Transforming the Air Transportation System
A business case for program acceleration
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1. Preface

This study is intended to provide input to the current industry dialogue about the cost benefits of accelerating various air traffic control (ATC) and air transportation system (ATS) transformation and modernization initiatives globally. We conducted this study to assist decision makers by using industrial cost benefit and business case analysis techniques, which results in net present value (NPV), internal rate of return (IRR) and payback period investment metrics. We have not conducted this study with methods typically found in a macro-economic analysis, including assessment of dependent variables, statistical analysis or econometric forecasting techniques.

We are mindful that the business case for investment in ATS transformation initiatives is highly dependent on assumptions of variables, such as forecasted fuel costs and air travel demand. We have made reasonably conservative assumptions and have modeled the business case on what we believe is a realistic scenario for the planning horizon. In some cases, we use parametric forecasting techniques where data is not readily available, in order to create a realistic scenario of cost benefits for transformation initiatives. This study assesses a wide range of potential future scenarios that contemplate differing assumptions and business case sensitivities with associated investment metrics to inform decisions makers.

Also, this study albeit global in scope, focuses proportionately more attention on United States (U.S.) ATS transformation initiatives and metrics, as the data and published reports were readily available and it has been studied to a great depth more recently. We have used U.S. Federal Aviation Administration (FAA) data in some cases as a proxy for rest of world (ROW) data where it was not readily available, with modification where appropriate.

We would like to thank our ATS association and industry colleagues, many of whom have informally reviewed this study and provided invaluable comments and input, although these organizations do not formally endorse this study nor vouch for its content in whole or in part.

“Our study estimated annual savings to include 3 billion gallons of fuel, elimination of 29 million metric tons of carbon emissions and reduction of 4 million hours of delay. These savings amounts to $29 billion of net benefits in the U.S. alone each year and $135 billion globally, in the first year of full system deployment in 2026.”
Deloitte has conducted a business case study for transforming the global ATS by transitioning to satellite based positioning, navigation and timing (PNT) technology, real time digital data communications, advanced weather sensing and precision navigation technologies. The U.S. Federal Aviation Administration (FAA) as well as the European Union (EU) EUROCONTROL ATS agencies are in the process of modernizing through the Next Generation ATS (NextGen) and Single European Sky Air Traffic Management (ATM) Research (SESAR) programs respectively. Other programs globally are in various stages of design and deployment. This study was conducted to provide additional input to the ongoing industry dialogue regarding quantification of benefits and costs, funding, scope, timing and potential merits of these transformation programs and economic value of accelerating these programs, as well as the impact of potential program delays.

**Savings:** Our study estimated annual savings to include 3 billion gallons of fuel, elimination of 29 million metric tons of carbon emissions and reduction of 4 million hours of delay. These savings amounts to $29 billion of net benefits in the U.S. alone each year and $135 billion globally, in the first year of full system deployment in 2026. These significant fuel savings, lower carbon emissions, time saved and economic benefit should result from the transition to advanced satellite based PNT technologies as well as new ATC procedures. This transition should help in overcoming most weather induced and ATC based delays, allowing for direct flight paths and closely spaced aircraft operations.

**Investment metrics:** Specifically, we found the projected NPV of global transformation programs through 2035 is $897 billion. The estimated regional break-down is as follows: U.S. NextGen program, $281 billion, EU SESAR program, $266 billion, and ROW, $350 billion. Globally, estimated savings accrued by different beneficiaries of implementation are as follows: airlines 31%, overall economy 30%, passengers 34%, and Air Navigation Service Provider (ANSP)/Airports/ATC organizations 5% of the total benefits.

Our study examined three ATS transformation timetables on a regional and global basis: (1) implementing transformation as planned by 2025, (2) accelerating implementation to 2020, and (3) delaying the scheduled implementation until 2030. In each implementation analysis, we estimated the present value of benefits, costs and the NPV. In each of these implementation timetables, our study projects significant positive net benefits for deployment of ATS transformation programs. The following chart summarizes the different NPV, IRR and payback period investment metrics, and our specific findings:

<table>
<thead>
<tr>
<th>Implementation Timetable (Steady Flight)</th>
<th>Investment Metrics (all values are obtained by using Tier 1, 2 &amp; 3 benefits)</th>
<th>U.S. NextGen</th>
<th>EU SESAR</th>
<th>Rest of World</th>
<th>Global Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned Implementation (2025)</td>
<td>NPV</td>
<td>$281.3</td>
<td>$286.2</td>
<td>$349.8</td>
<td>$897.3</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>44.8%</td>
<td>31.9%</td>
<td>43.5%</td>
<td>39.8%</td>
</tr>
<tr>
<td></td>
<td>Payback period</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Accelerated Implementation (2020)</td>
<td>NPV change</td>
<td>18.0</td>
<td>51.3</td>
<td>28.6</td>
<td>91.9</td>
</tr>
<tr>
<td></td>
<td>IRR change</td>
<td>21.7%</td>
<td>8.6%</td>
<td>20.1%</td>
<td>13.4%</td>
</tr>
<tr>
<td></td>
<td>Payback period change</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Delayed Implementation (2030)</td>
<td>NPV change</td>
<td>-47.6%</td>
<td>-39.8%</td>
<td>-60.7%</td>
<td>-148.1%</td>
</tr>
<tr>
<td></td>
<td>IRR change</td>
<td>-13.5%</td>
<td>-15.8%</td>
<td>-13.0%</td>
<td>-16.7%</td>
</tr>
<tr>
<td></td>
<td>Payback period change</td>
<td>-2</td>
<td>-4</td>
<td>-2</td>
<td>-2</td>
</tr>
</tbody>
</table>
Scope limitations: We have not included in the scope of this study the quantification of potential benefits associated with the general aviation community and military flight operations, nor improvements in safety which are expected. This was due to a general lack of consistent data and agreed on definitions on a global basis. There are other scope items recognized as generating potential additional upside benefits for ATS transformation, which were also not included in the scope of this business case such as some level of ATS facility and air space consolidation, possibly some level of ground based system termination, and delayed need for additional airport runway capacity.

Challenges and risks: This business case recognizes there are many challenges and risks to accelerating, let alone meeting the planned implementation date for ATS transformation initiatives, even though the business case estimates a net positive benefit for sooner implementation. These include, but are not limited to funding, technology risk, regulatory reform, ATC procedures, technical and certification standards and harmonization and workforce transformation. The most important specific challenges and risks for NextGen are noted below. The EU and ROW may have other challenges and risks albeit different, but could have similar impacts on schedules and budgets.

First, under the acceleration scenario, the study assumes that funding for the multibillion dollar NextGen program will be increased. Accelerating the program would require substantial annual increases by pulling forward funding intended to be spent for the 2021-2025 budget years. If the relevant constituents support acceleration of NextGen, this action would likely require an exemption from the president’s five-year budget freeze for the discretionary civil budget.

Second, we assume that the various interdependent technology platforms that are foundational for the NextGen system to work will be implemented on budget and on schedule. If one technology platform falls behind schedule or experiences cost overruns, this can materially affect schedules and budgets for other interfacing NextGen technologies. As we go to press, it appears that there are significant schedule slippages in one of its multibillion dollar systems for controlling air traffic at high altitudes. If these delays are not overcome, it is not likely that NextGen could successfully be accelerated to the 2020 milestone.

Third, we assume a plan will be developed and implemented to address aviation system delays attributable to the surface environment. NextGen technology platform benefits are dependent on successful resolution of capacity challenges of insufficient number of runways, gate shortages, and over scheduling of flights during peak traffic periods. Avoidance of the costs of system delays, whether occasioned by airborne congestion or ground-based constraints are included in the benefits found in this study. Therefore, the FAA’s development and implementation of a plan that addresses surface-based delays will be critical in order for the benefits found in this study to be achieved.

Funding challenge: Funding for ATS transformation initiatives is an investment decision made by governments and air travel constituents, and there remain concerns regarding the affordability and allocation of costs among numerous constituents, which include sovereign and local government agencies, commercial airline operators, other air space users, passengers, etc. For the overall system to work most effectively, adoption rates for equipage on the ground and in the cockpit for most if not all air space users needs to be substantial. For this reason, mechanisms for financing of upgrades and developing coordinated strategies for maximizing equipage adoption become critical.

Ongoing dialogue regarding proposals for funding sources and methods, such as public private initiative (PPI) financing, infrastructure banks, “best equipped, best served”, “cash for carbon”, government loans and other means to increase adoption rates have been discussed. Additional debate and study to understand and quantify the benefits and costs associated with ATS transformation will help guide the way for making appropriate trade-offs and finding a path for allocation of costs in this important and game changing investment decision. This cost and benefit allocation analysis might include relevant constituents, such as commercial aircraft operators, government ATS agencies, passengers and the
This business case recognizes there are many challenges and risks to accelerating, let alone meeting the planned implementation date for ATS transformation initiatives, even though the business case estimates a net positive benefit for sooner implementation.

general public. Addition of other air space users such as the general aviation community as well as the military in follow-ups to this study might provide a broader business case for this investment. The costs for implementation of SESAR do include the costs to be incurred by general aviation and military. This would result in a more conservative value of NPV for SESAR. Data for other cases were not available and hence have not been considered.
Deloitte has conducted a business case study for transforming the global ATS and transitioning to a global satellite-based PNT system along with other advanced communications and related technologies. The premise is that ATS transformation will significantly save fuel, reduce delays and travel time, increase air system capacity, improve safety and result in less carbon impact to the environment. As shown in the following chart, there are four major improvement categories in established programs to improve the global ATS, which are expected to generate specific qualitative as well as quantitative benefits.

Figure 1: Benefits of ATS transformation

- **Qualitative Benefits**
  - Reduced delays will lead to increased customer satisfaction for airlines, and reduction in lost wages and productivity
  - Better information sharing and improved aircraft spacing will lead to enhanced air travel safety
  - Requirement of trained personnel to operate the system will lead to job creation in both airlines and airports

- **Quantitative Benefits**
  - Benefit from reduced delays
    - Reduced fuel costs
    - Reduced carbon emissions
  - Benefit from improved operational efficiency
    - Reduction in direct operating costs for airlines
    - Increase in operating margins for airlines from higher load factors / higher flight frequencies
  - Benefits from increased capacity: Addition of value from increased air travel to national economies
3.1 Current situation:
The current ground based system of radar, radio beacons, voice communications and related systems and processes requires certain safety procedures to be followed, such as minimum separation distances between aircraft both vertically and horizontally, and altitude of flight and reserves for fuel. These systems and processes were designed when air traffic was limited and navigation, weather forecasting and communications technology was much less mature, and certainly before the invention and deployment of the game changing U.S. government owned global positioning system (GPS). Air travel has become more frequent, the price of fuel has increased, and the dependence on proper operation of the system has become more acute. Disruptions such as weather delays and capacity limitation at airports have increased costs to airlines, passengers and the global economy.

Currently the U.S. FAA as well as the EU EUROCONTROL ATS agencies are in the process of modernizing their systems through the NextGen and SESAR programs, respectively. Many governments in other part of the world are also in the process of planning and implementing similar programs. These initiatives take advantage of technology advances in PNT systems, real-time digital data communications, weather sensing and prediction systems, aircraft navigation and related technologies to make more efficient use of aircraft and ground systems. The FAA estimates its own costs associated with full implementation of the NextGen architecture by 2025 will total between $15 billion and $22 billion. The agency also acknowledges an additional $14 billion to $20 billion will likely be incurred by the airlines and other users of the national airspace system (NAS) who must retrofit their aircraft to make them NextGen compatible. Other industry experts and systems providers have estimated total aircraft equipage costs in the U.S. generally to be lower, in a range less than $12 billion.

For commercial airline operators according to the FAA, it is estimated that in 2009 in the U.S. alone, 780 billion revenue passenger miles were flown, by 75,000 airline pilots, co-pilots and flight engineers. As the global economy becomes more efficient with hundreds of millions of just in time freight, mail and small package deliveries, air transportation reliance has become more acute. From a volume perspective, FAA and contracted control towers manage more than 13 million flight operations per year. The system is increasingly safer in that accident rates have been declining for years and currently stands at 1.4 accidents per 1 million flight hours for large commercial carriers.

Although not in the scope of this study, flight operations in the general aviation community, consisting of piston, turboprop and business jets, comprise a large percentage of all aircraft flight operations including commercial, totaling approximately 51% of all airport operations at FAA and contracted civil public use airports. The air taxi community comprises another 18.5% of airport operations. These communities consist of about 240,000 aircraft, flying almost 30 million hours per year. A large majority, about 170,000 of these aircraft are piston powered, mostly flown for personal use. There are approximately 225,000 licensed private pilots in the U.S., with another 80,000 student pilots.

It should be pointed out that benefits of ATS transformation initiatives to the General Aviation (GA) community are significantly different in that they generally do not fly for compensation or hire, typically fly less in congested airspace (but are active in high density airspace as well) and do not fly scheduled routes. Thus the ATS transformation investment economics are different for the GA community than for the airlines.

The NAS has a far reaching impact on the air transportation industry and the U.S. economy. According to the FAA in their recent 2009 economic impact survey, civil aviation contributes $1.3 trillion annually to the U.S. economy or 5.6% of gross domestic product (GDP). It generates nearly 12 million jobs with earnings of $369 billion. The same report cites that the U.S. civil aviation manufacturing industry remains the single largest contributor to the nation’s balance of trade, exporting $70.5 billion and importing $22.2 billion in relevant products in 2009, for a net surplus of $48.3 billion. The industry contributes positively to the U.S. trade balance, creates high paying jobs, keeps just in time business models viable and connects friends, family and commercial opportunities.
According to the FAA website, without NextGen there will be gridlock in the skies in the medium term. By 2022, they estimate that failure to implement would cost the U.S. economy $22 billion annually in lost economic activity. That number grows to over $40 billion per year by 2033 if NextGen is not implemented. Even as early as 2015, FAA simulations show that without some of the initial elements of NextGen, the U.S. will experience delays far greater than what we are seeing today. Current estimates are that U.S. NAS capacity utilization will be reduced from 85% today to 65% of available usage by 2025 without NextGen\textsuperscript{8}. However, the current commercial traffic recession has significantly reduced travel demand and may affect that forecast as least in the short term. However, increased capacity benefits are expected to mainly accrue to airline operators in the future as transformation initiatives are implemented.

According to a recently released FAA-sponsored study by NEXTOR, it was estimated that the total cost of all U.S. air transportation delays in 2007 was $32.9 billion. This consisted of $8.3 billion of increased airline operator expenses for crew, fuel, and maintenance, among other direct costs. It also consisted of another $16.7 billion in passenger time lost due to schedule buffers, delayed flights, flight cancellations and missed connections. It also consisted of another $3.9 billion in welfare loss incurred by passengers who avoid air travel as the result of delays. Finally the study found that air transportation delays reduced the 2007 U.S. GDP by $4 billion\textsuperscript{9}.

The global dependence on air travel was highlighted in the recent European shutdown of flight operations for several days due to the eruption of an Icelandic volcano in April 2010. According to a recent IATA report, over 100,000 flights were cancelled during the six days of air space closure, and many European economies, let alone affected airlines, were financially affected. Hundreds of thousands of passengers and their related businesses were financially affected as well\textsuperscript{10}. Although global ATS transformation initiatives may not have completely mitigated that situation, it does illustrate our dependence on air travel and the significant economic impact ATS disruptions can cause.

3.2 Historical perspective

The history of ATC goes back to the early days of flight after the historic flight of the Wright Brothers in 1903. By 1919, the International Commission for Air Navigation (ICAN) was created to develop General Rules for Air Traffic to control the risk of mid-air collisions of a burgeoning number of aircraft being flown. Although the U.S. did not sign the ICAN convention agreement, it later developed its own set of air traffic rules after passage of the Air Commerce Act of 1926. This legislation authorized the Department of Commerce to establish air traffic rules for the navigation, protection and identification of aircraft, including rules related to safe altitudes of flight and rules for the prevention of collisions between vessels and aircraft. By 1930, the first radio-equipped control tower in the U.S. began operating at the Cleveland Municipal Airport and quickly multiplied by 1935 to 20 radio control towers operating in the U.S. thus creating the beginnings of what is today referred to as “terminal control”.

Increases in the number of flights created a need for ATC to be broadened and extended out along the flight paths and not just confined to airport areas. By 1935, leading airlines operating out of Newark, Chicago and Cleveland airports began coordinating airline traffic between those cities. The first Airway Traffic Control Center opened at Newark, New Jersey in late 1935. Chicago and Cleveland airports followed in 1936 and “en-route air traffic control” became a federal responsibility, with an appropriation of $175,000. The U.S. Federal Government provided airway traffic control service, but local government authorities where the towers were located continued to operate those facilities.

By 1941, the U.S. Congress appropriated funds for the Civil Aeronautics Administration (CAA) to construct and operate ATC towers and, by 1944, the CAA operated 115 towers. After World War II, the U.S. government took permanent responsibility for ATC towers as well as en-route ATC systems. The postwar years saw the beginning of a revolutionary development in modern day ATC - the introduction of radar. Originally developed by the U.K. for military defense, this new technology allowed controllers to detect the position of aircraft tracked on visual displays. In 1946, the CAA unveiled an experimental radar-equipped tower for control of civil flights. By 1952, the agency had begun its first routine use of radar
for approach and departure control. Four years later, it placed a large order for long-range radars for use in en route ATC. In 1960, the FAA began successful testing of a system under which flights in certain positive control areas were required to carry a radar beacon, called a transponder that identified the aircraft and helped to improve radar performance. Pilots in this airspace were also required to fly on instruments regardless of the weather and to remain in contact with controllers. Under these conditions, controllers were able to reduce the separation between aircraft by as much as half the standard distance. However, today’s ATS and control systems and processes continue to rely on this ground based radar, voice communications, navigation and surveillance (CNS) system, and the same radio beacons introduced in 1930. Some improvements brought about with technology innovations in the control tower and in aircraft cockpits such as GPS have been made, however the ATC system of record is still based on the original system of ground control, radar and radio beacons.

3.3 ATS transformation business case
Transitioning to new ATS initiatives is expected to generate considerable quantitative and qualitative benefits well beyond the costs of implementation. In the U.S. alone according to the FAA, by 2018 flight delays are expected to be reduced by approximately 35%\textsuperscript{12,13} saving almost 1 billion gallons of jet fuel\textsuperscript{12, 14}. In addition, significant additional capacity is expected to be created in the NAS, with an estimate of 85,000 to 250,000 additional flight operations enabled with the same number of people\textsuperscript{2}. Specific ATS technical and procedural improvements that enable increased capacity, efficiency and the other benefits cited previously include:

- Enhanced visual approaches
- Closely spaced parallel approaches
- Reduced spacing on final approach
- Reduced aircraft separations
- Enhanced operations in high altitude airspace for incremental evolution “free flight” concept
- Surface operations in lower visibility conditions
- Near visual meteorological conditions (VMC) capacities throughout the airspace in most/all weather conditions
- Improved ATC services in non-radar airspace

This study focuses on the economic benefits that could potentially be realized through ATS transformation initiatives and the business case to accelerate planned program timelines, as well as the impact of a potential delay in implementation. The study describes in a later section some of the key challenges and risks that would need to be overcome to successfully achieve these economic benefits should the case be made to implement sooner than planned.

Previous studies have been conducted regarding the merits of transitioning from the current U.S. and European ground based system currently operated by the FAA and EUROCONTROL. The numbers cited in other studies may not be comparable due to differing time periods, definitions, metrics, assumptions used, scope involved or the methodology used. However, this Deloitte business case study is global in scope and incorporates an up to date and more comprehensive set of benefits and costs, and then assesses several assumptions, variables, sensitivities and scenarios for further consideration.

In particular, we model various potential scenarios, for example a high rate of air traffic growth or low increases in the price of fuel. However, the principal reason for this business case is to model the net benefits and potential merits of accelerating these ATS programs globally, as well as assessing the economic impact of potential implementation delays. We hope this analysis will be useful to the ongoing industry dialogue regarding the related investment decisions.
4. Business case study process

4.1 Methodology
The structure of the business case methodology includes an assessment of the non-recurring and recurring costs and recurring benefits over the time horizon of 2010 through 2035, 10 years after the assumed implementation of NextGen and SESAR ATS transformation programs. Costs and benefits are stated in U.S. dollars and foreign currency conversions were completed to provide a globally integrated view of the investment metrics. Calculations were completed that resulted in NPV and IRR investment metrics for various scenarios, with ranges that contemplate differing assumptions, sensitivities and variables.

A “what-if” scenario was calculated to understand if there is an improvement in the investment case to accelerate the ATS transformation program by five years. The timeline in the accelerated business case is assumed to be 10 years, through the end of 2020. We also modeled a “what if” scenario that contemplates a delayed implementation by five years, with completion by 2030.

4.2 Scope
The business case scope includes a global view of the current and expected ATM and control systems, divided into three geographic categories: the U.S., Europe and the ROW. The scope focuses on commercial scheduled airline passenger and commercial air freight operations.

Due to the differences in operations and consequently the benefits derived from ATS modernization, the business case scope does not include GA (including unmanned aerial systems) or military operations, although there is acknowledgement of benefits that would be derived for these segments of the aviation industry. It also does not include a quantification of improvements in safety, a key stated goal of global ATS transformation initiatives. From a costs perspective, data were available for costs to be incurred by GA or military constituents in Europe and have been included while studying SESAR. This results in a lower NPV for Europe. Such data were not available for U.S. and ROW.

Data for the U.S. and the EU are specifically identified and utilized in this analysis. However, data for the ROW if not specifically identified, are largely extrapolated using existing U.S. and EU data, due to the difficulty in making assumptions about how and when transformation initiatives will be accomplished. The ROW is very heterogeneous and would be difficult to analyze in the context of this business case. Thus using U.S. and EU data was assumed to be a reasonable proxy, although not perfect, for the ROW analysis for conducting this business case. However, further study is required to assess the different situations and sensitivities for the multiple regions and countries involved in the ROW, in order to gain higher precision in the business case.

The scope includes benefit categories of fuel savings, decreased delays, passenger time savings, decreased emissions of CO₂, NOₓ and SO₂, decreased maintenance costs, repair and overhaul of equipment, and increased economic benefit. The scope includes non-recurring costs of implementation on the ground and in the air as well as recurring costs for new and remaining legacy processes.

The following list illustrates in more detail the components of these costs and benefits which were assessed in this business case:

Recurring benefits from decreased delays:
• Reduced fuel costs
• Reduced crew cost due to fewer hours of flight
• Increase in revenues from higher load factors/higher flight frequencies
• Reduction in maintenance and repair costs for aircraft
• Reduction in insurance cost due to fewer hours of flight
• Reduction in near accident delays

Non-recurring costs:
Infrastructure costs:
• Systems for NextGen programs: Automatic Dependent Surveillance System–B (ADS-B), System-wide Information Management (SWIM), Data Communications, Area Navigation (RNAV), Required Navigation Performance (RNP)
• Systems for SESAR: RNAV/FMS, SWIM, ADS-B, GNSS and GBAS CAT II and III for approaches

Equipment purchase and configuration costs:
• Aircraft avionics retrofit, electronic flight bags
• Installation of new precision landing systems compatible with aircraft avionics refits
• Cost of launching additional and replacement satellites for the U.S. GPS and European Galileo programs

Program management costs:
• Program management costs for development, evaluation and validation phase
• Human resource costs of teams working on the definition and development of new systems
• Costs for end user training and knowledge transfer
• Demonstration activities for users and costs of financial incentive programs
• Transformation costs for revised regulations, processes and procedures

Recurring costs:
Human resource costs:
• Differential headcount and salaries of personnel for new systems, where applicable
• Differential recurring training costs for NextGen/SESAR, where applicable

Maintenance costs:
• Incremental spare parts/tooling costs, where applicable

4.3 Assumptions
This business case for ATS transformation incorporates numerous assumptions. As described above, in order to provide meaningful and relevant information for consideration, we have relied on data from credible and well established sources and analyzed scenarios that incorporate a range of data assumptions being assessed.

Each scenario considers the following 15 types of data sets and assumptions and variations thereof:

• Historical air traffic volume (revenue passenger kilometers)\textsuperscript{15,16,17}
• Projected air traffic volume (revenue passenger kilometers)\textsuperscript{18,19,20}
• Historical delay data\textsuperscript{21}
• Projected delay data (without ATM transformation)\textsuperscript{22}
• Projected delay reduction (with ATM transformation)\textsuperscript{23}
• Historical capacity data (available seat kilometers)\textsuperscript{15,16,24}
• Projected capacity: Calculated based on assumption of historical load factors\textsuperscript{15} remaining constant at an average value from 1999 to 2009
• Projected capacity utilization (with ATM transformation)\textsuperscript{25,26,27,28,29}
• Cost of fuel ($/gallon): Historical global aviation fuel prices and growth rates of global crude oil futures from U.S. Department of Energy analysis. Crude oil growth rates were used for projections of aviation fuel prices in the future\textsuperscript{30}
• Fuel efficiency assumptions (gallons/mile): Assumes that fuel efficiency will improve by 25% between 2009 and 2025, which is consistent with Air Transport Association (ATA) and IATA projections\textsuperscript{31,32}
• Direct operating costs, including labor, ownership, maintenance and insurance\textsuperscript{33,34,35,36}
• Discount rate\textsuperscript{37}
• Inflation rate: Assumed constant at historical rates for U.S. and Europe (3.00%)
• Time horizon: 2010 to 2035. All investments for 2008 and 2009 are assumed to have occurred
• Value of carbon reduction: CO\textsubscript{2} carbon future prices from 2010 to 2025 ($/metric ton) for both the U.S. and European carbon trading markets\textsuperscript{38}

Each of the above assumptions is based on information obtained from relevant agencies and sources, which are cited in the appendix.

It is important to note that our analysis makes several important assumptions which make this business case conservative. There are several "upside" benefit opportunities that would likely make this business case more attractive. These assumptions and additional benefit opportunities were excluded because additional analysis, quantification and discussion among industry participants are required. These and other assumptions are as follows:

• The U.S. military and the Department of Homeland Security will likely require that portions of the existing radar surveillance capabilities of the CNS infrastructure will continue to provide primary radar surveillance capabilities. Foreign militaries would likely face the same requirement. The benefits of military aircraft inclusion and benefits derived thereof are not included, mostly due to the lack of available data and forecasts for NAS usage by country
• Enhanced air space security benefit - New processes, technologies, and procedures can help identify and
“This business case recognizes that there may be different levels of benefits that would be viewed as legitimate to include in a business case, from hard indisputable savings such as fuel savings, to benefits that may be viewed more skeptically, such as economic benefit.”

separate legitimate operations from potential security threats. This allows for controlling entities and security personnel to better focus the limited resources on a much smaller subset of possible threats. Not only can this free up resources, it can also allow for the legitimate operator to more freely conduct flights by minimizing operational disruptions due to security requirements. New technologies associated with transformation of the ATS provide for ready identification of flights as well as rapid determination of flight intent (speed, direction, etc.). Because threats to the aviation environment are constant and ever evolving, by accelerating the implementation of new technologies to improve air surveillance capabilities the risks of aircraft used for illicit purposes may be significantly lessened

• There may be savings that are not counted in the FAA or EUROCONTROL modernization plan that represent additional opportunities for efficiencies, including rationalization of ground infrastructure and navigation aids, facility consolidation and consolidation of large blocks of air space. Current FAA staffing plans do not take into consideration the post NextGen environment yet, although there is acknowledgment that more ATC operations per employee are possible, the pace of FAA controller hiring could potentially be decreased.

• The investment time horizon in this business case stops at 2035. Inclusion of benefits beyond that point would substantially increase the NPV of this business case.

• Certain improvements made by airlines for en route and terminal control are being made prior to ATS transformation, such as RNP, which are providing savings in fuel and carbon emissions already, although these improvements are implemented for a small percentage of the total air traffic operations globally. RNP will be needed for closely spaced operations.

• Costs for ATS transformation are assumed to be consistent with estimates provided by governmental authorities. Implementing ATS transformation programs across the world carries with it significant program risks related to program management issues, technology development challenges and change management associated with the current ATM control processes. Thus, we have added 10% contingency levels to these cost estimates to provide additional cushion in the business case. However, should these costs not be needed, this would represent additional upside NPV.

• There may be cost savings from the delayed need to expand airport capacity; e.g., building new runways or additional airports. These potential savings are not included here.

• Assumptions regarding allocation of implementation costs among the various constituencies of government air traffic authorities, passengers and airlines, etc., are not accommodated in this business case, as they may be policy matters where further dialogue and study may be necessary to match costs with beneficiaries.
4.4 Sensitivity analysis

The business case recognizes that there may be different levels of benefits that would be viewed as legitimate to include in a business case, from hard indisputable savings such as fuel savings, to benefits that may be viewed more skeptically, such as economic benefit. For that reason, we have separated and identified ATS transformation benefits into different levels, to acknowledge the need to assess the cost benefit and business case depending on the level of benefits included.

These three “tiers” of quantifiable benefits are as follows:

By assessing the different types of benefits that could be achieved based on categories of benefits included, we have provided a range of investment metrics to evaluate.
4.5 Scenarios

This business case analyzes and incorporates distinctly different potential future business conditions or scenarios. Each of these scenarios reflects plausible future conditions upon which the ATS implementation would occur. The four scenarios we analyze in this study are as follows:

- Grounded
- Turbulence
- Steady flight
- Takeoff

The following chart illustrates and describes each of the four scenarios where we have calculated investment metrics:

Figure 2: ATS business case scenarios

For purposes of this Deloitte business case for ATS transformation, we are assuming the “Steady Flight” scenario is the base business case for the non-accelerated, the accelerated and the delayed business case. The reason for this is that of the four scenarios analyzed, we believe this is based on conservative assumptions that represent the most realistic scenario in comparison to the others.
4.6 Variables

The four scenarios described above are built around certain varying levels of assumptions and integrated as four business case variables as follows:

- Air travel demand
- Change in airline fleet structure
- Price of fuel
- Environmental regulation

We have grouped related assumptions into these broad categories and indicated a value of high, medium and low, as pertains to the business case scenario. For example, in the “Turbulence” scenario, we assume that air travel demand is low, airlines are replacing their fleet with more fuel-efficient aircraft because the increases in the price of fuel is relatively high, and that environmental regulation is high resulting in the industry assuming the costs of carbon emissions.

The following illustrates the four scenarios, as well as a Deloitte rating of high, medium and low for each of the business case variables we have assumed in this business case methodology:

Figure 3: Values of independent business case variables for each scenario

Finally, for purposes of assessing the investment worthiness of the implementation of ATS transformation initiatives, we have calculated investment metrics typically used in making financial trade-offs in business cases. For each business case scenario, we have calculated NPV and IRR investment metrics, which forms the basis for the business case analysis.

“For purposes of this Deloitte business case for ATS transformation, we are assuming the “Steady Flight” scenario is the base business case for the non-accelerated, the accelerated and the delayed business case. The reason for this is that of the four scenarios analyzed, we believe this is based on conservative assumptions that represent the most realistic scenario in comparison to the others.”
5. Overall findings

The structure of the business case methodology includes aThe business case for transitioning from the current ground-based process of managing and controlling the global ATS to the satellite based PNT system and related processes and technologies varies depending on the assumptions and benefit levels considered. We found that the NPV for deployment under the current timelines planned through 2035 (assuming a non-accelerated timeline) ranges from a pessimistic $161 billion in the “Grounded” tier 1 benefit only scenario to a positive $1.3 trillion in the “Take-off” all benefit tiers scenario.

This wide range of NPVs illustrates just how sensitive the business case is to the assumptions, variables, sensitivities and scenarios used for calculating investment metrics. We have provided this wide range of estimated NPV metrics that represent plausible future conditions. However, we do not believe the metrics calculated at the extreme high and low ends of the range are realistic, but nonetheless they are presented here for consideration.

Our assessment and findings were focused on factors that impacted benefits of the ATS transformation programs and did not evaluate program costs. We accepted government and industry estimates of program costs as is, with the provision of adding a 10% contingency as described earlier.

The following sections provide our findings on each business case variable, followed by our findings for each scenario. The investment metrics for each scenario are summarized further in total as well as by geographic region in the appendix.

5.1 Business case variable #1: Air travel demand
We found that air travel demand has demonstrated growth of 4.1% over the last 10 years and is correlated to variations in global gross domestic product (GDP) growth rates. In 2009, air travel demand was estimated at 4.5 trillion Revenue passenger kilometers (RPKs). High, medium and low growth forecasts in terms of capacity, i.e., Available Seat Kilometers (ASKs), would depend on the likelihood of, or the absence of global economic recessions, due to the close correlation of these two factors.

We found that air travel demand is forecasted to grow to between 6 trillion and 14 trillion RPKs by 2025. In the high growth scenario demand and thus capacity are mostly driven by the comparatively higher growth economies of China and India, as well as increased general aviation activity globally. In the low growth scenario, air traffic is assumed to grow at a rate similar to that of the past 15 years with the global economy and GDP growth rates stay at historical averages.

The following chart illustrates the varying levels of forecasts for RPK growth in the U.S.

Figure 4: U.S. air traffic demand forecast (Billion RPKs), 1996-2025

Note: Historical air traffic volume was projected at three growth rates: 1. Base Case Growth Scenario (3.56% from Boeing CMO projections) 2. Low Growth Scenario (1.78% which is 50% lower than the base case), and 3. High Growth Scenario (5.34% which is 50% higher than the base case)
5.2 Business case variable #2: Changes in fleet structure

We found that changes to airline fleet structures have occurred in the past as the airline industry adopts new models to keep up with changing passenger traffic dynamics. For instance, average seats per aircraft declined from around 160 seats per aircraft in the mid 1990s to 135 seats in the mid 2000s as regional airlines mushroomed and narrow body aircraft demand increased dramatically. Average stage lengths also declined in the same period, and are now increasing again. By 2025, it is expected that global airline fleet structures will be more fuel efficient, create less noise and emit less hydrocarbons.

However, the type of aircraft operated will depend to a large extent on whether the hub and spoke airline business model dominates, with large twin aisle aircraft utilized at hub airports. The extent to which the existing fleet is exchanged for more modern equipment will depend on the number of long distance routes added, frequency of flights along the same routes and the extent of increase in air traffic demand.

The change in fleet structure was modeled on the basis of available capacity per available aircraft in terms of growth in Available Seat Kilometers (ASK’s) per flight. The drivers behind a high growth scenario are high passenger demand, necessitating large aircraft even on shorter routes, more hub and spoke operations, and high growth in traffic on long distance routes. The drivers behind the low growth scenario are lowered frequency of flights between existing routes and a smaller addition of new routes as air traffic demand is depressed, as well as a predominance of point-to-point low cost operations.

The following illustrates the possible growth scenarios in the U.S. for available capacity per flight.

Figure 5: U.S. fleet average capacity per aircraft forecast, 1996-2025

Note: Historical capacity per aircraft was estimated by dividing actual airline capacity expressed in ASKs by number of flights flown. Medium growth scenario assumes aircraft size will continue to increase at historical growth rates, and low and high growth cases assume an incremental change of -50% and +50% respectively.
5.3 Business case variable #3: Price of fuel

One of the most volatile variables in assessing the business case for ATS transformation is the assumed price of aviation fuel. As has been demonstrated in recent history, the price of fuel can swing widely, and since 2008, the price per barrel of oil based on monthly averages has spiked from $72 to $100 and back down to $61 in the span of 36 months. The price volatility can be seen clearly when viewed over time. The following chart illustrates this historical volatility in costs per barrel of oil from 1946 through today, both in nominal as well as inflation adjusted prices on a monthly average basis.

Figure 6: Historical average monthly crude oil prices (September 2010 U.S.$/barrel), 1946-2010

In this business case, we use the Energy Information Administration (EIA) reference index to forecast the price of fuel, and have created a high, medium, and low price forecast for fuel cost per gallon, which ranges from $1.44 to $4.88 per gallon of aviation fuel through 2025.

The following illustrates the past experience with price of jet fuel (prices in cents per gallon from 1996), and forecasts the expected increases though 2025 in a high, medium and low price forecast scenario.
Note: Aviation fuel price projections for low and high fuel price growth cases were all derived from U.S. Department of Energy estimates (2010) for future trends in crude oil prices. The base case is obtained from the latest U.S. Department of Energy Estimates (2011). For this projection, only the prices of aviation grade kerosene were considered.

Of course, fuel price is only one part of the picture, as aircraft become more fuel efficient. The fuel efficiency of passenger aircraft has improved from 1960 to 2000 by as much as 55% to 70%\(^\text{15}\), and going forward, aircraft are estimated to become up to 25% to 30% more fuel efficient by 2025\(^\text{45}\), compared to the baseline today. This will be driven by new engine technology and aerodynamic improvements as airlines start receiving deliveries of next generation passenger aircraft. The following illustrates actual fuel efficiency in liters per kilometer from 1996 through today, and forecasts improved efficiencies through 2025.

Figure 8: Forecasted fuel efficiency for commercial aircraft (liters/kilometer), 1996-2025

Note: Fuel efficiency from 1996–2009 was calculated by dividing total fuel consumption\(^\text{15}\) by total distance covered\(^\text{15}\) for respective years. For projecting efficiency from 2009 to 2025, fuel efficiency was assumed to improve by 25% by the end year\(^\text{31,32}\).
The overall amount of fuel purchased is impacted by time in the air, by delays due to NAS capacity constraints, inclement weather and late aircraft. The following is based on historical data and NextGen program forecasts, and illustrates the actual experience as well as the forecasted levels of delays with and without U.S. NextGen program implementation, which we assume for this business case is a reasonable proxy for expectations for Europe as well as the ROW.

Figure 9: Forecasted U.S. airline delays by cause, 2003-2025

Note: Historical NAS traffic related delay data was projected based on regression between weather delay and miles flown for the case without NextGen. For NextGen, it is assumed that by 2025 delay on clear weather days will be reduced by 85%, on moderate weather days by 92%, and on severe weather days by 78%. Weather definitions are NAS standard Weather Impacted Traffic Indexes.

Note: Historical data for late aircraft delay (or secondary delays caused by other aircraft delays) was projected based on regression between secondary delay and available commercial airline capacity for the case without NextGen. For NextGen, it is assumed that such delays will continue to be approximately 20% higher than delays due to primary causes such as weather and traffic congestion.
5.4 Business case variable #4: Environmental regulation

The business case for ATS transformation can be impacted by what is assumed to be the future regulatory environment regarding the cost of emissions. As climate change becomes a growing concern, governments across the world are beginning to consider various market-based measures to incentivize the reduction of CO\textsubscript{2} emissions from all sources. Although we cannot forecast the actual costs for environmental regulation and the potential implementation of emissions cost allocation schemes globally, we do expect regulatory actions during the business case time horizon, which is already happening in the EU. Although legislation in the U.S. has not been passed, for the purposes of this study, we have made certain assumptions that have been modeled financially to capture the benefits from such potential legislation. As such, we have included the costs for environmental regulation in this business case.

One such measure, known as an emissions trading scheme (ETS), is already in place in Europe. Currently, the EU’s ETS does not include aviation emissions, but starting in 2012 all airlines flying into, within or out of Europe would be required to join an emissions cap scheme. The control mechanism used by regulatory authorities would be in the form of certified emission reduction credits that will be allotted to each airline. These credits can be sold in the open secondary market by companies seeking to offload unused credits and bought by companies that have exceeded their allowed emissions quota for the period.

In this business case, the prices of CO\textsubscript{2}, NO\textsubscript{x}, and SO\textsubscript{x} emission credits, measured as $/metric ton, have been used to model the extent of regulatory control in the future. Assuming that there will be costs incurred, these were quantified in a high, medium and low forecast for this business case depending on how high or low the demand would be for emission credits traded in secondary markets in the future. The following illustrates the scenarios modeled for increase in CO\textsubscript{2} emission credits prices.

“The overall amount of fuel purchased is impacted by time in the air, by delays due to NAS capacity constraints, inclement weather and late aircraft.”
Note: Prices for CO\textsubscript{2} emissions are based on European Climate Exchange (ECX) Carbon Emission Reduction (CER) futures prices (contracts until 2014). Beyond 2014, the low growth scenario assumes prices will grow at 3% CAGR (lowest historical growth), medium growth assumes a 6.75% CAGR (current growth), and high growth assumes a 10% CAGR (highest historical growth). SO\textsubscript{X} and NO\textsubscript{X} prices were similarly obtained from NO\textsubscript{X} and Sulfur Financial Instrument (SFI) futures prices (contracts until 2014) traded on the Chicago Climate Exchange. SO\textsubscript{X} and NO\textsubscript{X} prices beyond 2014 were projected assuming the same growth rates as CO\textsubscript{2} credit prices (given the recent volatility of SO\textsubscript{X} and NO\textsubscript{X} futures, historical data is not useable).

The above described assumptions, sensitivities and variables were incorporated into an analysis of the previously described four business case scenarios: Grounded, Turbulence, Steady Flight and Take-off. Our findings regarding investment attractiveness for each of these scenarios are included in the following sections.

5.5 Scenario 1: Grounded
In this scenario, the assumption is that ATS transformation will occur in a prolonged period when air travel demand has slumped, the airlines are assumed to have changed their fleet structure to accommodate smaller aircraft, increases in the price of fuel are moderate, and environmental regulation has not been a significant factor. However, in this scenario, we found the business case is positive for ATS transformation, with an NPV of $614 billion, assuming inclusion of all three tiers of benefits. This is driven not only from savings in jet fuel and airline operating expenses, but also the inclusion of potential savings in carbon emissions, airline costs of delays, and increased productivity. We found that the IRR for the investment is estimated to be 33.7%.

However, if tier 2 and tier 3 benefits were not included, the business case is still positive, but less attractive, as potential airline operating expenses and fuel cost savings due to ATS modernization are minimized because aircraft are not flying as much. Assuming the inclusion of only these relatively minimal direct savings, the NPV for this scenario is $161 billion. However, many informed sources in the industry would view this scenario as plausible but highly unlikely, as a 15 year prolonged slump in air travel has never occurred previously. Indeed, travel demand is increasing globally as this study goes to press, after only a two-year reduction during the worst economic recession since the Great Depression in the early 1930’s.

As illustrated in the air travel demand sensitivity analysis, air travel over history has shown occasional drops or moderation in demand, but only for a short period during economic recessions. However, overall air travel has shown a steady historical increase of approximately 0.5% per year over the last 20 years. Indeed total RPKs have risen from approximately 1 trillion in 1981 to 4.5 trillion RPKs by 2009 as stated earlier, greater than a 300% increase over the last 30 years\textsuperscript{41}.
5.6 Scenario 2: Turbulence
In this scenario, the assumption is that ATS transformation initiatives will occur while air travel demand has slumped. In this scenario however, the price of fuel has increased significantly, incentivizing airlines to purchase more fuel-efficient aircraft. Furthermore, in this scenario, it is assumed that there will be vigorous environmental regulations implemented that will subject the industry to the costs of carbon emissions, although we recognize that in the U.S., cap and trade or tax legislation regarding carbon emissions has not been passed into law.

In this scenario, we found the business case for ATS transformation is positive with an NPV of $689 billion. This is driven by greater potential savings in fuel compared to the baseline price increase scenario and expected emissions savings as airlines broadly move to greener fleets. Overall efficiency of airline operations is assumed to increase as airlines largely adopt a hub-spoke model in the face of depressed air traffic demand, leading to increased economic benefit.

In the very conservative case where tier 2 and tier 3 benefits were excluded in this scenario, the business case for ATS transformation would still be positive, with an NPV of $193 billion and an IRR estimate of 13.2%. The IRR, after including all the benefits is 34.6%. The NPV is better than in the previous scenario because expense savings are higher, as it is assumed in this scenario that airlines operate more efficiently at higher load factors. However, similar to the previous scenario, air travel demand has shown resiliency in the past and is expected to grow continuously over the investment time horizon, with potential occasional short-term slowdowns due to economic recessions.

5.7 Scenario 3: Steady flight
This scenario assumes that air travel demand will grow at a moderate pace, airlines will continue to transition to more fuel efficient aircraft over time at a moderate pace, the price of fuel will continue to increase at a moderate pace, and that environmental regulation will be implemented at a moderate pace. In this scenario, we found that the ATS transformation business case is positive, with an NPV of $897 billion. This is largely driven by fuel savings and airline benefits from reduced delay-related operating costs combined with increased capacity at airports. It is also driven by reduced passenger costs related to delays and cancelled flights, benefits to the economy in terms of passenger opportunity costs and emissions savings.

It is expected that in this scenario, part of the total direct benefits would be $173 billion in reduced airline expenses and $107 billion through increased takeoffs and landings resulting in increased capacity and revenue service. In this scenario, the overall world economy is expected to realize over $327 billion in economic value of passenger time saved and stimulus from additional airport capacity.

Alternatively in the very conservative (and unlikely) case where tier 2 and tier 3 benefits were excluded in this scenario, the business case for ATS transformation would still be positive, with an NPV of $246 billion and an expected IRR of 15.3%. We believe the tier 1 only accounting of benefits in the Steady Flight business case scenario is not realistic because of the exclusion of emissions benefits, which in this business case is assumed to be monetized, as certified emission reductions and other emissions trading schemes. Also outside the scope of the conservative case is the positive impact of ATM transformation on the value of passenger time, and the benefits to the economy of up to 60 million additional commercial and cargo aircraft movements per year by 2025.

A key consideration is the potential for a rise in fuel prices, which could significantly improve this business case. Costs for fuel could also rise by proxy through increased costs for emissions. In that sense, this business case scenario represents a conservative future outlook where fuel prices increase only moderately over the investment time horizon.

5.8 Scenario 4: Take-off
In this scenario, it is assumed that air travel demand is high, the airlines have renewed their fleet structure, the price of fuel has moderated, and that environmental regulations are loosened as governments do not require airlines to cover their operations with necessary carbon credits. We found that this business case scenario is significantly positive, with an NPV of $1.27 trillion. The driver behind the NPV is the large expected operating expense savings and projected additional economic margins that are brought about due
to delayed savings and increased aircraft movements enabled by the new ATS technologies in the face of high air traffic growth. Importantly, the airline industry would not be able to meet the high demand for air travel in this scenario without the delay reduction measures and capacity increases brought about by ATM transformation. In other words, without ATM transformation, air travel demand is expected to be restricted due to capacity shortfalls in the Take-off scenario.

Alternatively in the conservative case where tier 2 and tier 3 benefits were excluded in this scenario, the business case for ATS transformation would still be very positive, with an NPV of $331 billion and a projected IRR of 17.8%. The IRR considering all the benefits (i.e., tier 1, 2 and 3) is 50.4%. The driver behind this positive finding is the inclusion of over $442 billion in expected direct benefits of fuel savings and increased airport movements.

As in the Steady Flight scenario, should the cost of aviation fuel rise dramatically for some or all of the investment time horizon, the business case would be even more positive. The reason for this is the large dollar savings that airlines can realize from delay minutes saved in a high oil price scenario. In such a scenario, every minute saved on the ground or in the air will have an increasingly positive impact on fuel and other operating cost.

5.9 Summary of base case findings (assuming no program acceleration)

This study confirms previous reports that ATS transformation initiatives have significant positive economic impact. The analysis of each of the plausible scenarios above illustrates a positive business case for global ATS transformation even in the most unlikely case in the Grounded scenario. This supports assertions by several industry associations, government ATM authorities and avionics suppliers that ATS transformation programs globally are expected to generate significant benefits, which have been previously described. Since there are many variables and assumptions that can impact the investment returns, positive and negative, the four business case scenario assessments are an effective way to gauge what assumed conditions the investment decision should be based upon.

We believe that the “Steady Flight” business case scenario, assuming inclusion of all tier 1, 2 and 3 benefits, is the most plausible, realistic and reasonable outlook, and thus among the four scenarios, represents the Deloitte “base” business case. This scenario is conservative in its assumptions, and provides significant upside improvements in investment returns, should the price of fuel spike, environmental regulations become more restrictive and/or air travel demand exceeds the forecasts described. As described above, there are several other “upside” savings opportunities that are not included in this business case scope, which might represent even further significant NPV improvements.

In summary, this base business case without program acceleration has tier 1, 2 and 3 benefits, not including costs through 2035, of $1,008 billion at PV, or $2,850 billion at nominal value, confirming previous reports that there is significant positive economic impact for ATS transformation. These benefits include reduced emissions of 216 million metric tons of carbon dioxide (CO$_2$), nitrous oxides (NOx) and sulfur oxides (SOx) and 27 million hours saved in flight delays through 2025. From a geographic perspective, these benefits at PV consist of $313 billion in the U.S., $303 billion in Europe and $392 billion in the ROW. When fully implemented by 2026, annual nominal then-year benefits are expected to be $135 billion, including reduced emissions of 29 million metric tons of carbon dioxide (CO$_2$), nitrous oxides (NO$_x$), and sulfur oxides (SOx), and 4 million hours saved in flight delays and 3,039 millions of gallons of fuel saved. From a geographic perspective, these annual benefits at PV consist of $10 billion in the U.S., $14 billion in Europe and $22 billion in the ROW. It should be noted that recurring annual benefits for implementation of NextGen are expected to be $29 billion in current dollars.

Breakdown of business case details for each region are included in the appendix. Business case benefits principally include direct savings of fuel and operating expenses for airlines, reduced carbon emissions, reduced noise, reduced weather and congestion delays, increased capacity, improved operational efficiencies, savings of passenger time, better passenger satisfaction and overall improved economic benefits.
In our analysis, we identified the primary beneficiaries of differing types of specific benefits that we categorized as tier 1, 2 and 3 benefits. As described earlier there are other categories of benefits that we did not include nor quantify due to difficulty in obtaining objective and/or complete and consistent data from all three global regions studied. The following chart illustrates the estimated benefit percentages for each category and shows the differing amounts by region.

Figure 11: Business case beneficiaries and percent by category

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
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<tbody>
<tr>
<td>Tier 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airline Fuel Cost Savings</td>
<td>19.7%</td>
<td>3.3%</td>
<td>34.1%</td>
<td>34.7%</td>
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<td>Airline Labor Cost Savings</td>
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<tr>
<td>Airline Ownership Cost Savings</td>
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<td>9.5%</td>
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<td>Airline Maintenance Cost (Non-labor) Savings</td>
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<td>0.2%</td>
<td>0.2%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Airline Insurance Cost Savings</td>
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<td>9.5%</td>
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<td>1.0%</td>
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<td>Airline Passenger Hard Costs Savings</td>
<td>2.3%</td>
<td>9.5%</td>
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<tr>
<td>Tier 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Economy Emissions Savings</td>
<td>0.8%</td>
<td>0.7%</td>
<td>1.4%</td>
<td>1.5%</td>
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<tr>
<td>Overall Economy Savings from Reduction in Noise</td>
<td>0.2%</td>
<td>0.6%</td>
<td>0.2%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Tier 3</td>
<td></td>
<td></td>
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<tr>
<td>Passengers Passenger Opportunity Cost Savings</td>
<td>79.5%</td>
<td>64.7%</td>
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<td>Passengers Extra Economic Value per Flight</td>
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<td>48.6%</td>
<td>25.3%</td>
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</tr>
<tr>
<td>Airline Airline Soft Costs due to Delay</td>
<td>2.9%</td>
<td>11.7%</td>
<td>6.6%</td>
<td>6.6%</td>
</tr>
</tbody>
</table>

Parallel to these benefits, we also analyzed the nonrecurring costs for implementation and recurring operations costs of ATS transformation programs globally. Costs are consistent with FAA and EUROCONTROL estimates for ATS modernization initiatives. We have added a 10% contingency for possible cost and schedule overruns, but should that not be needed, this would represent additional upside NPV. In summary, we found that the PV of implementation and operations costs to be $110 billion globally. From a geographic perspective, these costs are broken down at PV as follows: U.S. costs of $31 billion, Europe costs of $37 billion and ROW costs of $42 billion. Details of these expected costs are included in the appendix.

The following chart summarizes the range of business case findings on an NPV and IRR basis for investing in the ATS transformation initiatives globally, under the four different scenarios and the tiers of benefits counted within those scenarios.
The design, development and deployment of ATS transformation programs carry significant challenges and risks which can impact the cost and schedule for implementation. These include, but are not limited to funding, technology and program risk, regulatory reform, ATC procedures, technical and certification standards and harmonization, and workforce transformation. In addition, the aerospace and defense industry continues to be impacted by program management challenges of cost overruns and schedule delays due to technical complexity, requirements growth and systems testing and integration challenges.

We have identified certain key challenges and risks here for consideration when evaluating the feasibility for not only accelerating the ATS transformation initiatives, but for even meeting current program schedules or minimizing the very likely risks of significant delays in implementation.

- Funding: The estimated dollar benefits projected by this business case study, particularly under either the established baseline 2025 implementation date or the potential accelerated 2020 scenario, are contingent upon funding availability. This remains a challenge in the current political and fiscal environment.
  - This challenge applies not only to the U.S. FAA NextGen program; it also has some relevance to ATS transformation initiatives globally. Our study assumes that the U.S. NextGen transformation initiative will be funded appropriately in the base case and that annual funding will increase significantly over the next few years in the accelerated case. If the relevant constituents support acceleration of NextGen, this action would likely require an exemption from the President’s five-year budget freeze for the discretionary civil budget.
  - The issue of financing is challenging because the investments made by airlines in equipage, for example ADS-B transponders, may not yield the expected return.
in the short term until a more complete deployment of
NextGen has been accomplished.

• Technology and program risk: This business case makes
the assumption that large and complex technology
platforms necessary for the ATS transformation initiatives
to successfully operate in the en route, terminal and
tower environment will be developed and deployed as
planned. Under the accelerated scenario in this business
case, the assumption is that current schedules for
technology development and deployment can be moved
forward to meet the 2020 implementation date. If one
technology platform falls behind schedule or experiences
cost overruns, this can materially affect schedules for
other interfacing technology initiatives as well
  – In the U.S., according to a recent report⁴⁸ of the
Department of Transportation (DOT) Inspector
General, one major NextGen technology platform that
is used to control high altitude air traffic is already
experiencing schedule slippages and substantial
cost overruns⁴⁹. It is not clear whether the schedule
slippages can be overcome or whether the overruns
can be accommodated given current fiscal realities. It
is also unclear as to the eventual impact of a potential
late completion this en route management system will
have on parallel and dependent application systems
development
  – Technology risk can also be exacerbated by the use of
certain technology innovations that are not as mature
as would be required. Schedule dependence is created
where multiple technologies need to be integrated and
completed at a given time, whereas late completion of
an individual technology can potentially hold up the
entire schedule
  – Risk reduction and mitigation measures will
require time, and in many cases of complex and
interdependent technologies, a significant time period
for integration testing
  – As a program, NextGen represents a multi-billion
dollar investment warranting a tailored oversight and
governance strategy to ensure that:
  • Program cost, schedule and technical elements
are managed effectively and the continuity to
programmatic and systems engineering best practices
are consistently employed across all ATS programs/
projects
  • All key constituents have necessary insight to program
performance, issues and risks through consistent and
common reporting
  • Executive level program management and integration
is required to effectively and proactively address
issues, risks and performance concerns, with timely
course correction where needed
  • Regulatory reform: A fully operational regulatory
framework allows for full productive usage of ATS
transformational technology equipment (ground
and airborne), which in turn should mitigate the
environmental impact of air traffic. ATC and aircraft
equipage, as well as regulatory changes will need to
be implemented concurrently to deliver the envisioned
benefits. However, regulatory requirements have
not always changed in lockstep with equipage in a
coordinated manner. For example:
    – Instrument landing system (ILS) operations are
approved for simultaneous parallel instrument
approaches. In September 2009, RTCA Task
Force 5 recommended that area navigation
(RNAV) and required navigation procedures (RNP)
approaches should be included in this category. This
recommendation has yet to be fulfilled⁵⁰.
    – Legacy instrument approach procedures, such as
an ILS, have up to 20 mile extended final approach
segments, which have significant fuel consumption
and environmental impacts. This is because vertical
separation between aircraft landing on parallel
runways is required until the aircraft are established
on final approach. The current definition of “final
approach” was developed many years ago and does
not account for an RNP approach in many cases,
where the aircraft is established, at altitude, far from
the straight-in segment⁵¹.

• ATC Procedures: The FAA typically requires up to five
years to change controller separation criteria, which
includes airspace modeling, safety and workload
assessments, environmental impact assessments,
regulatory changes, and local and regional legal
challenges. There are a few examples of how this
challenge can materially impact the ability to implement
according to the established schedule, let alone
contemplate an accelerated schedule, as follows:
  – RNP/RNAV procedures require airspace redesign for
each airport’s airspace, including proximate airports
in congested regions, and will require significant
community coordination and environmental impact assessments that in the past have led to legal challenges. Optimized flight tracks results in concentrated flight paths and possibly increased noise over specific regions. Resulting potential litigation could delay airspace redesign implementation by two to three years, thus impacting the implementation schedule.

- At Louisville, initial NextGen initiatives, in particular ADS-B usage, have not reached their full potential benefits, as the air traffic procedures have not been changed to address cooperative separation standards. Decisions regarding which new air traffic separation tasks can be delegated from the controller to the aircrew have not been addressed yet.

- Wake vortex separation criteria are the same regardless of the winds. FAA and NASA studies have determined that winds affect wake vortex severity. Therefore, implementation of condition-dependent separation standards and procedures might be considered. The FAA is developing new wake turbulence avoidance criteria, but only a limited amount of testing has been conducted to date.

- Benefit studies have shown that the required vertical separation change to 1,000 feet vertical separation (versus the prior 2,000 foot standard) did not result in the projected traffic increases because the controller is still limited by the number of aircraft he/she can handle. The airspace is more efficient, but procedural changes in controller tasks are needed to take advantage of the technology.

- Environmental impact assessments, which are required on air traffic flow changes below 10,000 feet are expensive and typically take one - two years to complete.

- Existing environmental impact assessments are also based on the flight quantity and aircraft types. Increasing the number of flights and/or aircraft types, due to NextGen efficiencies, may require new environmental impact assessments. In the late 1990s, the environmental study for the New York airspace redesign was also the subject of substantial time consuming litigation.

Technical and certification standards and harmonization:

- In order for the ATS transformation initiatives to become effective, the technical and certification standards will require harmonization. Because some of the technology is still being developed, and in some cases, competing technologies are being developed, there will need to be a mechanism and process for achieving standardization. A few examples are as follows:
  - Integration of different country satellite based PNT systems, e.g., GPS, Galileo, GLOSNASS, etc.
  - Digital communications — The FAA digital communications program may have challenges with specifications, concerns over international harmonization of message sets, and challenges of full utilization of current aircraft equipage, e.g., revised pre-departure clearance for weather reroutes.
  - Flight management systems (FMS) - There are more than 20 FMS types, with different flight performance characteristics. The FAA is proceeding with regulatory reform for usage of different FMS types that was never envisioned in their original design and certification. The FAA has proposed standardizing FMS to resolve these different flight performance characteristics that limit use of terminal procedures today. The impact of FMS standardization (retrofit and aircraft replacement) versus mixed equipage on the current NextGen schedule will need to be assessed.
  - Aircraft avionics and flight deck operational procedures - flight operational procedures that form the basis for avionics and ground equipment performance standards could represent a technically challenging activity having an impact on the implementation schedule.
  - It may be a difficult task to develop system interface requirements, certification and operational procedures for the ground-based air traffic equipment in the required time frame.
  - Development of Technical Standard Orders (TSOs) for the development of the installation service bulletins — This process is likely complex and time consuming, and may take up to 5 years to complete and will require multiple committees with extensive FAA and aviation industry collaboration with avionics manufacturer and aircraft OEMs.
  - Surface environment coordination — It will be a challenge to avoid aviation system delays attributable to the surface environment, such as an insufficient...
number of runways, gate shortages, over scheduling of flights during peak traffic periods, etc. Avoidance of the costs of system delays, whether occasioned by airborne congestion or ground-based constraints, are included in the benefits identified for 2020 as well as 2025. Therefore, integration of the ATS transformation programs with the development and implementation of a surface environment plan that addresses surface-based delays will be critical.

- Workforce transformation: As with many technology based transformation programs, people are at the heart of effecting major change. The ATS transformation initiatives will require people to change how they operate in the new realm. There are likely to be implementation challenges and risks to the budget and schedule that focus on the human resource element. Some of these workforce transformation challenges are listed here:
  - Training — New operational procedures will be designed and implemented that change the ATC process in fundamental ways, such as procedural differences in flight planning, tracking, take off and landing. Training design should reflect the need to expedite the training delivery process, while at the same time require trainees to achieve a high level of proficiency in the concepts being presented. Multiple training methods, including face-to-face and web-based delivery, may be used to achieve the maximum impact for the time invested. Simulations may also be required to provide the trainees with realistic experience that will prepare them to operate successfully within the new environment.
  - Competency validation and certification — Because training is expected to be competency-based, it will be important to assess the competencies required of the workforce in the new environment, including knowledge, skills and behaviors. Competencies will need to reflect the unique responsibilities associated with each role performed by the workforce, and they will need to be verifiable so that they can be assessed and validated. Certification programs can also be developed to assist in the assessment and validation of the required skill sets. Both training and certification programs will need to reflect real world examples that track against the performance expectations of the workforce.
  - Job responsibilities — Air traffic controllers’ daily routine will likely be different — It will be important to define job responsibilities with respect to the different roles that each individual will perform, including both standard everyday roles and ad hoc roles specific to unique situations. Definitions of job responsibilities will need to reflect unique characteristics associated with variations in performance due to geography or other factors.
  - Communications strategy — The effort requires an effective communications, education and change adoption campaign to promote awareness and acceptance of the changes that the new program will bring. It is critical that all constituents share and embrace a common vision of the ATS transformation. An effective approach is to include a clear vision statement, leadership involvement in promotion of the vision, a consistent approach to messaging, and the opportunity for the workforce to engage in two-way feedback. Listening to the workforce, answering questions, and providing options for positive engagement that reduces inaccurate rumors and identifies and clarifies issues promptly, can aid in promoting positive acceptance of new policies, processes and systems.
  - Workforce demand — NextGen equipage implementation may place increased demand on the existing workforce in terms of avionics installers, airframe and power plant mechanics, as well as inspectors. Both the challenge of training and adequacy of the available workforce must be understood and addressed, especially in the accelerated implementation scenario. To the extent that the nature of the workforce will change, their skills, behaviors, job expectations, culture, communication and coordination processes, and performance expectations will likely change as well. For the effort to be successful, it will be necessary to address changes to the workforce that could impact their ability to successfully perform their jobs.
6. Acceleration of ATS transformation program

One of the primary purposes of this business case is to assess the investment return of the potential acceleration of global ATS transformation programs by five years, with completion by the end of 2020. However, as described in detail above, there are significant challenges and risks that would prevent an accelerated implementation, no matter what the financial merits. But given the opportunity to overcome these risks, we found that in all scenarios, an assumed inclusion of all three tiers of benefits, the business case improves in terms of NPV, payback and IRR metrics.

In summary, we found the business case NPV improvement is in a range of between $68 billion in the Grounded scenario to $131 billion in the Take-off scenario. Projected IRR investment metrics improve in a similar fashion under the ATS program acceleration case. As stated earlier however, the Grounded scenario at the lower end of the improvement range only includes tier 1 benefits of direct fuel and operating savings. We believe this is a very unlikely scenario, as air travel demand would be expected to grow at least moderately over the investment time horizon through 2035.

In summary, the Deloitte base business case (Steady Flight), without program acceleration, has an NPV of $897 billion as stated earlier. However, we found that by accelerating global programs with completion by 2020, the NPV increases $100 billion to $997 billion, an 11.1% improvement. For the U.S., accelerating the NextGen program increases the NPV $20 billion to $301 billion. Accelerating the SESAR program increases the NPV $51 billion to $318 billion. NPV increases for the ROW rise $29 billion to $378 billion.

With program acceleration in the base case, aircraft delay reductions by the end of 2020 are expected to reduce emissions by 128 million metric tons of CO$_2$, NO$_x$, and SO$_x$, and save 15 million hours saved in flight delays, representing $41 billion of additional benefit to airlines and a further $17 billion of savings to the global economy in passenger productivity. Finally, the transformation is expected to free up additional capacity in terms of increased aircraft movements, which translates to $21 billion in additional operating revenue for airlines and $49 billion in added value to the global economy.

The following table illustrates the varying levels of improvements in the business case under each scenario in the “what-if” case of accelerating the global ATS program initiatives.
Figure 13: Business case summary — comparison to accelerated option (“acc”)

<table>
<thead>
<tr>
<th>Scenario Investmen</th>
<th>Tier 1</th>
<th>Tier 1 “acc”</th>
<th>Change (Value)</th>
<th>Change (%)</th>
<th>Tier 1 &amp; 2</th>
<th>Tier 1 &amp; 2 “acc”</th>
<th>Change (Value)</th>
<th>Change (%)</th>
<th>Tier 1, 2 &amp; 3</th>
<th>Tier 1, 2 &amp; 3 “acc”</th>
<th>Change (Value)</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounded</td>
<td>169.5</td>
<td>176.5</td>
<td>15.9</td>
<td>9.9%</td>
<td>183.7</td>
<td>185.2</td>
<td>16.4</td>
<td>9.7%</td>
<td>513.5</td>
<td>631.5</td>
<td>68.0</td>
<td>11.1%</td>
</tr>
<tr>
<td>RR</td>
<td>11.9%</td>
<td>14.4%</td>
<td>2.5%</td>
<td>21.5%</td>
<td>12.5%</td>
<td>15.1%</td>
<td>2.6%</td>
<td>21%</td>
<td>32.7%</td>
<td>48.4%</td>
<td>14.7%</td>
<td>43%</td>
</tr>
<tr>
<td>Turbulence</td>
<td>193.2</td>
<td>217.4</td>
<td>24.2</td>
<td>12.5%</td>
<td>205.7</td>
<td>230.6</td>
<td>24.8</td>
<td>12.1%</td>
<td>588.6</td>
<td>788.0</td>
<td>91.4</td>
<td>13.3%</td>
</tr>
<tr>
<td>Payback (Years)</td>
<td>12</td>
<td>11</td>
<td>10%</td>
<td>10%</td>
<td>12</td>
<td>11</td>
<td>10%</td>
<td>10%</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>RR</td>
<td>13.2%</td>
<td>16.4%</td>
<td>3.2%</td>
<td>24%</td>
<td>14.0%</td>
<td>17.3%</td>
<td>3.4%</td>
<td>24%</td>
<td>24.6%</td>
<td>46.9%</td>
<td>12.3%</td>
<td>30%</td>
</tr>
<tr>
<td>Steady Flight</td>
<td>246.4</td>
<td>272.1</td>
<td>25.7</td>
<td>10.4%</td>
<td>259.7</td>
<td>285.2</td>
<td>26.5</td>
<td>10.2%</td>
<td>397.3</td>
<td>997.0</td>
<td>99.7</td>
<td>11.1%</td>
</tr>
<tr>
<td>Payback (Years)</td>
<td>12</td>
<td>11</td>
<td>10%</td>
<td>10%</td>
<td>12</td>
<td>10</td>
<td>2</td>
<td>10%</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>RR</td>
<td>15.3%</td>
<td>18.7%</td>
<td>3.4%</td>
<td>22%</td>
<td>19.1%</td>
<td>22.8%</td>
<td>3.7%</td>
<td>29%</td>
<td>50.4%</td>
<td>59.3%</td>
<td>8.6%</td>
<td>17%</td>
</tr>
<tr>
<td>Takeoff</td>
<td>331.3</td>
<td>364.0</td>
<td>32.7</td>
<td>9.9%</td>
<td>345.9</td>
<td>379.5</td>
<td>33.6</td>
<td>9.7%</td>
<td>1206.7</td>
<td>1399.7</td>
<td>93.0%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Payback (Years)</td>
<td>11</td>
<td>10</td>
<td>11%</td>
<td>20%</td>
<td>11</td>
<td>11</td>
<td>1</td>
<td>11%</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>RR</td>
<td>17.3%</td>
<td>21.2%</td>
<td>3.5%</td>
<td>20%</td>
<td>18.5%</td>
<td>22.3%</td>
<td>3.7%</td>
<td>29%</td>
<td>50.4%</td>
<td>59.3%</td>
<td>8.6%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Note:

- Tier 1 benefits include: Airline Operating Expense Savings, Operational benefits to infrastructure and additional economic value accruing to airlines from increased capacity in airports.
- Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise.
- Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity.
- Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment.

From a cost perspective, we estimate cumulative expenditures of $56 billion to global air network service providers (ANSP) and airports as well as $57 billion to global airline infrastructure are required. Expenditures consist of both one-time equipage and infrastructure costs, as well as recurring costs associated with personnel and programs to operate the transformed ATM systems. Taking into account the required investment and expenses, total program PV costs are estimated at $113 billion. As stated earlier, these costs are consistent with estimates made by global ATS authorities, but include a 10% contingency for risk as described earlier.

The following table illustrates the component benefits and costs that are incorporated into the above analysis.
Figure 14: Business case costs and benefits, nominal and PV

<table>
<thead>
<tr>
<th></th>
<th>Tier 1</th>
<th>Tier 1 \textsuperscript{“Acc”}</th>
<th>Tier 1 &amp; 2</th>
<th>Tier 1 &amp; 2 \textsuperscript{“Acc”}</th>
<th>Tier 1, 2 &amp; 3 \textsuperscript{“Acc”}</th>
<th>Base</th>
<th>“Acc”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grounded</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>843.2</td>
<td>888.8</td>
<td>860.5</td>
<td>912.9</td>
<td>1914.6</td>
<td>2042.6</td>
<td>160.2</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>271.5</td>
<td>296.2</td>
<td>279.7</td>
<td>304.9</td>
<td>724.4</td>
<td>801.2</td>
<td>110.3</td>
</tr>
<tr>
<td><strong>Turbulence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>987.1</td>
<td>1049.6</td>
<td>1033.5</td>
<td>1097.2</td>
<td>2221.9</td>
<td>2392.2</td>
<td>160.2</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>304.2</td>
<td>337.1</td>
<td>316.7</td>
<td>350.3</td>
<td>709.6</td>
<td>899.7</td>
<td>110.3</td>
</tr>
<tr>
<td><strong>Steady Flight</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>1202.8</td>
<td>1268.9</td>
<td>1250.7</td>
<td>1318.3</td>
<td>2849.6</td>
<td>3035.2</td>
<td>160.2</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>357.3</td>
<td>391.8</td>
<td>370.6</td>
<td>405.9</td>
<td>1008.2</td>
<td>1116.7</td>
<td>110.3</td>
</tr>
<tr>
<td><strong>Takeoff</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>1576.5</td>
<td>1658.1</td>
<td>1628.7</td>
<td>1712.1</td>
<td>4070.3</td>
<td>4312.7</td>
<td>160.2</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>442.2</td>
<td>483.7</td>
<td>456.8</td>
<td>499.2</td>
<td>1379.6</td>
<td>1519.4</td>
<td>110.3</td>
</tr>
</tbody>
</table>

Note: Nominal costs and benefits differ between base case scenario and “what-if” scenario because of the ROW business case results. The relevant analysis is explained below:

- In the base case scenario, ROW benefits were calculated by multiplying U.S. business case benefits by the ratio of air traffic volumes in ROW to air traffic volumes in the U.S.
- In the base case scenario, ROW costs were similarly calculated by multiplying U.S. business case costs by the ratio of airport investments in the ROW to airport investments in the U.S.
- In the accelerated “what-if” scenario, while the ratio of air traffic volumes and airport investments did not change from year to year, the nominal benefits and costs for the U.S. business case did change from year to year, and this changed the cumulative nominal benefits and costs for the Rest of the World. Thus the total nominal costs have changed for the accelerated case. Costs for the accelerated case have been calculated by spreading the costs incurred during 2020–2025 over 2015–2020 uniformly. The PV values of costs are higher for the accelerated case because of discounting while calculating the PV.

Due to this difference between the accelerated “what-if” and base case scenarios for the Rest of the World, cumulative nominal costs and benefits are different between the two scenarios for the business case as a whole.
7. Delay of ATS transformation program

So far we have looked at the scenarios of implementation that contemplate a planned completion by 2025 as well as an accelerated timeline with completion by 2020. We have also assessed the financial impact of a delayed implementation, with completion by 2030.

We found that in all scenarios, an assumed inclusion of all three tiers of benefits, the business case for a delayed implementation is still positive, but degrades significantly in terms of NPV and IRR metrics over the non-accelerated base case. In summary, we found the business case is between $500 billion in the Grounded scenario to $1,130 billion in the Take-off scenario. Projected IRR investment metrics are positive, but degrade in a similar fashion under the ATS program non-acceleration case. As stated earlier however, the Grounded scenario at the lower end of the improvement range only includes tier 1 benefits of direct fuel and operating savings. We believe this is a very unlikely scenario, as air travel demand would be expected to grow at least moderately over the investment time horizon.

In summary, the Deloitte base business case (Steady Flight), under a non-accelerated implementation schedule, has an NPV of $897 billion as stated earlier. However, we found that by delaying global programs with completion by 2030, the NPV decreases $148 billion to $749 billion, a 16.5% decrease. For the U.S., delaying the NextGen program reduces the NPV $47 billion to $234 billion. Delaying the SESAR program reduces the NPV $40 billion to $226 billion. NPV for the ROW decreases $61 billion to $289 billion.

Figure 15: Business case summary — comparison to delayed option

Note:
• Tier 1 benefits include: Airline Operating Expense Savings, Operational benefits to infrastructure and additional economic value accruing to airlines from increased capacity in airports
• Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise
• Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity
• Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment
Note: Nominal costs and benefits differ between base case scenario and “what-if” scenario because of the ROW business case results. The relevant analysis is explained below:

- In the base case scenario, ROW benefits were calculated by multiplying U.S. business case benefits by the ratio of air traffic volumes in ROW to air traffic volumes in the U.S.

- In the base case scenario, ROW costs were similarly calculated by multiplying U.S. business case costs by the ratio of airport investments in the ROW to airport investments in the U.S.

- In the delayed “what-if” scenario, while the ratio of air traffic volumes and airport investments did not change from year to year, the nominal benefits and costs for the U.S. business case did change from year to year, and this changed the cumulative nominal benefits and costs for the Rest of the World. The PV of costs is lower for the delayed case because the cash flows for 2020–2025 were equally distributed over 2020–2030. The time value effect reduced the total PV for costs for the delayed scenario.

Due to this difference between the delayed “what-if” and base case scenarios for the Rest of the World, cumulative nominal costs and benefits are different between the two scenarios for the business case as a whole.

The following chart summarizes the NPV comparisons of the four scenarios studied; demonstrating that program acceleration improves the investment case for ATS transformation. As indicated we believe the Steady Flight scenario represents the most realistic forecast upon which to base this business case.
“Due to this difference between the delayed ‘what-if’ and base case scenarios for the Rest of the World, cumulative nominal costs and benefits are different between the two scenarios for the business case as a whole.”
The Deloitte business case for ATS transformation generally confirms other previous reports that the investment case is positive and implementation going forward for the NextGen, SESAR and other global initiatives would bring benefits well beyond their costs. Furthermore, we found that the investment case improves significantly where transformation programs are accelerated by five years and completed by the end of 2020. Implementing the accelerated ATS transformation program results in an NPV increase of $100 billion, an 11.1% improvement. For the U.S., accelerating the NextGen program increases the NPV $20 billion to $301 billion. Accelerating the European SESAR program increases the NPV $51 billion to $318 billion.

These benefits would accrue to various constituents such as government ATM organizations, airline operators, passengers, the general public and associated sovereign economies. Of the total benefits identified above, we found that specific estimated benefits accrued to constituents as follows: airlines 31%, passengers 34%, ANSP/Airports/ATC Organizations 5%, and the overall economy 30%.

There are potentially additional other "upside" benefits not included in this business case scope that might significantly improve the return on investment. These include benefits such as the potential for some level of ATS facility and air space consolidation, reduced pace of hiring air traffic controllers in the U.S., some level of shutdown of the ground based ATC system, delayed need to expand airport capacity, application to general aviation, and military aircraft control. Validation of these actions and quantification of resulting benefits might be considered for further analysis. In addition, given the current economic climate and significant emphasis on the creation of new jobs, many have recognized the range of employment opportunities both in new and enhanced jobs that the NextGen, SESAR and other ATS programs might create in fields such as engineering, systems integration, manufacturing and mechanics/inspectors, etc. Lastly, should the 10% contingency for possible cost and schedule overruns not be needed, this would represent additional upside NPV.

Principal benefits of program acceleration are driven primarily by projected lower relative fuel usage where there are increases in air traffic and to more efficient flight paths, which are expected sooner in this ATS acceleration business case. These benefits also include the following expectations: decreases in weather delays, increased airspace capacity and lower environmental impact of emissions. These benefits are enabled by the deployment of satellite based navigation, real time digital data communications, advanced weather prediction technologies and precision airspace situational awareness technologies in out years when the system is forecasted to be more congested and capacity in the air space capacity is more constrained.

Funding decisions for ATS transformation initiatives like NextGen and SESAR are made by governments globally, and there remain concerns regarding the affordability and allocation of costs among sovereign and local government agencies, airline operators and passengers. For the overall system to work most effectively, adoption rates for equipage on the ground and in the cockpit need to be substantial. For this reason, mechanisms for financing of upgrades in a coordinated manner become important.

8. Summary
Ongoing dialogue regarding proposals for funding, such as public private initiative (PPI) financing, infrastructure bank, “best equipped- best served”, “cash for carbon”, government loans and other means to increase adoption rates are encouraging, given the difficult economic environment we face. Additional debate and study to understand and quantify the benefits and costs associated with ATS transformation will help guide the way for making appropriate trade-offs and finding a path for allocation of costs in this important and game changing investment decision. This cost and benefit allocation analysis could include various constituents, such as commercial aircraft operators, government ATS agencies, the general public and passengers. This study did not include in its scope the potential benefits of ATS transformation on the general aviation community nor military use. However, these constituents might also have a role in the cost allocation analysis. Cost allocation breakdown data (costs incurred by military, general aviation) was available for the case of SESAR and have been considered in the study. This has not been done for U.S. and ROW due to unavailability of data.

In addition, there are many challenges to accelerating ATS transformation initiatives even though the business case might find a net positive benefit for sooner implementation. These include, but are not limited to funding, technology risk, regulatory reform, ATC procedures, technical and certification standards and harmonization and workforce transformation. Lastly, the aerospace and defense industry continues to be impacted by program management challenges of cost overruns and schedule delays due to technical complexity, requirements growth and systems testing and integration challenges. These are but some of the issues that could impact a potential accelerated implementation, let alone by the scheduled implementation 2025 date.

In summary, this business case does demonstrate that the investment case for accelerating ATS transformation programs is positive, even when considering more conservative assumptions of only including direct savings as well as higher costs for implementation. Indeed, the additional NPV of $100 billion on a global basis compares favorably to the costs for equipage. In the U.S., with industry expert estimates in a range lower than $12 billion for equipage, the additional NPV of $20 billion from NextGen program acceleration would compare favorable to those costs alone. However, as described above, there are very real challenges and risks associated with an accelerated implementation schedule.
9. Next steps

In this study, we have alluded to several actions that could be taken, which are further amplified and summarized below for consideration:

1. Discuss and evaluate the findings in this study to gain consensus as to overall benefit of program acceleration and agree on next steps

2. Evaluate and quantify benefits of additional scope areas not included in this study, such as inclusion of general aviation, as well as military aircraft, more efficiency of air traffic controllers, potential consolidation of ATC infrastructure, organization, systems and processes, as well as reduction of costs associated with less reliance on the legacy ground based system, etc.

3. Conduct cost allocation studies to further understand and quantify the overall benefits and costs associated with transforming ATS. This information can then be input into the policy discussions regarding what adjustments might be considered based on numerous criteria such as public good, expediency, affordability, and other criteria. This information is vital to conduct ongoing discussions about who pays for what

4. Conduct further investigation and analysis of the technical, organizational, process, systems and human resource challenges for program acceleration, and develop a revised plan, road map and timetable for achievement of a potential 2020 implementation completion date

5. Conduct additional feasibility assessments on potential funding mechanisms and develop programs based on constituents’ requirements and funding availability; e.g., equipage incentive strategies, infrastructure banks, cash for carbon, PPI’s, etc

6. Conduct risk mitigation planning to protect against cost and schedule overruns, in order to avoid degradation of the business case investment metrics, as shown in the delayed implementation scenario

7. Establishment of an oversight or governance program that can better ensure the overall program performance and accountability. NextGen represents a multi-billion dollar investment that warrants a tailored governance strategy to ensure program cost, schedule and technical elements are managed effectively and that all key constituents have necessary insight to program performance issues and risks
10.1 Major business case assumptions and sources

1. Historical Air Traffic Volume (revenue passenger kilometers)
   a. U.S.: Bureau of Transportation Statistics
   b. Europe: Association of European Airlines

2. Projected Air Traffic Volume (revenue passenger kilometers)
   b. U.S. Low Case: Historical Growth Rate (4.17% CAGR 2010–2025)
   c. U.S. High Case: Boeing Projections (Tripled demand by 2025)
   d. Europe Base Case: EUROCONTROL (3.5% CAGR 2010–2025)
   e. Europe Low Case: Historical (2.5% CAGR 2010–2025)
   f. Europe High Case: Airbus Market Outlook Projections (4.3% CAGR 2010–2025)
   g. Rest of the World Base Case: Boeing Market Outlook (2009-2028)
   h. Rest of the World Low Case: Historical Growth Rate
      i. Rest of the World High Case: Base Case + 2%

3. Historical Delay Data
   a. U.S.: Bureau of Transportation Statistics
   b. Europe: EUROCONTROL CODA database
   c. Rest of the World: Assumed proportional to ratio of Air Traffic Volume with U.S. Air Traffic Volume

4. Projected Delay Data (without ATM transformation)
   a. U.S.: Projected based on regression with data on Total Kilometers Flown (obtained from Bureau of Transportation Statistics)
   b. Europe: Projected based on regression with revenue passenger kilometers (obtained from EUROCONTROL CODA database)
   c. Rest of the World: Assumed proportional to ratio of projected Air Traffic Volume with projected U.S. Air Traffic Volume

5. Projected Delay Reduction (with ATM transformation)
   a. U.S.: Weather Delay: Based on delay reduction factors for clear, moderate, and severe weather obtained from FAA NextGen estimates, and calculations of average clear, moderate and severe weather days per year historically
      i. NAS Delay: Delay reduction estimates from JPDO
      ii. Late Aircraft Delay (or secondary delay caused by delay in nearby traffic): Multiplier based on historical values
   b. Europe: Calculated separately for on-ground and en-route delay reduction projected by EUROCONTROL for different years
   c. Rest of the World: Reduction factors assumed equivalent to U.S.

6. Historical Capacity Data (Available Seat Kilometers)
   a. U.S.: Obtained from Bureau of Transportation Statistics
   b. Europe: Calculated from historical load factors given by Association of European Airlines
   c. Rest of the World: Assumed proportional to ratio of Air Traffic Volume with U.S. Air Traffic Volume

7. Projected Capacity: Calculated based on assumption of load factor remaining constant from 1999 to 2009

8. Projected Capacity Utilization (with ATM transformation)
   a. U.S.: Capacity Utilization improvement from 65% to 78% by 2025 as stated by FAA
   b. Europe: Capacity increase enabled by SESAR implementation as stated by EUROCONTROL
   c. Rest of the World: Assumed utilization increase is similar to U.S.
    a. Base Case: 4% CAGR from 2009 to 2025
    b. Low Case: -2% CAGR from 2009 to 2025
    c. High Case: 7% CAGR from 2009 to 2025

10. Fuel Efficiency Assumptions (Gallons/mile): Assumes that fuel efficiency will improve by 25% between 2009 and 2025, which is consistent with Air Transport Association (ATA) projections.

11. Other airline direct operating costs:
    a. U.S.: Historical costs obtained from Bureau of Transportation Statistics. Projections are based on historical growth rate of total other airline direct operating costs.
    b. Europe: Historical costs per minute obtained from Association of European Airlines, and projections based on EUROCONTROL-sponsored University of Westminster study conducted in 2004.
    c. Rest of the World: Assumed constant proportion of fuel prices to operating expenses based on U.S. ratios.

12. Direct operating costs include:
    a. Labor costs (Crew + Maintenance)
    b. Ownership costs (Lease included)
    c. Service costs (Passenger services)
    d. Maintenance costs (Material and other non-labor)
    e. Insurance costs
    f. Landing and other airport charges

13. Discount rate:
    a. U.S.
       i. Equipage: Based on Wall Street WACC estimates of 5 major U.S. airlines (7.02%)
       ii. FAA: Equal to 30 Year U.S. T-Bill rate (4.63%)
    b. Europe
       i. Equipage: Based on European investment analyst report WACC estimates of 5 major European airlines (7.51%)
       ii. ANSP and Airports: Equal to 30-year government bond rate for select European nations (4.50%)
    c. Rest of the World
       i. Equipage: Based on investment analyst WACC estimates of major airlines from Asia Pacific (9.00%)
       ii. Government Investment: Equal to 30-year government bond rates for select nations (7.00%)

14. Inflation rate: Assumed constant at historical rates for U.S. and Europe (3.00%)

15. Time horizon:
    a. U.S.: 2007 to 2025
    b. Europe: 2008 to 2025
    c. Rest of the World: 2010 to 2025

16. Value of emissions reduction: CO$_2$, NO$_x$, and SO$_2$ future prices from 2010 to 2025 ($/metric ton) for both the U.S. and European carbon trading markets.

10.2 Comparison of the non-accelerated case with the accelerated case

10.2.1 U.S. FAA NextGen program investment summary

Figure 18: U.S. business case summary — net present value

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Investment Analysis</th>
<th>Tier 1</th>
<th>Tier 1 “Acc”</th>
<th>Tier 1 &amp; 2 “Acc”</th>
<th>Tier 1, 2 &amp; 3 “Acc”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounded</td>
<td>NPV (USD Billion)</td>
<td>44.4</td>
<td>48.8</td>
<td>46.5</td>
<td>51.1</td>
</tr>
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<td></td>
<td>Payback (Years)</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>12.4%</td>
<td>14.9%</td>
<td>13.0%</td>
<td>15.7%</td>
</tr>
<tr>
<td>Turbulence</td>
<td>NPV (USD Billion)</td>
<td>48.2</td>
<td>53.4</td>
<td>51.5</td>
<td>56.8</td>
</tr>
<tr>
<td></td>
<td>Payback (Years)</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>13.4%</td>
<td>16.4%</td>
<td>14.2%</td>
<td>17.4%</td>
</tr>
<tr>
<td>Steady Flight</td>
<td>NPV (USD Billion)</td>
<td>58.4</td>
<td>64.1</td>
<td>61.7</td>
<td>67.6</td>
</tr>
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<td>12</td>
<td>11</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>14.5%</td>
<td>18.2%</td>
<td>15.7%</td>
<td>19.2%</td>
</tr>
<tr>
<td>Takeoff</td>
<td>NPV (USD Billion)</td>
<td>62.9</td>
<td>68.4</td>
<td>65.8</td>
<td>71.6</td>
</tr>
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<td>12</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>15.2%</td>
<td>18.2%</td>
<td>15.9%</td>
<td>19.2%</td>
</tr>
</tbody>
</table>

Note:
- Tier 1 benefits include: Airline Operating Expense Savings and additional economic value accruing to airlines from increased capacity in airports
- Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise
- Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity
- Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment
Note: Cumulative nominal costs are the same for both base case scenario and “what-if” scenario because the time value of money is not being considered in the cash flows. However, nominal cash flows differ from year to year in the two scenarios. Costs for the accelerated case have been calculated by spreading the costs incurred during 2020–2025 over 2015–2020 uniformly. The PV

### 10.2.2 European SESAR program investment case

#### Figure 20: Europe business case summary — net present value

- Tier 1 benefits include: Airline Operating Expense Savings and additional economic value accruing to airlines from increased capacity in airports
- Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise
- Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity
• Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment

Figure 21: Europe business case summary - nominal cumulative benefits and costs

<table>
<thead>
<tr>
<th>Investment Analysis by Scenario (US$B)</th>
<th>Benefits*</th>
<th>Costs*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tier 1</td>
<td>Tier 1 &amp; 2</td>
</tr>
<tr>
<td>Grounded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>276.8</td>
<td>386.7</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>90.5</td>
<td>96.3</td>
</tr>
<tr>
<td>Turbulence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>289.0</td>
<td>309.0</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>91.2</td>
<td>101.9</td>
</tr>
<tr>
<td>Steady Flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>373.8</td>
<td>393.8</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>113.9</td>
<td>124.5</td>
</tr>
<tr>
<td>Takeoff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal</td>
<td>504.7</td>
<td>535.4</td>
</tr>
<tr>
<td>2010 Present Value</td>
<td>147.0</td>
<td>162.9</td>
</tr>
</tbody>
</table>

Note: Cumulative nominal costs are the same for both base case scenario and “what-if” scenario because the time value of money is not being considered in the cash flows. However, nominal cash flows differ from year to year in the two scenarios. Costs for the accelerated case have been calculated by spreading the costs incurred during 2020–2025 over 2015–2020 uniformly. The PV values of costs are higher for accelerated case because of discounting while calculating the PV.
10.2.3 ROW Program investment case

Figure 22: Rest of the World business case summary — net present value

Note:
- Tier 1 benefits include: Airline Operating Expense Savings and additional economic value accruing to airlines from increased capacity in airports
- Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise
- Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity
- Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment
- Benefits for the ROW business case were calculated by multiplying U.S. business case benefits by the ratio of ROW air traffic volumes to U.S. air traffic volumes for each year
- Costs for the ROW business case were calculated by multiplying U.S. business case costs by the ratio of airport investments52, 53 in the ROW to airport investments in the U.S. for each year
As explained in the note above, since ROW benefits and costs depend on the U.S. business case, in the accelerated “what-if” scenario, while the ratio of air traffic volumes and airport investments did not change from year to year, the nominal benefits and costs for the U.S. business case did change from year to year, and this explains the difference in cumulative nominal benefits and costs for the ROW in the two scenarios. Costs for the accelerated case have been calculated by spreading the costs incurred during 2020–2025 over 2015–2020 uniformly. The PV values of costs are higher for accelerated case because of discounting while calculating the PV.

10.3 Comparison of the non accelerated case with the delayed case

10.3.1 U.S. FAA NextGen Program investment summary

Note:
- Tier 1 benefits include: Airline Operating Expense Savings and additional economic value accruing to airlines from increased capacity in airports
• Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise.

• Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity.

• Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment.

Figure 25: U.S. business case summary - nominal cumulative benefits and costs

Note: Cumulative nominal costs are the same for both base case scenario and “what-if” scenario because the time value of money is not being considered in the cash flows. However, nominal cash flows differ from year to year in the two scenarios. The PV of costs is lower for the delayed case because the cash flows for 2020–2025 were equally distributed over 2020–2030. The time value effect reduced the total PV for costs.
10.3.2 European SESAR Program investment case

Figure 26: Europe business case summary — net present value

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Investment Analysis</th>
<th>Benefit 1</th>
<th>Benefit 1 “Delayed”</th>
<th>Benefit 1 &amp; 2</th>
<th>Benefit 1 &amp; 2 “Delayed”</th>
<th>Benefit 1, 2 &amp; 3</th>
<th>Benefit 1, 2 &amp; 3 “Delayed”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounded</td>
<td>NPV (US$ Billion)</td>
<td>53.2</td>
<td>40.5</td>
<td>56.5</td>
<td>43.7</td>
<td>187.7</td>
<td>149.7</td>
</tr>
<tr>
<td></td>
<td>Payback (Years)</td>
<td>14</td>
<td>16</td>
<td>13</td>
<td>16</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>10.7%</td>
<td>7.6%</td>
<td>11.3%</td>
<td>8.2%</td>
<td>27.6%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Turbulence</td>
<td>NPV (US$ Billion)</td>
<td>54.0</td>
<td>39.6</td>
<td>57.5</td>
<td>42.8</td>
<td>219.4</td>
<td>179.7</td>
</tr>
<tr>
<td></td>
<td>Payback (Years)</td>
<td>14</td>
<td>17</td>
<td>14</td>
<td>17</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>10.0%</td>
<td>6.4%</td>
<td>10.0%</td>
<td>6.9%</td>
<td>26.0%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Steady Flight</td>
<td>NPV (US$ Billion)</td>
<td>76.7</td>
<td>62.2</td>
<td>81.0</td>
<td>66.2</td>
<td>268.2</td>
<td>228.4</td>
</tr>
<tr>
<td></td>
<td>Payback (Years)</td>
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<td>15</td>
<td>13</td>
<td>15</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>12.9%</td>
<td>9.1%</td>
<td>13.0%</td>
<td>9.7%</td>
<td>31.0%</td>
<td>15.2%</td>
</tr>
<tr>
<td>Takeoff</td>
<td>NPV (US$ Billion)</td>
<td>100.8</td>
<td>101.8</td>
<td>116.0</td>
<td>106.4</td>
<td>302.2</td>
<td>304.2</td>
</tr>
<tr>
<td></td>
<td>Payback (Years)</td>
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<td>11</td>
<td>13</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>16.2%</td>
<td>11.8%</td>
<td>17.0%</td>
<td>12.3%</td>
<td>59.3%</td>
<td>18.2%</td>
</tr>
</tbody>
</table>

Note:
- Tier 1 benefits include: Airline Operating Expense Savings and additional economic value accruing to airlines from increased capacity in airports
- Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise
- Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity
- Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment

Figure 27: Europe business case summary - nominal cumulative benefits and costs
10.3.2 European SESAR Program investment case

Figure 27: Europe business case summary - nominal cumulative benefits and costs

Note: Cumulative nominal costs are the same for both base case scenario and “what-if” scenario because the time value of money is not being considered in the cash flows. However, nominal cash flows differ from year to year in the two scenarios. The PV of costs is lower for the delayed case because the cash flows for 2020–2025 were equally distributed over 2020–2030. The time value effect reduced the total PV for costs
10.3.3 ROW Program investment case

Figure 28: Rest of the World business case summary — net present value

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Tier 1</th>
<th>Tier 1 &quot;Delayed&quot;</th>
<th>Tier 1 &amp; 2</th>
<th>Tier 1 &amp; 2 &quot;Delayed&quot;</th>
<th>Tier 1, 2 &amp; 3</th>
<th>Tier 1, 2 &amp; 3 &quot;Delayed&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounded</td>
<td>62.9</td>
<td>48.3</td>
<td>65.6</td>
<td>50.5</td>
<td>209.5</td>
<td>170.3</td>
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<td>15</td>
<td>12</td>
<td>14</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Tier 1</td>
<td>12.8%</td>
<td>9.4%</td>
<td>13.4%</td>
<td>9.8%</td>
<td>35.1%</td>
<td>24.8%</td>
</tr>
<tr>
<td>Turbulence</td>
<td>91.0</td>
<td>73.0</td>
<td>96.8</td>
<td>77.8</td>
<td>265.3</td>
<td>220.3</td>
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<tr>
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<td>13</td>
<td>11</td>
<td>13</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Tier 1</td>
<td>16.3%</td>
<td>12.5%</td>
<td>17.1%</td>
<td>13.1%</td>
<td>39.3%</td>
<td>28.1%</td>
</tr>
<tr>
<td>Steady Flight</td>
<td>111.3</td>
<td>88.7</td>
<td>117.1</td>
<td>93.3</td>
<td>349.8</td>
<td>289.1</td>
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<td>Payback (Years)</td>
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<td>13</td>
<td>11</td>
<td>13</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Tier 1</td>
<td>18.0%</td>
<td>13.5%</td>
<td>18.8%</td>
<td>14.1%</td>
<td>43.5%</td>
<td>30.6%</td>
</tr>
<tr>
<td>Takeoff</td>
<td>158.6</td>
<td>130.8</td>
<td>165.0</td>
<td>135.9</td>
<td>515.0</td>
<td>450.7</td>
</tr>
<tr>
<td>Payback (Years)</td>
<td>10</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Tier 1</td>
<td>20.7%</td>
<td>16.1%</td>
<td>21.6%</td>
<td>16.6%</td>
<td>49.5%</td>
<td>35.1%</td>
</tr>
</tbody>
</table>

Note:
- Tier 1 benefits include: Airline Operating Expense Savings and additional economic value accruing to airlines from increased capacity in airports
- Tier 2 benefits include: Economic value derived from saved emissions and savings in social costs of airport noise
- Tier 3 benefits include: Savings in passenger opportunity cost due to reduced delays, value of reduction in passenger losses to airlines from delays, and the economic benefit to society resulting from increased air traffic capacity
- Costs include recurring and one-time investments for equipage, plus investments and costs borne by ATM service providers and federal/government agencies in airport equipment
- Benefits for the ROW business case were calculated by multiplying U.S. business case benefits by the ratio of ROW air traffic volumes to U.S. air traffic volumes for each year
- Costs for the ROW business case were calculated by multiplying U.S. business case costs by the ratio of airport investments in the ROW to airport investments in the U.S. for each year
Note: As explained in the note above, since ROW benefits and costs depend on the U.S. business case, in the accelerated “what-if” scenario, while the ratio of air traffic volumes and airport investments did not change from year to year, the nominal benefits and costs for the U.S. business case did change from year to year, and this explains the difference in cumulative nominal benefits and costs for the ROW in the two scenarios. The PV of costs is lower for the delayed case because the cash flows for 2020–2025 were equally distributed over 2020–2030. The time value effect reduced the total PV for costs.
10.4 ATS Transformation cost analysis

Figure 30: NextGen Program Expenditure (Non Recurring plus Recurring, U.S.$ Billion), 2008–2015

Figure 31: NextGen Program Investment (U.S.$ Billion), 2010 – 2025
Figure 32: NextGen Program Recurring Personnel Costs (U.S.$ Billion), 2010 – 2025

Note: Fig 30 represents the breakup of total costs as recurring and non recurring (CAPEX) costs. Fig 31 shows the breakup of non recurring (CAPEX) costs as R&D and F&E costs

Figure 33: NextGen Total Expenditure by Stakeholder (U.S.$ Billion), 2010 – 2025

Figure 34: SESAR Equipage Expenditure (Investment plus Recurring, U.S.$ Million), 2008 – 2025
Figure 35: SESAR Other Expenditure (Investment plus Recurring, U.S.$ Million), 2008 – 2025

Figure 36: SESAR Total Expenditure by Stakeholder (U.S.$ Billion), 2010 – 2025
Figure 37: Rest of the World ATS Transformation Expenditure (Investment plus Recurring, U.S.$ Billion), 2010 – 2025

Note: Costs for the ROW business case were calculated by multiplying U.S. business case costs by the ratio of airport investments\(^52, 53\) in the ROW to airport investments in the U.S. for each year.

“The PV of costs is lower for the delayed case because the cash flows for 2020–2025 were equally distributed over 2020–2030. The time value effect reduced the total PV for costs.”
10.5 Frequently asked questions

1. Is the positive finding that there is a significant financial benefit to accelerating NextGen, SESAR and other ATS transformation programs, based on realistic assumptions? What are the risks and “upsides”?

**Answer:** Realistic and conservative assumptions have been made for this study that include projections of air traffic demand, growth of oil prices, estimates of the impact of ATS transformation on airport capacity, monetization of passenger opportunity costs, and quantification of the value of reduced emissions. Most of the projections and estimates made for the study lie within the ranges for these variables estimated by major regulatory, industry or academic organizations. The study also considered variability in the way the airline industry and the world economy could evolve, and has looked at four different scenarios which cover a realistic range of possibilities for each of the major parameters that affect the business case for transformation.

Business case benefits include significant savings which could accrue to airlines in operating costs and an increase in operating cash flow. These are a result of potential reduction in flight delays and an increase in aircraft operations capacity at airports. Other upsides that can result from the business case are expected major savings in aircraft emissions. Finally, the ATS transformation is estimated to positively impact the world economy by saving several million hours of passenger time and reducing associated productivity losses, as well as stimulating business and commerce by adding additional air transport capacity across the world. We have not included a set of upside benefits that many experts and other informed parties might otherwise include.

Of the applicable risks, the specific risks considered for the business case are related to volatility in macroeconomic factors such as oil prices and air traffic demand. Both of these factors have a significant effect on the NPV of the business case for ATS transformation. Other risks include program management issues, for which a 10% contingency was added to the projected costs. Finally, delays in implementation of the program could also impact the value of benefits realized and bring down the NPV of the business case for the transformation.

2. Why didn’t the study include the benefits to the general aviation community?

**Answer:** Consistency of, and agreed definitions of data associated with delays caused by ATC, weather and capacity constraints for this group was not readily available on a global basis. In addition, GA fuel consumption and use of the NAS, as well as their use in other countries, were not readily available.

3. Why didn’t the study include the benefits to military flights and UAV’s?

**Answer:** The study has considered the impact of ATS transformation on the economy. Military and unmanned flights were excluded because of smaller contributions to commerce and unquantifiable benefits, particularly in nations outside of the EU and North America. Further, military flights and UAVs also operate extensively outside the NAS in the U.S. and non-civilian air space in other countries, which is out of scope for this study. Finally, because the UAV industry is still nascent and difficult to forecast, realistic assumptions to account for the impact of ATS transformation on UAV flights are difficult to make.

4. Why is the business case more positive in the Turbulent scenario than in the Steady State scenario?

**Answer:** The Turbulent scenario assumes a high growth rate for fuel prices and Certified Emission Reduction credit prices. As contemplated by the scenario assumptions, this could lead to a large amount of realized savings as every minute of delay saved will result in a greater positive impact on airline operating costs, monetized emissions costs and the economy.

5. How are noise and safety treated in the business case?

**Answer:** ATS transformation is expected to significantly reduce the sound exposure levels in and around airports by reducing the length of time passengers and communities on the ground near airports are exposed to aircraft noise.
This has been monetized by considering the effect of noise reduction on the valuation of houses in areas surrounding airports of major European and U.S. cities. Safety improvements are widely recognized as a positive benefit for ATS transformation programs. However, we did not include the monetization of safety improvements in this study due to difficulty in obtaining consistent and global data.

6. Why is it assumed that the current ground based system will stay intact after implementation?

**Answer:** ATS transformation program is assumed to be rolled out in a phased manner (three epochs for NextGen and four successive service level improvements for SESAR). During the implementation, and for a certain buffer period beyond the complete roll-out, older systems will likely have to be maintained in order to continue normal operations. Further, airline adoption schedules for the necessary next generation equipage may differ, and certain operators might need to keep using older systems operating in the interim. The continued maintenance of some portions of the current ground based systems is seen by some as a good backup system. This matter is still up for further debate, dialogue and study.

7. Why do total benefits jump almost three fold when including Tier 3 benefits?

**Answer:** Tier 3 benefits are largely indirect, which implies that they do not accrue to any one stakeholder, or are quantifiable but “soft”, which implies that they typically do not result in accounting cash flow. The first component is passenger opportunity cost savings, which is the monetized value of passenger time saved through reduced delays. Given that ATS transformation will affect millions of passengers and potentially save several million hours, the opportunity cost savings are substantial and tower over the other identified savings.

The second component is the economic value of additional flights that are estimated to be enabled through the ATS transformation. Transportation adds value to the economy by enabling supply chains, stimulating ancillary economic activity and enabling commercial transactions. The value to the general economy of the millions of possible additional flights projected as a result of the transformation is significant.

The third component of Tier 3 costs are airport and airline costs associated with passenger delays. For airlines, this represents costs arising from loss of goodwill, customer satisfaction, cancellations and customer attrition to other modes of transport. For airports this represents additional burden on airport services. These soft costs are far greater than the direct accounting costs attributable to delays in the system.

8. If we assume carbon caps, trade or tax will not occur given the political difficulties, what is the impact on the study findings? What if it happens partially, e.g., in one region but not another?

**Answer:** Emission savings, captured in Tier 2 benefits are approximately 4% of Tier 1 benefits, and are therefore relatively minor in dollar terms. However, the qualitative environmental benefits of reduced aircraft emissions are significant. If aircraft emissions are not tightly regulated in the future or the airline industry is excluded from carbon emission controls, the monetary benefits would be lower than the base case Steady Flight scenario in the study, and closer to the benefits modeled in the Turbulence scenario. However, while the value of savings in monetary terms may be depressed in a loose regulatory environment, the impact of ATS transformation in terms of reduced CO$_2$, NO$_2$, and SO$_2$ emissions would be unchanged.

However, there is a school of thought that sees a more tightly regulated environmental emissions scenario, which would have the effect of higher fuel prices. In that scenario, the business case for an accelerated ATS transformation timeline becomes more attractive. Regional variance in environmental regulations is possible. For instance, Europe has already set emission quotas for airlines operating within European airspace. If similar regulations are not put into place in the U.S. or other parts of the world, the quantitative benefits included in Tier 2 in this study would be reduced slightly. However, as stated previously, this would not have effect on the reduction in physical emissions itself.
9. Does NextGen make sense given that improvements such as RNP are being implemented by airlines anyway?

**Answer:** RNP helps enable certain types of trajectory based operations, which are only a small part of the full scope of improvements in ATS through the proposed transformation. NextGen, for example, will enable collaborative air traffic planning and management, integrated aircraft operations, improved system wide information management and better prediction and sharing of weather data. Taken as a whole, NextGen is expected to deliver benefits that go much further than RNP in reducing air traffic delays and increasing capacity in participating airports. However, RNP implementations have been accomplished for only a small fraction of the global commercial airline operators thus far.

10. What discount rate assumptions were used to forecast the costs and benefits?

**Answer:** Cash flows applicable to public investment or realized benefits to the general economy were discounted back using long term regional specific government borrowing rates, since this best reflects the cost of capital to the public. Cash flows applicable to airlines were discounted using an average weighted average cost of capital for major airlines in each region.

11. What is assumed to be the cost of people’s time? Is that a soft cost?

**Answer:** Passenger opportunity cost per hour was assumed to be the average hourly work related compensation, evaluated separately for each region. It is assumed that this is the benefit the passenger foregoes by being delayed en-route or in the airport. This is a soft cost because it is not accounted for directly by any stakeholder. However, while it is not an accounting cost, it is an economic cost and is included in our evaluation of the economic impact of ATS transformation.

12. Why did you pick 2020, five years earlier, as the goal for the accelerated ATS transformation business case?

**Answer:** Firstly, acceleration will likely be easier towards the back end of the implementation timeline as program management stabilizes, basic infrastructure is put in place and sufficient momentum is generated among all constituents. Secondly, the proposed investment schedule is such that major investments occur starting in 2016. Therefore, the full impact of the acceleration will likely be realized if it is initiated in 2016, with full rollout occurring in 2020. However, as described in detail in this study, there are many significant issues and challenges in implementing a normally scheduled implementation date of 2025, let alone an accelerated 2020 schedule.

13. When extra capacity is added due to the implementation of ATS transformation programs, is it assumed that airlines will stop buying airplanes for a period of time until traffic growth catches up?

**Answer:** Not necessarily, as it is assumed that the ATS transformation will affect current aircraft manufacturer projections for new aircraft demand in the short term. This fluctuation in demand-supply dynamics is assumed to happen within the timeline of the transformation as air traffic demand ramps up quickly. The time value of potential deferred investment in new equipment was not included in the calculation of benefits.

14. What is the assumed price per barrel of oil in 2025 when these initiatives are scheduled to be completed?

**Answer:** The price of light crude oil has been projected to be $72 per barrel in the low growth case, $119 per barrel in the base case and $224 in the high growth case.

15. How sensitive are the business case findings to fluctuations in the price of oil?

**Answer:** Fluctuations in oil prices will strongly affect the NPV of the business case. While considering direct benefits resulting from the ATS transformation, i.e., Tier 1 benefits only, NPV for the highest oil price growth scenario is 22% higher than the low oil price growth scenario. Considering all benefits, i.e. tier 1, 2, 3, the NPV of the business case differs by 5%.
16. Would the business case turn negative if alternative fuels were introduced into the system?

**Answer:** Large scale introduction and adoption of alternative fuels was not considered for the purposes of the study. However, the impact of ATS transformation on fuel savings for airlines could be considerably reduced in dollar terms if the price of the fuel is depressed by the use of alternative fuels priced attractively. This can be compared to a scenario where the price of fuel drops below the lowest price increase assumed. It is a scenario worthy of further study as credible data and projections of widespread adoption become available. However, as of the time of this study, alternative fuels have a relative price point significantly above the price of fossil fuels, and as such would not affect the NPV of this business case in the short term.

17. Does the planned introduction of alternative non-U.S. based GPS constellations such as Galileo and GLONASS change the business case?

**Answer:** This case study assumes the availability of any satellite based PNT systems being available and does not differentiate among the varying satellite systems planned or in-orbit already. ATM applications would be only part of the benefits of Galileo, GLONASS or similar initiatives by China and India. Therefore, the costs of such satellites would form only a part of a business case for PNT applications. We have not included the costs of additional deployment of such satellites beyond the U.S. GPS satellite constellation. At a high level, additional PNT systems deployed in other countries would bring down costs of ATS transformation in those regions as they would probably operate at lower user costs than comparable GPS systems. This would only serve to increase the overall NPV of the ATS transformation business case.

18. What happens to the business case if NextGen and SESAR are delayed?

**Answer:** Delaying the implementation of any of the transformation programs would reduce economic value in terms of the NPV of the benefits. This business case does describe in detail the NPV degradation impact of a potential delay in ATS transformation programs.

19. Who should pay for aircraft equipage?

**Answer:** This question is not within the scope of this study and is best answered by policy makers and regulatory officials. It is clear there are costs for equipage of aircraft as well as ground based equipment, and that costs will be incurred that benefit government, sovereign economies, passengers, and airline operators. Other air space users such as general aviation aircraft owners at some level as well as the flying military might also benefit. Objective studies to understand and quantify the benefits and costs associated with ATS transformation should help guide the way for making appropriate trade-offs and finding a path for allocation of costs in this important and game changing investment decision. Costs allocation for military and general aviation was available for SESAR and have been included.

20. Why did this business case add only 10% to the costs for implementation?

**Answer:** We assumed that the FAA and EUROCONTROL have considered cost and schedule risks in their estimates of non recurring costs and have already added a margin for contingency. Thus a reasonably conservative level of 10% was added in this business case. Due to the technical complexity, challenges in transitioning over a prolonged period, and the number of aircraft and constituents involved, a lower contingency factor, of for example 5%, in our opinion would not be prudent. A number higher than 10%, e.g., 15% might be considered, but it would not materially change the outcome of this business case. For this business case, we chose 10% as a realistic management reserve for possible cost overruns. Keep in mind that for the U.S. for example, these contingency costs amount to approximately $4 billion in nominal costs.

21. Why does the poor economic environment in the grounded scenario result in the purchase of more regional aircraft?

**Answer:** In this scenario, we assumed that as a result of poor recovery from the recent recession, demand for long haul flights will decline. Further, given the better per trip economics of regional aircraft, airlines would start investing more in such aircraft for shorter duration trips.
22. The business case states that with program acceleration in the base case, aircraft delay reductions by 2020 are expected to reduce emissions by 128 million metric tons of CO₂, NOₓ, and SOₓ, and save 15 million hours in flight delays, representing $44 billion of additional benefit to airlines and a further $20 billion in savings to the global economy in passenger productivity. Finally, the transformation is expected to free up additional capacity in terms of increased aircraft movements, which translates to $21 billion in additional operating revenue for airlines and $50 billion in added value to the global economy. Over what time period does this occur?

Answer: In the accelerated business case, it is assumed that the investments planned in 2021 and beyond occur in prior years, and as a result Next Gen Epoch 3 and SESAR Service Level 3 are completed by 2020. This will result in additional benefits in NPV terms for the ATS transformation business case, with the nominal cash flows increasing after 2016 when the first of the advanced investments planned for 2021 and beyond start taking effect.

23. Even if the business case for ATS program acceleration is positive, the technical, managerial and budgetary challenges to implement are enormous. Can this be done?

Answer: This still is yet to be determined. There are many challenges to accelerating ATS transformation initiatives even though the business case might find a net positive benefit for sooner implementation. These very real challenges include but are not limited to policy agreement, funding availability, standardization, technical complexity and maturity of system equipage (e.g., real time digital communications), integrated systems testing and validation, workforce training, equipment certification, schedule realism and staged deployment. Lastly, the aerospace and defense industry continues to be impacted by program management challenges of cost overruns and schedule delays due to technical complexity, requirements growth, systems testing and integration challenges. These are but some of the issues that could impact a potential accelerated implementation. It will be a matter for ATS authorities to determine if the size of the additional NPV is worth implementing program, risk and management mitigation measures to successfully implement in the accelerated timeframe.

24. Why does the capacity utilization reduce from 85% (2009) to 78% (post implementation of NextGen) even after implementing NextGen?

Answer: Capacity utilization reduces because of a more than proportionate growth in air traffic in comparison to the handling capabilities. Without NextGen the capacity would have fallen to 65% (in 2025). However, NextGen implementation is projected to increase capacity utilization and it is expected to fall only to 78% (in 2025 in a non accelerated case). This corresponds to a gain in capacity.

25. In the “Delayed Implementation” case, why does the capacity utilization reach 78% in 2020?

Answer: In the Delayed Implementation case, we assumed that the NextGen systems will be fully operational in 2030. This would result in slower addition of capacity and hence a faster reduction in capacity utilization. Thus the capacity utilization is projected to reach 78% before 2025 (the date for non accelerated case of full implementation of NextGen). We assumed that it will reach 78% in 2020.

26. Why is the positive impact of acceleration higher for Europe in comparison to the U.S.?

Answer: Europe accrues more infrastructural and noise savings in comparison to the U.S. in the accelerated and non accelerated case. This leads to a higher impact of acceleration in overall NPV.

27. Why does delaying implementation result in higher losses for the U.S. in comparison to Europe?

Answer: Europe accrues more benefits in infrastructural benefits and noise with respect to the U.S. On delaying implementation, it is expected to lose more of those benefits than the U.S. because the accruing of larger benefits will be delayed. Hence, impact of delay results in higher losses for Tier 1 and Tier 2 savings in Europe in comparison to the U.S. The Tier 3 Savings for the U.S. are higher than that of Europe. Delaying implementation...
results in more loss of Tier 3 savings for the U.S. in comparison to Europe. Also, the contribution of Tier 3 benefits to the total benefits is more for U.S. in comparison to that of Europe. Thus, the total loss suffered by the U.S. is higher than that of Europe for the time period considered.

28. Why is the contribution of Tier 1 benefits to total benefits more for Europe in comparison to the U.S.?

Answer: Infrastructural benefits are higher for Europe in comparison to the U.S. and hence the contribution of Tier 1 benefits to the total is higher for Europe in comparison to the U.S. (The U.S. also has higher total benefits in comparison to Europe which leads to a smaller value for the percentage contribution of Tier 1 benefits).

29. Why is the fuel savings more for Europe in comparison to the U.S.?

Answer: Fuel cost per minute is higher for Europe in comparison to the U.S. Also, delay minutes savings for Europe is higher than the U.S. Hence, the fuel savings are more for Europe in comparison to the U.S.

30. Why is the passenger hard cost savings higher for Europe in comparison to the U.S.?

Answer: The passenger hard costs savings per minute value and the delay minute savings for Europe are higher in comparison to the U.S. This results in a higher value of passenger hard costs savings for Europe.

31. Why is the Airline soft costs savings higher for Europe in comparison to the U.S.?

Answer: Airline soft costs savings are calculated by taking the ratio of hard costs to soft costs as a multiplier. Thus, it exhibits the same trend as followed by hard costs.

32. Why is the contribution of Tier 3 savings higher for the U.S. in comparison to Europe?

Answer: The Tier 3 benefits of the U.S. are higher than that of Europe because of the higher value for Passenger opportunity cost savings (in Tier 3) accrued in comparison to any other component of benefit under any Tier for the U.S.. In Europe this is not the case.

33. Why is passenger opportunity cost saving higher for the U.S. in comparison to the Europe?

Answer: Passenger opportunity costs are calculated by taking the product of Passenger opportunity cost per hour of delay, the delay savings and the number of passengers per flight. Europe has a significantly lower value of passengers per flight resulting in a very low value of passenger opportunity cost savings in comparison to that to the U.S.

34. Why is the extra economic value per flight higher for Europe in comparison to the U.S.?

Answer: The value of extra economic value per flight for Europe is calculated by using a multiplier based on the value for the U.S. The value of this multiplier is greater than 2. Thus, the extra economic value per flight is higher for Europe.

35. What is the relationship between the savings for the U.S. and the ROW?

Answer: The values for all the savings under all Tiers for ROW are based on the values of savings for the U.S. along with a multiplier.

36. Why was 2035 picked as the business case decision time horizon?

Answer: The investment time horizon for this study is 2010 through 2035. This end date was determined to be a reasonable date to stop inclusion of recurring benefits as it represents 10 years of post implementation operation.
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18. Projected for three growth scenarios:
   a. U.S. Low Growth Case: Used Boeing CMO 2010 rates reduced by 50%
   b. U.S. Medium Growth Case: Used Boeing CMO 2010 rates
   c. U.S. High Growth Case: Used Boeing CMO 2010 rates increased by 50%
19. Projected for three growth scenarios:
   a. Europe Low Growth Case: Used Boeing CMO 2010 rates reduced by 50%
   b. Europe Medium Growth Case: Used Boeing CMO 2010 rates
   c. Europe High Growth Case: Used Boeing CMO 2010 rates increased by 50%
20. Projected for three growth scenarios:
   a. Rest of the World Low Growth Case: Used Boeing CMO 2010 rates reduced by 50%
   b. Europe Medium Growth Case: Used Boeing CMO 2010 rates
   c. Europe High Growth Case: Used Boeing CMO 2010 rates increased by 50%
21. Historical data from:
   a. U.S.: See 15
   c. Rest of the World: Assumed proportional to ratio of historical Air Traffic Volume in the Rest of the World from 17 to historical Air Traffic Volume in the U.S. from 15
22 Projected:
   a. U.S.: Regression of historical delay data against historical air traffic statistics. See 15
   b. Europe: Regression of historical delay data against historical air traffic statistics. See 16
   c. Rest of the World: Assuming delay is proportional to ratio of projected Rest of the World Air Traffic Volume to projected U.S. Air Traffic Volume (see 18 and 20)

23 Projected:
   a. U.S.:
      i. Weather Delay: Based on delay reduction factors for clear, moderate, and severe weather based on data from: Steve Penny, Bob Hoffman and Jimmy Krozel, Metron Aviation Inc., Anindya Roy, University of Maryland, Classification of Days in the National Airspace System Using Cluster Analysis, 2005
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      iii. Late Aircraft Delay (or secondary delay caused by delay in nearby traffic): Assuming historical ratio of secondary delay duration to primary delay duration. For data, see 15
   b. Europe: Calculated separately for on-ground and en-route delay reduction from data in 35. Also see: University of Westminster, The Challenge of Managing Airline Delay Costs, September 2009
   c. Rest of the World: Reduction factors assumed equivalent to U.S.

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25 U.S.: Capacity utilization improvements stated in JPDO: Business Case for the Next Generation Air Transportation System, August 2007. Also see 26


27 Capacity increase enabled through SESAR full implementation as stated in 3. Also, see 28

28 EUROCONTROL and EU: European Air Traffic Management Master Plan, March 2009

29 Assumed capacity utilization levels will be similar to those achieved by Next Gen. See 25 and 26


31 Air Transport Association of America, 21st Century Aviation — A Commitment to Technology, Energy and Climate Solutions. Also see:

32 IATA, A global approach to reducing aviation emissions, November 2009

33 Direct operating costs include
   a. Labor costs (Crew + Maintenance)
   b. Ownership costs (Lease included)
   c. Service costs (Passenger services)
   d. Maintenance costs (Material and other non-labor)
   e. Insurance costs
   f. Landing and other airport charges

34 U.S.: Historical data from 15. Projections are based on historical growth rates

35 Europe: Historical data from 16. Projections are based on data from Andrew Cook, Graham Tanner and Stephen Anderson, University of Westminster, Evaluating the True Cost to Airlines of One Minute of Airborne or Ground Delay, May 2004

36 Rest of the World: Assumed the same ratio of airline fuel expenses to airline non-fuel operating expenses as in the U.S. For U.S., see 33
37 Assumptions:

a. (i) For U.S. Equipage: Based on average of investment analyst WACC estimates of select U.S. airlines (7.02%)
   (ii) For U.S. FAA and Airports: Equal to 30 Year U.S. T-Bill rate (4.63%)

b. (i) For Europe Equipage: Based on average of investment analyst WACC estimates of select Europe airlines (7.51%)
   (ii) For Europe ANSP and Airports: Equal to 30 Year government bond rate for select European nations (4.50%)

c. (i) For rest of the World Equipage: Based on average of investment analyst WACC estimates for select airlines from Asia Pacific (9.00%)
   (ii) For Rest of the World Airports: Equal to 30 Year government bond rates for select nations (7.00%)

38 CO₂, NOₓ, SOₓ futures prices from both the U.S. (www.chicagoclimatex.com) and European (www.ecx.eu) carbon trading markets


40 Boeing current market outlook, 2010

41 IATA, Economic Briefing, The Impact of Recession on Air Traffic Volumes, December 2008

42 Projected for all three regions (graph shows U.S.):
   a. U.S.: Historical capacity per seat data from 15. Projections — (i) Low Growth Case: Historical growth rate — 2%,
      (ii) Medium Growth Case: Historical growth rate, (iii) High Growth Case: Historical growth rate + 2%
   b. Europe: Historical capacity data from 16. Projections for capacity — (i) Low Growth Case: Historical growth rate,
   c. Rest of the World: Capacity and fleet structure assumed to be the same as the U.S. case

43 Oil Prices were obtained from the Illinois Oil and Gas Association historical crude oil tracker and adjusted for inflation by using the CPI-U inflation index maintained by the U.S. Bureau of Labor Statistics Oil Prices: www.ioga.com/Special/crudeoil_Hist.htm
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   (http://www.airlines.org/News/Releases/Pages/news_9-2-08.aspx)
   Note that a more conservative estimate of 25% was used over the ATA target for this business case

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51 NextGen Investments for Operators and Airports, NextGen Implementation plan, Mar 2011


Passenger opportunity costs were estimated based on the assumption of foregone salary during the delay experienced by passengers — this is higher in Europe because of a greater proportion of business travelers and easily available alternative transportation options, especially railways. U.S. Source for Passenger Opportunity Cost: Joint Economic Committee Majority Staff, U.S. Senate, Flight Delays Cost Passengers, Airlines and the U.S. Economy Billions, May 2008. Europe Source for Passenger Opportunity Cost: Based on IATA estimates in 59.

Economic value was calculated based on estimates of consumer surplus generated by each passenger flight and revenues generated by cargo flights. U.S. Consumer Surplus per flight was calculated from data in: Richard Golaszewski, Measuring Economic Impacts and Assessing the Benefits of Aviation Capacity Enhancements, NEXTOR MIT Meeting, April 2004. Europe Consumer Surplus per flight was calculated from data in: Oxford Economic Forecasting, The Economic Contribution of the Aviation Industry in the UK, October 2006 Cargo Flight Revenues from: IATA, Economics Briefing, Air Freight Market Outlook, September 2007.
