system are significant. In Europe, by implementing the Single European Sky, average fuel consumption per flight could be reduced by up to 10%. And, despite the additional flights that will use the system as capacity constraints are reduced, it is thought that between 2013 and 2030, projects implemented by the SESAR technical programme to introduce the Single European Sky would save around 50 million tonnes of avoided CO_2[7].
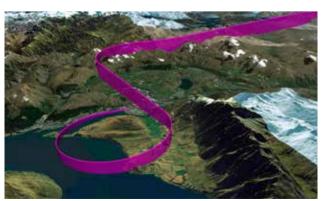
A number of these new technologies and operational procedures can have an impact on the amount of noise experienced by airport communities too. With much more accurate navigation, flights can be routed around communities, land using steeper descents or with engines on idle to limit noise impacts for those living near airports.

Cost reductions to airlines
In 2011, over $176 billion was spent on jet fuel by the world's airlines – the number one operating cost. The GE Aviation analysis of RNP implementation at 46 regional airports in the US suggests that

implementing this one technology will save airlines $65.6 million in fuel costs.

In a trial implementing ADS-B systems (see page 12) along just two routes in the South China Sea, the three ANSPs involved – from Indonesia, Singapore and Vietnam – have worked together to share data and coordinate operations. A cost benefit study released by CANSO and the International Air Transport Association (IATA) indicates that by introducing the new processes on these two routes, there will be annual savings of around 1,300 tonnes of fuel (or 4,500 tonnes of CO_2) with an annual cost reduction of $4 million dollars. This trial is being expanded to include two more routes and ANSPs in the Philippines and Brunei[8].

Consolidation of the air traffic control infrastructure can also lead to reductions of the user fees that airlines pay for air navigation services. Europe's 37 ANSPs operate around 65 area control centres (ACCs) each duplicating the task of its neighbour. By contrast, over an area roughly the same size, the US has 20 ACCs, which it is working to consolidate. Russia's plans are more impressive; it is consolidating its centres from 118 to 13 over an even larger area.

Required navigation performance procedures at Queenstown Airport in New Zealand have saved fuel and emissions for flights into this challenging airport.

Potential benefits of RNP

GE Aviation has calculated the potential savings if RNP approaches (see page 10) were standardised at just 46 regional airports in the USA. This is one operational procedure in one country and is based on current traffic figures. The savings are significant.

17,928 hours of avoided delays

$65.6 million savings for airlines

39 thousand tonnes of fuel saved

124,556 tonnes of CO_2 saved.

Fragmentation of the control space means that aircraft fly longer routes due to increased pockets of restricted airspace. This makes traffic flow management more complex, makes civil-military cooperation more difficult, and leads to delays, lack of capacity and increased costs to airlines which have to pay for the infrastructure. Eventually, if demand continues to rise, this will also have safety implications. The overall economic cost of fragmentation in Europe alone is estimated at $1.3 billion per year. This figure is in addition to the nearly $4 billion per year wasted through avoidable delays and 429 million unnecessary flight kilometres.

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Maintained and improved safety

Flying is the safest form of travel. One of the ways in which the industry has maintained an impressive record is by being ultra-cautious about flight operations and the introduction of new technology into daily use. But new equipment such as satellite surveillance and a number of the technologies outlined in this publication have now reached a level of maturity to appropriately support air traffic navigation. By having greater visibility of aircraft locations at all times, air traffic controllers can be more confident about using more of the available airspace for operations.

Aircraft can now fly closer together and capacity can increase substantially, without affecting the safety of operations. In fact, in some regions of the world (such as Africa and Central Asia), these new technologies and the culture change required in the new world of ATM will enable significant improvements in aviation safety.

The technology is available and can start being deployed today. The risk of delay for both the deployment of new technology and changes in the governance of ANSPs is a lack of growth – both in air transport and in the wider economy. This publication can help move all partners, together, in the right direction to achieve the benefits that a truly efficient air traffic system can bring.

none→ **CASE STUDY**
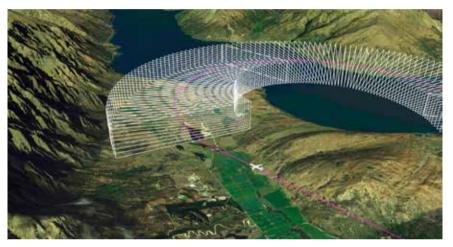
RNP PROCEDURES PAVE THE WAY

As air traffic continues to increase, current air traffic management (ATM) systems will not be able to keep up with demand. Today's obsolete airspace infrastructure relies on radio-based navigation aids which restricts aircraft to flying indirect paths over ground-based radio beacons. Inefficiencies stemming from this create unnecessary fuel consumption, excess carbon emissions, longer flight times and increased noise impact. Required Navigation Performance (RNP), which benefits from new navigation technologies, especially satellite-based systems, is one way in which to alleviate this waste while reducing flight delays and air traffic congestion.

RNP technology allows aircraft to fly precisely-defined paths without relying on ground-based radio-navigation signals. The paths can be deployed at any airport, allowing aircraft to fly predictable, repeatable paths with an accuracy of less than a wingspan. This precision enables pilots to land aircraft in weather conditions that would otherwise require them to hold, divert to another airport, or even cancel the flight before departure. In addition, RNP paths can be designed to shorten the distance an aircraft has to fly en-route, reducing fuel burn, CO_2 emissions and noise pollution in communities near airports. Because of RNP's precision and reliability, the technology can help air traffic controllers reduce flight delays and alleviate air traffic congestion.

RNP technology defines a precise 'tunnel' through which an aircraft is programmed to fly.

GE Aviation's performance-based navigation (PBN) Services team has been deploying RNP at airports around the world since 2003. In January 2007, Airservices Australia, Qantas, the Civil Aviation Safety Authority of Australia and GE collaborated on the Brisbane Green Project – the world's first integration of RNP into a busy terminal environment. The purpose of the project was to determine the most effective way to integrate RNP at a busy international airport supporting mixed (RNP and conventional) operations.

The first year findings reported a savings of 10-24 track miles and 90 gallons of fuel per approach compared to the conventional procedures; over 15,500 RNP procedures were conducted including more than 8,000 approaches.

In the first 18 months of the project, Qantas saved approximately 125,700 gallons of fuel, 1,100 tonnes of CO_2, 17,800 track miles and 4,200 airborne minutes. Non-RNP aircraft also benefited through reduced delays resulting from shorter arrivals for RNP aircraft. With success in

Brisbane, Qantas continued to expand its RNP network to other Australian airports.

When RNP procedures were implemented at Ayers Rock, Broome, Kalgoorlie, Karrathe and Mt. Isa, the airports saw an average savings of up to 25 gallons of fuel and 250 kg of CO_2 per approach, over conventional procedures. In Canberra, the community reported a 10 dBA reduction in noise (this equates to approximately 50% reduction in perceived noise) due to the new curved flight paths that guide the aircraft around the populated areas.

RNP procedures were also implemented at Queenstown, New Zealand, one of the most weather and terrain challenged airports served by Qantas. Aircraft operators are often plagued with flight delays and diversions due to the inclement weather conditions. The GE-designed RNP procedures improved Qantas' operations into Queenstown, significantly reducing fuel burn and emissions from flight diversions and increased accessibility and predictability into the mountainous terrain.

RNP procedures are now deployed at 16 Australian airports and one New Zealand airport, Qantas flies approximately 120 RNP procedures a day. Roughly half of their 737-800 operations are RNP procedures with almost 700 pilots trained to fly them.

As of April 2011, Qantas has carried more than 22 million passengers – equivalent to the entire population of Australia – on RNP flights and has performed more than 50,000 RNP departures and 80,000 RNP approaches. On a daily basis, Qantas' network of RNP benefits yields significant fuel, track mile, noise and emissions savings. The airline estimates that once the RNP system goes nationwide, it will save them at least $20 million a year in fuel and other costs.

Qantas and Airservices Australia have been frontrunners in the effort to modernise ATM systems to improve airspace capacity and airline productivity. More and more airlines and ANSPs have followed in their footsteps to reap the similar benefits..

ASPIRING AND INSPIRING CHANGE ACROSS THE OCEANS

ASPIRE (Asia-Pacific) and INSPIRE (Indian Ocean) Initiatives to Reduce Emissions are multilateral partnerships between air navigation service providers and airlines. They share a common overall objective to make tangible improvements to the environmental performance of aviation through incremental harmonised changes to the ATM system and to increase awareness and utilisation of air traffic management best practices

In these programmes, a series of ATM best practices at each stage of the flight, from taxiing on the ground, through the climb phase, cruising altitude, descent and landing, have been agreed and are deployed in cooperative arrangements. The availability of these best practices is monitored on a daily basis and reported publicly each month. The programme encourages the delivery of ATM best practice and shares the performance across the aviation industry. In 2010 and 2011, a series of demonstration flights were carried out by the partners in each region, investigating several efficiency procedures:

- **User preferred routes (UPRs)** are custom-designed for each individual flight in order to meet the specific needs of the aircraft for that flight, including fuel optimisation. They are calculated based on factors such as forecast winds, aircraft type and performance, convective weather and scheduling requirements. UPRs are frequently used in oceanic flights where limited air traffic control operations previously required that aircraft fly on fixed routes. Air New Zealand has projected that the implementation of UPRs between New Zealand and Japan would yield a total annual saving in fuel burn of 1,090 tonnes (or 3,444 tonnes less CO_2).
- **Dynamic airborne reroute procedures (DARP)** are coordinated oceanic in-flight procedures designed to take full advantage of updated atmospheric conditions. Typically, flight plans are filed well before an aircraft's departure time. Frequently, new upper wind forecasts are available after the flight plan is filed or the aircraft departs. DARP allows aircraft to adjust their present position to a new point in order to realise savings in fuel or time. This is coordinated by the airlines with the flight crew, and sent to air traffic control as a request to change route from the aircraft. When fully realised, the

DARP can provide significant savings in fuel and emissions. Recent analysis concluded that 58% of all flights from Auckland to North America resulted in an average fuel burn reduction of 453 kg, or roughly 1431 kg of CO_2, per flight.

- **Reduced vertical separation minima (RVSM).** Improvements in the modern fleet of aircraft, new procedures and monitoring requirements have all allowed for a reduction of vertical separation between aircraft operating at certain heights. This standard allows the vertical spacing of qualified aircraft to be reduced from 2,000ft to 1,000ft in airspace where the standard has been implemented. Oceanic RVSM allows aircraft to fly closer to fuel efficient altitudes, and execute smaller climbs, which require less fuel.
- **Flexible track.** In an oceanic environment where the use of UPRs is not feasible, flexible track systems can provide a more efficient alternative than fixed air traffic services routes. Flexible tracks allow an aircraft to ride the winds on long distance flights. Published every day they provide airlines with 'non-fixed' air traffic routes that are optimised for the weather conditions and can deviate from the normal fixed or direct routes by hundreds of kilometres.
- **Continuous descent arrivals (CDAs) and tailored arrivals (TAs)** are flight descent procedures that have been optimised so that the aircraft can be flown with engines at idle thrust from a high altitude – potentially from cruise – until touchdown on the runway. A variety of CDAs have been developed for air traffic management purposes through the careful analysis of traffic patterns, aircraft descents and performance and airspace restrictions. This includes the modification of published standard arrival routes. Another form of CDA is known as a 'tailored arrival'. This is a procedure where trajectories are

dynamically optimised for each aircraft to permit a fuel-efficient, low-noise descent that will provide separation assistance and meet arrival sequencing requirements and other airspace constraints. Aircraft executing a CDA achieve far more efficient fuel burn during the descent and arrivals phase of flight, as compared to a traditional arrival path.

- **Required time of arrival management** is a sophisticated sequencing tool required in order to achieve consistent CDAs and TAs. This tool needs to take advantage of the RTA function and Flight Management System calculations of suitably equipped aircraft, and be able to accommodate non-equipped aircraft. Modelling tools that can compute four dimensional trajectories for aircraft of varying equipages and share that information with all stakeholders will be required.

The partners involved in the ASPIRE project include: Airservices Australia, Airways New Zealand, United Airlines, Qantas, Japan Airlines, Singapore Airlines, the Federal Aviation Administration, Japan Civil Aviation Bureau, the Civil Aviation Authority of Singapore and AeroThai. INSPIRE partners include Airservices Australia, Airports Authority of India and Air Traffic Navigation and Services of South Africa.

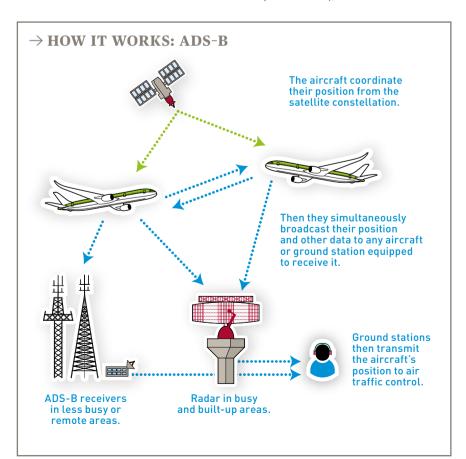www.aspire-green.com
www.inspire-green.com

HARMONISATION IN ACTION

Air navigation service providers and regulators around the world are moving towards more adaptable and flexible airspace and flight operations to improve traffic flow, capacity, efficiency, and safety. Transitioning from radar surveillance to Automatic Dependent Surveillance - Broadcast (ADS-B) to more accurately and reliably track aircraft in flight is essential to improving operational efficiency.

ADS-B is certified as a viable, lower-cost replacement for conventional radar and tracks aircraft in non-radar airspace. With ADS-B, air traffic controllers can monitor and control aircraft with greater precision and over a far larger percentage of the earth's surface than has ever been possible. For example, large expanses of Australia, Gulf of Mexico, and Hudson Bay in Canada, previously without any radar coverage, are now visible on air traffic controller screens. ADS-B is a result of the collaboration of regulators, ANSPs, aircraft manufacturers, airlines, avionics and ground system providers.

What is it?

ADS-B brings together satellite navigation systems and a network of on-the-ground receivers to ensure much broader surveillance of aircraft positions. The radar stations used currently in many places are very expensive and are, therefore, restricted to the regular traffic areas. Other locations (such as over oceans and in the middle of sparsely populated areas), have very strict operating restrictions because there is no surveillance. With ADS-B, the network of global positioning system satellites is used in conjunction with less costly receivers (almost like cell-phone towers), located across the ground. The technology also allows for more dependable surveillance of aircraft positions, as it allows for continuous monitoring of aircraft location, as opposed to radar which detects aircraft only when the system sweeps the area.

Owing to the much greater confidence in monitoring, the separation between aircraft can be reduced, allowing more efficient routes and greater airspace capacity. The United States Federal Aviation Administration (FAA), Nav Canada, Air Transport Canada, Australia's Civil Aviation Safety Authority, Airservices Australia, and Eurocontrol have been jointly working to develop and deploy ADS-B based surveillance services. This collaborative effort has paved the way to harmonising both ADS-B system approaches used in each of the regions and equipment on international aircraft. These groups have also rallied behind developing common ADS-B standards. In December of 2009, a common set of ADS-B minimum operation performance standards were published simultaneously in Europe and the United States.

Australia and Indonesia

Australia was the first country to implement ADS-B across the continent to provide five nautical miles separation throughout its en-route airspace. The ground network in Australia consists of 43 ADS-B receivers across the continent to provide complete coverage of airspace above flight level 290 (29,000 feet above sea level) and a lot of coverage below that; often to the ground at many locations.

The Australian and Indonesian aviation authorities have recently agreed to exchange ADS-B flight data for aircraft travelling across the two countries' Flight Information Region boundaries. This exchange allows air traffic controllers to precisely track aircraft up to 150 nautical

→ HOW IT WORKS: ADS-B

The aircraft coordinate their position from the satellite constellation.

Then they simultaneously broadcast their position and other data to any aircraft or ground station equipped to receive it.

Ground stations then transmit the aircraft's position to air traffic control.

ADS-B receivers in less busy or remote areas.

Radar in busy and built-up areas.

Nav Canada ADS-B tower at Puvirnituq, Quebec on Hudson Bay

→ HOW IT WORKS: ADS-B COVERAGE

Australia

Examples of current ADS-B coverage

ADS-B coverage
- 10,000 feet
- 30,000 feet

Radar coverage
- 10,000 feet
- 30,000 feet

miles inside the other country's airspace using ADS-B technology to identify an aircraft's call sign, position, altitude, and velocity. Indonesia has installed 27 ADS-B ground stations across its archipelago, 18 of which display information to controllers in Makassar. The successful results demonstrated by Australia and Indonesia are expected to be a model for further aeronautical data sharing projects within the Asia-Pacific region.

Gulf of Mexico

Air traffic controllers at the FAA's Houston Air Route Traffic Control Center began using ADS-B technology to separate and manage helicopters flying over the Gulf of Mexico in 2010. Helicopters equipped with approved ADS-B systems have experienced more efficient radar-like separation standards and direct controller/pilot communications. Direct communications coverage rapidly responds to pilot requests for route changes due to weather avoidance, optimal altitudes, transmission of timely position reports, and flight plan cancellations. Dedicated altitudes have been reserved for ADS-B equipped helicopters for radar-like separations between Houston Center and Gulf Coast Approach and provide them with direct routings to their destinations, traffic permitting. Non-equipped helicopters are held to lower altitudes to reduce mixed equipment complexities and are managed under non-radar separation procedures to their destinations.
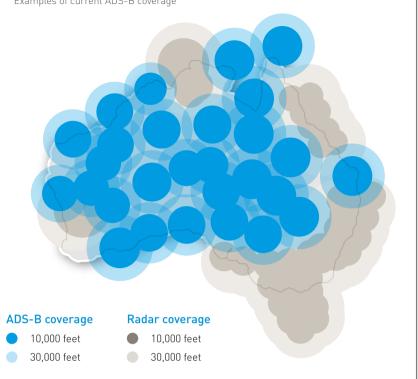
ADS-B has reduced ground holds and increased capacity for more airspace operations. ADS-B equipped helicopters:

1. dramatically reduce clearance delivery wait times;
2. save 90 – 100 lbs of fuel per flight;
3. result in flight mile savings ranging from 6 to 25 miles per flight;
4. increase load factors for helicopters with reduced fuel requirements;
5. reduce required separations from 12 nm lateral or 10 minutes and 20 nm longitudinal to 5 nm; and
6. allow offsets without extensive reroutes on weather impacted routes

Hudson Bay, Canada

Nav Canada extended its ADS-B coverage in early 2012 to a 1.3 million square-kilometer portion of airspace over the North Atlantic. This latest ADS-B expansion followed previous deployments over Hudson Bay in 2009, covering over 850,000 square kilometres, and northeastern Canada in 2010, which added more than 1.9 million square kilometres.

The deployment of ADS-B in this remote region of the world is made possible by 15 ground stations installed along the Hudson Bay shoreline, the northeast coast, as well as southern Greenland. The combined impact of all these ADS-B deployments, projected to 2020, is estimated to be $379 million in fuel cost savings for air carriers, and a reduction in greenhouse gas emissions of over a million tonnes. With this additional coverage, an intercontinental flight could go through approximately 3,300 kilometres of ADS-B coverage, representing a significant improvement in service for airline customers. Incorporating ADS-B surveillance in oceanic airspace required considerable engineering and software upgrades to Nav Canada's oceanic air-traffic system known as GAATS+. The GAATS+ display automatically detects when an equipped aircraft moves into ADS-B airspace permitting oceanic controllers to safely reduce separation from around 80 to 10 nautical miles, leading to more cost effective flight profiles, including earlier climbs to more fuel-efficient altitudes.

Beyond these areas, Nav Canada has recently joined a project to extend ADS-B coverage around the globe, working closely with Iridium to put ADS-B receivers on its low-earth orbiting satellites. The planned joint venture, called Aireon, promises to enable continuous aircraft tracking using space-qualified ADS-B receivers built into each of the satellites in Iridium NEXT, Iridium's second-generation satellite constellation. Assuming all required agreements are finalised, this capability would go into operation in 2018. It is estimated that there could be $100 million per year in fuel savings for airlines in the North Atlantic alone as a result of this new surveillance capability.

COLLABORATION ACROSS EUROPE

Increased European airspace traffic increases the complexity of air traffic management. As a result, it is becoming more difficult to efficiently handle air traffic at airports. Aviation industry stakeholders continue to individually create more efficient processes, but collaboration and the sharing of information can have very real benefits across the spectrum of airspace and ground operations.

An example of this takes place when, for instance, an aircraft takes off from Cape Town two hours late, it arrives at Schiphol Airport approximately two hours later than scheduled. This has repercussions for other stakeholders in the partner chain because the reserved gate does not need to be available for two hours and aircraft handling services can also be delayed for two hours.

Sharing operational information such as landing times, taxi times and 'on block' (at the gate) times with all operational partners as soon as possible increases the predictability of the ground handling process. This information is necessary for others to deploy resources and coordinate infrastructure more effectively. When partners share key information, they can then respond more quickly and efficiently to changes in the operational environment, for example delays or special weather conditions.

Aviation industry partners collaborating and sharing information on a network across the spectrum of airspace and airport operations is known as Airport Collaborative Decision Making (A-CDM). Trial operations of A-CDM have been implemented at over 20 European airports.

Industry partners working together on the European A-CDM project include Eurocontrol, Airports Council International (ACI), IATA and CANSO. A-CDM showcases the value of a collaborative environment involving airport operators, airlines, ANSP, Eurocontrol Central Flow Management Unit (the en route European traffic management centre), and ground handling agencies.

A-CDM improves airport operations by reducing delays, predicting events during flight and allocating resources in a more effective way. A-CDM is to be introduced as a standard working method within Europe by 2013 to improve airport efficiency, better predict air traffic operations and to minimise the loss of slots within the European Community. Eurocontrol is encouraging European airports to also implement A-CDM locally.

Munich Airport was the first to fully implement A-CDM in June 2007, followed by Brussels, Paris and Frankfurt. At Munich Airport, the project consisted of sharing data between the airport operator Flughafen München, the German ANSP DFS, airlines, handling agencies, ground handling agencies, and the European air traffic flow management unit. The collaboration has led to better management of airport and airline resources, reduced turn times, and overall reduction in delays. Similarly, Amsterdam Schiphol Airport, Air Traffic Control the Netherlands and AirFrance / KLM took the initiative to launch A-CDM at Schiphol Airport. Other parties will join the implementation process, including handling agents and other airlines.

A-CDM partners input more accurate take-off data into the information network to determine Air Traffic Flow Management slots. As more airports implement A-CDM, the partners are able to assign available slots more efficiently and reduce inefficient

Airport CDM benefits

Potential Benefit	Airport	Air Traffic Control	Airlines	Handling Agent
Fuel savings			●	
Lower noise and emissions	●		●	
Improved punctuality	●	●	●	●
More efficient gate planning and management	●		●	●
Increased airport capacity	●		●	
Reduced workload due to greater predictability		●	●	●
Smaller risk of errors		●	●	
Better order for departing aircraft	●	●	●	
Improved customer focus		●	●	●
Positive airspace network effects	●	●		
Shorter taxi times, less waiting at gates and runways	●		●	
More capacity from the same fleet			●	
Better use of resources, lower costs			●	●
Improved customer satisfaction	●		●	●
Increased productivity and competitiveness	●		●	●

Airports participating in the European A-CDM project

buffers. A-CDM partners can make more informed decisions by sharing accurate and timely information and adapting their operational procedures and automatic processes with new user-friendly tools.

Through A-CDM, airport stakeholders (such as the airport operator, aircraft operators, ground handlers, the air navigation service provider, Eurocontrol and support services), can now collaborate with each other by sharing their preferences and constraints regarding the actual or predicted airport capacity situation.

Sharing information across the network creates common situational awareness (e.g. the exact time the aircraft will leave the gate and the take-off time as well as

pre-departure sequencing and special procedures during adverse conditions). With situational awareness, airport stakeholders can more accurately predict aircraft turnaround-time to plan their resources more efficiently. Situational awareness also helps air traffic control use pre-departure sequencing where different bottlenecks occur to maximise traffic capacity. When local A-CDM elements are successfully implemented, the airport can connect with the Central Flow Management Unit at Eurocontrol, which leads to improved regional collaboration and capacity management.

The A-CDM process of sharing information among all stakeholders provides economic benefits to the aviation industry. As more

airports share information, the overall system gains in efficiency, which benefits all parties through more predictable and punctual arrival and departure times. As a result, passengers receive more accurate flight information and experience fewer delays and better connections in the case of transfers. The end result of A-CDM is a positive impact on the environment as fewer queues at gates and runways lead to lower CO_2 and NOx emissions as well as to less noise pollution.

→ **CASE STUDY**

FAB moves in UK and Ireland
The UK-Ireland Functional Airspace Block was established in July 2008 and has now completed three years of operations. The FAB brought together the control area at the upper airspace level across the United Kingdom and Ireland to create a seamless airspace area. Since its introduction, it has reduced emissions by 152,000 tonnes and saved $57 million in fuel for airlines. A substantial amount of work continues to be undertaken by the ANSPs, the airlines and military contributors to implement the ongoing FAB Plan. The centrepieces of the next phase of the FAB Plan from 2011-14 are the so-called ODNET projects (Optimise Domestic, North Atlantic and European Traffic) which include an on-going focus on measures to reduce fuel burn and emissions, including:
- *En-route Shannon upper airspace redesign – the removal of fixed routes in Shannon upper airspace (in 2009) to allow direct routing and flight planning from entry point to exit planning – with estimated annual savings of 2.2 million km flown, 14,800 tonnes fuel and 46,800 tonnes CO_2;*
- *Fuel saving routes – the continuing roll-out of flight plannable direct routes, especially at night time, which are reducing distances flown and fuel burn – with estimated annual savings of 5,700 tonnes fuel and 18,100 tonnes CO_2.*

AIR TRAFFIC CONTROL

AIRCRAFT OPERATORS

EUROCONTROL CENTRAL FLOW MANAGEMENT UNIT

GROUND HANDLING

AIRPORT OPERATIONS

Benefits of CDM
- **Improve predictability**
- **Improve on-time performance**
- **Reduce ground movement costs**
- **Optimise/enhance use of ground handling resources**
- **Optimise/enhance use of stands, gates and terminals**
- **Optimise the use of the airport infrastructure and reduce congestion**
- **Reduce slot wastage**
- **Flexible pre-departure planning**
- **Reduce apron and taxiway congestion**

FLEXIBLE ROUTING SAVES FUEL

Over 90% of today's aircraft could fly more flexible 'direct' routes from departure to destination - routes that are free of pre-defined air route structures and free to take advantage of beneficial winds. This capability is well demonstrated in the International Air Transport Association's (IATA) iFlex project

For years, aircraft have navigated from their point of departure to their destination along highways in the sky, defined by a series of radio beacons linked into a network. This network, while useful and convenient, is based on ground systems providing navigation and does not ordinarily lead to short, efficient routes. Today's aircraft with space-based GPS can fly safely to their destination without reference to ground navigation aids or airways. If an aircraft could plan and fly a 'flexible route' which is the shortest feasible, wind-adjusted route, then significant fuel savings are possible. Over 90% of aircraft today could fly a flexible route that takes full advantage of the wind, but fewer than 10% actually do.

Just as personal computers and personal GPS systems are now able to calculate the fastest or most fuel-efficient route to our driving destinations, airline flight planning computers and aircraft satellite-based navigation systems can do the same for air travel. Airlines invest heavily in modern aircraft navigation and flight planning systems but their abilities to leverage these capabilities into operating cost advantages are hindered in regions where flights are required to conform to the legacy network of fixed routes. It is, therefore, essential for air navigation service providers to work collaboratively with their customers towards the goal of flexible use of airspace.

Flexibility is derived from the design of the airspace. Opportunities for flexibility exist in almost all operating environments, whether in high or low traffic density by allowing and employing flight routings that optimise trajectories considering winds aloft.

Since today's aircraft can spend hours in the air, their total fuel burn is naturally sensitive to the winds at attitude. These winds, often over 100 knots (185 kph), can be a headwind, a crosswind or most favourably, a tailwind. By reducing the impact of

Routes have traditionally been selected by consulting paper charts and catalogues of standard routes.

headwinds and finding tailwinds – even if the flight ends up flying further in distance – it can do so in less time and using less fuel.

As aircraft design has improved over the decades, so has the range. It is now a matter of routine to have flights operating routes of well over 12 hours between continents. Current maximum airliner endurance approaches 17 hours. Initial computer modelling of long-haul flights has shown a major opportunity to leverage operating benefits by using flexible routings.

Preliminary benefit analysis[9]
Air traffic controllers are often very good at offering short-cuts to the route when they become operationally available. These short-cuts are valuable to the flight when they eliminate routing constraints that had been imposed when the flight plan was

developed. However, there is an overhead cost to carry the extra fuel weight required by the original plan. The overhead for a 12 hour flight is approximately 4.7% for a Boeing 747, for example[10].

Using the price of jet fuel at the end of 2011 ($979.90 per tonne) and the example of a Boeing 747 on a 12 hour flight (with a 4.7% weight penalty), one minute saved on a direct route segment represents a fuel saving of 156 Kg (490 kg of CO_2) and a cost saving of $153. If this same direct segment had been authorised prior to departure, the fuel penalty of 88 kg ($86) would have been avoided. Thus the total benefit would have grown to 156% of the original tactical benefit. Now, assume this single flight operates daily!

At the end of the year, a single daily minute saved strategically by a typical 747 on a 12 hour flight has translated into savings of 88,950 kg of jet fuel, 279,934 kg of CO_2 and $87,163.

There are several efforts taking place around the world to realise some of this untapped potential for savings. The Asia-Pacific region is the world's fastest growing aviation market, where commercial aircraft carried over 34% of all world passengers in 2010. Asia has replaced North America as the world's largest market. The Seamless Asian Skies is a project whereby the multitude of flight information regions (FIRs) in the region are to harmonise their air traffic management into a seamless entity which would, in turn, lead to increased efficiencies and reduced fuel burn and emissions.

IATA's iFlex project concentrates on ultra-long-haul flights and the ability of ANSPs to offer more flexible routings. The iFlex programme builds on existing best-practices, current technology and solutions that can be implemented safely across several flight information regions in day-to-day operating conditions. Following the first iFlex trial between Johannesburg and Atlanta, Delta Air Lines reported that the implementation of the iFlex concept resulted in an average time saving per flight of 8 minutes, equating to 900 kg of fuel and 2.9 tonnes of CO_2.

→ CASE STUDY

I-4D for SESAR
As part of the Single European Sky ATM Research (SESAR) programme, Airbus ProSky has been working on 4D-trajectory management, in order to cope with traffic growth and increasing environmental constraints. 4D trajectory management relies on an aircraft function that predicts and transmits data to the ground enabling the aircraft to accurately fly a route after coordination with the ground systems. This will allow aircraft to fly an optimised and efficient profile without the need for controllers to provide instructions, improving predictability of the traffic flows and facilitating smooth continuous descent operations into airports.

This concept is based on the use of 4D-trajectories from take-off to landing (and ultimately, even for airport surface operations), and requires significant improvements and upgrades in ground Air Traffic Management systems and procedures, as well as in the airline operations control centres. It is called '4D' as it is described in three dimensions (lateral, longitudinal and vertical) and it includes a target arrival time (with time as the fourth dimension).

The move to 4D requires common standards and global interoperability for both air and ground side to ensure safe and efficient operations. As this full step will take time to be deployed, SESAR's partners have defined an intermediate step called the initial 4D-trajectory (i-4D) management, less demanding in terms of improvements for the short/mid-term, but able to be deployed faster to start achieving results early on. Airbus, with SESAR's partners, conducted in the world's first 4D trajectory test flight in February 2012 on an A320 test aircraft.

The main benefits of I-4D are the reduction of fuel burn and CO_2 emissions and a decrease of delays, in line with SESAR's target to reduce the environmental impact per flight by 10%. I-4D is the first step in developing one of the essential pillars of the SESAR programme, conciliating the increasing traffic density with the efficiency of flights. More flight trials and simulations are planned in 2012 and 2013 and the first I-4D operation is planned in Europe from 2018 onwards.

Potential savings from deploying iFlex on simple routes

Sample: Dubai – São Paulo (Boeing 777-200)	Fuel (kg)	Time (mins)	CO2 (Kg)
Savings per flight	1,000	6	3,150
Savings per year	365,000	2,190	1,149,750
Sample: Atlanta – Johannesburg (Boeing 777-200)	Fuel (kg)	Time (mins)	CO2 (Kg)
Savings per flight	670	8	2,111
Savings per year	244,623	2,190	770,562

EFFICIENT DESCENTS

Airline operators and air traffic controllers have long recognised that eliminating intermediate level-offs and diversions for arrivals is one of the most significant changes than can save fuel and reduce CO2 emissions. The Three Dimensional Paths in Arrival Management (3D PAM) and Initial Tailored Arrivals (ITA) projects are making these new procedures a reality.

The 3D PAM and ITA projects are part of the United States Federal Aviation Administration's Next Generation air transportation system (NextGen) efforts to institute fuel-efficient arrivals at medium- to high-density airports, reducing fuel use and emissions, streamlining operations and increasing airport capacity. Both projects are aimed at flying aircraft on a fuel-efficient, conflict-free trajectory from cruise to the runway threshold with an optimised descent profile. While they differ in the aircraft avionics and ground automation tool in use, both projects represent a step in implementing more efficient airport arrivals.

The FAA, NASA, Boeing, United, Continental and American Airlines initiated the 3D PAM project to make use of existing flight management systems capabilities along with the Traffic Management Advisor controller tool that calculates a scheduled time of arrival for each aircraft. The system uses the scheduled arrival time for each aircraft to generate a fuel-efficient, conflict-free trajectory to meet that time at a specific location. The 3D PAM concept increases the likelihood of a successful optimised profile descent by adding a small delay path if necessary that allows continuous descent and efficient aircraft merging to arrival. In other words, it takes into account all aircraft lining up to land on a given runway and slots them into a single approach path in the most optimal way. Even if it means some of those flights actually travelling a slightly longer distance, but at a lower engine power setting.

Over 1,500 flight trials conducted in 2010 and 2011 in Denver, Colorado showed aircraft were able to meet scheduled time with ±20 second accuracy and with significant fuel savings. The trials were conducted using radio instructions from controllers, but they also proved that the system is well-suited for future data link delivery, which will reduce controller and pilot workload and radio transmissions.

It is anticipated that 3D PAM will be implemented throughout the U.S. between 2014 and 2018.

Initial tailored arrivals
The ITA project was a collaborative initiative between the FAA and Boeing with airline partnership and NASA support. It was developed to use existing data link and ground system capabilities at US oceanic control centres to provide an electronic clearance for a fuel-efficient path to the runway.

Currently, all aircraft are treated in a similar way on the approach to a runway. The ITA technique takes each aircraft type and modifies its flight path to make most efficient use of its own flight characteristics in order that it slots in to the arrivals path with all other aircraft at a particular point, to keep a smooth flow of aircraft. As the modifications are initiated from the top of the descent, the aircraft can realise some significant fuel savings as it can use low power settings.

Boeing worked with 11 airlines and controllers from Oakland, Los Angeles, and Miami to refine ITA operational procedures. Flight trials conducted from December 2007 through 2009 demonstrated savings of 225 to 1,270 kg of fuel per descent, even for descents that were discontinued early because of congestion in the air space. Participating airlines at San Francisco saved over 1.5 million kg of fuel and reduced CO2 emissions by over 5.7 million kg. As a result of these early trials, ITAs have continued at San Francisco, Miami and Los Angeles, with thousands of flights now having participated.

Boeing also collaborated on similar trials at Amsterdam with the Dutch Knowledge and Development Centre consisting of the Dutch air navigation service provider LVNL, KLM Royal Dutch Airlines, and Schiphol Airport to validate the Speed and Route Advisor tool to tailor arrivals into Schiphol Airport. Air Services Australia conducted tailored arrivals trials at Melbourne Airport with Qantas, Emirates, and Singapore Airlines.

Currently, the FAA is transitioning to full operations at the three initial locations (San Francisco, Los Angeles, and Miami) and is considering expanding the capability to other airports as soon as practical.

TYING IT ALL TOGETHER

One of the essential elements for achieving system-wide operational efficiency is the coordination of air navigation improvements throughout the world. This process is often referred to as 'global harmonisation' or 'global interoperability', and implies that operating procedures and technologies are standardised across all States and regions. This commonality reduces international equipment variations, minimises procedural differences and the opportunities for human error that can arise from them and helps operators and manufacturers realise significant cost-savings and increase R&D investment certainty.

In 2010, the International Civil Aviation Organization (ICAO) embarked on a significant project to achieve global interoperability between now and 2030. It began by developing a framework for a systems-engineering approach to global ATM improvements known as the aviation system Block Upgrades (BUs).

The BU framework is based on specific performance capability 'modules' which reflect the sector-wide consensus of the latest technologies and procedures entering service from existing ATM modernisation programmes. These were added to industry-agreed projected capabilities and concepts. The block upgrades should be adopted on a global basis to deliver a seamless ATM system.

Importantly, the mandate to deploy these modules is flexible and based on the specific operational needs of the State or region where they are to be implemented.

The BU modules aim to systematically improve international interoperability through a standardised set of specific ATM enhancements which:
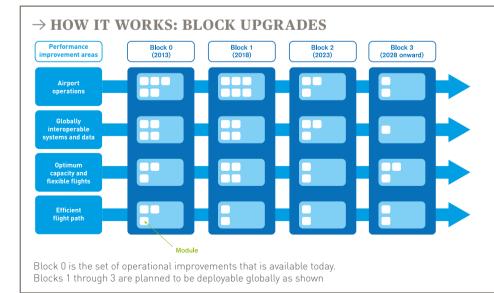
1. Provide measureable operational improvements.
2. Capitalise on existing aircraft capabilities.
3. Standardise operational procedures and certification.
4. Yield a positive business case for implementation.

These modules are not required in all airspaces, only where they offer the most benefit.

Each block in the ICAO system represents a target availability timeline for the performance modules it contains. Block '1' (2018), for instance, features modules characterised by operational improvements which will be available for implementation by that date. This includes the procedures, technologies, regulatory approval plans, standards and guidance material.

The modules have also been organised on a reductive basis across the blocks, decreasing in number as they realise their operational benefits and target performance capabilities.

The module specifics were developed with the assistance of the full spectrum of State and industry experts that attended the Global Air Navigation Industry Symposium. Over 500 participants attended this event, which featured critical inputs from organisations such as CANSO, ACI, IATA, the International Business Aviation Council (IBAC), the International Coordinating Council of Aerospace Industries Associations (ICCAIA) and many others.

ICAO presently estimates that funds spent on air traffic systems modernisation over the next decade, not only in Europe and the USA but also in Latin America, Russia, Japan, China, India and South-East Asia, will exceed $120 billion. Several of these States and others not mentioned here have already begun to map their air navigation planning to the Block Upgrade methodology.

→ HOW IT WORKS: BLOCK UPGRADES

The ICAO Block Upgrades (blue columns) refer to the target availability timelines for a group of operational improvements (technologies and procedures) that will eventually realise a fully-harmonised global air navigation system. The technologies and procedures for each block have been organised into 'modules' (smaller white squares) which have been determined and cross-referenced based on the specific performance improvement area they relate to. ICAO has produced the systems engineering for its member states so that they need only consider and adopt the modules appropriate to their operational need.

Block 0 is the set of operational improvements that is available today.
Blocks 1 through 3 are planned to be deployable globally as shown

The NATS regulatory environmental performance metric

If you can't measure it, how can you reduce it? That was the question NATS asked itself in 2009. How does the UK's national air traffic service provider meet its strategic 10% emissions reduction target for each flight it handles by 2020? With no equivalent metric available anywhere in the world, NATS developed its own – the '3D inefficiency score' (3Di).

NATS developed a new metric in collaboration with airlines (including British Airways, Virgin, BMi, Aer Lingus, Ryanair, EasyJet, Flybe and IATA) and the UK Civil Aviation Authority. After three years of research and development, analysing radar tracks from every flight since January 2010, and further large samples of operations every year going back to 2006, NATS has established an average efficiency rating in terms of vertical and horizontal trajectories – how smooth a climb and descent, and how direct a route can be provided for each flight.

The 3Di metric was deployed on 1 January 2012, making NATS the first air traffic management company in the world to be financially incentivised on its environmental performance. Initial analysis shows there is scope to save around 600,000 tonnes of CO_2 over the next three years and saving airlines around $200 million in fuel.

→ CASE STUDY

The ATM long range optimal flow tool (ALOFT)

A curfew is in place at Sydney International Airport from 23:00 to 06:00 each day and international arrivals are scheduled in order to land after the curfew is lifted each morning. In order to manage the demand, ATC would put aircraft in holding patterns outside of Sydney. Without a coordinated approach to managing arrivals, airlines were incentivised to arrive earlier in order to improve their position in the arrival queue.

Airservices Australia implemented ALOFT so that arriving aircraft are provided with a time up to 1,000 nautical miles from the airport to arrive at a specific point located 160 nautical miles from Sydney. This allows aircraft to use their flight management computer to best manage fuel burn associated with meeting a time constraint. The aircraft are then issued an additional time to arrive at a point 40 nautical miles from Sydney. Both the times at 160 and 40 nautical miles allow sufficient pressure for ATC to fine-tune the sequence and manage additional flow and separation changes as needed – while guaranteeing that no slots for arrival are missed.

By using the ALOFT tool, it is not uncommon to observe 3,000 minutes of delay absorbed in the cruise phase of flight per month, while still leaving enough pressure to compress aircraft onto the runways at Sydney. The amount of fuel saved per aircraft is also significant.

A REGIONAL VIEW

The challenge is great - to reduce global net aviation emissions by 50% by 2050 compared to 2005 and to continuously improve ATM efficiency to achieve 95% efficiency by 2025 and 98% efficiency by 2050. But the rewards are also great - a more efficient air transport system to grow the tourism and trade on which sustainable economies are built.

The air transport system is working to bring about efficiency improvements at a global level through the following action steps:

- *improve the collective understanding of the operational benefits for more efficient ATM operations;*
- *increase stakeholder collaboration;*
- *accelerate operational trials and procedures that take advantage of existing aircraft technologies;*
- *accelerate 'real time' collaborative decision making through enhanced information sharing;*
- *reduce airspace restrictions that lead to inefficient operations;*
- *accelerate the approval process for new procedures and operations; and*
- *promote common best practices in ATM to ensure international harmonisation.*

The aviation industry is standing by to implement the upgrades needed, and with help from governments around the world this can be achieved. You have seen some of the projects we have been working on and the plan to bring them together - that technology exists already today. Now it is time for governments to help us turn the exceptional into the everyday and also help bring about the needed institutional and cultural change. The industry has identified some of the key steps in each region that will help us build a more economically and environmentally efficient future...

AFRICA

Air traffic in Africa

The African continent currently handles just 3% of global passenger traffic, but this is set to more than double by 2025, both as a response to economic growth and a driver of development across the continent. New opportunities in terms of business, conferencing and tourism throughout the region will result in an increase in air traffic activities and, unlike in the developed world where the economy (and air traffic control system) is mature, the African economy is still in the development phase. This will allow the use of best practices and newer technologies in ATM, thus avoiding the legacy issues that more developed regions have to contend with as they contemplate ATM modernisation. The potential exists for the region to better deal with the congestion and capacity challenges that more mature markets are currently experiencing, and for trade and tourism in Africa to benefit from a better performing air transport system. However, these opportunities can only be grasped if governments on the continent introduce policies and measures to improve aviation safety and the governance arrangements for ATM.

African ATM challenges

As air traffic increases, capacity challenges will become real – not just in terms of aircraft congestion, but also the technical and operational capabilities of communication, navigation and surveillance systems, as well as training and recruitment of people to run ANSPs. Airport capacity in relation to apron space and runway capability, will put pressure on the continuous growth of air traffic. Some of the other relevant challenges include:

- The need to train personnel to install, operate and maintain new technologies in air traffic management. A number of current aviation staff will need to acquire new skills for highly-technical positions in the new aviation regime.
- The age of a substantial portion of African-registered aircraft, many of which cannot be retro-fitted with new navigation technology and which may find themselves unable to operate into other regions as requirements develop.

In mid-2012, ICAO joined with leading aviation stakeholders IATA, AFRAA, AASA, AFCAC, ACI Africa, ASECNA, CANSO, IFALPA, Airbus and Boeing in committing to a five-step Africa Strategic Improvement Action Plan to address safety deficiencies and strengthen regulatory oversight in the region by 2015.

1. Adoption and implementation of an effective and transparent regulatory oversight system.
2. Implementation of runway safety measures.
3. Training on preventing loss of control.
4. Implementation of flight data analysis.
5. Implementation of safety management systems.

This plan has been further improved and presented to African Ministers for their adoption. The aim is to reduce two most prominent accident types, runway excursions and loss of control, by 50% by 2015.

Policy solutions

The following are some of the fundamental issues relating to ANSPs which the governments need to address:

- **Undertake a region-wide and systematic approach to delivering the required upgrades in ATM proficiency.** Aviation safety remains a significant challenge in many parts of the African region. While new ATM technology will provide a very valuable tool for improving safety, it must be seen as part of a broader package which includes more stringent regulatory oversight of aircraft maintenance and operations, airport operations and security.
- **Foster good governance through separating the regulator from the air navigation service provider.** This separation of roles will ensure clearer accountability and greater customer focus by the ANSP. For example, if ANSPs are in control over their budget and the proceeds from air navigation charges are reinvested in improving air navigation services, then the air transport system will benefit as a result, as well as the wider national economy. It is vital that ANSPs in the region be free of political interference and be financially independent.
- **Put in place the institutional framework that would incentivise and empower ANSPs to deliver the performance expected of them.** This means, for example, providing the financial autonomy for ANSPs to plan ahead and to invest in infrastructure and human capital.
- **Recognition by politicians that in ATM, safety and efficiency transcends national borders.** Governments need to encourage cross-border collaboration among ANSPs so that flight safety and efficiency can be optimised for the entire flight from gate to gate and not only within national borders. governments should encourage their ANSPs to enhance regional collaboration and pave the way for the sharing of industry best practices and the benchmarking of performance against the best in class.
- **Commit and put in place the necessary processes to implement the ICAO aviation system block upgrades.** This may include rectifying the governance arrangements that will encourage a business-oriented approach to ANS delivery, and opening up opportunities for private financing of ATM infrastructure.
- **Open up currently closed military air space.** This would allow for greater capacity increases and more direct (and efficient) routes. There are several ways to achieve this – either through a complete opening of airspace, or a more flexible use of airspace (FUA), whereby civil and military use can occur at alternate times.

→ CASE STUDY

Emirates operates CO$_2$-saving demonstration flight over Africa
Ahead of the 2011 UN climate talks in Durban, Emirates airline operated a demonstration flight carrying the UAE delegation to the conference. Through close coordination with air navigation providers in seven countries between the UAE and South Africa, Emirates was able to use techniques in-air and on the ground to reduce flight emissions and save over five tonnes of CO$_2$ compared to the same aircraft, a Boeing 777, flying a normal flight plan. This was the first flight over the African continent for the INSPIRE programme (see page 11). Demonstrating the importance of collaborative actions, the INSPIRE flight was made possible by close cooperation from ANSPs in Kenya, Oman, Mozambique, Somalia, Tanzania, South Africa, the UAE and Yemen; Dubai Airports; Dubai Air Navigation Services; the UAE General Civil Aviation Authority; ATNS South Africa, and the Abu Dhabi Department of Transport. In addition to the INSPIRE flight, Emirates has also been a key member in the 'flex tracks' initiative (see page 16) over the airspace of the Middle East, Africa, Asia and Australia. In the first five years alone, Emirates' participation in the project has resulted in savings of 10 million litres of fuel, 26,644 tonnes of CO$_2$ and more than 722 hours of flight time.

ASIA-PACIFIC

Air traffic in the Asia-Pacific region

Asia-Pacific is now the world's largest aviation market and home to more than half of the world's population. In 2010, the region accounted for 34% of the world's passenger traffic with annual growth rate of 6.9% projected for the period 2010 to 2015.

With continued economic growth, rising incomes and populations with a greater propensity for air travel, ATM in the region must keep pace with fast rising demand for air transportation to support greater trade, tourism and investment flows.

Asia-Pacific ATM challenges

The immediate challenges for ATM in the Asia-Pacific region are those associated with growth. Is the region ready to handle the projected increase in air traffic? And what are the consequences if capacity fails to keep pace?

Asia-Pacific includes a wide spectrum of ANSPs – from the most developed and efficient, to the developing. Therefore, while ATM technology to raise the level of flight safety and efficiency already exists, it is a major challenge introducing new and sophisticated technology and procedures that are interoperable while ensuring harmonised implementation by all ANSPs.

Recognising this challenge and related developments in other regions, an Asia-Pacific Seamless ATM Planning Group comprising States and international organisations has been set up by ICAO recently to determine the means for seamless ATM development in the region. ICAO's recent introduction of the aviation system block upgrades was a timely development for the region as it provides a global framework for planning and ensuring that national ATM plans and their implementation are harmonised across the region. However, for the less developed ANSPs, there will be a need to also address the more fundamental issues of technical assistance, specifically the availability of funding, expertise and training.

There are other constraints faced by the ANSPs of the region that are not technological or financial. These are governance and institutional issues. Most ANSPs in the region are part of a government department or statutory authority and their ability to respond to changes in a rapidly evolving aviation landscape can be constrained by government bureaucracy. ATM infrastructure requires long-term investments in equipment and human capital. ANSPs that do not have financial autonomy and have to compete for funds with other government departments will be disadvantaged compared to those whose management is empowered and incentivised to deliver superior performance.

Policy solutions

The problems faced by ANSPs can be overcome only if governments understand the issues at stake and have the political will to address them. Safe and efficient air transport is crucial to the continued growth of the region but this will not be possible if the capacity of the aviation system is unable to keep pace with air traffic demand. Therefore, the prosperity and the economic well-being of countries in the region are at stake. The following are some of the fundamental issues relating to ANSPs which the governments need to address:

- **Foster good governance by separating the regulator from the air navigation service provider.** This means separating the service provision from state regulatory and oversight functions. This is fundamental to good governance and can be achieved through organisational separation or functional separation.This separation of roles will avoid a conflict of interests and ensure clearer accountability and customer focus by the ANSP.
- **Put in place the institutional framework and regulations that would incentivise and empower ANSPs to deliver the performance expected of them.** Management of ANSPs should be free to implement business principles that deliver the best results, supported by independent funding.This means providing ANSPs with the financial autonomy to plan ahead and to invest in infrastructure and human capital. For example, if ANSPs are in control over their budget, the proceeds from air navigation charges can be reinvested to improving air navigation services thus benefiting the air transport system and the wider national economy, governments can also incentivise ANSP performance through appropriate regulations for example through incentives in the ANSP funding model that link performance and service quality to revenue.

- **Recognition by politicians that in ATM the efficiency and safety of flights transcend national borders.** Governments need to encourage cross-border collaboration among ANSPs so that flight safety and efficiency can be optimised for the entire flight from gate to gate and not only within national borders. Governments should encourage their ANSPs to enhance regional collaboration and pave the way for the sharing of industry best practices and the benchmarking of performance against the best in class.
- **Set in place the necessary framework to implement the ICAO aviation system block upgrades as a vital component of national airspace planning.** This should be supported by government as well as air transport partners and should address implementation issues such as financing, expertise and staff training.
- **Improve civil-military coordination.** For example, by opening up currently closed military airspace for civilian use and the joint use of airspace where civil flights and military training can occur at alternate times. Thus increasing capacity and the establishment of more direct (and efficient) routes.

EUROPE

Air traffic in Europe

European airspace is among the busiest in the world with over 33,000 flights on busy days and high airport density. The region accounted for 27% of the world's passenger traffic in 2010, with traffic forecast to grow further, although at a slower rate than in some emerging economies. The aviation industry in Europe supports 8.7 million jobs and $749 billion in GDP.

The airspace in Europe is organised in a fragmented way. Despite it being less than half the area of the continental United States, there are nearly 40 different flight control zones and dozens of air navigation service providers. These are generally government-owned. In 2004, the Single European Sky (SES) initiative was launched to harmonise this fragmented architecture of air traffic management in Europe for improved performance.

The key objectives are to achieve by 2020 (relative to 2005):
- A three-fold increase in ATM capacity where needed;
- Improve safety performance by a factor of 10;
- A 10% reduction in the impact of flights on the environment; and
- ATM services provided at a unit cost which is at least 50% less than current costs.

This can only be achieved through a synchronised and coordinated effort and integration across borders. This also requires civil-military coordination in airspace and air traffic management. The ATM master plan of Europe has taken into account the ICAO block upgrade (see page 19) framework ensuring global interoperability for future ATM system.

European ATM challenges

Forecasts indicate air traffic levels are expected to double in the next 20 years and the current fragmented system will not be able to handle this significant increase in traffic. There are three major challenges to progress towards a new performance-based ATM system in Europe.

The first challenge is to create a mature performance system with appropriate targets and incentives across the entire ATM supply chain; the second to modernise ATM infrastructure by ensuring key stakeholders synchronise and coordinate their efforts from research to industrialisation to deployment; and the third challenge is to have the support of policy makers to change the institutional structure of Europe's ANSPs through consolidation.

A first milestone of the SES initiative is already well underway. Today, research and development efforts are synchronised through SESAR (Single European Sky ATM Research), which is a public-private partnership of the European Commission, Eurocontrol and industry.

However, there is still a lack of progress in the reforms of national ANSPs to allow for the necessary change in structure for truly efficient European air space. In addition, while the need for transformation of European airspace management is agreed, there is still a lack of common understanding amongst all stakeholders on the path required to get there. Diverging interests from States and their institutions, ANSPs, airspace users (including airlines and military), staff organisations, and manufacturers are a challenge to compromise and a way forward. There is a need for balancing the interests of airspace users who are under significant cost pressure and call for cost reductions as foreseen in the Single European Sky targets, and ANSPs who need to plan for longer-term capacity enhancements through investments in new system capabilities and training. All parties, including the industry and governments, must work collaboratively to gain a better understanding of the requirements of air transport in the future.

The risks of a decade delay in deployment of the new European ATM system have been calculated as[11]:

- cost of about €124 billion in direct GDP, representing 72% of the overall direct value;
- including indirect and induced benefits, the negative impact rises to €268 billion (or 0.10% of combined GDP);
- a reduction of 189,000 in job creation in the wider economy;
- in environmental terms, 55 million tonnes worth of reductions in CO_2 emissions would also be put at risk.

Policy solutions

The major elements of the new framework for air traffic management in Europe consist of:

- separating regulatory activities from service provision, and introducing cross-border services;
- simplifying the institutional landscape and eliminating duplication of regulations;
- reorganising European airspace so that it is no longer constrained by national borders;
- setting common rules and standards, covering a wide range of issues, such as flight data exchanges and telecommunications.

With the SES, the key objectives are to restructure European airspace as a function of air traffic flows and to increase the overall efficiency of the ATM system.

The new performance regulation is a key step towards a Single European Sky. SES has established performance targets in key areas of safety, network capacity and environmental impact, whilst reducing the cost of air navigation services. Now these metrics must be achieved.

> ## REPORT
>
> *In February 2013 IATA, with the Association of European Airlines and the European Regions Airline Association, published a report, A Blueprint for the Single European Sky. It suggests three key reforms are essential to achieving Single European Sky:*
> - *First, an independent European regulator must establish a binding and robust performance system for air navigation charges.*
> - *Second, air traffic management structures need to be rationalised. The number of air traffic control centers in Europe should be reduced from 63 to no more than 40. The rationalisation process would also enhance safety and environmental performance through reduced transfer points, improved information sharing, and better matching of resource to demand.*
> - *Third, next generation systems must be implemented. These will facilitate more efficient routes and flight profiles that will reduce fuel usage by an average of 300kg per flight. Multiplied by millions of flights a year, the potential carbon savings are in the millions of tonnes.*
>
> *For the full report:*
> *http://tinyurl.com/c4hsbl2*

LATIN AMERICA AND THE CARIBBEAN

Air traffic in Latin America and the Caribbean

Today, the Latin America and Caribbean region accounts for approximately 7% of the world's air traffic in terms of passengers. The region is facing considerable traffic growth in the near-term.

The implementation of performance-based navigation is a top priority for ANSPs in the region, given its significant operational and environmental benefits. ANSPs in South America have implemented several RNAV routes, reducing CO_2 emissions by around 23,000 tonnes per year. For example, in Cuzco, Peru, PBN has contributed to the reduction of 3,500 tonnes of CO_2 per year. In Brazil, the first phase of PBN implementation was achieved in March 2011 and the second phase was achieved in October across selected airways. Such projects demonstrate how the region is moving forward with technological and procedural initiatives, in order to maintain safety while contributing to a more efficient air transport system. However, these are generally implemented on a case-by-case basis, rather than a systematic programme across the region.

ATM challenges

The Latin America and Caribbean region has not yet reached saturation point with regard to air transport, but this situation is changing rapidly. Forecasts indicate that demand for air transport is expected to rise by about 5% per annum over the next 20 years.

Against the backdrop of ATM modernisation efforts, a significant proportion of the region's air traffic control workforce is nearing retirement. The region is, therefore, constantly searching for ATM professionals. Similarly, with so much change facing in the ATM industry, ANSP staff must understand new procedure design, project execution, innovation and implementation. The importance of effective training is therefore well-recognised.

Policy solutions

The following are some of the fundamental issues relating to ANSPs which the governments need to address:

- **Foster good governance through separating the regulator from the air navigation service provider.** This separation of roles will ensure clearer accountability and greater customer focus by the ANSP. For example, if ANSPs are in control over their budget, they are able to properly plan their investments with less uncertainty and less dependency of political cycles. The proceeds from air navigation charges can be reinvested in improving air navigation services, benefiting the air transport system and as a result, the wider national economy. It is also vital for ANSPs to be free of political interference.
- **Put in place the institutional framework that would incentivise and empower ANSPs to deliver the performance expected of them.** This means, for example, providing the financial autonomy for ANSPs to plan ahead and to invest in infrastructure and human capital, management autonomy allowing to highter competency for activity diversification to assure business success.
- **Recognition by politicians that in ATM the efficiency and safety of flights transcend national borders.** Governments need to encourage cross-border collaboration among ANSPs so that flight safety and efficiency can be optimised for the entire flight from gate to gate and not only within national borders, allow for a more business-oriented culture, creating a capacity to expand and collaborate in ATM related activities.
- **Invest in the education of the next generation of air traffic controllers.** Working in ATM is a good profession, but while ANSPs can train on the specifics of air traffic control, they need trainees that have a solid education as a base. For that matter, the aviation industry in general in these fast-growing regions needs well-trained engineers and pilots to fly for generations to come – air transport is a solid and reliable industry that will pay dividends to an educated society.

- **Set in place the necessary procedures to implement the ICAO aviation system block upgrades.** This may include rectifying the governance issue of creating a business-oriented ANSP, opening up the opportunities of private financing of ATM infrastructure.
- **Open up currently closed military air space.** This would allow for greater capacity increases and more direct (and efficient) routes. There are several models for achieving this – such as complete opening of airspace, or mixed-use, where civil and military training can occur at alternate times.

→ CASE STUDY

GE Aviation's work with LAN on RNP
The 'Green Skies' project, a collaborative effort among LAN Airlines, GE Aviation, Peru's air navigation service provider CORPAC and regulator DGAC, provides aircraft flying from Cusco to Lima with a highly-efficient, predictable flightpath throughout the entire flight. The inaugural flight, which took place in February 2012, was Latin America's first continuously guided flight from take-off to landing using Performance-based Navigation (PBN) technology.

The GE-designed PBN departure, en-route, arrival and approach procedures save participating airlines on average 19 track miles, 6.3 minutes, 200 kg of fuel and 640 kg of CO_2 emissions per flight. The PBN paths also enable increased capacity at Lima's Jorge Chavez International Airport – while helping to reduce the carbon footprint at Cusco, the access point to the popular tourist destination Machu Picchu. LAN flies the route 11-17 times a day, depending on the season.

The highly-accurate paths also provide capable-aircraft with precise lateral and vertical arrival and departure guidance and improve the air traffic management variance and flow for controllers, benefiting all airspace users in the region.

MIDDLE EAST

Air traffic in the Middle East

The Middle East is playing an increasingly important role on the global aviation stage, given its strategic location connecting Europe, Asia and Africa. With 13 flight information regions to manage, the region's ANSPs control more than 1.7 million movements between 15 international airports, as well as 700,000 movements between 45 domestic airports every year. On average, the region's ANSPs handle around 800 over flights per day.

Today, most of the region's air traffic management centres are equipped with the state-of-art technologies which support short-, and medium-term conflict alerts, route prediction, arrival and departure managers tools, and online data interchange. Some are introducing ADS-B (see page 12) or have plans to do so. The majority of ANSPs in the region are part of governmental civil aviation authorities, although there are plans underway to transform and privatise the services in some countries.

The challenges

Although the Middle East ANSPs are fairly modern with regards to technological and operational capacity, the region's airspace is highly fragmented on the operational level. This restricts a potential regional response to airspace and airport capacity; cooperation and resource exploitation; inter-ANSP coordination on the operational, procedural and technological levels; introducing and coordinating collaborative decision making (see page 14); preparing for human resource shortfalls; civil-military coordination; and capitalising on existing aircraft and ANSP capabilities.

ANSPs recognise that the industry must engage the political decision-makers at all levels, so that they can create a productive dialogue to address the challenges that lie ahead. One potential solution, currently underway through CANSO, is a comprehensive review of all Middle East airspace. Based on a thorough evaluation of current and future needs, recommendations could be put forward for a new structure that considers all stakeholders' requirements as well as the ICAO block upgrades initiative (see page 19). Political decision-makers need to support the region's ATM community with this endeavour.

Policy solutions

The following are some of the fundamental issues relating to ANSPs which the governments need to address:

- **Foster good governance through separating the regulator from the air navigation service provider.** This separation of roles will ensure clearer accountability and greater customer focus by the ANSP. For example, if ANSPs are in control over their budget, the proceeds from air navigation charges can be reinvested in improving air navigation services, benefiting the air transport system and as a result, the wider national economy. It is also vital for ANSPs to be free of political interference.
- **Invest in the education of the next generation of air traffic controllers.** Working in ATM is a good profession, but while ANSPs can provide training on the specifics of air traffic control, they need trainees that have a solid education as a base. For that matter, the aviation industry in general in these fast-growing regions needs well trained engineers and pilots to fly for generations to come – air transport is a solid and reliable industry that will pay dividends to an educated society.
- **Set in place the necessary procedures to implement the ICAO aviation system block upgrades.** This may include rectifying the governance issue of creating a business-oriented ANSP, opening up the opportunities of private financing of ATM infrastructure.
- **Open up currently closed military air space.** This would allow for greater capacity increases and more direct (and efficient) routes. There are several models for achieving this – such as complete opening of airspace, or mixed use, where civil and military training can occur at alternate times.

→ CASE STUDY

Abu Dhabi introduces PBN
In September 2011, Quovadis was contracted by operator Etihad Airways and Abu Dhabi Airport to develop procedures for approaches into both Abu Dhabi International and Al Bateen Airports. These new technology approaches enable Etihad Airways to use continuous descent operations and optimised trajectories, shortening flightpaths to the runway. In May 2012, Etihad Airways performed its first optimised RNP-AR approach in Abu Dhabi with an A330. Each time the operator performs an RNP-AR approach, they are able to reduce their noise footprint, flight time, fuel consumption by 100 to 200 kg and CO_2 emissions by at least 20,000 tonnes a year. In addition, such approaches help reduce Abu Dhabi air traffic controllers' workload and optimise airspace management.

NORTH AMERICA

Air traffic in North America

The North American air traffic region remains the busiest in the world although the growth rate has slowed in the last decade. This region, including both the United States and Canada, covers over 30 million square kilometres and handles over 55,000 flights per day at over 600 busy airports (with the US responsible for about 80% of these flights).

There are only two ANSPs in this region, the FAA and Nav Canada. This region has 25 separate air traffic control centres (18 in the US and seven in Canada) with over 16,000 air traffic controllers working to ensure safe flights. The two ANSPs work seamlessly to manage cross-border and international flights.

Both countries are implementing the latest technologies to make air travel safer and more efficient. Through the Next Generation air transportation system (NextGen) programme in the US and Nav Canada's collaborative initiatives for emissions reductions (CIFER), they are systematically implementing Performance Based Navigation throughout the airspace, RNAV/RNP based airport approaches, ADS-B, optimum descents as well as increased use of data link instead of voice messages between air and ground personnel and system wide information management. The US is also faced with government agencies requiring airspace availability for unmanned air vehicles for national security.

The key objectives of the NextGen programme are:

- a reduction in delays by 38% by 2020;
- a cumulative reduction in carbon emissions of 14 million tonnes by 2020;
- a total complement of about 700 ADS-B stations in the Continental US by early 2014;
- significant efficiency improvements in several metroplex areas (large population regions with several major airports) by 2014; and
- increased advocacy and use of sustainable alternative fuels.

Nav Canada – which also includes some of the busy North Atlantic oceanic airspace in its region – forecasts a reduction in CO_2 emissions of 21 million tonnes by 2020 leading to $7 billion in fuel cost savings for the operators.

North American ATM challenges

The challenges in this region are similar to those in Europe but without the airspace fragmentation and multiple ANSPs. Traffic is expected to begin increasing again at a 1 to 2% annual basis as the 2008-2010 recession effects wear off.

The primary task is implementing the desired new operations in a coordinated way that offers real benefits to the users. The FAA and the NextGen programme and Nav Canada's CIFER initiatives have implemented a 'foundation for success' to enable a more effective organisational and management structure for ensuring the timely, cost-effective delivery of NextGen capabilities. The FAA is also exploring financial incentives that could help aircraft operators install avionics equipment to take advantage of the new technology. The goal is to adjust the current 'mixed fleet' ratio in which there are a few NextGen equipped aircraft and many non-equipped, to one with many equipped and only a few non-equipped.

Another challenge is obtaining user 'buy-in' to the technology and proposed efficiency enabled by the new operations. The FAA is actively engaging with aircraft operators (commercial, cargo, business, military and general aviation) to prioritise the path to implementation and to help make a robust business case.

A third challenge towards increased automation requires vastly enhanced collaborative decision-making. The large operators in the US have expressed strong concern that with more automation, the overall air traffic system will have to coordinate much more with flight operations centres to balance efficiency and potential rationing of limited airspace resources with operator business objectives and do it in an equitable way. As NextGen heads towards trajectory based operations and increased digital controller-pilot interactions, they want to ensure the decision making process explicitly includes the flight operations centres.

Policy solutions

Policymakers in North America should:

- **Ensure the continued funding of NextGen initiatives that provide the earliest and greatest actual benefits in reducing fuel use and carbon emissions.** Initiatives that offer actual savings will receive the strongest support from the aviation community. Ongoing funding must be provided to continue with the implementation of: PBN initiatives, especially the optimisation of airspace procedures in busy metroplex regions; ADS-B; and internationally-harmonised 4D trajectory operations with advanced data communications.
- **Increase the public-private partnership for NextGen equipage.** By finding ways to create financial opportunities and incentives for operators to install new equipment, the ratio of equipped to non-equipped aircraft can be accelerated and efficiency improvements can be realised earlier.

- **Invest in the training of the next generation of air traffic controllers to support the advanced procedures of a mixed equipage environment.** While air traffic controllers are well trained on current procedures, significant investment must be made in the next generation of controllers to become air traffic managers in a more complex environment with equipped and non-equipped aircraft performing mixed procedures.
- **Encourage the FAA to explore metrics that accurately reflect the impact of efficiency improvements due to operational changes.** Current metrics primarily emphasise safety and total average fuel use. Reductions in average fuel use can be due to a combination of factors such as newer, more efficient airplanes and a single metric can mask the portion due to ATM improvements.
- **Ensure that NextGen implementation is coordinated with aircraft manufacturers' plans and operator upgrade plans.** The expense of developing new airborne equipment and putting them on thousands of aircraft can vastly outweigh the cost of the ground system or the ability of operators with thin to non-existent profit margins to afford them. This coordination must also ensure the global system is harmonised to prevent different implementations in different regions (such as occurred in Europe with Link-2000+). The timing of upgrades in ground systems must be better planned and matched to the long upgrade cycles for aircraft and equipment suppliers. Operators cannot afford frequent upgrades to airborne equipment to take advantage of small, incremental ground system improvements.
- **Nav Canada should continue with its modernisation and automation investments.** Continued implementation of ADS-B and PBN over remote regions will offer increased safety and air traffic operations on northerly flights.
- **Accelerate the process for new procedures that take advantage of new technology.** Historical data shows that new technology-enabled operations requiring new air traffic procedures can take 15-30 years to: define, create standards, design and integrate the airborne and ground equipment, conduct trials, obtain regulatory approval and rollout the capability. Policymakers must maintain pressure on ANSPs to safely streamline the entire lifecycle process to bring new capability to operational use if there is any hope of meeting the demand, capacity and efficiency objectives required for aviation over the next few decades.

→ CASE STUDY

Flight AC991
On 18 June 2012, Air Canada performed North America's first 'perfect flight' over international borders, with the goal of cutting CO_2 emissions by more than 40% compared to a regular flight. The commercial flight on an Airbus A319 aircraft from Toronto to Mexico City has combined the use of a modern, state-of-the-art aircraft, powered by sustainable alternative fuels, guided by streamlined air traffic management procedures and facilitated through best practice operations to under-pin the industry's four pillar strategy to tackle carbon emissions.
The Air Canada flight was the second leg out of a series of four biofuel flights which delivered the Secretary General of the International Civil Aviation Organization (ICAO) Raymond Benjamin to Rio de Janeiro for the United Nations Conference on Sustainable Development (Rio+20).
The flight combined the best operational and environmental practices available, including:
- *use of a sustainable biofuel blend (50% biofuel and 50% regular jet fuel) made from used cooking oil supplied by SkyNRG;*
- *optimised routings and flight altitude with the support of Nav Canada and FAA air traffic management, the flight took the most direct route, using the most efficient vertical flight profile;*
- *applying a continuous descent approach into Mexico City to save fuel and limit noise; and*
- *a combination of several eco-efficient operational procedures such as single engine-taxiing, external aircraft cleaning for improved aerodynamics and light weight cabin equipment.*

→ CASE STUDY

Delivering near-term environmental improvements
The NATS airspace efficiency database holds hundreds of potential near-term fuel burn and CO_2 improvements in the UK airspace network suggested by airline and airport customers or NATS staff. Since the start of the database in 2009, the ANSP has put into operation more than 100 operational and procedural changes relating to air traffic flows in NATS airspace. This has saved an estimated 115,000 tonnes of CO_2 emissions representing a fuel saving worth some $37 million. In 2011 alone NATS delivered 26 changes, enabling fuel savings of $16 million and 51,000 tonnes of CO_2.
Most of the changes take the form of flight plannable direct routes and / or changes to procedures. Examples of those delivered in 2011 include:
- *Increased access to routes through military airspace in Wales providing more fuel efficient direct routes for aircraft flying to/from Ireland and North America – providing savings of 300 tonnes of fuel (1,000 tonnes of CO_2) per annum;*
- *A new route through military airspace in South West England for weekend and night-time flights to/from Ireland – saving around 150 tonnes of fuel (480 tonnes of CO_2) per annum.*

→ CASE STUDY

Introducing PBN in Canada
For a number of years, Nav Canada has been working with customers on introducing performance-based navigation (PBN) concepts in the Windsor-Toronto-Montreal area, the busiest air traffic corridor in Canada, covering approximately 140,000 square kilometers. In 2012, Phase I of the changes was implemented, including new area navigation (RNAV) standard terminal arrival routes at Toronto, Ottawa and Montreal airports, a new RNAV standard instrument departure structure at Toronto and an overhaul of the en-route structure in the corridor between Toronto and Montreal, making the airspace study the largest package of changes ever implemented at one time in Canada. As a result of these changes, four additional routes have be added in the corridor, expanding capacity and enabling better segregation of overflights from climbing and descending portions of departure and arrival routes, and reducing the overall requirement for in-trail sequencing. Nav Canada estimates that the changes will have the following benefits:
- *reduced greenhouse gas emissions by 14,300 tonnes – a reduction equivalent to the annual emissions from 2,800 passenger cars;*
- *reduced aircraft fuel burn by 5.4 million litres annually, resulting in annual savings of approximately $4.3 million in avoided fuel costs; and*
- *reduced cumulative flight time by over 10 hours daily based on current traffic volumes.*

CONTACTS

If you are interested in receiving further information about the technologies or operational projects in this publication, these organisations may be able to assist.

Boeing
Boeing has a comprehensive portfolio of ATM solutions to optimise the efficiency of the worldwide system, including research and development, airspace design, navigation services, modelling and simulation, airplane equipage, air-ground integration and system-wide information management.
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Airbus ProSky Group
Dedicated to improving the performance of global ATM, the Airbus ProSky Group (including Metron Aviation, Quovadis and ATRiCS) delivers ATM research and development, air traffic flow management, surface management, performance-based navigation and collaborative decision making solutions.
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Civil Air Navigation Services Organisation (CANSO)
The global association of air navigation service providers.
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GE Aviation
With performance-based navigation design and deployment, high resolution geospatial earth imagery, pre-arrival flow management, flight management systems and more, GE Aviation is building the foundation of air traffic management.
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FURTHER READING

Accelerating Air Traffic Management Efficiency: A Call to Industry published by CANSO and Boeing: http://tinyurl.com/8vfrucz
ICAO Block Upgrades project: check www.icao.int
Africa strategic improvement action plan, published by ICAO: http://tinyurl.com/ckhhext

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4 Total delay impact study: A comprehensive assessment of the costs and impacts of flight delay in the United States: Nextor and the FAA, October 2010. http://tinyurl.com/2dq3uor
5 Transforming the air transportation system: a business case for program acceleration: Deloitte, 2011. http://tinyurl.com/97cyc2q
6 Motion for a European Parliament resolution on the Implementation of the Single European Sky Legislation, October 2012: http://tinyurl.com/8k4jqgg
7 Single European Sky ATM Research programme. Assessing the macroeconomic impact of SESAR: SESAR JU and McKinsey, June 2011. http://tinyurl.com/9n9pwcn
8 Promoting ADS-B in the Asia-Pacific Progress Report, CANSO and IATA, April 2011. http://tinyurl.com/9575kvo
9 Note: Owing to upper winds changes on a daily basis, a definitive comparison falls outside the scope of this document. The values shown here are indicative and used as a baseline and conservative estimate.
10 IATA compilation of aircraft manufacturer and airline fuel burn data.
11 SESAR fact sheet on a macroeconomic study by McKinsey, 2011: http://tinyurl.com/brumj5r