

Abstract

The current paper explores Next Generation Air Transported System (NextGen) including its technologies, benefits, environmental sustainability, and challenges encountered in the implementation which leads to conclusions of some recommendations. The main purpose of the paper is to determine NextGen's initiatives towards sustainability of the environment as a major impetus behind the project coupled with the need for efficiency in the air transport system. The major findings on technologies used is the project's concentration on satellite-based aircraft control marked with the use of Automatic Dependent Surveillance-Broadcast (ADS-B) system. Performance Based Navigation technology is also employed, which aims at reducing flight distances through direct routes thus enhancing efficiency, reducing fuel burnt and emissions such as greenhouse gases. Commercial Aviation Alternative Fuels Initiative (CAAFI), Continuous Lower Energy, Emissions, and Noise (CLEEN), Aviation Environmental Design Tool (AEDT), Fuel-Saving Performance Based Navigation (PBN), Airport Improvement Program (AIP) and Voluntary Airport Low Emissions (VALE) are some of the programs undertaken by FAA to monitor the environmental impacts of NextGen. Noise pollution was reported in Phoenix as a result of the project and increased use of petroleum fuel was still present. More interventions on environmental sustainability and availing grants to innovations and proposals dealing with production of alternative drop-in jet fuels is recommended.

Next Generation Air Transportation System

Introduction

The following research paper is on Next Generation Air Transportation System usually known as NextGen. NextGen is a project initiated in 2004 to transform the National Airspace System (NAS) with its broad characteristics including human resource, airspace, physical facilities, services and processes. The current paper explores NextGen project in terms of its technologies, benefits toward environmental sustainability, challenges and criticism. Thus, on the basis of the analysis, the research draws recommendations. The paper will be presented to peers and to a professor from Engineering 100W class; the audience is fairly educated with some form of technical background. The research can be used generally to give insights, knowledge, and technical background on green air travel. Information gathered will promote NextGen's technology to airport authorities in different countries as a way of adopting global green air travel. The paper will be divided into sub-sections including the introduction, background information, NextGen's technologies, environmental sustainability, challenges and critiques, recommendations, and conclusion. The purpose of the paper is to explore the Next Generation Air Transport System and make recommendations on its implementation.

Background Information

A Joint Planning and Development Office (JPDO) was started in 2003 by the United States Congress to oversee the planning and harmonization of a project known as Next Generation Air Transportation System normally shortened as NextGen. The major motive behind NextGen project was a complete overhaul of the National Airspace System through a shift to an efficient satellite approach from the obsolete ground-based management of the air traffic. The project NextGen was initiated in 2004 to transform the National Airspace System (NAS) with its

broad characteristics including human resource, airspace, physical facilities, services and processes. The project had several long-term goals including the deployment of new flight processes that were based on performance, efficient systems to ease air traffic controlling and the use of modern and highly sophisticated infrastructural technologies.

A plan was developed through Federal Aviation Administration (FAA) as a mandate from the Congress to be used as a platform for the implementation of the project to achieve the long-term goals by 2025. The original scheme was mainly based on the set timeframe of up to 2025, but later mid-term objectives were focused on leading to another blueprint of years 2012 to 2018. The rationale behind NextGen was the creation of an efficient, safe, viable and reliable air transport system with a major goal of environmental sustainability and friendliness. Another impetus towards the project was to ease growing air traffic with a modern system of management, which would increase the nation's economic performance through improved mobility of citizenry involved in commercial activities. The project aimed at the safe accommodation of the vast number of people flying within United States through air transport system transformation.

NextGen Technologies

JPDO plan comprised of three major phases mainly focusing on technologies that would help meet the growing demands for air transport and improve flight services and flexibility leading to diversification of the management system. The phases also referred to as epochs and are discussed in the following section.

Foundational Capabilities

The phase was to run from 2007 to 2011 and was tasked with the implementation of technologies such as Automatic Surveillance that would deliver information with precision and on time to the controllers as well as to the pilots easing the management of flights. The

technology is known as Automatic Dependent Surveillance-Broadcast (ADS-B) and is considered as the foundation for NextGen prospects as shown in the figure 1 below.

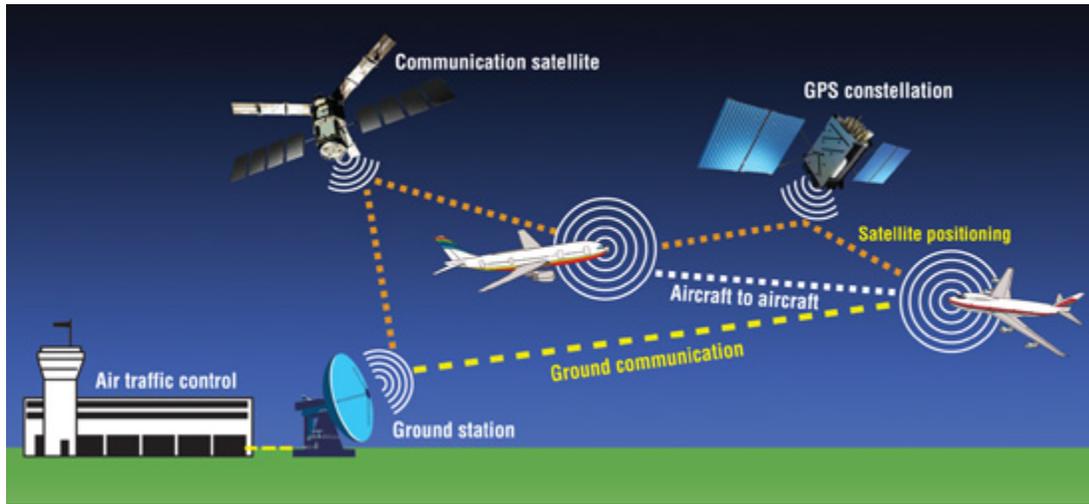


Figure 1. An illustration of ADS-B system.

Hybrid System

The stage is a rollout of the years 2012 to 2018 and includes complete automation that would allow for pilot's full and active participation as well as environmental sustainability. NASA and FAA are working collaboratively to introduce sophisticated automated air transport control system that will oversee reception of timely information on weather, air traffic and control with precision as shown in Figure 2 below. The automation in the phase is geared towards efficient use of fuel and minimal emissions leading to less pollution.



Figure 2. NASA labs with ADS-B system simulation.

NextGen Operations

The stage is a planned phase of the years 2019 to 2025 tasked with expanding NextGen around the United States by increasing the complexity of the system, eased by satellite-based technologies that will have been installed. The phase will oversee full utilization of the airspace with precision. The resulting NextGen’s plan is summarized by the figure below extracted from United States Government Accountability Office (GAO) Testimony Report on NextGen.

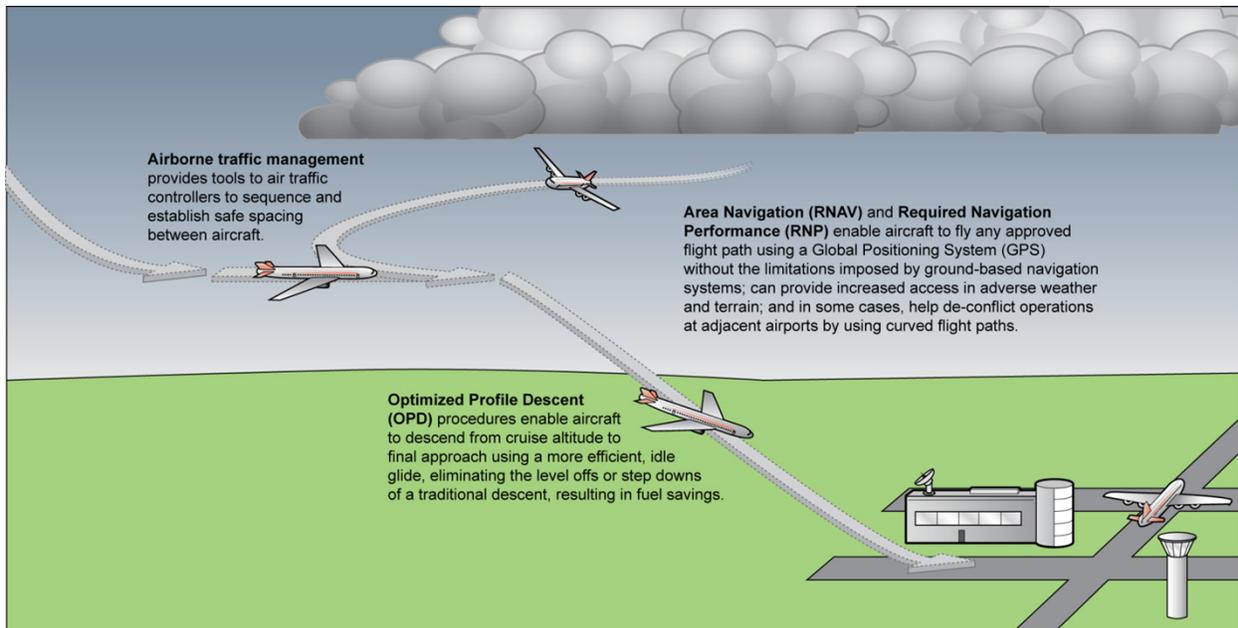


Figure 3. NextGen's Technological Plan.

NextGen and Environmental Sustainability

Environmental sustainability is the major purpose behind NextGen project. Environmental management system is a strategy being used by FAA to incorporate objectives seeking utmost environmental sustainability as NextGen progresses from stage to stage. The aim is followed by availing energy and environment objectives into NextGen's plans, decisions and processes.

FAA envisages NextGen's environmental protection as a way of allowing for sustained growth of the aviation industry. Ecological aspects such as the quality of air, water, energy and climate as well as other issues such as noise are the major factors affect the environment. The aforementioned factors have intense ability to derail the development of the aviation industry, especially in terms of efficiency, capacity and advancement of technologies. When it comes to noise pollution by the aircraft industry, there is need to minimize the number of individuals affected or predisposed to such disturbances around the airports and neighborhoods. The concern calls for provisions in NextGen's plan to ultimately address noise pollution through measures that are directed towards natural resource protection and social welfare in aviation growth. Addressing noise pollution will ensure people's health and hence, environmental protection.

Environmental sustainability in turn calls for measures tasked with ensuring that the quality of air is maintained with advancement in aviation technology and growth. Air quality and health are the key goals in NextGen. Sustaining healthy and clean air requires initiatives to ensure that emissions containing carbon dioxide from the aircrafts are lessened to decrease their impacts. Carbon dioxide is known to be a major cause of the global climate change. Thus, NextGen seeks to achieve growth of neutral carbon by the year 2020 with a long-term goal of reducing aircraft emissions that impacts climate by year 2050.

The improvement of the National Airspace System also requires efficiency in energy use. NextGen vision is to reduce energy consumption by 2% every year through introduction of alternative fuel to be used by commercial aircrafts. Protection of water bodies through control measures limiting aviation discharges into United States' waters also is the key in NextGen environmental sustainability programs.

Advancement in aircraft technology will also bring its environmental benefits. Proper tracking of aircrafts with precision and efficiently both on the ground and in the air will result into greater saving of fuel consumed. Therefore, it will minimize emissions or pollutants such as greenhouse gases that have detrimental effects on both health of individuals and climate, and also lessen the impact of aviation on communities. Advancement of technology in NextGen is also directed towards reduction of fuel levels burnt, noise and emissions.

All the efforts are aimed at reduction of noise pollution, dangerous emissions and minimal energy consumption as a way of sustaining the environment as discussed below:

Reduction in Air and Noise Pollution

Environmental Management System spelled out in NextGen's plans aims at making the air transport more noiseless, fuel-efficient and cleaner in terms of emissions. The goals are achieved through shorter flight distances and time as a result of direct routes from different points of destination rolled out in the wake of NextGen project. A partnership of the Federal Aviation Administration with the aviation industries to introduce operating processes gives room for flexibility and prediction including in times of extreme weather conditions. The factor is backed by renewal of air fleets with fuel-efficient and less noisy ones by U.S. carriers and other global companies. The United States' metropolitan regions are marked with multiple airports that have

been adjusted to streamline the arrival and departure of as many aircrafts as possible fitted with advanced technology to increase environmental sustainability while easing air transport.

Adaptation to Climate Change

Efforts have been made in NextGen project to incorporate National Weather Service's (NWS) data and other weather sources linked to Federal Aviation Administration (FAA). Moreover, the decisions made by National Airspace System through a domain referred to as Common Support Services – Weather or CSS-Wx, which is charged with offering support services, are crucial factor in NextGen. The domain coupled with technological advancements integrated in NextGen to ease air traffic and navigation enables the system to be more adaptive to weather and climate change through fast and efficient communication of the weather reports in various destinations with a lot of precision and time consciousness.

Environmental Initiatives by FAA

Impact on the environment by the aviation industry is greatly reduced with NextGen technological advancements. The reason is the numerous efforts by FAA to advance technology and reduce the amount of fuel burnt, pollutants emitted, and the noise produced by aircrafts. Alternative jet fuel efforts have been made too. Environmental goals have been set touching on noise, the quality of air, energy and climate by FAA. The goal is achieved through certain collaborative approaches discussed in the following section.

CLEEN Initiative. The term stands for Continuous Lower Energy, Emissions, and Noise. The program is introduced by FAA with a main purpose of lessening the impact of aviation industry on the environment by introducing new engines that are modelled with advanced technology that utilizes substitute jet fuels. The impetus towards the program is to bring

controlled developments in terms of aircrafts with less noise and a potential to burn minimal fuel while emitting less pollutants to the airspace as compared to present technologies.

CLEEN Initiative has certain goals as a rollout plan of the years 2015 to 2018 including:

- The production of an aircraft with sustainable technology that will lessen the levels of noise created by 32 dB in a cumulative way in relation to standards of Stage four;
- The support of manufacturing of an aircraft engine that lessens emissions of nitrogen oxide generated by the cycle for landing and taking off by sixty percent, which is below the set standard that was approved in 2004 by ICAO- International Civil Aviation Organization;
- Backing up of a technology that produces an aircraft that minimizes the amount of fuel burnt by 33% in relation to the contemporary one, leading to even more reduction in energy consumed and the amount of greenhouse gases emitted into the airspace;
- Utilization of substitute jet fuels that are of quantifiable benefits to the aircraft industry for the purposes of sustainability;
- And production of an aircraft technology that penetrates easily into the commercial market due to its engine suitability.

The above goals can be summarized as in Table 1 below:

| Category | NextGen's Goal by FAA |
|---|------------------------------|
| Noise Reduction (cumulative and below Stage four) | -32dB |
| Landing and Taking off Nitrogen Oxide emissions | -60% |

Jet fuel burn

-33%

Table 1. Showing FAA's Goals in CLEEN Program (2015-2018).

Source: FAA.

In order to ensure the success of the CLEEN program, FAA has charged Honeywell, Boeing, Pratt and Whitney and Rolls-Royce aircraft companies with the task of testing the alternative jet fuels' performance and properties and well as demonstrating its capacity to enhance environmental sustainability. The efforts of the CLEEN program aim at the standardization of the novel fuel (drop-in jet fuel) by ASTM International, which is responsible for setting fuel standards.

CAAFI Initiative. The current approach by FAA stands for Commercial Aviation Alternative Fuels Initiative. The program is mainly sponsored by FAA. Energy for the aviation industry is very expensive; thus, CAAFI seeks to embrace security in terms of energy. The goal is utilized through the introduction of substitute energy sources to change the conventional petroleum. FAA clearly recognizes the security, stability and cost of alternative fuels compared to that of petroleum counterparts. The initiative is a collaborative effort with other partners and co-sponsors in the aviation industry such as Airports Council International for the North America, Aerospace Industries Association, American Airlines, and major airports. Moreover, it includes other stakeholders such as agencies of the United States' government, universities, suppliers of fuel, and the commercial industry for aviation internationally.

Jet fuel used in the commercial aviation industry has caused challenges such as high costs, environmental pollution through greenhouse gas emissions, and security problems associated with petroleum energy. CAAFI seeks to address all the aforementioned challenges through the provision of sustainable sources of energy or jet fuels. The use of the substitute fuels aims at

reducing the emissions that contribute to air pollution and global climate change. The alternative fuel will also be measured in terms of the ability to be produced in the local market and stability in price and supply. Moreover, it should have the potential to act as a source of income to rural communities and of the overall economic development of the nation. The goal is envisioned by FAA to be attained by the year 2018 through production of drop-in fuels aiming at reduction of the number of gallons of jet fuels used in the U.S. The drop-in fuels resemble the petroleum counterpart and usable in the current aircraft technology without further modification with similar safety and performance levels. The development of a sustainable jet fuel as an alternative to petroleum one is part of the plan passed to the United Nation's International Civil Aviation Organization by the United States, i.e. The U.S. Aviation Greenhouse Gas Emissions Reduction Plan.

BAA, PARTNER and ACRP Initiatives. FAA has an Environment and Energy office that is tasked with monitoring and directing activities that are geared towards the use and development of alternative sustainable jet fuels. Some of the activities undertaken to achieve the energy security include: BAA- Alternative Aviation Fuels Broad Agency Announcement, which is involved in research. The group aims at achieving four vital aspects comprising of the development of a substitute drop-in jet fuel, controlling the quality of the drop-in fuel, providing guidance on sustainability to users and ensuring performance, as well as testing for durability of the novel fuels. PARTNER, Partnership for Air Transportation Noise and Emissions Reduction, measures the pollutants emitted by aircrafts and on the basis of the data collected. The analysis of emissions is done to ensure sustainability of alternative jet fuels as well as reduce the environmental impact associated with the alternative fuels. PARTNER is also charged with educating the aircraft industry participants about environmental sustainability, ways to improve it

and assessing the economies of alternative jet fuel's cost of production. It is for the above reason and function that PARTNER is referred to as the Center for Excellence. Finally, ACRP.- Airport Cooperative Research Program, is charged with the provision of guidance and the necessities for availing sustainable alternative jet fuels when needed.

NextGen's developments in alternative drop-in jet fuels have motivated the Federal Aviation Administration (FAA) attempting to ensure that there are a billion gallons of the substitute fuel being used by the year 2018. The novel alternative fuels will ensure that there are reduced levels of carbon dioxide emitted from aircrafts thereby enhancing the quality of air. As a result, the attainment of one of NextGen's goals of growth of neutral carbon by the year 2020 in comparison to year 2005 will be addressed. FAA supports the standardization of drop-in fuel that was third in order to be blend by ASTM International in 2014. The collaboration with the CLEEN initiative provided vital information through research to the procedure. The third blend is a mixture of the normal petroleum jet fuel at 90% and renewable sources mainly from sugars at 10%.

Other seven alternative blends of alternative jet fuels are being developed at different stages and three of them have been already approved. Two are blends of the conventional fuel and other sources ranging from discarded oils, organic wastes and vegetable oils at 50% and 50% respectively. Tests conducted on the blended alternative jet fuels have proved to lessen pollution from emissions. Therefore, they present an opportunity to ensure air quality while keeping the aircraft engines intact. A potential for reduction in aircraft emissions by 90% at a full life-cycle of a plane has been registered with some of the novel alternative jet fuels. Production cost are also being weighed as currently they are determined by the alternative blends used, which promises a competition with the conventional fuels.

AEDT Initiative. The abbreviation stands for the Aviation Environmental Design Tool, which is a program or a system software that monitors the performance of aircrafts both in terms of time and space to determine the levels of noise and emissions produced and fuel burnt. The information obtained is used to assess the environmental impact of the different aircraft models with a view of helping designers to develop the best plans and designs than are conscious on sustainability. The initiative is geared towards the production of the best aircraft models and designs with reduced noise and air pollution potentials while maximizing performance and lowering fuel consumed. The tool is currently in use by the United States' government.

Boeing Company has introduced the development of new technologies in aircraft through the CLEEN initiative by FAA, including trailing adaptive edge on the wing and on the engine exhaust of an aircraft . The adaptive trailing edge technology is said to have a capacity of reducing the levels of fuel consumed by 2%, and noise by 1.5dB.

The following figure shows a glimpse of an Aviation Environmental Design Tool (AEDT) that was presented to a Noise Workshop by the program's deputy manager Rebecca Cointin in the year 2011.

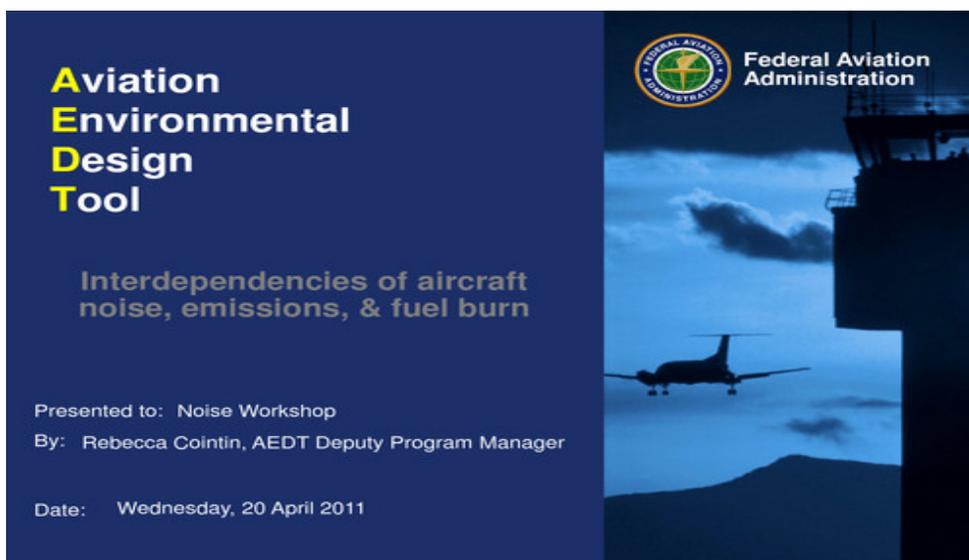


Figure 4. AEDT Presentation to Noise Workshop

PBN Initiative. PBN is an initiative by Federal Aviation Administration (FAA) meaning Performance Based Navigation. The project is tasked with the establishment of direct routes for flights with a motive of saving fuel, reducing greenhouse gas effects through lessened emissions. Direct routes that are of short distance decrease the time spent in air by aircrafts, hence reducing the energy consumed and pollutants emitted. NextGen's technologies that are satellite-based and performance-based render the aircraft industry free from the challenges of ground controls. Moreover, the new technology increases the ability to respond quickly to situations such as extreme weather conditions.

VALE Initiative. Voluntary Airport Low Emissions is another program by FAA. The program is tasked with reduction of all ground emissions or pollutants from airports. The initiative funds projects designed to enhance environmental sustainability including installation of pollution control gadgets in airports, use of pollution-free electric gates, as well as the employment of vehicles that are designed to reduce emissions from the fuel burnt. The program was initiated in 2004 under the Clean Air Act and holds all the sponsors of airports responsible in meeting the set threshold on air quality. AIP or Airport Improvement Program is a platform through which VALE achieves its goals by offering grants. The main purpose is to enhance planning for sustainable efforts in emission reduction within the United States' airports.

Challenges and Recommendations

There are several challenges that may derail the implementation of NextGen towards full transformation of the NAS (National Air Space System) as reported by FAA. The problems arise from the absence of executable plans and conflicts in making decision regarding designs. An

example of the issues is the failure of initial plans to address costs on technology development and integration of the same into the current ground-based system.

NextGen project would succeed if there was continuous integration of performance-based navigation (PBN) routes and processes to all the major airports so as to realize short-term benefits and to gather massive support from the users. The success has been stalled by FAA's bureaucracy in the development and initiation of novel routes. The process is lengthy and marked by unsettled hindrances including deficiencies in controller strategies and processes that are up-to-date increasing the uncertainty of when mass benefits can be delivered to the airspace users. Derailed implementation of the envisioned technologies and procedures by FAA overhauls the idea of the airlines experiencing the eagerly anticipated benefit of automated air traffic control system as promised by NextGen.

There is also the need for installation of automated systems to be used by controllers in the management of air traffic if the advancement of NextGen is to be realized. FAA faces challenges including technical hitches, cost and program hazards associated with modernization and advancement. Thus, the program requires an overhaul of the existing technologies with NextGen's automation systems at terminal airports are affecting agencies for not having identified nor settled the pre-requisites in terms of hardware and software. An estimate of the cost for the requirements should be given to airline agencies by FAA in order to implement the requirement.

The communities in areas such as Phoenix are in constant complains due to increased loud noises associated with NextGen project. CBS News writer Tracy Ben reported increased noise pollution in Phoenix. A woman interviewed (Nicole Marquez) claimed growing number of aircrafts flying over her home with intervals of about 30 seconds continuously for periods of one hour. NextGen technological advancement and use of automated satellite-based system has led to

increased number of flights due to direct routes devised creating shorter distances between subsequent planes. The strategy lead to larger the number of aircrafts in the air at the same time. Phoenix's noise pollution was as a result of the policy. The public concern creates a need for FAA to partner with the local communities during implementation of NextGen's stages of development and to motivate community participation. The citizenry involvement aims to inquire for the feedback on the impacts of the project, especially on the impetus on reduction of emissions and noise.

Noise pollution in Phoenix challenges the CLEEN (Continuous Lower Energy, Emissions and Noise) program with a roll out of the years 2015 to 2018. The basic areas of concern is the feedback from the affected communities, which will act as a platform to lay out plans and procedures. In Phoenix, NextGen project has changed the usual aircraft schedules of taking off and making turns at 9 miles to less than 3 miles U-turn over densely populated regions, increasing not only the number of planes operating at a certain time but also the noise produced. Complaints from Phoenix citizens due to noise pollution has risen from two hundred and twenty one in 2013 to more than 3,300 cases now.

The envisaged environmental benefits of NextGen project especially on oil saving is also a challenge for FAA. NextGen initial system plan was to decongest airports in the wake of increased air transport system leading to fewer planes being on the ground. Hence, burning fuel that pollutes the environment through emission and noises is to be decreased; it impacts the economy negatively as well. The motive behind fuel saving programs initiatives by FAA such as CAAFI, CLEEN and VALE is to bring efficiency in aircrafts as a way of enhancing environmental sustainability. The projections are possible through NextGen but the challenge remains that most

of the planes in the U.S. are still dependent on petroleum oil, which leads to economic repercussions.

In order to achieve the ultimate goal of NextGen, which is efficiency and environmental sustainability, there is need for rethinking and additional efforts towards the production of alternative drop-in fuel. Therefore, the U.S government should develop intervention in terms of providing incentives for innovations rather than dwelling excessively on research. The strategy should include provision of grants to regions and states that have demonstrated potential in their proposals and policies to lessen the amount of fuel used in aircrafts.

Conclusion

Next Generation Air Transportation System usually known as NextGen was initiated in 2004 to transform the National Airspace System (NAS) with its broad characteristics including human resource, airspace, physical features, services and processes. Current paper explored NextGen in terms of its technologies, benefits towards environmental sustainability, and challenges encountered in the implementation leading to some recommendations being made. Several initiatives that are geared towards environmental sustainability were determined as suggested for implementation by FAA. At the same time, the information obtained established that noise pollution is evident in Phoenix resulting from increased number of flights as a result of direct routes created by NextGen. Continued consumption of petroleum fuel was also established. The major recommendation is to speed up the processes and initiatives tasked with noise reduction and production of alternative drop-in jet. Lengthy bureaucratic procedures in making airlines agencies NextGen-compliant is a challenge that has led to stalled implementation of parts of the programs. Moreover, lack of information provision by FAA and initial plans on technological cost and requirements necessary for the transition (ground-based control to satellite based) present

hindrance to the initiative as well. Hence, there is a need to simplify the procedures to ensure timely compliance. For the success of NextGen project, a multi-sectoral approach with the involvement of all the stakeholders, including neighborhood communities who will feel the effects such as noise pollution, is an essential step.