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**Разработал: студент группы 148-09 «УВД»
Нурмухамедов Тохир Рустамович**

Направление: «Управление воздушным движением»

Руководитель: Сулайманов А.А

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_____ prof. Eshmuradov D.

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Prepared by: student of 148-09 group
Nurmukhamedov Tokhir Rustamovich

Field : «Air Traffic Control»

Supervisor: Sulaymanov A.A

Consultants:

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ОБРАЗОВАНИЯ РЕСПУБЛИКИ УЗБЕКИСТАН**

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ЗАДАНИЕ

НА ВЫПОЛНЕНИЕ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

Студенту _____
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AAC Aeronautical administrative communications
ABAS Aircraft-based augmentation
ACARS Aircraft communication addressing and reporting system
ACAS Airborne collision avoidance system
ACC Area control centre
ADS Automatic dependent surveillance
ADS-B* ADS-broadcast
AFS Aeronautical fixed service
AFTN Aeronautical fixed telecommunication network
AIDC ATS inter-facility data communications
AIP Aeronautical information publication
AMSS Aeronautical mobile-satellite service
ANC Air Navigation Commission
ANP Regional air navigation plan
ANS Air navigation service
ANSEP Air Navigation Services Economics Panel
AOC Aeronautical operational control
APC Aeronautical passenger communications
ASDE Airport surface detection equipment
ASM Airspace management
ATC Air traffic control
ATFM Air traffic flow management
ATIS Automatic terminal information service
ATM Air traffic management
ATMCP Air Traffic Management Operational Concept Panel
ATN Aeronautical telecommunication network
ATS Air traffic services
ATSC Air traffic services communications
BORPC Basic operational requirements and planning criteria
CAA Civil aviation administration
CAEP Committee on Aviation Environmental Protection
CASITAF CNS/ATM Systems Implementation Task Force
CATCs Civil aviation training centres
CDTI Cockpit display of traffic information
CNS Communications, navigation and surveillance
CNS/ATM Communications, navigation, and surveillance/air traffic management

COCESNA Central American safety Services Corporation
CPDLC Controller-pilot data link communications
DARP Dynamic air route planning
D-ATIS Digital-automatic terminal information service
DCPC Direct controller-pilot communications
EANPG European Air Navigation Planning Group
EATMS European ATM System
ECAC European Civil Aviation Conference
EUROCONTROL European Organisation for the Safety of Air Navigation
FANS Phase II Special Committee for the Monitoring and Coordination of Development and Transition Planning for the Future Air Navigation System
FANS Special Committee on Future Air Navigation Systems
FASID Facilities and services implementation document
FDPS Flight data processing system
FESG Forecasting and Economic Analysis
FIC Flight information centre
FIR Flight information region
FIS Flight information service
FMS Flight management system
FPL Flight plan
FUA Flexible use of airspace
GBAS Ground-based augmentation systems
GES Ground earth stations
GLONASS Global orbiting navigation satellite system
GNE Gross navigation error
GNSS Global navigation satellite system
GPS Global positioning system
HF High frequency
HMI Human-machine interface
IATA International Air Transport Association
IAVW International airways volcano watch
ICAO International Civil Aviation Organization
IFR Instrument flight rules
ILS Instrument landing system
IMC Instrument meteorological conditions
INS Inertial navigation system
IPCC Intergovernmental Panel on Climate Change
IRS Inertial reference system
ISO-OSI International Organization for Standardization — Open Systems Interconnection
JAA Joint Aviation Authorities
LTEP Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS
MAP Aeronautical charts
MASPS Minimum aircraft system performance specifications
MET Meteorological services for air navigation

MIDANPIRG Middle East Air Navigation Planning and Implementation Regional Group
MLS Microwave landing system
MMR Multi-mode receiver
MNPS Minimum navigation performance specifications
MNT Mach number technique
MWO Meteorological watch office
NDB Non-directional radio beacon
NOTAM Notice to airmen
NPA Non-precision approach
NPV Net present value
OPMET Operational meteorological information
PA Precision approach
PANS Procedures for Air Navigation Services
PAR Precision approach radar
PIRG Planning and implementation regional group
PSR Primary surveillance radar
RAFC Regional area forecast centre
RAIM Receiver autonomous integrity monitoring
RAs Resolution advisories
RCP* Required communication performance
RDT&D Research, development, trials and demonstrations
RF Radio frequency
RFI RF interference
RGCS Review of the General Concept of Separation Panel
RNAV Area navigation
RNP Required navigation performance
RSP* Required surveillance performance
RTSP* Required total systems performance
RVSM Reduced vertical separation minimum
SADIS Satellite distribution system for information relating to air navigation
SAR Search and rescue
SARPs Standards and Recommended Practices
SBAS Satellite-based augmentation
SCAR **SADIS** cost allocation and recovery scheme
SIDs Standard instrument departures
SIGMET Information concerning en-route weather phenomena which may affect the safety of aircraft operations
SIGWX Significant weather
SMGCS Surface movement guidance and control systems
SSR Secondary surveillance radar
STARs Standard instrument arrivals
STDMA Self-organizing time division multiple access
STP Standardized training package
SUA Special use airspace
TCB Technical Co-operation Bureau
TCDC Technical cooperation amongst developing countries

TDMA Time division multiple access
TDWR Terminal Doppler weather radar
TIS-B Traffic information service broadcast
TLS Target level of safety
TMA Terminal control area
UNFCCC United Nations Framework Convention on Climate Change
UTC Coordinated universal time
VAAC Volcanic ash advisory centre
VDL VHF digital link
VFR Visual flight rules
VHF Very high frequency
VMC Visual meteorological conditions
VOLMET Meteorological information for aircraft in flight
VOR VHF omnidirectional radio range
VSAT Very small aperture terminal
VSM Vertical separation minimum
WAFC World area forecast centre
WAFS World area forecast system
WGS-84 World Geodetic System — 1984

INTRODUCTION

As technology advances, new systems and concepts will continue to emerge, offering potential improvements in terms of safety, efficiency and/or economy of international flights. The emerging technologies will support a variety of system designs and implementation options.

One of the objectives of this revised Global Plan is to define and illustrate ICAO's process for CNS/ATM and FAA's NextGen systems planning and implementation as a logical progression of the work already accomplished. This includes an analysis of the structured relationship between the global, regional and national planning processes as well as the relationship between the Global Plan and other ICAO planning activities. An inventory of materials, tools and documentation now in existence, indicating where and how these can be used, will provide a readily-available source of reference material for planning purposes. As work on the ATM operational concept is ongoing, consensus on several emerging concepts have to be reached required communication performance, required surveillance performance. The operational requirements and functional specifications of some technologies also have to be developed. The Global Plan offers background information on the different elements and entities involved in these systems planning and implementation with the goal of creating, within one document, a nucleus of information necessary to facilitate the move towards the next phase of CNS/ATM planning and implementation. At the same time, the Global Plan attempts to bring up to date, in a consolidated format, the progress generally achieved by the regions and illustrates, with appropriate time lines, the work remaining, forming the implementation schedule for the future. It also offers, under one cover, a global snapshot of progress achieved and work remaining toward the implementation of CNS/ATM systems, thereby serving as a consolidated planning tool.

The challenge for the planner and designer is to develop an adequate understanding of the costs, benefits and operational suitability of these alternatives while considering the legal, organizational, environmental and financial aspects; to orchestrate a coordinated programme of ATM improvements that takes into account the user's needs, their willingness to upgrade their capabilities to achieve operational benefits, and also to pay for the changes required by ATM services providers. The Global Plan is intended to guide the international aviation community toward meeting this challenge and implementing CNS/ATM systems.

The Next Generation Air Transportation System, or NextGen, is a transformative change in the management and operation of how authorities fly. NextGen enhances safety, reduces delays, saves fuel and reduces aviation's adverse environmental impact. This comprehensive initiative, which is already providing benefits, integrates new and existing technologies, including satellite navigation and advanced digital communications. Airports and aircraft in the National Airspace System (NAS) will be connected to NextGen's advanced infrastructure and will continually share real-time information to provide a better travel experience. The foundations of NextGen have been solidly built upon four major pillars:

- safety;
- sustainability;
- flexibility;
- economic impact.

Safety is the ICAO's and FAA's first priority. The NextGen systems, policies and procedures that authorities are implementing are designed to ensure that the U.S. air transportation system remains the safest in the world. Satellite-based surveillance improves upon radar by providing controllers with more frequent and more accurate aircraft location information. This information can also be delivered to the cockpit, offering operators of properly equipped aircraft unprecedented traffic awareness. Up-to-date weather and airspace status information delivered directly to the cockpit will enable operators to safely make better-informed decisions while new communications technologies hold the promise of reducing misunderstandings between controllers and flight crews by supplanting many voice transmissions with digital instructions.

Chapter 1. Introduction to NextGen and CNS/ATM

1.1 A brief look at CNS/ATM and NextGen. Benefits of the new systems

The main elements of CNS/ATM systems are summarized below and are dealt with in detail in later chapters of the Global Plan.

In CNS/ATM systems, the transmission of voice will, initially, continue to take place over existing very high frequency (VHF) channels; however, these same VHF channels will increasingly be used to transmit *digital data*. Satellite data and voice communications, capable of global coverage, are also being introduced along with data transmission over high frequency (HF) channels. The secondary surveillance radar (SSR) Mode S, which is increasingly being used for surveillance in high-density airspace, has the capability of transmitting digital data between air and ground. An aeronautical telecommunication network (ATN) will provide for the interchange of digital data between end-users over dissimilar air-ground and ground-ground communications subnetworks. The regular use of data transmission for ATM purposes will introduce many changes in the way that communications between air and ground takes place, and at the same time offer many new possibilities and opportunities.

The benefits expected from the future communications systems lie in the fact that they will allow more direct and efficient linkages between ground and airborne *automated* systems in conjunction with pilot/controller communications. In fact, digital data link can be seen as the key to the development of new ATM concepts leading to the achievement of real benefits.

Navigation

Improvements in navigation include the progressive introduction of area navigation (RNAV) capabilities along with the global navigation satellite system (GNSS). These systems provide for worldwide navigational coverage *Global Air Navigation Plan for CNS/ATM Systems* and are being used for worldwide en-route navigation and for non-precision approaches. With appropriate augmentation systems and related

procedures, it is expected that these systems will also support most precision approaches

GNSS, as specified in Annex 10, will provide a high-integrity, high-accuracy and all-weather worldwide navigation service. The successful implementation of GNSS would enable aircraft to navigate in all types of airspace, in any part of the world, offering the possibility for many States to dismantle some or all of their existing ground-based navigation infrastructure. However, the removal of conventional radio navigation aids should be considered with caution and after a safety assessment has demonstrated that an acceptable level of safety can be met and after consultation with users through the regional air navigation planning process.

Traditional SSR modes will continue to be used, along with the gradual introduction of Mode S in both terminal areas and high-density continental airspace. The major breakthrough, however, is with the implementation of automatic dependent surveillance (ADS). ADS allows aircraft to automatically transmit their position, and other data, such as heading, speed and other useful information contained in the flight management system (FMS), via satellite or other communications links, to an air traffic control (ATC) unit where the position of the aircraft is displayed somewhat like that on a radar display. ADS can also be seen as an application that represents the true merging of communications and navigation technologies, and, along with ground system automation enhancements, will allow for the introduction of significant improvements for ATM, especially in oceanic airspace. Software is currently being developed that would allow this data to be used directly by ground computers to detect and resolve conflicts. Eventually, this could lead to clearances being negotiated between airborne and ground-based computers with little or no human intervention. Benefits would be derived quickly through ADS in oceanic and some continental areas that currently have no radar coverage. ADS-broadcast (ADS-B)* is another concept for dissemination of aircraft position information. Using this method, aircraft periodically broadcast their position to other aircraft as well as to ground systems. Any user, whether airborne or on the ground, within range of the broadcast, receives and processes the information. All users of the system have real-time access to precisely the same data, via similar displays, allowing a vast improvement in traffic situational awareness.

Air traffic management

In considering implementation of new communications, navigation and surveillance systems and all of the expected improvements, it can be seen that the overall main beneficiary is likely to be ATM. More appropriately, the advancements in CNS technologies will serve to support ATM. When referring to ATM in the future concept, much more

than just air traffic control is meant. In fact, ATM refers to a system's concept of management on a much broader scale, which includes ATS, air traffic flow management (ATFM), airspace management (ASM) and the ATM-related aspects of flight operations.

An integrated global ATM system should fully exploit the introduction of new CNS technologies through international harmonization of Standards and procedures. Ultimately, this would enable the aircraft operators to conduct their flights in accordance with their preferred trajectories, dynamically adjusted, in the most optimum and cost-efficient manner. Figure I-1-1 illustrates how the utilization of CNS technologies will result in ATM benefits.

Benefits for the airlines

The benefits of CNS/ATM systems will ensue through the formation of a more close-knit relationship, allowing rapid and reliable transmission between ground and airborne system elements. More accurate and reliable navigation systems will also allow aircraft to navigate in all types of airspace and operate closer together.

In anticipation of the advantages of CNS/ATM systems, the airlines expect reduced separation standards over oceanic airspace; increased access to remote areas; the gradual introduction of 1 000 ft vertical separation above 29 000 ft; increased opportunities for more dynamic and direct routings; and an overall enhancement of safety.

Benefits for the States that provide the global air navigation infrastructure

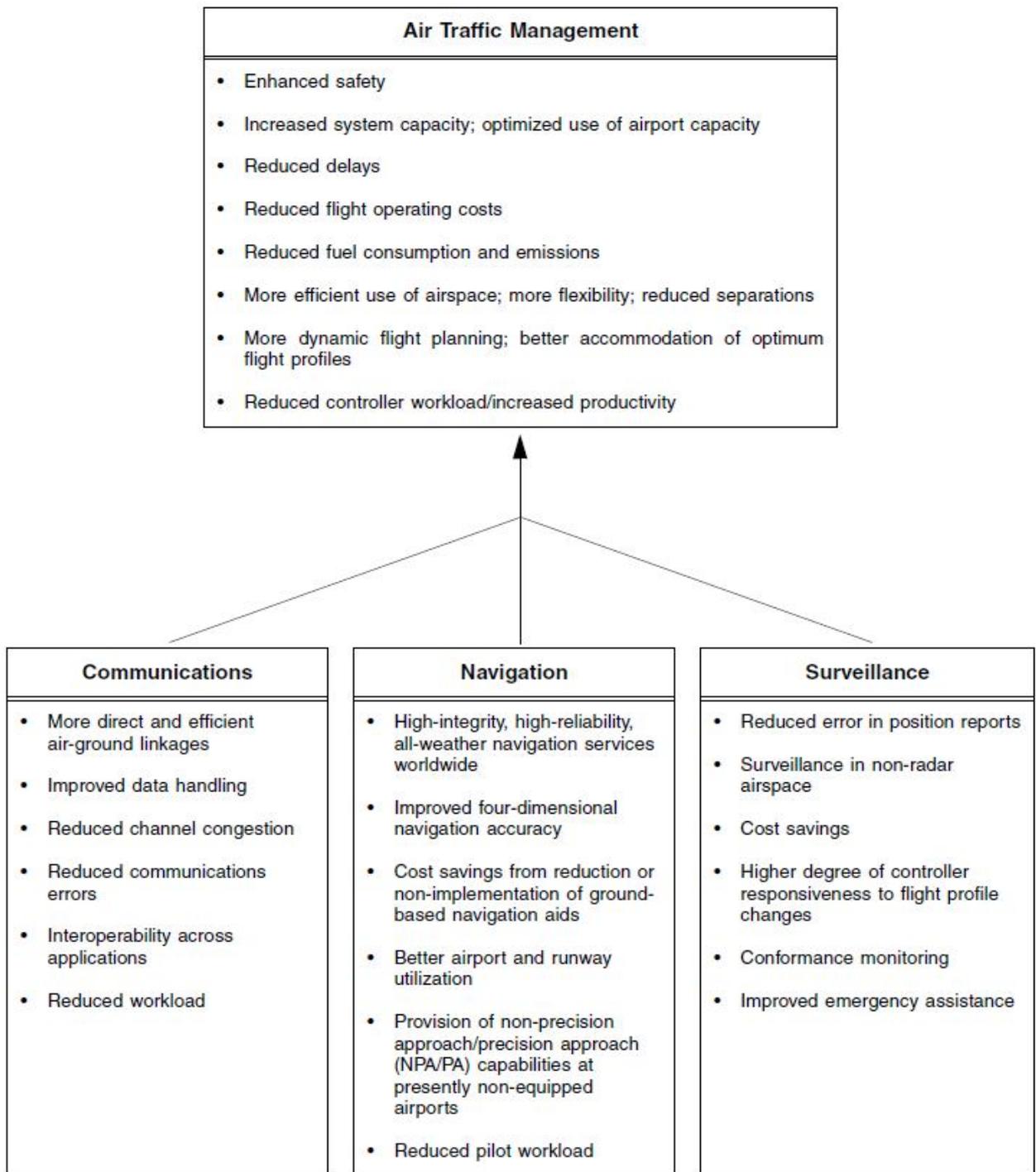
For those States that provide and maintain extensive ground infrastructures, a reduction in the overall cost of operation and maintenance of facilities is expected as the traditional ground systems become obsolete and satellite technology is increasingly employed. They will also benefit from enhanced safety.

CNS/ATM provides a timely opportunity for developing States to enhance their infrastructures to handle additional traffic with minimal investment. Many of these States have large areas of available but unusable airspace, mainly because of the expense involved in purchasing, operating and maintaining the necessary ground infrastructures. CNS/ATM systems will afford them opportunities to modernize inexpensively, which includes the provision of precision and non-precision approaches.

Environmental benefits

As the aviation industry grows more and more rapidly, the impact of air traffic operations on the global atmosphere becomes increasingly important in addition to the local effects of noise and air quality. Efforts to control or reduce the environmental impact of air traffic have identified a range of options that might reduce the impact of aircraft engine emissions. In particular, it is expected that improvements in ATM could help reduce aviation fuel burn, and thereby reduce the levels of aircraft engine emissions.

ICAO's Committee on Aviation Environmental Protection (CAEP) has developed a methodology and tool for estimating global emissions and fuel usage and evaluating the impact of various CNS/ATM enhancements, which is described in more detail in another chapters.



Advanced CNS/ATM systems will also see the implementation of ground-based computerized systems to support increases in traffic. These ground-based systems will exchange data directly with FMS aboard aircraft through a data link. This will benefit the ATM provider and airspace user by enabling improved conflict detection and resolution through intelligent processing, providing for the automatic generation and transmission of conflict-free clearances, as well as offering the means to adapt quickly to changing traffic requirements. As a result, the ATM system will be better able to accommodate an aircraft's preferred flight profile and help aircraft operators flight operating costs and delays. Table I-1-1 describes the objectives and resulting benefits of CNS/ATM systems

Figure I-1-1. A high-level view of expected benefits of the new systems

General aviation

General aviation and utility aircraft will find increasing access to avionics equipment that will allow them to operate in flight conditions, into and out of airports, that they would normally have been prohibited from using because of the operating cost and associated requirements.

Furthermore, as a result of implementing CNS/ATM systems, many remote areas that are currently inaccessible to most general aviation aircraft because of their inability to communicate or safely navigate over them, would become accessible.

Indirect benefits

In addition to the direct benefits listed above, there are also many indirect benefits, such as:

- lower fares and rates;
- passenger timesavings;
- transfer of high-technology skills;
- productivity improvements and industry restructuring;
- stimulation of related industries;
- enhanced trade opportunities; and
- increased employment.

COST-BENEFIT STUDIES

To ensure the successful implementation of CNS/ATM systems, the providers of air traffic services, the users of these services, and financing organizations all need to be advised of the financial implications and convinced of the economic viability of new CNS/ATM systems. This can be achieved through a comprehensive cost-benefit analysis, (complemented by the development of business cases as required), which includes the financial consequences

	AIR TRAFFIC MANAGEMENT	FLIGHT OPERATIONS
General	<ul style="list-style-type: none"> ensure that all necessary information, including information needed for dynamic flight planning, is available to all ground and airborne systems enhance functional integration of ground systems with airborne systems and the ATM-related aspects of flight operations enhance the accuracy of conflict prediction and resolution and the provision of real-time information to controllers and operators 	<ul style="list-style-type: none"> enhance the accuracy of information related to flight progress enhance functional integration of airborne systems and flight operations with ground systems ensure the provision of accurate information between airborne system elements and ground system elements necessary for dynamic flight planning
Safety	<ul style="list-style-type: none"> ensure the provision of well-adapted and harmonized safe procedures on a global basis ensure that separation between aircraft is maintained ensure that clearance between aircraft and obstacles is maintained provide for enhanced contingency planning ensure that rapid alerting service is available ensure that safety levels are maintained as the use of automation increases 	<ul style="list-style-type: none"> improve pilot situational awareness* ensure adequate clearance from terrain enable aircraft to maintain their own separation under specific circumstances* ensure that safety levels are maintained as the use of automation increases ensure integrity of database information
Regularity and efficiency	<ul style="list-style-type: none"> provide for the application of global ATM under all operational conditions improve the application of tactical airspace management through dynamic user involvement, leading to more efficient airspace utilization improve strategic airspace management while increasing tactical airspace flexibility ensure the provision of information necessary for tactical and strategic ATFM enhance overall tactical and strategic ATFM so that demand does not exceed capacity increase available capacity without increasing controller workload 	<ul style="list-style-type: none"> ensure that aircraft can operate under all types of weather conditions provide for the application of user-preferred flight profiles ensure that the necessary infrastructure is available to support gate-to-gate operations improve user capability to optimize flight planning dynamically, in order to improve airspace capacity through more flexible operations minimize aircraft operating cost penalties minimize differing equipment carriage requirements between regions
COMMUNICATIONS, NAVIGATION AND SURVEILLANCE		
Communications	<ul style="list-style-type: none"> to enhance coverage, accessibility, capability, integrity, security and performance of aeronautical communication systems in accordance with ATM requirements 	
Navigation	<ul style="list-style-type: none"> to enhance coverage and allow for all weather navigation capability in all airspace, including approach and landing, while maintaining or improving integrity, accuracy and performance in accordance with ATM requirements 	
Surveillance	<ul style="list-style-type: none"> to enhance and extend effective surveillance to oceanic and remote areas while improving air traffic situational awareness* in the cockpit in accordance with ATM requirements 	

Figure I-1-2. Objectives of CNS/ATM systems

NEXTGEN BENEFITS

ESTIMATING FUTURE OPERATIONAL VALUE

NextGen will provide a number of benefits for National Airspace System (NAS) users, environment and economy. In fact, authorities are already seeing substantial improvements from reduced fuel use, environmental performance and airspace flexibility. As more NextGen capabilities become available, those benefits will continue to grow, contributing

greatly to the economic vibrancy of aviation in the United States. Recognizing that NextGen provides improvements is not enough, however. Authorities must also understand that without NextGen authorities will not be able to sustain the performance of the U.S. airspace system and economy will suffer. To estimate future benefits, authorities incorporate data from capabilities already implemented in the NAS into everimproving models. This enables us to refine overall NextGen benefit estimates each year. latest estimates show that by 2020: NextGen improvements will reduce

- delays, in the air and on the ground, by 38 percent compared with what would happen if no further NextGen improvements were made beyond what authorities have done already.

- Delay reduction will provide \$24 billion in cumulative benefits to aircraft operators, the traveling public and the FAA.

- Authorities will save 1.4 billion gallons of fuel, reducing carbon dioxide emission by 14 million metric tons, also cumulative.

These high-level benefit estimates for 2020 are very similar to the 2018 benefits on which authorities reported in last year's update of the NextGen Implementation Plan. The two-year difference arises from a number of factors. The soft economy and reduced passenger demand prompted airlines to reduce schedules, often resulting in fewer delays throughout the NAS. Internal factors include challenges in deploying complex systems such as En Route Automation Modernization (a key enabler of many NextGen capabilities), refinements to modeling inputs and budget pressures. baseline delay estimates include benefits authorities expect from new and expanded runways, including those at Chicago O'Hare, Fort Lauderdale and Philadelphia airports. These contribute to the "no further progress" scenario. To determine near-term benefits, authorities focus estimates on time frames eight to 10 years in the future. Those time frames also correspond to the NextGen break-even point. The breakeven point is the year when cumulative benefits, to the FAA and NAS users, equal and then exceed the cumulative costs of implementation. Last year authorities estimated NextGen would break even in 2018; now authorities believe authorities will attain that milestone in 2020.

It takes a longer time horizon, however, to understand the full life cycle of most of mid-term and later projects. Indeed, some NextGen improvements will just be coming on line to full effect in 2020, with an expected 10 to 20 years of service life ahead of them. Looking out to 2030, then, and comparing

benefits with the full cost of deploying and maintaining mid-term improvements, authorities estimate that the overall NextGen initiative has a benefit-to-cost ratio of more than two-to-one. In addition to incorporating new operations, NextGen will support the introduction of

new aircraft, engine and fuel technologies that will increase the environmental benefit that come from operations. Authorities believe that over time, the fuelsaving and environmental benefits from these new technologies will exceed those from operational changes. As in earlier updates to the Implementation Plan, these estimates reflect current view of budgets and schedules, based on congressional appropriations for FY 2012 and the FAA's FY 2013 budget request to Congress. estimates are system-wide aggregates and do not reflect improvements at specific localities or airports. Achieving NextGen benefits depends heavily on decisions by airspace users on whether and when to equip their aircraft with the avionics that will enable them to take advantage of the specific NextGen capabilities authorities deploy. Except for Automatic Dependent Surveillance–Broadcast Out avionics, which authorities mandate by 2020 for aircraft operating in most controlled airspace, operators' equipage decisions will depend on their ability to leverage NextGen improvements to improve their own bottom line.

Qualitatively, the argument for equipping is straightforward. Airspace users who equip will reduce their operating costs and travel time through greater efficiency on the airport surface, more-direct routes, precision navigation in departures and approaches, and collaborative decision making in all phases of flight. In some cases, those who equip sooner will benefit sooner. And all users will benefit if travelers experience more predictable flights with less time lost to delays.

Quantitatively, equipage questions become complicated. Operators must consider the costs of equipment, installation, training and operations; incentives to equip; the timetable for FAA deployment of capabilities; users' confidence in benefit estimates, and other factors. Many of these decision criteria remain uncertain, leading many operators to take a wait-and-see approach to equipping. To keep abreast of cost estimates, the FAA needs the steady refinement of its benefit estimates enabled by analyzing a continuing stream of data from the demonstrations, trials, flight evaluations and simulations authorities conduct as a normal part of developing NextGen systems and procedures. Following are a few examples of FAA activities during the past year that contributed to analyses of benefits or the business case for NextGen:

- Optimization of Airspace and Procedures in the Metroplex study teams estimated substantial fuel saving in the Washington, D.C., and north Texas metroplexes, mainly from systematic application of multiple Optimized Profile Descents and reduced distances in flight. For Washington, the estimate is \$6.4 to \$19 million per year in fuel savings, and the prospective north Texas saving is \$10.3 to \$21.7 million. In addition, reduced radar vectoring will decrease pilot-controller communications and the complexity of the controller workload. The

Washington and north Texas projects moved to the design and implementation phase in 2011.

- Atlantic Interoperability Initiative to Reduce Emissions (AIRE) demonstrations continued in 2011, delivering more data on benefits from real-time rerouting and other fuel-saving measures. By optimizing lateral tracks relative to winds aloft between Portuguese and U.S. airspace, 65 Air Europa A330 and Iberia A340 flights from Madrid to the Americas and the Caribbean were able to save an average of 274 gallons of fuel and reduce carbon dioxide emissions by 2,608 kilograms per flight. In a limited number of Air France Transatlantic Green Flights, Air France 777s saved an average of 70 gallons of fuel per flight through real-time lateral and vertical optimization.

ICAO'S planning structure for CNS/ATM and FAA'S planning structure for NextGen

2.1 CNS/ATM partners and tools

ICAO's current forecast of the future growth in air transport is depicted in Figure I-2-1. The increasing demands on the global air navigation system can be expressed in terms of aircraft movements at airports and in the airspace. Aircraft departures and arrivals at airports are expected to increase by nearly 30 per cent between 1995 and 2005. Aircraft-kilometres flown are expected to increase by 55 per cent over the same period. Further growth in these parameters is likely in the decade beyond. As traffic volumes grow, the demands on the ATS provider in an airspace increase. For given separation standards, the number of flights unable to follow optimum flight paths increases. This creates pressure to upgrade the level of ATS. In the past, this may have required expenditures on additional facilities such as VHF omnidirectional radio range (VOR) and radar and communications equipment. CNS/ATM systems, however, will provide for increased capacity to meet such demands and will also produce benefits in the way of more efficient flight profiles.

Although implementation of the new CNS/ATM systems is well under way, the major challenge for ICAO now is to guide the evolutionary development and implementation of a seamless, global ATM system that will enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimum constraints. The first version of the Global Coordinated Plan for Transition to ICAO CNS/ATM systems was an important milestone towards achieving this goal. Transition and implementation remains as the continuing challenge, which poses many difficult and complex issues for those involved in the overall planning and implementation process.

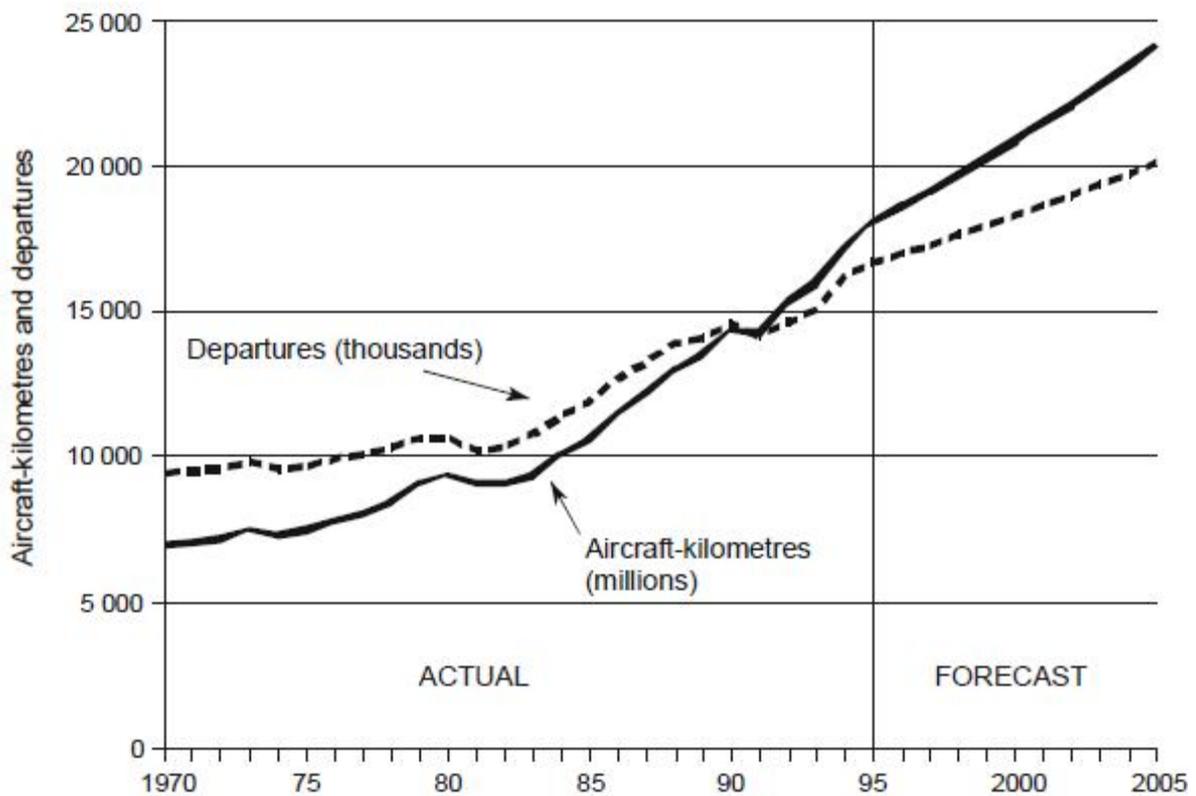


Figure I -1-3 Outlook for aircraft movements

THE REGIONAL PLANNING PROCESS

The regional planning process is the principal engine of ICAO's planning and implementation work. It is here that the top-down approach, comprising global guidance and regional harmonization measures, converges with the bottom-up approach constituted by States and aircraft operators and their proposals for implementation options.

In its most basic form, the output from the regional planning process should be a listing of air navigation facilities and services, together with their achievable time frames, necessary for CNS/ATM systems implementation. These listings are already, or will be, included in the ANPs, which are produced by ICAO regional air navigation meetings and maintained by the ICAO PIRGs with the assistance of ICAO's regional offices

Traffic forecasts have a special role in planning the implementation of CNS/ATM systems. The forecasts represent the demand for future ATM. The PIRGs must therefore base their work on well-developed traffic density forecasts. The plans developed from this work then specify the infrastructure and arrangements which will supply the required level of ATS. A uniform strategy has been adopted by ICAO for the purpose of preparing traffic forecasts in support of the regional planning process. This involves the establishment of a small group of forecasting experts in each of the ICAO regions. Each traffic forecasting group will provide the corresponding PIRG with forecasts of aircraft movements within homogeneous ATM areas and along major international traffic flows.

Planning for implementation of facilities and services associated with CNS/ATM systems involves the combined efforts of ICAO, States, users, service providers and industry. These entities are more commonly known as the CNS/ATM partners. The partners conduct their work at several levels with the aim of developing planning documentation which, either directly or indirectly, forms the foundation for development of the regional ANPs. ANPs then list the requirements for facilities and services necessary for the safe and efficient conduct of international civil aviation, and also depict time lines. ICAO provides guidance at the global level in order to ensure harmonization and standardization of regional ANP

2.2 Nextgen: a collaborative endeavour

NextGen is a complex undertaking, and the FAA is working with aviation partners to lay the groundwork for meeting commitments to transform the National Airspace System (NAS). What follows are select examples of collaborative efforts that have produced tangible achievements in support of the NextGen transformation. As ongoing collaboration is critical to NextGen success, authorities will continue to work with the stakeholder community through various forums to set NextGen priorities and pursue NextGen solutions.

At the FAA's request, RTCA formed the NextGen Mid-Term Implementation Task Force in 2009. One of most effective collaborative efforts, this consortium of 300-plus representatives of the aviation community came together to provide recommendations for moving forward together on NextGen implementation.

The FAA responded to those recommendations with plans for achieving Task Force objectives. Authorities have completed more than a third of Task Force response actions, making progress in areas identified by the Task Force as high priority, including metroplex operations. Work continues as scheduled on nearly half of the response actions, while the remaining actions are subject to delay because of budget constraints and program challenges. Authorities have also been working with the aviation community to prioritize where authorities should implement Performance Based Navigation (PBN) routes and procedures. Authorities also streamlined the PBN operations approval process. One example of collaboration is the progress authorities have made with special activity airspace (SAA) — airspace set aside for military training and other specialized use. The Task Force advocated electronic schedules and updates of SAA to provide operators with real-time knowledge of the active status of SAA. Today's scheduling method is not automated and does not acknowledge whether SAA is inactive and available to civil operators. The FAA in 2011 published a concept of operations for SAA data automation, documented end-to-end functional requirements, set deployment timelines and conducted benefits analyses.

Another successful partnership is the Joint Planning and Development Office (JPDO), which coordinates NextGen efforts among the FAA, NASA, the departments of Defense, Commerce and Homeland Security, the White House Office of Science and Technology Policy and the Office of the Director of National Intelligence. The JPDO laid the groundwork for the future vision for NextGen by developing the long-term research plan for improvements that extend beyond the FAA's mid-term operational vision. The FAA and NASA conduct joint NextGen technology research, simulation and field trials through Research Transition technology to separate suitably equipped aircraft in areas with ADS-B coverage: Louisville, Ky., and Houston as of 2009; Philadelphia and Juneau, Alaska, as of 2010. ADS-B updates the aircraft tracking function in the automation system more frequently and with greater accuracy than radar, providing information such as aircraft type, call sign, heading, altitude and speed. With ADS-B, controllers can use airspace more efficiently. In July 2011, the FAA achieved initial operating capability with ADS-B data integrated into the ATC automation system at the New York terminal radar facility, which controls air traffic in one of the busiest areas of airspace in the United States. This facility handles arrivals and departures from New York John F. Kennedy and LaGuardia, as well as Newark. ADS-B Out involves the transmission of a GPS position (or that of comparably performing navigation equipment meeting integrity and accuracy requirements) from an aircraft in order to display the aircraft's location to controllers on the ground or to pilots in the cockpits of aircraft equipped with ADS-B In. ADS-B In is the capability of aircraft to receive ADS-B data from other aircraft or from the ground. ADS-B In complements ADS-B Out. a repeatable transfer process that can be used with any partner.

Collaboration with NASA and the departments of Defense and Homeland Security helps us explore NextGen concepts, including efforts to facilitate the entry of unmanned aircraft systems (UAS) into the NAS. Currently, unmanned aircraft may enter the NAS only after obtaining a certificate of authorization from the FAA. In cooperation with Homeland Security's Customs and Border Protection, authorities are operating remotely piloted Predator B aircraft in Florida's Cape Canaveral to conduct Automatic Dependent Surveillance– Broadcast and digital data communication flight trials in support of UAS integration. To help facilitate the FAA's collaboration with the Department of Defense, a U.S. Air Force Research Laboratory liaison works closely with FAA experimenters to identify opportunities to leverage research, laboratory capabilities and other expertise.

This partnership advances work on UAS, alternative aviation fuels and human factors research. NextGen will dramatically change the way weather information is provided to pilots, controllers and airline dispatchers, and improve the way they operate by providing a common picture of current and forecast conditions. In pursuit of these goals, the

FAA is actively collaborating with the U.S. Air Force, the U.S. Navy, NASA and the National Oceanic and Atmospheric Administration's National Weather Service. Authorities also work with international partners to ensure that NextGen standards, technologies and procedures are developed in concert with global air traffic modernization efforts, such as those in Europe, Japan and Australia. Much of this collaboration is accomplished through bodies such as the International Civil Aviation Organization, which makes recommendations on global standards and practices, and industry groups such as the Civil Air Navigation Services Organization, which represents both government and private air navigation service providers. aim is to ensure investments operators make in NextGen technology, procedures and training will deliver benefits anywhere. provided to air carriers using ADS-B In equipment. In August 2011, the FAA initiated a 12-month operational evaluation of In-Trail Procedures (ITP), using ADS-B In over the Pacific Ocean. The evaluation of ITP will be based on data from the flights of about a dozen United Airlines Boeing 747-400s. The FAA is providing the necessary avionics for United to obtain these ADS-B In data.

Pilots of aircraft equipped with ADS-B In can now see the location, identity and speed of nearby aircraft on a cockpit display. This improved situational awareness enables pilots to know when to request a climb from controllers to reach a more fuel-efficient altitude. Preliminary FAA estimates show that, thanks to ITP, an air carrier operating between the United States and the South Pacific might earn \$200,000 in additional payload revenue per aircraft each year by being able to carry less fuel. This benefit translates into approximately 270 pounds of additional payload per flight. Authorities published initial requirements and specifications for airborne equipment including ADS-B In installation guidance in February 2011, which followed ADS-B Out equipment standards and installation guidance issued in 2010. Additional specifications for ADS-B In will be published in 2012, including those for the ITP application. For the general aviation community, ADS-B offers an even wider range of benefits. Pilots of properly equipped general aviation aircraft can receive up-to-the-minute graphical weather information in the cockpit, as well as other flight information, including Notices to Airmen advisories. Pilots of aircraft equipped to receive and display this information can benefit now from these data when flying over many areas of the United States. Authorities offer these services at no cost. In addition to gathering data on a variety of ADS-B In benefits, the FAA convened an Aviation Rulemaking Committee (ARC) in June 2010 to explore a strategy for ADS-B In implementation. This group of stakeholders made its recommendations to the agency in September 2011. The ARC called for some policy adjustments and asked the FAA to pursue early development of equipment standards and timely completion of regulatory guidance for ADS-B In applications. The ARC wants the FAA to enable a variety of ADS-B In capabilities by

2017. The ARC has placed the highest priorities on the following capabilities:

- Cockpit Display of Traffic Information Assisted Visual Separation:

This application is for use after a pilot has already visually identified the aircraft ahead to follow during an approach. It allows the pilot to maintain visual approach spacing after losing visual contact at night or in other situations where tracking is difficult. This application will sustain arrival rates closer to those attained under visual approach operations.

- Flight Deck Based Interval Management–Spacing:

This application will reduce fuel burn, aircraft noise and exhaust emissions while maintaining high-density operations and efficient flight operations in the NAS.

- Traffic Situational Awareness and Alerting:

This application will enhance safety in the NAS by providing alerts to general aviation pilots of conflicting traffic nearby. Information regarding the FAA's schedule for developing guidance and standards for these applications can be found in Appendix A. The ARC also requested that the FAA continue ADS-B In flight trials with early adopters to validate benefits, define policies and procedures, and improve understanding of equipment and operational requirements.

PBN procedures help reduce fuel use, miles flown, emissions and the number of people exposed to noise while aircraft transition during the arrival or departure phase of flight. The application of PBN also aids en route cruise at high altitude (Q-routes) and at lower altitudes around terminal areas (T-routes). These procedures could reduce delays during inclement weather. In FY 2011, authorities published 49 Area Navigation (RNAV) routes including, for the first time ever, two helicopter routes connecting New York City to Washington, D.C. Also during FY 2011, authorities published 55 RNAV arrival and departure procedures. Authorities also published 51 Required Navigation Performance (RNP) Authorization Required approach procedures. Production of additional RNP procedures will focus on those with the most significant benefits. During the past five years, authorities have completed 28 Standard

NextGen is already producing significant economic, environmental and safety benefits.

Terminal Arrival Routes (STAR) with Optimized Profile Descent (OPD) capability. Traditional arrival procedures have multiple segments of level flight during descent and each step-down requires a change in power settings. OPD procedures enable arrival aircraft to descend from cruise altitude to final approach at or near idle power with few, if any, level-offs. Because aircraft can use lower and steady power settings,

OPD procedures result in reduced fuel burn, lower aircraft exhaust emissions and often less noise.

Another type of efficient arrival procedure is the Tailored Arrival (TA), which provides fuel, emissions and noise benefits similar to those of OPDs. The pilot initiates a TA with a request to an air traffic controller while the aircraft is still at cruise altitude, typically over the ocean. The controller then transmits a descent profile to the aircraft so it can be loaded in the onboard navigation computer. The commercial aircraft participating have to be equipped with FANS avionics to receive the data needed to make the approach. By contrast, other types of OPDs, such as RNAV arrival procedures, are published for all users and serve a wide variety of aircraft types. Through technology transfer from research and development to NAS implementation, authorities made TAs operational at the following international gateways in 2011: Miami, San Francisco and Los Angeles. Authorities are exploring the use of TA procedures at more airports in 2012: Anchorage, Alaska; Travis Air Force Base, Calif.; and Andrews Air Force Base,

Md. Another type of PBN is especially beneficial for smaller airports, where general aviation aircraft often operate. This form of PBN is the RNAV Wide Area Augmentation System (WAAS) Localizer Performance with Vertical Guidance (LPV) approach procedure. Authorities published 354 WAAS LPVs in FY 2011. As of February 2012, there were nearly 2,800 LPVs at more than 1,400 airports throughout the NAS. With LPVs, aircraft often can land in low-visibility conditions, providing more access to those airports throughout the year. WAAS LPVs provide satellite-based approaches primarily to airports and runways where no ground-based instrument landing systems exist. General aviation aircraft are the primary users of LPV procedures and about 30 percent of the fleet is equipped for LPV approaches.

2.3. Global Air traffic Management

The planning for implementation of CNS technologies is well under way in varying degrees in the ICAO regions. It is necessary that the transition be focused with a clear concept of how to integrate those elements into a coherent and seamless global ATM system. The global ATM system must be developed and organized to overcome the limitations listed above and to accommodate future growth, so as to offer the best possible service to all airspace users and to provide adequate economic benefits to the civil aviation community.

Implementation goals and strategies of global ATM

The primary goal of an integrated, global ATM system is to safely meet the expectations of the ATM partners. For example, the ATM system should enable aircraft operators to meet their planned times of

departure and arrival, to the extent possible, and adhere to their preferred flight profiles with minimum constraints and no compromise to safety. To accomplish this goal, the new CNS technologies must be fully exploited through international harmonization of ATM Standards and procedures. From the aircraft operator's point of view, it is desirable to equip aircraft operating internationally with a minimum set of avionics usable everywhere. Additionally, many of the expected service improvements cannot be meaningfully implemented by one State, but must be implemented in contiguous regions. Therefore, the ATM regional concept of providing ATM over expanded areas must be pursued.

International scope

The emerging and future ATM system design must meet the test of international acceptance and interoperability. It must allow for implementation at various levels of sophistication to provide services tailored to specific applications and regions. In this context, it is essential to ensure that adjacent systems and procedures are able to interface in such a way that boundaries are transparent to airspace users.

Evolutionary transition process

The development and implementation of the new ATM system must be evolutionary. It is recognized that it is impractical for this evolution to be completed in time frames of less than several years. Such long transition periods place

a heavy burden on users and service providers when the new systems replace in-service systems because the two must be operated side by side during the transition period. Long transitions also amplify the problem of aircraft having to operate in a mixed environment where aircraft have differing levels of CNS/ATM capability. Similarly, there will be a need for an exchange of information between ATM service providers with differing levels of information technology. Furthermore, aircraft operators that have taken a decision to invest at an early stage should achieve some corresponding and appropriate benefits.

While change in the ATM system will be evolutionary, the operational concept, ATM system architecture, and ATM system design and implementation must provide a well-understood, manageable and cost-effective sequence of improvements that keeps pace with users' needs and culminates in a system meeting the ATM

Goals of a global system

- To provide greater flexibility and efficiency by accommodating user-preferred flight profiles.
- To improve the existing level of safety.
- To accommodate the full range of aircraft types and airborne capabilities.
- To improve the provision of information to users, including weather conditions, the traffic situation, and the availability of facilities.
- To organize airspace in accordance with ATM provisions and procedures.
- To increase user involvement in ATM decision-making, including air-ground computer dialogue for flight plan negotiation.
- To create, to the maximum extent possible, a single continuum of airspace where boundaries are transparent to users.
- To increase capacity to meet future air traffic demand.

A large number of technologically related opportunities and benefits are now available for implementing a worldwide ATM system that will improve ATM services to better meet user requirements. The new technologies and associated ATM procedures will also provide for an improvement in controller productivity and overall enhancement of the work environment. A summary of the benefits expected from new ATM systems is depicted in Figure I-4-2.

NEED FOR AN ATM OPERATIONAL CONCEPT

Attaining the goal of an integrated, global ATM system requires harmonization and standardization of regional and national system elements and procedures. ICAO is developing new SARPs as part of its work on global ATM. States and industry will then use this material as a guide toward the development and implementation of ATM systems leading toward global harmonization. 4.14 The basis for developing the Standards necessary for harmonization and integration is an ATM operational concept for the emerging and future ATM system which is under development by the Air Navigation Commission with the assistance of the Air Traffic Management Operational Concept Panel (ATMCP) established by the commission for this purpose. The ATM concept will clarify the expectations and benefits of these ATM systems and give States and industry clear guidance for designing and implementing them. Work on the ATM concept is aimed at obtaining consensus on several issues (i.e. separation assurance*, situational awareness*, etc.).

2.4. Global navigation satellite system (GNSS). GNSS augmentations. Global Harmonization

The GNSS is a worldwide position and time determination system, which includes one or more satellite constellations, aircraft receivers, and system integrity monitoring, augmented as necessary to support the RNP for the actual phase of operation.

The satellite navigation systems in operation are the global positioning system (GPS) of the United States and the global orbiting navigation satellite system (GLONASS) of the Russian Federation. Both systems were offered to ICAO as a means to support the evolutionary development of GNSS. In 1994, the ICAO Council accepted the United States' offer of the GPS, and in 1996 it accepted the Russian Federation's offer of GLONASS.

The GPS space segment is composed of twenty satellites in six orbital planes. The satellites operate near-circular 20 200 km (10 900 NM) orbits at an inclination angle of 55 degrees to the equator, and each satellite completes an orbit in approximately 12 hours.

The GLONASS space segment consists of twenty operational satellites and several spares. GLONASS satellites orbit at an altitude of 19 100 km with an orbital period of 11 hours and 15 minutes. Eight evenly spaced satellites are arranged in each of the three orbital planes, inclined 64.8 degrees and spaced 120 degrees apart

To overcome inherent system limitations and to meet the performance requirements (accuracy, integrity, availability and continuity of service) for all phases of flight, GPS and GLONASS require varying degrees of augmentation. Augmentations are classified in three broad categories: aircraft-based, ground-based and satellite-based

One type of aircraft-based augmentation (ABAS) is called receiver autonomous integrity monitoring (RAIM), which can be used if there are more than five satellites with suitable geometry in view. With five satellites in view, five

independent positions can be computed. If these do not match, it can be deduced that one or more of the satellites are giving incorrect information. If there are six or more satellites in view, more independent positions can be calculated and a receiver may then be able to identify one faulty satellite and exclude it from the position determination calculations.

Other aircraft-based augmentations can also be implemented and are usually termed aircraft autonomous integrity monitoring (AAIM). An inertial navigation system, for example, can aid GNSS during short periods when the satellite navigation antennas are shadowed by the aircraft during manoeuvres or during periods when insufficient satellites are in view. Augmentation techniques particularly useful for improving availability of the navigation function also include altimetry-aiding,

more accurate time sources or some combination of sensor inputs combined through filtering techniques.

Ground-based augmentations

For ground-based augmentation systems (GBAS), a monitor is located at or near the airport where precision operations are desired. Signals are sent directly to the aircraft in the vicinity (approximately 37 km (20 NM)). These signals provide corrections to increase the position accuracy locally along with satellite integrity information. This capability requires data link(s) between the ground and the aircraft.

Satellite-based augmentations

It is not practical to provide coverage with ground-based systems for all phases of flight. One way to provide augmentation coverage over large areas is to use satellites to transmit augmentation information. This is known as satellite-based augmentation (SBAS).

The provision of satellite-based augmentation by geostationary satellites has certain limitations and therefore cannot be expected to support all phases of flight, especially precision approach and landing of higher categories. Since these satellites orbit above the equator, their signals would not be available in polar regions and may be masked by aircraft structure or terrain. This suggests that other GNSS augmentation satellite orbits and/or ground-based augmentation might need to be considered to alleviate these shortcomings.

PBN encompasses a set of enablers with a common underlying capability to construct a flight path that is not constrained by the location of ground-based navigation aids. There are varying performances and functional requirements in the

PBN family, from the 10 nautical mile (nm) course width accuracy and few waypoints required by Required Navigation Performance (RNP) 10 to the 0.1 nm precision and curved paths of RNP 0.1 Authorization Required (AR) approaches.

For oceanic en route navigation, RNP 10 and RNP 4 will continue to be the standards. Domestically, Area Navigation (RNAV) 2 provides the required capability en route. RNAV 1 is the mainstay in the terminal area, except where obstacles or airspace conflicts demand the improved performance provided by RNP 1. To achieve access to runways during limited visibility (instrument conditions), three capabilities offer different advantages and costs. The most basic, RNP 0.3, is a conventional non-precision approach capability achievable with GPS alone. Adding vertical guidance requires either barometric Vertical Navigation (VNAV) or a Satellite Based Augmentation System. Operators can also use a basic VNAV capability with RNP 0.3., which when coupled with tighter lateral navigation systems, or the application of more advanced systems, can allow access

to RNP AR approaches. LPV typically offers the lowest approach minimums, providing a satellite-based approach that is operationally equivalent to conventional Category I Instrument Landing Systems (ILS). The current aircraft fleet is well equipped with PBN capability. For example, in the air carrier community, the heart of the PBN capability is the Flight Management System (FMS). The FMS uses input from multiple Distance Measuring Equipment (DME), or from the Global Navigation Satellite System (GNSS) using a GPS sensor or a GPS with Wide Area Augmentation System (WAAS) sensor. DME-only navigation has coverage limitations and will not be supported on every published procedure. Most FMS installations can support RNAV operations and RNP with curved path, but less than half can support RNP AR approaches. LPV requires a WAAS receiver and integration with cockpit displays. In the general aviation community, the PBN enablers are typically implemented in a GNSS navigator installed in an aircraft's instrument panel. These systems have become increasingly complex and capable, integrating other types of navigation, voice communication and uplinked weather information. Most of these installations can support RNAV,

and those equipped with WAAS can support LPV. Some of these configurations have fully implemented RNP with curved path and others may be upgradeable to RNP with curved path capability. Operational advantages provide the primary motivation for equipping with PBN enablers. Operators who equip obtain a direct efficiency and access benefit because of the new routes, procedures, and approaches. However, in some instances the FAA cannot design the new route or procedure, or use it optimally, because of the need to accommodate traffic that is not equipped with these enablers. The FAA will not retain the full legacy ground structure so a further incentive for PBN capability will come through the reduction of services to the non-equipped aircraft. As the National Airspace System (NAS) moves to a trajectory operations-based construct, new requirements will be placed

on aircraft navigation systems. The widespread use of trajectory operations will require aircraft navigation systems to perform to a new degree of standardization. The FAA is working with industry stakeholders in determining these new trajectory operations performance standards.

AUTOMATIC DEPENDENT SURVEILLANCE–BROADCAST

There are many different ADS-B enablers, with different cost and benefit implications. The most basic participation with ADS-B is ADS-B Out, where the aircraft's position and certain other data are broadcast by avionics. Ground receivers and other aircraft within range can receive these broadcasts and use them for their own applications. ADS-B Out enables the next generation of air traffic surveillance. Using ground

receivers across the country, controllers will receive and process precise ADS-B broadcasts to provide air traffic separation and advisory services. Building on the ADS-B Out capability, operators can integrate ADS-B avionics with different controls and displays to implement ADS-B In enablers. The most basic types of enablers provide enhanced situational awareness, improving the ability of the flight crew to identify where aircraft are around them and the direction in which they are headed. This technology works in the air or on the ground, although coverage issues and the availability of quality airport surveys may limit the ground capability (see airport enhancements on page 48). This basic type of display is referred to as a Cockpit Display of Traffic Information (CDTI). A CDTI may be a new display, or it may be integrated with a conventional Traffic Alert and Collision Avoidance System (TCAS) traffic display. Another set of ADS-B In enablers uses the ADS-B data for speed or timing guidance, typically maintaining spacing or separation from another aircraft. This includes both algorithms for oceanic In-Trail Procedures (ITP) and display of alongtrack guidance cues for interval management. Beyond these lie advanced alerting to improve airport safety and reduce the risk of collision for aircraft without TCAS. Eventually, the FAA expects ADS-B to be integrated with other capabilities to support access to closely spaced runways in almost all weather conditions, and to enable airspace with separation similar to visual operations today. The equipage for ADS-B is just beginning, with rule-compliant ADS-B equipment having gained approval in late 2010. Equipage in some aircraft began in 2011. In air carrier aircraft, authorities expect operators to implement ADS-B as upgrades to the Mode S transponder and aircraft displays.

Operators will be able to upgrade or replace this equipment to support ADS-B as well as its original function. The various ADS-B In capabilities reflect different levels of integration with the controls and displays in the cockpit. Situational awareness is available using side console-mounted displays that are not integrated. Instrument panel-mounted displays that are not integrated can provide along track guidance. Longer-term capabilities will require integration with other navigation data integrated into flight crew displays. For general aviation aircraft operating below 18,000 feet, ADS-B can be implemented through the transponder or through a radio called the universal access transceiver (UAT). The UAT also provides access to weather and other FAA aeronautical data services. ADS-B In capabilities for general aviation will use displays similar to those for air carriers. The FAA mandated ADS-B Out equipage in most controlled airspace starting in 2020. The agency is encouraging operators to equip portions of their fleets with ADS-B before the nationwide rule goes into effect by providing early benefits. As the operators experience the operational benefits, they will have an incentive to accelerate and expand the ADS-B equipage to the rest of their fleet. For air carrier operators, this strategy uses memorandums of agreement in which each party provides in-kind

contributions critical to the success of the project. Each agreement is unique, reflecting the specific operator’s business model, route structure and existing avionics infrastructure, among other factors. For general aviation operators, deployment of Traffic Information Services–Broadcast and Flight Information Services–Broadcast (FIS-B), uplinked over the UAT, will enhance benefits and motivation to equip. The FAA is also evaluating additional locations where surveillance may be expanded by employing ADS-B. In September 2011, the ADS-B In ARC recommended implementation of ADS-B In capabilities for suitably equipped aircraft by 2017. The FAA will incorporate these recommendations into its planning for NextGen and the plan for developing guidance and standards is reflected in the ADS-B enabler table.

Overview of Aircraft Operator Enablers							
Avionics Enablers	Aircraft and Operator		Capability Overview	Target Users	Target Area	Maturity	
	Guidance	Schedule					
Performance Based Navigation							
RNP 10	Order 8400.12C	Complete	Reduces oceanic separation	 			
RNP 4	Order 8400.33	Complete	Further reduction of oceanic separation (in conjunction with FANS-1/A)	 			
RNAV 1, RNAV 2	AC 90-100A	Complete	Enables more efficient routes and procedures	   			
RNP 1 with Curved Path	AC 90-105	Complete	Enables precise departure, arrival and approach procedures, including repeatable curved paths	 	 		
Vertical Navigation	AC 90-105, AC 20-138B	Complete	Enables defined climb and descent paths	 			
LPV	AC 20-138B, AC 90-107	Complete	Improves access to many airports in reduced visibility, with an approach aligned to the runway	   			
RNP Approaches (Authorization Required)	AC 90-101A	Complete	Improves access to airports in reduced visibility with an approach that can curve to the runway; improves procedures to separate traffic flows	 			
Trajectory Operations Navigation	TBD	2014	Enhances PBN capabilities	   			

DATA COMMUNICATIONS

Data communications were first deployed as part of the Future Air Navigation System (FANS) program. Boeing and Airbus developed integrated communication and navigation capabilities (FANS 1 and FANS A, respectively), providing a pilot-and-controller data link and the ability to autonomously send some data from the aircraft to the air traffic control (ATC) system through Automatic Dependent Surveillance–Contract (ADS-C). Operators targeted these new navigation and communication capabilities primarily for oceanic airspace, where they provided the greatest initial benefits, enabling a safe reduction in separation between aircraft from 100 nm to as low as 50 nm. As the FAA moves forward with deploying a domestic ATC data link system, it is important to make use of the FANS capabilities already

installed within some fleets, particularly the wide-body air carriers conducting international operations. As such, the domestic program will use an adaptation of FANS appropriate for high-density, surveilled environments through FANS 1/A+ over VHF Digital Link (VDL) mode 2. These aircraft will be able to receive departure clearances and airborne reroutes. A newer capability, ATN, was developed through the International Civil Aviation Organization to provide a more universally capable and reliable ATC data communications system. The capability that will be needed for full participation in NextGen in continental U.S. airspace will be the second version, called ATN Baseline 2. In April 2011, RTCA SC-214/ EUROCAE WG-78 agreed to change its data link standards development strategy. ATN Baseline 3 was discontinued and its capabilities were merged with ATN Baseline 2. The standards for this version are under development and are being harmonized internationally. Earlier versions of ATN provide interim capabilities. Europe has begun to implement ATN Baseline 1, which operators can retrofit into aircraft without modification of the navigation system. The FAA plans to implement ATN Baseline 2 with a larger set of operational capabilities, such as revised departure clearances, to provide greater incentive for retrofitting aircraft.

Operators of fleets that fly internationally already have adopted FANS 1/A widely for oceanic applications. The implementation strategy for domestic ATC data communications will include some equipage incentives. The FAA is evaluating potential scenarios for best-equipped, best-served in which aircraft with this capability may receive more rapid or efficient reroutes during inclement weather.

2.5. Avionics. Meteorological systems to support global CNS/ATM

Simple GPS or GLONASS receivers that do not include RAIM capability (or similar forms of integrity monitoring) generally cannot meet the requirements for all phases of flight.

Multi-sensor systems, using GNSS as one of the sensors, are expected to be in use for the foreseeable future. Such navigation systems generally exhibit better levels of performance than the individual sensor or stand-alone systems. Aircraft using multi-sensor navigation systems, such as integrated GNSS/IRS or GNSS/IRS/FMS, may be certified as meeting levels of RNP which could not be obtained by use of GPS or GLONASS alone.

Traditionally, the provision of meteorological information to support international civil aviation was based primarily at the national level and organized hierarchically, with a specific meteorological office designated to be associated with each flight information centre (FIC)/area control centre (ACC), approach control unit and air traffic control tower. The associated meteorological offices supplied selected meteorological information necessary to enable each of the air traffic services units to meet its various obligations.

The meteorological information provided was related to an FIR and particular aerodromes required as destinations and alternates in that FIR and in immediately adjacent FIRs. Communication of this information beyond the FIRs concerned was tightly controlled so as not to overload the AFTN unnecessarily. The meteorological information was provided to pilots, *inter alia*, in face-to-face briefings in an airport meteorological office, using controller/pilot voice communications and through the automatic terminal information service (ATIS) and HF/VHF meteorological information for aircraft in flight (VOLMET) broadcasts.

It was inevitable, however, that the fundamental changes in international civil aviation in the 1980s, such as deregulation, increased air traffic and longer, direct flights, and the increased associated costs of the provision of facilities and services, which essentially prompted the creation of CNS/ATM systems, would also drive a parallel need for changes in the provision of meteorological services for international civil aviation.

These changes in the provision of meteorological services, which began in the early 1980s, comprised two main elements. The first was the development of the ICAO world area forecast system (WAFS) which, initially, centralized the production of global upper wind and temperature forecasts by two world area forecast centres (WAFCs), along with the production of significant weather (SIGWX) forecasts and the dissemination to States by fifteen regional area forecast centres (RAFCs) of WAFC and RAFC-produced charts. The second element concerned the gradual change in the content and format of the meteorological information provided to pilots and a relaxation of the rules governing the exchange of operational meteorological information (OPMET) messages to permit a wider distribution.

In the recent past, changes which had generally progressed steadily over the previous decade began to accelerate markedly. This was not due to any sudden change in the operational requirements — essentially these were still being driven by the explosive growth in global air traffic and the need for cost-effective means to satisfy the attendant requirements — but by the technological developments in computing and telecommunications. These developments made possible a complete rethinking of the ways and means of providing the required meteorological information. Traditionally, the provision of meteorological information to support international civil aviation was based primarily at the national level and organized hierarchically, with a specific meteorological office designated to be associated with each flight information centre (FIC)/area control centre (ACC), approach control unit and air traffic control tower. The associated meteorological offices supplied selected meteorological information necessary to enable each of the air traffic services units to meet its various obligations.

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and in immediately adjacent FIRs. Communication of this information beyond the FIRs concerned was tightly controlled so as not to overload the AFTN unnecessarily. The meteorological information was provided to pilots, *inter alia*, in face-to-face briefings in an airport meteorological office, using controller/pilot voice communications and through the automatic terminal information service (ATIS) and HF/VHF meteorological information for aircraft in flight (VOLMET) broadcasts.

It was inevitable, however, that the fundamental changes in international civil aviation in the 1980s, such as deregulation, increased air traffic and longer, direct flights, and the increased associated costs of the provision of facilities and services, which essentially prompted the creation of CNS/ATM systems, would also drive a parallel need for changes in the provision of meteorological

In the recent past, changes which had generally progressed steadily over the previous decade began to accelerate markedly. This was not due to any sudden change in the operational requirements — essentially these were still being driven by the explosive growth in global air traffic and the need for cost-effective means to satisfy the attendant requirements — but by the technological developments in computing and telecommunications. These developments made possible a complete rethinking of the ways and means of providing the required meteorological facilities and services in a cost-effective manner, while at the same time improving safety. Taking advantage of these technological developments so that aviation meteorology contributes effectively to the smooth transition to global CNS/ATM systems is the challenge facing the international meteorological community today.

NextGen is transforming the National Airspace System (NAS) through a number of operational improvements. Authorities implement each improvement through a series of capabilities, or increments, that provide individual benefits and combine to provide a transformative change in the way authorities operate the NAS. In this appendix, authorities have summarized work plans, timelines and locations (when available) to deliver operational improvements.

Work is progressing to deliver related capabilities in eight implementation portfolios and two portfolios with supporting activities that address safety, environmental and energy considerations. See graphic above for a list of the portfolios. The capabilities in the implementation portfolios depend on several common services and new or existing infrastructure, which authorities manage in a Common Services and Infrastructure portfolio.

Development of capabilities in one portfolio often depends on or impacts development in other portfolios. A change in the schedule of a capability in the Common Services portfolio, for example, could also impact all the increments that capability supports. Development and implementation can also be affected by other internal and external

factors, such as program interdependencies, realignment of priorities, concept validation work or funding. This means that authorities may have to adjust the timeline or the scope of a capability. The capabilities displayed in the implementation portfolio timelines depict current plans through 2015. Several increments have been delayed from the time frame shown in last year's update to the NextGen Implementation Plan. However, detailed planning for capabilities beyond the 2015 time frame is ongoing. Additionally, some increments are in concept development and authorities have not yet determined when these capabilities will be available. While these increments are shown in the implementation portfolio timelines as becoming available in 2016 or later, preliminary work to further develop those increments is ongoing.

METEOROLOGICAL SYSTEMS TO SUPPORT GLOBAL CNS/ATM

The need for aviation meteorology to think increasingly in terms of global rather than regional or national concepts had already been foreshadowed in the development of the WAFS and in the changes made to the content, format and exchange pattern of OPMET messages. In fact, the original concept of the WAFS, as approved by the ICAO Council, included a final phase in which all WAFS data and products would be produced by computer at the two WAFCs, with global dissemination of the information direct from the WAFCs to States by satellite broadcast. The rapid developments in computer technology and associated forecasting techniques, and satellite broadcasting technology have rendered it possible to plan for the final phase of the WAFS much earlier than had hitherto been anticipated. In parallel with these developments, the introduction of a data link has permitted, for the first time, the automated uplink of meteorological information direct to the cockpit, either at the initiation of the ATM system or in response to the pilot's request, and the automated downlink of data from the aircraft including wind and temperature, turbulence and humidity.

Two other components of the global meteorological system are the ICAO international airways volcano watch (IAVW) and the ICAO tropical cyclone warning system, both of which are of particular importance for international air navigation since volcanic ash and tropical cyclones are the only weather phenomena which would normally result in the cancellation of a flight at the pre-flight planning stage. The IAVW was initially introduced to be operated on a voluntary basis but has since been consolidated into a well-structured global system consisting of nine volcanic ash advisory centres (VAACs) which issue volcanic ash advisories both in alphanumeric and graphical formats to be used by MWOs for issuing SIGMET messages, by international NOTAM offices for the issuance of NOTAMs for volcanic ash and ASHTAMs, by ATM for re-routing and activation of contingency arrangements, and by operators for pre-flight and in-flight planning. The ICAO tropical

cyclone warning system was established consisting of six tropical cyclone advisory centres (TCACs) which issue tropical cyclone advisories to be used by MWOs for issuing SIGMET messages, by ATM for re-routing and activation of contingency arrangements, and by operators for pre-flight and in-flight planning.

In a limited way, ATM is already employing additional and enhanced meteorological information made possible by the aforementioned technological advances in meteorological systems. The application of these systems to current operations is focused mainly on specific elements of ATM, where it can be demonstrated that the provision of enhanced or additional meteorological data and products is either critical to the operation concerned or provides a costbenefit. An example of this is the provision of additional and enhanced meteorological information to support the following:

- the provision of medium-level SIGWX forecasts and en-route diversion aerodrome reports and forecasts for one-engine inoperative drift-down procedures for extended range operations;
- the provision of the latest SIGMETs and upper wind/temperature data from meteorological watch offices (MWOs) and WAFCs respectively, direct to ATC computers, for updating flight plans for dynamic aircraft routing over the Pacific Ocean;
- the daily selection of the organized tracks over the North Atlantic based upon upper wind fields produced by the WAFCs; and
- the use of real-time information on hazardous enroute and destination weather and updated upper wind fields for air traffic flow control.

All of the examples provided in the previous paragraphs concern pre-flight planning and en-route operations. These depend upon the WAFS, direct satellite broadcasts, and the direct and preferably automated provision of updated meteorological forecasts or real-time data to ATC. But examples need not be restricted to en-route operations. In the terminal area, the advent of data link has already spurred the development of systems for the automated provision of meteorological information direct to aircraft, some examples of which are:

- uplink of reports from automatic weather observing stations;
- uplink of wind shear/microburst warnings from automated terminal Doppler weather radar (TDWR); and
- automatic downlink of wind/temperature data from aircraft on approach and during climb-out.

EVOLUTIONARY INTRODUCTION

GNSS implementation will be carried out in an evolutionary manner, allowing gradual system improvements to be introduced. Near-term applications of GNSS are intended to enable the early introduction of satellite-based en-route navigation, using the existing satellite systems (GPS and GLONASS) and primarily aircraft-based augmentations.

Medium-term applications will make use of existing satellite navigation systems with any augmentation or combination of augmentations required for operation in a particular phase of flight. Longer-term applications will apply to future GNSS.

Three levels are generally accepted for the introduction of GNSS-based operations:

- a) supplemental-means GNSS must meet accuracy and integrity requirements for a given operation or phase of flight; availability and continuity requirements may not be met. Other navigation systems supporting a given operation or phase of flight must be on board;
- b) primary-means GNSS must meet accuracy and integrity requirements, but need not meet full availability and continuity of service requirements for a given operation or phase of flight. Safety is achieved by limiting operations to specific time periods and through appropriate procedural restrictions. Other navigation systems can be retained on board to support the primary-means GNSS;
- c) sole-means GNSS must allow the aircraft to meet, for a given operation or phase of flight, all requirements: accuracy, integrity, availability and continuity of service.

SYSTEMS TO SUPPORT APPROACH, LANDING AND DEPARTURE OPERATIONS

The standard non-visual aids for precision approach and landing are defined in Annex 10, Volume I, Chapter 2. It is intended that the introduction and application of these non-visual aids will be in accordance with the global strategy set forth in Annex 10, Volume I, Attachment B. This strategy will:

- a) continue ILS operations to the highest level of service as long as operationally acceptable and economically beneficial;
- b) implement MLS where operationally required and economically beneficial;
- c) promote the use of multi-mode receivers (MMR) or equivalent airborne capability to maintain aircraft interoperability;
- d) validate the use of GNSS, with such augmentations as required, to support approach and departure operations, including Category I operations, and implement GNSS for such operations as appropriate;

e) complete feasibility studies for Category II and III operations, based on GNSS technology, with such augmentations as required. If feasible, implement GNSS for Category II and III operations where operationally acceptable and economically beneficial; and

f) enable each region to develop an implementation strategy for future systems in line with the global strategy.

The terminology above applies to the required state of avionics equipment and the ability of aircraft to meet RNP requirements with, in case of “sole means”, no other navigation equipment on board. It is also related to the intended operation (or phase of flight). Operational approvals for aircraft are therefore issued for particular operations and normally identify specific conditions or restrictions to be applied. To this end they may vary from State to State.

GNSS sole-means approval is therefore a necessary, but not sufficient, condition for termination of present radio navigation services. A number of aircraft may be approved for sole-means GNSS navigation for particular operations or phases of flight. However, the air traffic service provider must provide a navigation service to all users to support all phases of flight. It is therefore necessary to harmonize withdrawal of conventional navaids with the introduction of GNSS navigation service. These considerations are not applicable to airspace where present navaids are not available and GNSS alone can be introduced to benefit GNSS-equipped users.

When introducing GNSS-based services, each State shall identify the elements of GNSS that are provided (e.g. GPS, GLONASS, SBAS, GBAS) and develop an implementation plan. Where navigation services such as VOR, DME and ILS already exist, States could credit the economic savings associated with the decommissioning of ground-based navigational aids. The cost of implementing SBAS and GBAS should be tied to the provision of user benefits and increased airspace efficiency associated with area navigation and the potential to support lower decision altitude/height to more runways.

Advantages of GNSS services include the use of GPS/ABAS for en-route and non-precision approach operations where the coverage of ground-based navigation aids does not exist or is limited. In such an environment, GNSS would become the only navigation service as soon as it is introduced. SBAS-based precision approach capability to runways that currently only have a non-precision approach capability will provide further advantages in terms of increased safety and operational efficiency.

Several technical concerns have been raised with respect to the reliance on GNSS services. Principal among them is the possibility for intentional interference, or jamming, that has the potential to disrupt GNSS navigation services over relatively large areas. States and air navigation service providers should develop plans to reduce the likelihood of such occurrences, to detect and eliminate sources of

interference and to ensure that aircraft can continue to operate safely during periods when GNSS signals are disrupted. Depending on the traffic density in a given airspace and the degree of integration and automation of the air navigation system, a safety assessment might demonstrate the need for navigational information derived from different independent sources to address certain threats such as intentional jamming.

Other risk areas are expected to be mitigated as GNSS continues to evolve to more comprehensive service, such as the introduction of additional signals for aeronautical use on GPS and GLONASS satellites, augmentation system improvements, and the introduction of additional satellites and satellite systems. Each State will have to evaluate the effectiveness of the mitigation techniques applied in its airspace to determine if it is acceptable to rely on GNSS alone for the provision of navigation service.

SURVEILLANCE SYSTEMS

CURRENT SURVEILLANCE SYSTEMS

The surveillance systems presently in use can be divided into two main types: dependent surveillance and independent surveillance. In dependent surveillance systems, the aircraft position is determined on board and then transmitted to ATC. The current voice position reporting is a dependent surveillance system in which the position of the aircraft is determined from on-board navigation equipment and then conveyed by the pilot to ATC by radiotelephony. Independent surveillance is a system that measures aircraft position from the ground. Current surveillance is either based on voice position reporting or based on radar PSR or SSR, which measures range and azimuth of aircraft from the ground station.

FUNCTIONAL DESCRIPTION

Voice position reporting

Surveillance through voice position reporting is mainly used in oceanic airspace and aerodrome control service or area control service outside radar coverage. Pilots report their position using VHF and/or HF radios.

Primary surveillance radar (PSR)

The ground-based PSR system provides information on the bearing and distance of the aircraft. PSR does not require carriage of any equipment by aircraft and is capable of detecting almost any moving target. With increasing usage of more advanced surveillance systems, the use of PSR for international air traffic management will diminish. PSR will, however, continue to be used for national applications. Primary radars are currently used for surface movement detection as well as weather detection. Precision approach radars (PARs) are primary radars used for approach operations based on specific procedures for the pilot

and the controller; however, use of PARs for civil applications is rapidly decreasing.

Secondary surveillance radar (SSR)

The SSR interrogates transponder equipment installed in the aircraft. In Mode “A”, the aircraft transponder provides identification information, aircraft bearing and distance and in Mode “C”, it provides pressure-altitude information. The current SSR is in wide use in many parts of the world where terrestrial line-of-sight surveillance systems are appropriate. The accuracy, resolution and overall performance of range and azimuth information are significantly improved by the application of monopulse (including large vertical aperture antennas) and other advanced processing techniques. The beneficial role of SSR for surveillance purposes can be enhanced through the use of Mode S, which is a technique that uses a unique address (the 24-bit address) for each aircraft. It permits the selective interrogation of Mode S transponder-equipped aircraft and therefore eliminates garbling. It also provides for a two-way data link capability between Mode S ground stations and Mode S transponders. SSR Mode S is the appropriate surveillance tool in high-density traffic areas. The interconnection of ground stations in clusters provides an enhanced surveillance and communications system.

The introduction of air-ground data links, together with sufficiently accurate and reliable aircraft navigation systems, presents the opportunity to provide surveillance services in areas that lack such services in the present infrastructure, in particular, oceanic and other areas where

ADS–broadcast (ADS-B*)

ADS-B* is an expansion of the ADS technique that involves a broadcast of the position information to multiple aircraft or multiple ATM units. Each ADS-B*- equipped aircraft or ground vehicle periodically broadcasts its position and other relevant data derived from on-board equipment. Any user segment, either airborne or groundbased, within range of this broadcast, can process the information. ADS-B* is currently defined only for line-of-sight operations (e.g. broadcast over VHF digital link or by SSR Mode S extended squitter). ADS-B* is also envisaged to be applied for surface movement, thus being an alternative to surface radar such as airport surface detection equipment (ASDE).

TECHNICAL OPTIONS OVERVIEW

Implementation of ADS requires:

- a) position data supplied by the on-board navigational equipment;
- b) message time stamp within 1 second coordinated universal time (UTC);
- c) air-ground data link;

d) a ground infrastructure providing the information to ATC; and

e) appropriate air traffic services procedures.

In the case of ADS, a two-way air-ground data link capability is required, whereas in the case of ADS-B*, one-way data links will suffice because the information is transmitted in a broadcast mode. In addition, synchronized time, such as GNSS time, is highly recommended for the operation of ADS and ADS-B*.

ATM REQUIREMENTS FOR SURVEILLANCE

ATM requirements for surveillance will vary with the airspace concerned and the traffic density and complexity. The requirements can be defined as follows:

a) current surveillance systems shall provide updated aircraft position reports so as to assure safe separation;

1) for oceanic and low-density airspace including remote areas, an update rate of 12 seconds is adequate;

2) in high-density en-route/terminal environments, an update rate of 4 seconds is more appropriate;

b) the accuracy of the surveillance system should support the separation minima for the defined airspace;

c) the surveillance system should enable the ATM to provide the user with a choice

of flight path en route and to fully accommodate emergency procedures; and

d) the surveillance system should assist search and rescue operations.

The emergence of several types of surveillance systems or procedures, in addition to existing surveillance facilities to support ATM functions, has raised concern that the air navigation system is becoming too complex. Admittedly, it would have been ideal to have a single surveillance system capable of meeting the surveillance requirements for all phases of flights in all kinds of airspace. From a cost-effective standpoint, however, surveillance systems with different characteristics and capabilities are required to handle traffic conditions that vary significantly from low density traffic areas to high-density terminal areas. Until such time as one surveillance system is able to meet all requirements, the aviation community has to consider all options. While the availability of surveillance alternatives provides flexibility during the planning process, it does complicate the harmonization of the surveillance functions. To facilitate the planning, one solution would be

to translate all relevant operational requirements into a series of surveillance performance parameters. The term “required surveillance performance (RSP)”* therefore refers to a set of well-quantified surveillance performance requirements such as capacity, availability, accuracy, and update rate. Once RSP* has been specified for an operational scenario in a given airspace, any single system or combination of surveillance systems, meeting the set parameters, can be considered operationally acceptable.

FUTURE TRENDS

ADS-B* has the potential to complement SSR in terms of coverage (gap filler) and even to replace SSR for low- to medium-traffic density. If aircraft are adequately equipped, the ADS-B* information can also be used as a basis for a cockpit display of traffic information (CDTI)*.

The level of equipage is expected to increase in accordance with the global mandatory carriage of ACAS and pressure-altitude SSR transponders.

Airborne separation assurance systems are being developed that may enable the pilot to exercise responsibility in certain circumstances for separation from other aircraft. These systems may provide alert and protection zones around aircraft, together with information to help the pilot monitor and resolve potential conflicts. Other applications are being considered which may include traffic information service-broadcast (TIS-B), ADS-B*, CDTI* and conflict detection and resolution functionality.

Future surveillance may include an ACAS III* system, which will provide both horizontal and vertical resolution advisories.

GENERAL TRANSITION ISSUES

Guidelines for transition to the future systems encourage equipage by users for the earliest possible accrual of systems benefits. Although a transition period of dual equipage, both airborne and ground, is often necessary to ensure the reliability and availability of a new system, the guidelines are aimed at minimizing this period to the extent practicable. Appendix A to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing CNS/ATM systems or planning for implementation of such systems.

Chapter 3. Integrating new capabilities

3.1 General transition issues

NextGen capabilities are not turned on all at once. Before the FAA can deliver each new capability, myriad activities have to be accomplished, some of which include:

- safety management system and risk assessments;
- environmental assessments;
- demonstrations to ensure the capability delivers its intended benefits;
- tests to determine how the capability affects the workload of FAA technicians, air traffic controllers and pilots;
- training so that controllers and operators know how to use the capability;
- identification, development and installation of needed infrastructure and software;
- development and installation of new aircraft equipment, if needed; and
- changes to orders and policies to conform to federal and international standards.

The development of NextGen capabilities is not carried out in a vacuum. Throughout the process, the FAA collaborates with aviation community stakeholders, including operators, equipment manufacturers, academia and other federal agencies. Authorities work with the international community, including air navigation service providers, to make sure that equipped aircraft can take advantage of similar capabilities around the world. And authorities carefully plan how to integrate new capabilities into the airspace, which is active around the clock. departure clearance trials in 2012 and 2013 at three airports:

Memphis, Newark and Atlanta.

A WORLD OF FLIGHT

As the FAA and its aviation-community partners are developing NextGen capabilities and accompanying avionics in the United States, air navigation service providers around the world are putting similar systems in place. The increasingly global face of aviation requires that airplanes be able to use the same avionics to conduct similar operations to reap benefits around the world. The FAA is collaborating with international air navigation service providers to make sure that happens. Over the next few years, work under a U.S.-European Union memorandum of cooperation continues to ensure interoperability between NextGen and Single European Sky Air Traffic Management Research, the European air traffic control modernization effort. The scope of cooperation includes activities grouped in five areas of work: transversal, or cross-cutting, activities, such as architecture, standards development and concept of operations work; information management; trajectory management; communications, navigation, surveillance and airborne interoperability; and other collaborative projects, such as the

Atlantic Interoperability Initiative to Reduce Emissions. FAA's harmonization work also supports ICAO's Aviation System Block Upgrades initiative, which aims to harmonize global upgrades to air traffic management that can be achieved in 5-year blocks. The first block of aviation system advances comprises existing capabilities and those planned for implementation in 2013, including PBN and flexible use of airspace. These advancements do not require development of new technology, standards or infrastructure and they use avionics that are already available. The next block includes well-defined capabilities planned for implementation by the end of 2018.

As authorities implement NextGen, the FAA is enhancing the safety, flexibility and environmental performance of the NAS. In concert with aviation-community partners, at home and abroad, authorities are implementing the capabilities, policies and safety structure necessary for a successful NextGen operating environment that will ensure aviation's continued contributions to the U.S. economy.

The transition from today's ATM structure to one of collaborative air traffic management enabled by the global ATM system should be carefully planned to avoid degradation in system performance. The level of safety attainable today will need to be assured throughout the transition. Careful planning will also be necessary to ensure that aircraft are not unnecessarily burdened by the need to carry a multiplicity of existing and new CNS equipment during a long transition cycle.

For reasons of both economy and efficiency, it is necessary to ensure that differences in the pace of development around the world do not lead to incompatibility among elements of the overall system. In particular, given the wide coverage of satellite systems, worldwide coordination is necessary.

It is recognized that there are major long-term consequences of adopting new systems that will eventually permit the elimination of a variety of current systems. Decisions on whether particular systems can be removed will depend on many factors. One essential factor is the demonstrated capability of a new system. Moreover, a clear and compelling case for transition to the global ATM system must include consideration of the benefits perceived by the aviation community.

Guidelines for transition to the future systems encourage equipping by users for the earliest possible accrual of systems benefits. Although a transition period of dual equipage, both airborne and ground, is often necessary to ensure the reliability and availability of a new system, the guidelines are aimed at minimizing this period to the extent practicable. Appendix to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing CNS/ATM systems or planning for implementation of such systems.

PBN procedures help reduce fuel use, miles flown, emissions and the number of people exposed to noise while aircraft transition during the arrival or departure phase of flight. The application of PBN also aids en route cruise at high altitude (Q-routes) and at lower altitudes around

terminal areas (T-routes). These procedures could reduce delays during inclement weather.

In FY 2011, authorities published 49 Area Navigation (RNAV) routes including, for the first time ever, two helicopter routes connecting New York City to Washington, D.C. Also during FY 2011, authorities published 55 RNAV arrival and departure procedures. Authorities also published 51 Required Navigation Performance (RNP) Authorization Required approach procedures. Production of additional RNP procedures will focus on those with the most significant benefits.

ICAO defines RNAV as: “a method of navigation which permits aircraft operation on any desired flight path within the coverage of the station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these”. This concept was introduced to allow greater flexibility in the design of routes and procedures, not associated with or constrained by an underlying navigation aid, so that users could select preferred routes that consider factors such as pressure, altitude and wind. In general terms, RNAV equipment operates by automatically determining aircraft position, establishing the desired flight-path, and providing path guidance to the next waypoint. The aircraft position is derived from one, or a combination of, input(s) from various navigation systems e.g. VHF Omnidirectional Radio Range (VOR), Distance Measuring Equipment (DME) and GNSS.

The RNP concept was defined by ICAO in ICAO Document 9613. An RNP type is used to specify the minimum performance accuracy required within an airspace. Therefore RNP 1 requires that the navigation system ensures the predicted track be within a 1NM lateral containment level of the true track 95% of the time. Basic RNAV (B-RNAV) equates to RNP5 and Precision RNAV (P-RNAV) equates to RNP1. It was envisaged that most operations within airspace designated an RNP type would be RNAV operations but that other operations would be permitted temporarily. This concept would allow aircraft with RNAV equipment on-board to utilize the airspace, but the equipment must be capable of monitoring its performance and alerting the crew if performance is not met. The RNP concept moved away from previous sensor-based requirements which specified particular navigation sensors and equipment models certified for operations within an airspace.

In order to bring the RNAV concept within the scope of the performance based navigation concept of RNP, the idea of RNP-RNAV was developed. Following the development of GNSS, a true RNAV capability using omnipresent signals was realizable for the first time without the constraints provided by the range of traditional NavAids. The benefit of on-board monitoring then enables independent operations with the means to choose both a route and navigation infrastructure to meet operational requirements. In parallel to the conceptual development, the use of RNP-RNAV to represent the performance parameters accuracy, integrity, continuity and availability was introduced.

In light of this, RNP-RNAV is an extension of the RNP concept by quantifying the additional navigation parameters of integrity, continuity and availability of the navigation function. This goes beyond the initial RNP accuracy performance parameter. In fact, the original ICAO definition included additional other navigation performance parameters such as coverage, reliability, capacity, time to recover and

the now more familiar integrity, continuity and availability. The numerical performance parameters related to each of these concepts was left to appropriate technical bodies. This task was taken upon by the RTCA and led to the definition of the RNP-RNAV performance parameters. In accordance with the ICAO Global Air Navigation Plan for CNS/ATM Systems and international agreements, the concepts of RNAV, RNP and RNP-RNAV are being applied to aircraft operations. B-RNAV is currently implemented within the airspace of several ICAO states, as well as some areas of international airspace.

ICAO's PBN concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of different navigation specifications in use world-wide. It is a new concept based on the use of RNAV systems. Significantly, it is a move from a limited statement of required performance accuracy to more extensive statements of required performance in terms of accuracy, integrity, continuity and availability, together with descriptions of how this performance is to be achieved in terms of aircraft and crew requirements. The PBN concept represents a shift from sensor-based to performance-based navigation. The move from sensor-based requirement to performance based requirements allows greater flexibility because as the technologies change existing operations and navigation specifications will cover the application of these Nav aids. This will allow operators to make a cost-effective decision on which Nav aid infrastructure to use for a given navigation application but also allows operators the added responsibility for certifying their aircraft. At present PBN is to be applied within operations with linear lateral performance requirements. ICAO currently suggests that the PBN concept will be extended to angular and vertical requirements

Environmental Stewardship

As authorities develop NextGen capabilities, the FAA is placing a high priority on reducing aviation's adverse environmental impact. This effort is proceeding on several fronts, including a reduction in aircraft exhaust emissions through advanced engine and airframe technologies, a shift to biofuels, efforts to allow jets to cruise more often at or near optimal altitudes to reduce fuel burn, reconfigured arrival routes to allow for optimal profile descents to reduce aircraft noise and emissions, and improved departure routing to reduce miles flown and flying time.

The FAA is proactively managing aviation environmental issues within an Environmental Management System framework. The FAA is working with other agencies and aviation stakeholders, including airports, air carriers, manufacturers and local communities, to develop environmental objectives to meet aviation environmental and energy goals. At the same time, the FAA is reviewing its procedures for meeting the requirements of the National Environmental Policy Act to ensure compliance and to improve the agency's ability to complete the process in a timely fashion. Under the auspices of the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection, the FAA continues to pursue several measures to decrease aviation's environmental footprint, including supporting development of a significant international standard for aircraft carbon dioxide emissions

levels. The committee is aiming for a 2013 completion date for the standard. Environmental initiatives include:

Continuous Lower Energy, Emissions and Noise (CLEEN)

program. The objective is to reduce aircraft fuel burn by 33 percent and to reduce oxides of nitrogen by 60 percent compared with ICAO emissions standards. CLEEN aims to achieve these goals through a combination of new engine and airframe technologies. In addition, the goal is to reduce aircraft noise — from the engine or the airframe — by a cumulative 32 decibels from the current ICAO standard. CLEEN technologies include sustainable alternative aviation fuels, lighter and more efficient gas turbine engine components, noise-reducing engine nozzles, adaptable wing trailing edges, optimized flight trajectories using onboard flight management systems, and open rotor and geared turbofan engines. CLEEN will accelerate the development of these technologies for potential introduction into aircraft and engines beginning in 2015. Progress in 2011 included a test of a new jet engine combustor design. Preliminary results from 2011 tests show that the CLEEN oxides-of-nitrogen goal will be met.

- The FAA is a member of the Commercial Aviation Alternative Fuels Initiative, a government/industry consortium working to develop and deploy alternative 14 NextGen Implementation Plan jet fuel (see sidebar on page 14).
- The FAA completed testing of its Aviation Environmental Design Tool (AEDT) in 2011. AEDT uses dynamic aircraft performance algorithms to calculate aircraft noise levels, fuel consumption and exhaust emissions affecting air quality and greenhouse gas emissions. The FAA plans to make AEDT available for use by aviation environmental specialists in 2012.
- The FAA, in association with the National Air Traffic Controllers Association (NATCA), tested a surface traffic management strategy called N-Control at Boston in 2011. The goal was to reduce taxi times by taking multiple factors, such as wind and other weather conditions, into account when calculating a target rate for pushing aircraft back from the gate. Researchers in the ATC tower suggested an optimal number of pushbacks in 15-minute intervals for controllers to use. A two-month trial in the summer of 2011 resulted in substantial fuel savings and overall taxi-time reductions. The FAA plans to test the N-Control strategy at an additional airport in 2012.

The Safety Factor

The FAA's Office of Aviation Safety and commercial air carriers have established a data exchange known as the Aviation Safety Information

Analysis and Sharing (ASIAS) system. ASIAS houses large amounts of proprietary airline and internal FAA data. Government and industry sharing of ASIAS data makes this approach well suited to support the systemic changes being planned for the NAS under NextGen.

3.2 CHALLENGES

The past year has been a demanding one for NextGen policymakers and managers in many ways, chief among them the increasing requirement to overcome new uncertainties. Difficulties in applying new technology to old applications as well as brand-new capabilities are nothing new to the FAA or NextGen. They are common in any undertaking of NextGen's scope. What is new, however, is the need to deal with common problems under uncommon circumstances. Under the best of circumstances, management and coordination of the NextGen suite of systems and procedures is a complex undertaking. It must be managed and implemented as a portfolio, not as a series of independent programs. Under the economic and budget conditions of 2011, the demands the FAA faces have grown. In response, authorities adapt and adjust plans to these demands and their impact on resources. The combination of shifting federal budget priorities and technical problems led to changes in some of plans and schedules for deployment of NextGen components. In the 2011 update of the NextGen Implementation Plan, for example, authorities reported difficulties and delays in testing En Route Automation Modernization (ERAM) as the new automation system at en route centers, and making ERAM operational throughout the National Airspace System (NAS). Authorities are now implementing a recovery plan aimed at minimizing further delay. Authorities developed important aspects of the recovery plan in close collaboration with the National Air Traffic Controllers Association (NATCA), the controllers' union. At an FAA inservice decision meeting in March 2011, reviewers concluded that high risks remained regarding two key capabilities — tracking aircraft accurately and handing off tracking data from one center to another. But a further review, this time including specialists from NATCA, found many potential problems in ERAM's core functionality. A team at the FAA's William J. Hughes Technical Center in Atlantic City, N.J., mapped problem reports from ERAM testing to the core functionality and found many potential change requests. If not for the core-functionality analysis, these problems would have turned up later, unexpectedly. Authorities have known for a long time — and commented in previous Implementation Plan editions — that the systems and procedures that make up NextGen are highly interdependent. Thus authorities are trying not only to minimize further delays in the ERAM program, but also delays in achieving major NextGen capabilities that depend on ERAM. One such capability involves data communications, which is dependent on the Data Communications (Data Comm) program, a NextGen

transformational program, and ERAM, both of which have been re-planned in order to accommodate new realities in the funding authorities can expect and the technical progress authorities can achieve. Capabilities offered by another of transformational programs, System Wide Information Management, also depend on ERAM, as do some of the advanced service capabilities enabled by Automatic Dependent Surveillance–Broadcast. current uncertainties and constraints increase the importance of managing NextGen with the skill, determination and subtlety that such a complex system engineering project requires. Fortunately, the FAA’s Foundation for Success initiative is providing the kinds of management improvement authorities need.

Authorities implemented NextGen-related provisions of Foundation for Success last fall, after Congress enabled them by accepting proposals to reprogram budget. Two Foundation provisions are central to NextGen:

- The head of NextGen used to be the senior vice president, NextGen and operations Planning, reporting to the Air Traffic Organization’s (ATO) chief operating officer (COO). Now this person is the assistant administrator for NextGen, reporting directly to the deputy administrator of the FAA. This change increases NextGen’s visibility, both internally and externally, and it creates a direct line of authority and responsibility that no longer passes through the FAA’s operating arm.
- Management of individual NextGen development programs previously resided in the ATO units whose operations would be improved by their deployment. Thus the acquisition program managers reported to different vice presidents, each with important operational responsibilities. Foundation for Success created a central program management office in the ATO, headed by a new senior executive reporting to the COO. This executive will increase coordination among the programs and improve the interface between the program offices and the NextGen organization. Authorities have made considerable progress during the past year on NextGen management challenges that authorities cited in the 2011 update of the Implementation Plan. Authorities can attribute much of this progress to efficiencies and improvements authorities have already attained through the Foundation for Success. During 2011 we:
- Streamlined and will continue to streamline the environmental review process required for some NextGen capabilities, particularly precision departures and approaches that change noise patterns on the ground. Similarly, authorities are streamlining the processes authorities use to set standards and certifications for equipment, and to develop procedures for its use.

- Took steps to improve collaboration with stakeholders and own governance. The NextGen Advisory Committee (NAC), established at RTCA to succeed the Air Traffic Management Advisory Committee, delivered its first substantive recommendations last fall, and the FAA has responded to them (see Response to NextGen Advisory Committee Recommendations).
- Continued to emphasize human factors in all development programs. Human-in-the-Loop simulations and demonstrations are important inputs as authorities develop operating concepts. Operations personnel have a prominent role in development programs.
- Stepped up efforts to harmonize NextGen with international activities, launching collaborative programs with Europe under a new memorandum of cooperation, finalized in 2011.

Authorities continue to recognize that authorities must integrate NextGen technologies and procedures, including training and support capabilities into the NAS while it remains active 24 hours a day, seven days a week. Similarly, authorities must integrate the reconfiguration of FAA facilities for NextGen into the ongoing maintenance and upgrade programs that keep NAS operations safe and reliable. Policy issues remain key NextGen challenges within the FAA and at the NAC. Central among them are how to create incentives for operators to equip their aircraft to take advantage of newly fielded NextGen capabilities. Authorities are continuing to explore operational and financial incentives that could improve the benefit-cost ratio in users' business-case analyses. For operational incentives, often referred to as the bestequipped, best-served concept, the FAA would establish procedures by which operators of aircraft equipped for and capable of using a specific NextGen improvement would receive advantages over and above the benefits that result directly from the improvement itself. Authorities are continuing to explore options for financial incentives, both within the agency and with the NAC. With or without equipage incentives, authorities need to synchronize investments with those of other government agencies and aviation stakeholders in order to maximize timely benefits from NextGen deployments. If authorities do not deploy NextGen capabilities by the time stakeholders equip for them, or if stakeholders do not equip without significant delay to use the capabilities once authorities have deployed them, the aviation community will not fully realize as timely a return on investments. Throughout NextGen implementation, the FAA will have to manage NAS operations in ways that accommodate a mix of aircraft that are and are not equipped for specific NextGen capabilities. Authorities have managed fleets with mixed configurations and capabilities since the beginnings of air traffic control, and authorities will continue to do so. Authorities will work with the aviation community on a strategy that

serves all types of operators with varying levels of equipage, maximizes overall system performance and enhances safety

Human resource development is an area of particular importance when considering transition to CNS/ATM systems. The main function of human resource development is to help organizations meet the challenges created by change, to adapt to new requirements and to achieve the levels of human performance needed. The transition to CNS/ATM systems represents significant change. As a result of this change, human resource development managers will need to review organizational structures, plan for the human resources needed, review selection criteria for new staff and plan for the development of new training programmes.

As an integral part of transition planning, each service provider should include a review of its organizational structure. CNS/ATM systems are global in nature and usually planned and implemented at a regional or global level, in some cases by collective regional entities or commercial service suppliers. This may mean that a State's service provider's organizational structure may need to change in order to adapt to these conditions. The changes to job profiles, elimination of some types of jobs and creation of new jobs as a result of the new technologies will also cause changes that may need to be reflected in organizational structures.

The aim of human resource planning is to ensure that the operational organizations have the right number of people at the right time and with the right skills. As a result of technological changes and the lead time required to train personnel, human resource planning is one of the major challenges faced by civil aviation managers. Human resource planning has a direct effect on training, as one of its outputs is a training demand forecast. This forecast is an essential element in the preparation of a training programme. It provides an estimate of both the number of staff to be trained and the broad types of training required.

Planners will need to take the following human resource planning factors into consideration:

- a) there are several job disciplines that will no longer be required once a State has fully implemented the new systems;
- b) there will be new job disciplines as a result of the implementation of the new systems;
- c) most of the existing jobs will require additional training for the new systems;
- d) there will be a period of time in which the old and new systems will operate in parallel; and

e) much of the training will be in areas that involve a greater use of automation.

Typically, human resource plans should project needs for at least five years ahead. This period is normally required to provide enough time to re-deploy staff and recruit new staff to other jobs when needed and prepare training as required. As outlined in 10.17, ICAO is developing a manual to assist States in human resource planning. The manual will assist States in projecting human resource requirements for both new and existing technologies. The human resource and training requirements during the transition period should be a major focus of CNS/ATM systems implementation planners. From a human resource planning standpoint, the factors listed above can create a complex planning problem. In particular, the need to operate old and new systems in parallel, in combination with an evolutionary transition in which some job disciplines will be eliminated while others will be created, will require careful planning.

Existing personnel will be involved in much of the training during the transition period. Their time spent in training can have a profound effect on human resource plans and should also be considered. While some of this training can be done using distance learning techniques, there is still a significant amount of training that will need to be done in a training centre. It is expected that the *I-10-6 Global Air Navigation Plan for CNS/ATM Systems* amount of training will peak during the transition period. Typically, staffing will have to be adjusted during this period to account for personnel in training, as well as the operational personnel that may be required to deliver training that is conducted in a training centre and on-the job training that is conducted in the field.

It is recommended that States begin the process of planning for the human resources and training needed to implement the new systems as soon as possible. Much of this will depend on regional and national CNS/ATM systems implementation plans. However, it is possible for States to begin a preliminary study that can be used as the basis for creating a human resource plan for the implementation of CNS/ATM systems. An audit of the current staffing needs, as well as a projection for the next five years in established posts, will form an important basis for the formation of the future human resource plans. Most States already perform this type of analysis on an ongoing basis. However, if this analysis has not been done recently, it is highly recommended that it be undertaken as soon as possible. Typically, the analysis begins with an audit of current staffing levels. A projection is then made in all current job categories as to the need for staffing based upon the current deficit or surplus of staff, projected retirements and staff “wastage” over a five-year period. Wastage is defined as staffing losses due to potential reductions in staffing, premature retirements, resignations and deaths. Typically, wastage will be expressed as a percentage and is derived by analysing the historical data for each job category. If historical data is not available, the use of average wastage rate of three per cent per year

may be used. A methodology for the conduct of a human resource audit is available from the ICAO Air Navigation Bureau's Personnel Licensing and Training Section.

Selection criteria for new staff in all jobs should be reviewed as a part of each State's transition planning for the new systems. The introduction of new technologies, especially those using higher levels of automation, will require new sets of skills. To ensure that the majority of the newly hired employees can succeed in training and eventually perform their jobs in a safe and efficient manner, it will be important that they are recruited with appropriate aptitudes, skills and previous education. If the selection criteria are not adjusted to meet the changing needs of the workplace, training then becomes the primary means for selection. Those trainees without the required aptitudes and who do not succeed during training are "screened out". While this approach can serve the same purpose as a selection, it is extremely expensive to maintain. This approach may also make it very difficult to meet the demand for skilled personnel on a timely basis.

The development of training for automated systems is more difficult than for non-automated systems. One of the primary challenges in developing training for automated systems is to determine how much a trainee will need to know about the underlying technologies in order to use automation safely and efficiently. It is recommended that task analysis techniques be used as the basis of the design for training in automated systems. Course development based on a task analysis can be somewhat more timeconsuming than traditional training development techniques. However, typically the resulting training tends to be more effective and ultimately more cost-efficient.

As mentioned above, some of the training for the new systems could be implemented using distance learning techniques. Implementation of this type of training can be more efficient as it reduces the time spent at a centralized training centre. Training technologies in this area have, over the past few years, improved dramatically. Computer-based training and training over the Internet are becoming more effective and cost-efficient. The foundation training needed to provide all civil aviation personnel with the prerequisite skills for their job-specific training is one area in which distance learning could be used very effectively. Personnel could take this type of training while at their workplaces and thereby reduce the overall amount of time that may be required in a training centre.

Planners should also be aware that the implementation of a higher level of automation represents a great deal of change to many civil aviation personnel. The training needed to introduce this change should begin as soon as possible by providing a foundation in computers and automation. Frequently, experienced personnel that are learning new concepts related to automation can be resistant to this type of change. The possible

resistance to change is another challenge that should be anticipated and addressed by planners.

Chapter 4. Cost-benefit and economic impacts

4.1 General. COST-BENEFIT METHODOLOGY

The decision by States on whether and when to enter into the financial commitments necessary to implement CNS/ATM systems in the FIRs for which they have the responsibility to provide ATM should be preceded by appropriate cost-benefit analysis, taking into account the economic impacts on service providers, aircraft operators, passengers and freight consigners. The reasons for costbenefit analysis were considered. User participation in cost-benefit analysis is encouraged. Additionally, each service provider or operator may carry out its own business case or financial evaluation, which will be closely related to the cost-benefit study. Finally, an understanding of the broader economic implications of new systems might be helpful in promoting their implementation.

COST-BENEFIT METHODOLOGY

A cost-benefit analysis is used to estimate the economic viability of a planned investment project, i.e. the extent to which the total benefit from the investment

exceeds its total cost. CNS/ATM systems are complex and consist of a package of investments. Measures of the viability of the *new* investment package (the project case) are based on a comparison with the *existing* systems (the base case). The existing systems are defined to include their normal and expected maintenance and possible development over the planning horizon. The new facilities replace the existing facilities, and as the latter are phased out, their costs can be regarded as benefits from installing the new systems. The most important benefits of CNS/ATM systems are the cost reductions from more efficient flight operations and reduced flight times, which are expected to emerge as CNS/ATM systems are implemented.

Fueling Sustainable NextGen Flights

Over the last year, the FAA and its partners made great strides toward the commercial use of drop-in alternative jet fuels. Drop-in fuels are functionally identical to conventional jet fuel and do not differ in performance or operational capability. Operators can use these fuels without any modification to existing engines or fuel infrastructure. On July 1, 2011, the aviation community reached a major milestone when ASTM International, a standards-setting organization, approved the use of a drop-in biofuel known as Hydroprocessed Esters and Fatty Acids (HEFA) jet fuel.¹ This amended fuel specification is the culmination of a collaborative effort among the FAA, the Department of Defense (DoD) and the aviation industry through the Commercial Aviation Alternative Fuels Initiative.

The approval assures the safety and performance of this type of bio-derived fuel for commercial use by

airlines globally. HEFA biofuel can be mixed up to 50 percent with standard kerosene. It is the second drop-in alternative fuel that ASTM has approved for operational use. Fifty-percent synthetic fuel blends created from a process known as Fischer-Tropsch synthesis were approved in 2009. Over the last year, the FAA has partnered with the U.S. Department of Agriculture to develop a Feedstock Readiness Level Tool. Released in November 2011, this tool assesses the development and availability of various agricultural or forest-based feedstocks for the production of commercial and military aviation biofuels. There is no single renewable jet fuel solution that will meet all of aviation's needs. Crop availability, diverse climates and the energy production potential of a given region are variables

that necessitate multiple solutions for meeting fuel demand. To that end, the FAA is working to get ASTM approval of as many commercially viable and environmentally sustainable drop-in alternative jet fuel options as possible. The FAA, DoD and the aviation industry plan cooperative tests of jet fuels from biomass, sugars and alcohols. The FAA is funding these activities through grants from the U.S. Department of Transportation's Volpe Center and through the Continuous Lower Energy, Emissions and Noise program, which also supports maturation of green engine and airframe technologies.

In December 2011, the FAA announced contract awards to analyze fuel quality control procedures, conduct engine durability tests with alternative fuels and perform key testing to support qualification and certification of jet biofuels from alcohols, organic matter and other renewable materials. Authorities expect these activities to support the next round of fuel approvals, scheduled to begin in 2014. Reducing aviation's contribution to aircraft exhaust emissions and climate change impacts are key potential benefits of alternative jet fuels. Measuring those benefits requires quantifying the full life-cycle emissions from alternative fuel production, distribution and use. The FAA and the U.S. Air Force are jointly funding the development of greenhouse gas life-cycle analyses through the FAA's Partnership for Air Transportation Noise and Emission Reduction Center of Excellence. Results show that certain alternative jet fuels could reduce carbon dioxide emissions by as much as 80 percent over regular jet fuels when considered on a life-cycle basis. Tools enable the FAA, NASA and air carriers to conduct safety analyses, develop benchmarks, find emerging system risks, feed system safety modeling projects and enhance the effectiveness of risk mitigation actions. To facilitate participation, information that could be linked back to a specific company is removed from voluntarily reported air carrier data. Since its inception in October 2007, ASIAs has established individual data- and report-sharing agreements with 43 commercial air carriers that account for more than 95 percent of commercial operations in the NAS. The FAA continues to evaluate other sources of data and will add them to ASIAs when merited. Several important data sources will be added in the next two years, including ADS-B and

pilot/controller voice recordings. As of December 2011, these data sets include 110,000 voluntary reports submitted by pilots under the Aviation Safety Action program and 40,000 voluntary reports submitted by controllers and other FAA employees under a similar safety initiative called the Air Traffic Safety Action Program. In addition, ASIAs includes Flight Operational Quality Assurance program recorded flight data from more than eight million airline flights as well as FAA radar and runway positional data. Due to these rich sources of data, ASIAs is emerging as the most comprehensive collection of air safety data in the U.S. aviation industry. This government-and-industry partnership has already produced safety benefits for air carriers, the FAA and the travelling public. Recent studies using the ASIAs data set and analytical tools have helped improve insights on a variety of possible safety risks. For example, ASIAs is helping the FAA and stakeholders with better characterization and understanding of missed approaches, runway overruns, rejected takeoffs, auto braking and energy states on final approach. This nuanced understanding is expected to aid in accident prevention. The FAA's Air Traffic Organization (ATO) assesses and manages the risks involved in changing the way authorities manage air traffic in the NAS. And in current practice, the FAA's Safety Management System employs safety risk management, safety assurance, safety policy and safety promotion to rigorously manage risk. To date, efforts have been focused on individual programs and projects, including systems procedures and airspace changes that can be analyzed in one safety risk management document. Now the FAA is enhancing this effort by adding a holistic hazard analysis of interacting systems under a process called Integrated Safety Risk Management. This enhanced approach will contribute to the safe implementation and integration of both new and legacy NAS capabilities. NextGen will also enhance safety management via the Safety Analysis System (SAS), which will provide an automated environment for analyzing and addressing NAS-wide safety risks and enable users to extract information from multiple databases and systems. With a functioning SAS, the ATO will be able to collect, assimilate, share, analyze and view information to ensure all NAS users have a consistent view of system safety. SAS will facilitate risk-based decisions and enhance the agency's predictive capabilities. SAS, an internal ATO system, will complement ASIAs by drawing data directly from some NAS sources not tied to ASIAs. SAS will also be capable of sharing safety data with the ASIAs platform.

Improving Approval Processes

In 2011, the FAA focused on a number of initiatives to ensure consistent and efficient evaluations and approvals of NextGen technologies and operations. For example, Aviation Safety and the ATO collaborated on how authorities develop and improve Instrument Flight Procedures (IFP). The FAA began this initiative in response to a Task Force recommendation and issued an implementation plan in 2011 following a review of all processes, tools, standards and policies used by the agency

to develop PBN and other instrument procedures. This process improvement implementation plan guides future FAA actions on procedure initiatives.

FAA objectives for improved procedure development include standardizing the data used by government and industry and automating the transfer of information across several ATC automation platforms currently in use. Authorities have already taken steps to enhance the exchange of data, improve database management and advance the environmental compliance process involved with procedure development. In addition to revising the approval process, the FAA continues to show how aircraft operators and airports can achieve various capabilities and reap benefits from enablers such as ADS-B or LPV avionics (see Appendix A). This schedule provides transparency for manufacturers who are developing the equipment and operators who are interested in scheduling multiple aircraft modifications at the same time to reduce the overall cost of implementation. Many enablers build on capabilities already installed or available for aircraft today.

A rigorous approach to developing a measure of the expected economic performance of an investment project is the net present value (NPV) or life-cycle approach, which focuses on the annual flows of costs and benefits (cash flows) related to the project. The costs and benefits in cash flow terms are not distributed evenly over time. Typically, there are large capital expenditures in the early years of a new project followed by many years of benefits, and also of operating and maintenance costs. There could be significant costs during the period of transition from the existing to the new systems, and these must be included in the analysis. The benefits will normally be in the form of cost savings. The net benefit in each year is equal to the sum of all the benefit items minus the sum of all the cost items expected in that year. The NPV (i.e. current year capitalized value) of the stream of net benefits (net cash flows) can be determined by a process of discounting the future cash flows. This process takes into account the effect of the rate of interest on the present value of each future cash flow.

Estimation of the future flows of the costs and benefits, and hence the NPV associated with the implementation of satellite-based CNS/ATM systems in an airspace, requires many assumptions about the prices and quantities of communications, navigation and surveillance equipment and services, and about the amount of potential savings in aircraft operating costs. Therefore, there is an element of uncertainty and risk in the NPV results. The financial risks can be appreciated by studying the effects on the NPV estimate resulting from changes in the assumptions. A particularly important assumption is that the transition to CNS/ATM systems by ATM providers and aircraft operators occurs in a coordinated fashion so that net benefits are maximized.

Comprehensive guidance material to assist States in carrying out cost-benefit studies of the implementation of CNS/ATM systems in their

own airspace is available in Circular 257, *Economics of Satellite-based Air Navigation*

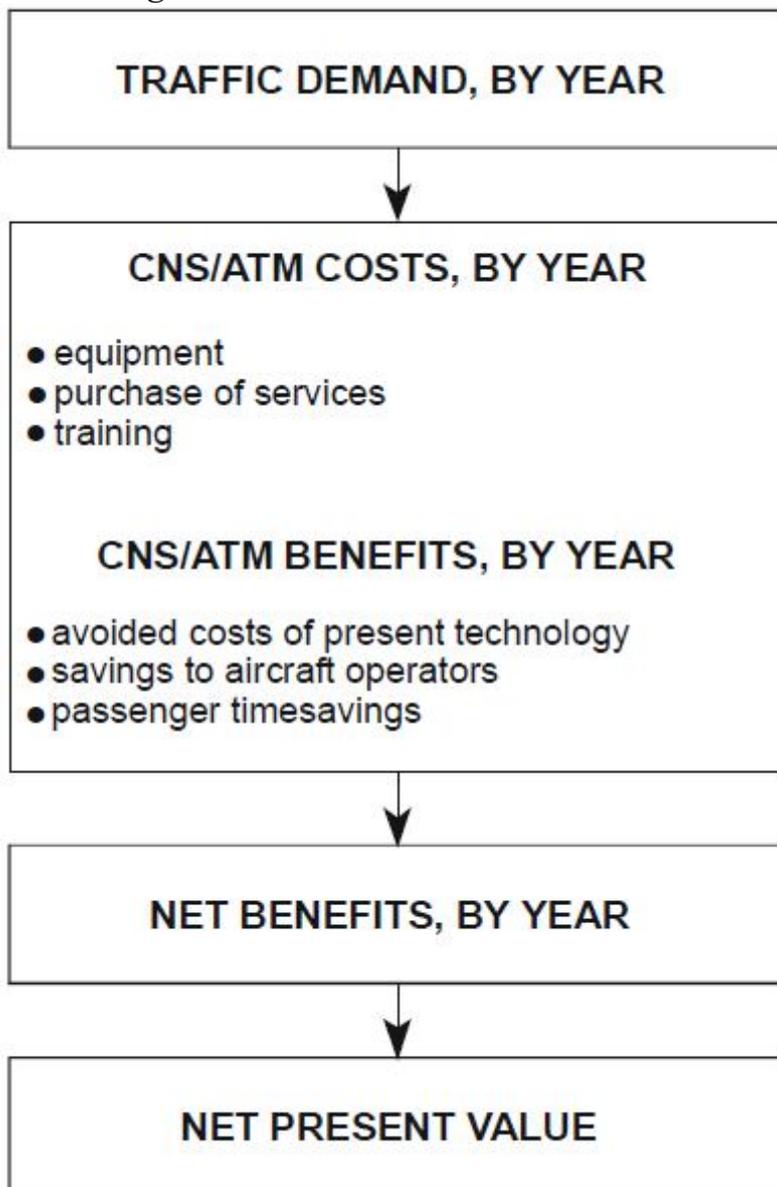


Figure IV-4-1 Overview of the net present value (NPV) approach

Services — Guidelines for cost/benefit analysis of communications, navigation and surveillance/air traffic management (CNS/ATM) systems. This circular focuses on the NPV methodology, which is widely recognized and used by financial institutions such as those potentially involved in funding CNS/ATM systems. The methodology is presented using a step-by-step tabular approach, which may be applied manually or through a computer spreadsheet; formatted spreadsheets using Quattro Pro, Lotus or Excel software are available to States from the ICAO Secretariat.

INTERPRETATION OF COST-BENEFIT RESULTS

The interest rate used for discounting future cash flows should be the minimum rate of return required from investment in the CNS/ATM

systems project. If a rate of 7 per cent per annum (real) was used, then any NPV result above zero would imply a forecast of a real rate of return greater than 7 per cent per annum from the investment project. More precisely, the project was expected to earn a real rate of return of 7 per cent per annum plus a surplus equal to the NPV value. 13.7 NPV calculations can be repeated for alternative implementation plans in order to assess which particular plan is the most cost-effective. For example, the NPV of an implementation employing SSR Mode A/C and VDL for surveillance and data communications can be compared with the NPV of an implementation plan with Mode S for both surveillance and data. As another example, the economic consequences of extending or shortening the period during which services are provided by both the present technology and the new technology systems (in parallel) can be assessed in a similar way.

A cost-benefit analysis can be done for the airspace of a State or group of States. It is recommended that separate cost-benefit analyses be done for the ATM provider or the relevant State authority and for the aircraft operators. Where this is done, it is possible that the State authorities may see only a modest net benefit (NPV) or perhaps even a net financial cost associated with the implementation of CNS/ATM systems. Any such net benefit or net cost experienced by a service provider should be accompanied by adjustments to air navigation charges so that the organization earns a reasonable return on capital invested. It is expected that the cost-benefit analysis for the airlines should produce a large positive NPV, depending on regions and traffic characteristics. Even if some of this net benefit was needed to compensate the service provider, through increased en-route charges, there should normally be an overall surplus.

The resulting effect on the airlines' net financial benefit attributable to implementation of CNS/ATM systems in a region or State must be examined. Figure illustrates the three options for using these benefits: by compensating the service providers, if necessary, improving airlines' financial performance or reducing fares and rates.

Competitive market forces should ensure that the airlines' net benefit, which remains after compensating the service providers, will be passed on by the airlines to the passengers, both local residents and visitors, and freight shippers, including exporters and importers, in the form of lower fares and rates, in real terms. This represents the main contribution of CNS/ATM systems to the economy of States. In due course, lower fares should increase the demand for air travel and tourism, and lower freight rates should improve the cost structure of companies and increase trade. The benefits associated with this extra demand are expected to be much smaller than the benefits received by the existing air traffic and are more difficult to measure.

RISKS FOR STATES

There could be a financial risk for some States associated with the diversion from their airspace of international overflight traffic as a result of the regional implementation of CNS/ATM systems. From a regional perspective, a redistribution of traffic flows associated with CNS/ATM systems should contribute to the overall economic benefit of the new systems. However, from the perspective of a single State, the impact of the redistribution could be quite complex, with either positive or negative consequences. For example, if the geographic pattern of the traffic were such that the realignment of flight paths reduced the traffic in the State's airspace, the State would have access to less revenue. The loss of revenue might be even greater if the State did not convert to the new systems.

The prospect of new flight patterns emphasizes the importance of international cooperation, not only for implementing the most efficient routes, but also for achieving an acceptable distribution of benefits and for reducing the financial risks faced by individual States. Cost-benefit studies for regional State groupings have an important role in the regional planning of CNS/ATM systems. The net economic impact may be more accurately measured at the regional or subregional level, since it is at this level, rather than at the State level, that some of the costs will be incurred, and the benefits received. Because of the long time frame of the studies, it may also be necessary to update the validation, for example after five years of operation of the new systems.

Business case evaluation

The development of a business case for the implementation of CNS/ATM systems by a service provider or an operator involves taking the financial cost-benefit analysis a step further. In particular, changes in revenues resulting from changes in the price of the product sold must be taken into account. It is generally expected that CNS/ATM systems will facilitate reduced operating costs and a lower price for the service provided. From the point of view of a specific organization, assessment of the net financial impact, in present value terms, must include not only the implementation cost and operating cost savings, which are included in the cost-benefit analysis, but also consequent changes in revenues.

For a service provider, a business case evaluation must include the impact on revenues of changes in route charges associated with the implementation of CNS/ATM systems. Assuming that the ATM service provider is an autonomous organization operating on a commercial basis and is currently covering its costs with the present technology systems, the basic issue is for the service provider to be satisfied that the changes in revenues expected from the planned changes to en-route charges will match the net change in costs, measured by the cost-benefit analysis. However, if the relationship between costs and revenues is not being monitored (e.g. if costs are met from the government budget and

revenues are treated independently as general government revenues), then the ATM

services are not being provided on a commercial basis. Even in these circumstances it is recommended that a business case evaluation be conducted to assess the financial impact of the new systems on the service provider.

For an airline, a business case evaluation would include, among other factors, assumptions about the impact on its costs of expected changes in route charges and the impact on revenues of changes in airline fares and rates, where these changes are associated with the implementation of CNS/ATM systems. These impacts are in addition to the direct investment costs and operating cost savings attributable to the new systems and identified in the costbenefit analysis described above. The impact of route charges will depend on the outcome of the policies and evaluations of the service providers. Assumptions about fares and rates will reflect competitive pressures in air travel and freight markets.

Other economic effects of CNS/ATM systems implementation

States may be interested in the broader economic and social impact of CNS/ATM systems as well as the financial viability of the new systems. For example, implementation of the new systems should produce passenger timesavings, improve safety, produce environmental benefits and may also lead to some industry restructuring and changes in skills required.

CNS improvements, which produce benefits for ATM such as more direct flight paths and less delay from airspace congestion, will reduce the passenger travel time for a given journey. If passengers value these timesavings, they represent an additional benefit. The evaluation of this benefit is discussed in Circular 257.

CNS/ATM systems are expected to bring environmental benefits because of reductions of nitrous oxide and carbon emissions through more direct routing of aircraft. These benefits will accrue to the global community in general and are not limited to participants in the air transport industry. Recognition of these benefits provides a reason for subsidizing investment in CNS/ATM systems. The increase in automation of ATM, the withdrawal of some ground-based navigation aids, and the possible relocation of some ATM facilities to fewer centralized locations should result in labproductivity improvements, and hence reductions in unit costs, over the long term. The labreleased by this process should, in most regions, be absorbed by the requirement to service expanded traffic volumes generated by general economic growth. However, there may be situations where some redeployment of staff to other economic sectors is necessary, with further economic and social consequences.

The reduced costs and lower price of air transport made possible by CNS/ATM systems, and the resulting increased air traffic demand, could increase the viability of investment in activities closely related to air transport, not only accommodation and tourism, but also those manufacturing and agricultural industries which ship materials and products by air. These indirect benefits are part of a dynamic process of economic growth and should not be attributed *entirely* to CNS/ATM systems. They will only be fully exploited provided the complementary investment in the associated industries is undertaken. The various economic effects are highlighted in Figure

An understanding of the contribution of air transport to general economic activity can increase the political commitment to the process of transition to CNS/ATM systems. National accounting and industry data and employment surveys may be used to determine the share of air transport in total economic activity and its importance as an employer. The input/output tables of a State's national accounts can illustrate the interrelationships among the various elements of the air transport industry and other industries and economic sectors. Other industries purchase air transport services or supply products and services to the air transport industry. From a national or regional economic planning perspective, it is especially important to appreciate the role of air transport in generating employment and incomes and in supporting other nonaviation economic activities. This will put into perspective the value of supporting and investing in state-of-the-art national and regional air transport facilities.

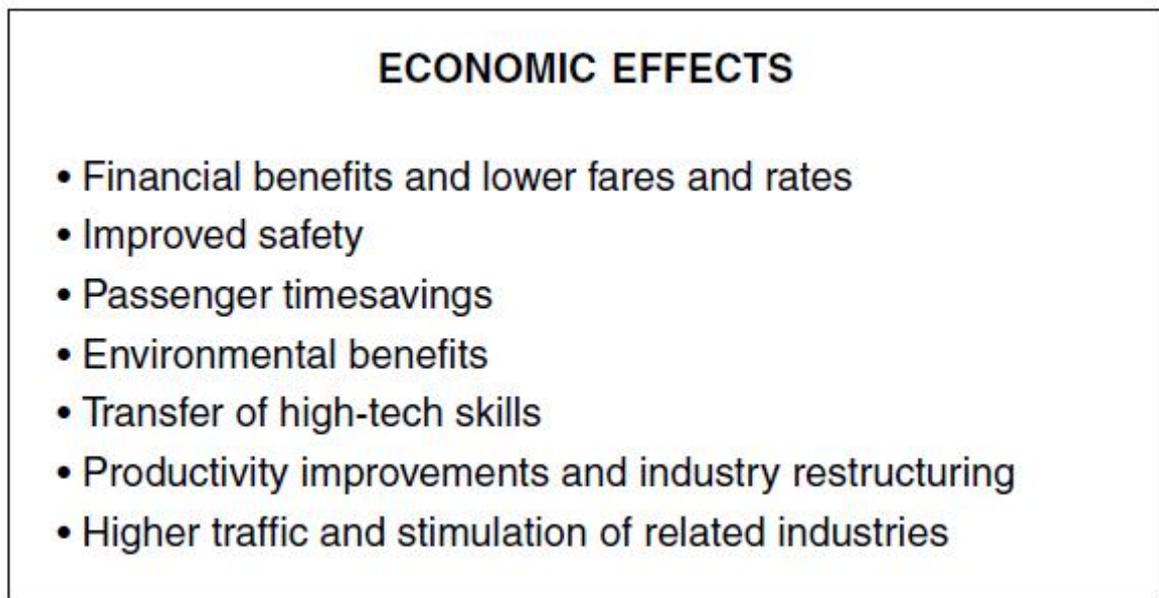


Figure –III-4-2 Summary of economic effects of CNS/ATM

4.2 Environmental benefits associated with CNS/ATM initiatives.

Future activities.

Against a background of increasing concern regarding the impact of aircraft engine emissions on the environment, ICAO has been considering what steps could be taken by the international aviation community to control emissions.

Aircraft engines burn fuel, producing emissions that are similar to other emissions resulting from fossil fuel combustion. However, aircraft emissions are unusual in that to a significant degree they are emitted at altitude. These emissions give rise to important environmental concerns regarding their global impact and their effect on local air quality.

At a global level, the principal concern is aviation's contribution to climate change. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) requires developed countries to reduce their collective emissions of greenhouse gases by approximately 5 per cent by the period 2008–2012, compared to 1990. These targets do not apply to emissions from international aviation. Instead, Article 2, paragraph 2 of the Kyoto Protocol states that the responsibility for limiting or reducing emissions from international aviation shall fall to the UNFCCC parties, working through ICAO.

Future concerns about aviation's role in both climate change and local air quality are largely due to the projected continued growth in this sector. While past technological improvements have reduced the growth rate of emissions and this progress is expected to continue in the future, total emissions will nevertheless continue to increase. For example, the Intergovernmental Panel on Climate Change (IPCC)'s report projects growth in the sector of 5 per cent per year between 1990 and 2015 with CO₂ emissions growing at 3 per cent annually over the same period.

16.5 Against this background, ICAO's Committee on Aviation Environmental Protection (CAEP) has been studying possible means to reduce aircraft engine emissions including the reduction at source, through operational measures or using market-based options.

In addressing concerns associated with aircraft engine emissions, CAEP is guided by the following principles:

- a) measures to address emissions should take into account environmental need, technical feasibility and economic reasonableness;
- b) measures to address emissions should also take into account any potential implications for safety, which must not be compromised, and for aircraft noise. Measures aimed at one type of emission (for example, CO₂) or one emission-related problem (for example, climate change) should take into account any potential implications for other types of emissions or for other emission-related problems;
- c) measures to address emissions should be developed on a harmonized worldwide basis, wherever possible.

Reducing fuel burn through improved operational measures

Currently, aircraft operations often involve indirect routings, non-optimal flight profiles, congestion resulting in airborne holding and queuing, delay and other factors that may contribute to increased or unnecessary fuel burn and associated emissions. CAEP is undertaking an initial analysis of the impact on aircraft emissions from the planned CNS/ATM systems enhancements and will make the results available to those involved in planning future air traffic improvements at the regional level.

The initial CNS/ATM study and the extension for a global analysis

At the direction of the Council, CAEP's Working Group 4, Emissions — Operational Issues, initiated a study *Global Air Navigation Plan for CNS/ATM Systems* of the environmental benefits made possible through the implementation of CNS/ATM systems. This work is driven in part by the IPCC Special Report on Aviation and Global Atmosphere (1999), which concluded: "As the aviation industry grows more and more rapidly, the impact of air traffic operations on the global atmosphere becomes increasingly important. Efforts to control or reduce the environmental impact of air traffic have identified a range of options that might reduce the impact of aviation emissions. In particular, it is expected that improvements in air traffic management (ATM) and other enhanced operational procedures for air traffic systems could help reduce aviation fuel burn, and thereby reduce the levels of aviation emissions."

The terms of reference (TOR) of Working Group 4 established by the CAEP are to "quantify and ensure that relevant environmental impacts of aviation emissions are taken into account in the global and regional planning of CNS/ATM and incorporated into airport planning." In response to the TOR, CAEP directed Working Group 4 to "evaluate the potential impact of CNS/ATM systems enhancements and recommended actions to facilitate implementation on a regional and global basis."

The data from the first analysis were presented to the CAEP in January 2001 with preliminary results referring to the benefits of implementation of CNS/ATM systems in two regions of the world. These regions have been used for developing a parametric model. The actual TOR established that Working Group 4 would expand this model to the rest of the world in cooperation with the PIRGs and the ICAO Secretariat.

Potential benefits from CNS/ATM systems for this initial study were based on planned implementation strategies for Europe and the United States.

THE PARAMETRIC MODEL

Basis of the model

Implementation of CNS/ATM systems will generally have benefits in three areas: improved airport capacity that reduces delays at congested airports, shorter cruise times through the use of more direct routes, and an increase of unimpeded taxi times. The model looks at many types of CNS/ATM systems enhancements, e.g. route network optimization through reduced separations, airspace management and civil/military coordination, collaborative flight planning and re-routing, strategic capacity management, reduced vertical separation minima (RVSM) and wind-optimized direct routes resulting in shorter cruise times.

Summary of the methodology

The scope of the study included baseline and optimized scenarios for the years 1999, 2007, 2010 and 2015. A baseline scenario was established that showed the case without CNS/ATM initiatives, but with non-CNS/ATM measures such as an additional runway or aircraft engine improvements included. Then, an optimized scenario was developed that incorporated planned CNS/ATM measures as well as the non-CNS/ATM measures included in the baseline scenario.

In the parametric model, the following variables that directly influence fuel consumption were identified for use in the model:

a) phase of flight;

— surface (taxi-in and taxi-out)

— take-off

— initial climb below 3 000 ft (914.4 m)

— cruise, phase of flight occurring above 3 000 ft (914.4 m)

— final approach below 3 000 ft (914.4 m)

— aircraft type and engine

b) airborne delays;

c) ground delays (taxi-in and taxi-out delays);

d) approach delays (air holds in the “last tier” due to congestion at the destination airports);

- e) demand (the number of current and forecasted flights between city-pairs);
- f) traffic growth rate (using the Forecasting and Economic Analysis Support Group's (FESG) annual growth rate); and
- g) rate of improvement in aircraft performance and fleet mix changes (using FESG's assumption of a 20 per cent total reduction in fuel burn rates in the next 20 years).

Other variables, such as airport capacity and weather conditions, can impact upon one of the direct variables described above. For example, demand growth and airport capacities can affect ground and arrival delays. CNS/ATM measures may increase airport capacities. Queuing theory approximations are used to estimate the percentage change in delay caused by capacity or demand increases. Similarly, airport capacities under visual flight rules (VFR) and instrument flight rules (IFR) conditions are estimated for the baseline and optimized scenarios.

Model input

The following summarizes the input needed by the model to assess the potential fuel savings from any CNS/ATM systems implementation plan. Some of the data is universal (i.e. specific aircraft fuel burn rates) while some of it is specific and unique to each region. To expand the study to other ICAO regions, and to develop a truly global assessment, specific or unique data would need to be gathered from each region based on regional CNS/ATM implementation plans. Where region-specific data are not available, global assumptions or other available data can be used. The model uses the following input:

- a) planned CNS/ATM enhancements;
- b) fuel burn rates (lbs/min) for phase of flight; idle, take-off, climb (up to 3 000 ft (914.4 m)) and approach;
- c) minimum take-off, climb and approach times;
- d) "cruise" phase median, low and high fuel burn rate (lbs/min) for existing aircraft types using all flights, and flights between city-pairs of less than 500 miles great circle distance;
- e) identification of aircraft types (regional fleet mix), and future fleet mix forecast;

- f) the amount of delay on the ground (taxi) and on approach (arrival delay due to congestion at the airport) for major airports in the region;
- g) current and future airport capacities and improvements expected to result from airport capacity changes, physical and procedural, and from CNS/ATM initiatives;
- h) identification of capacity-constrained airports;
- i) unimpeded taxi times for major airports;
- j) airport weather information (average VFR and IFR);
- k) future growth forecast;
- l) estimated approach delays;
- m) estimated taxi-out and taxi-in delays; and
- n) current routes for baseline scenarios.

The model can be improved to encompass on a more comprehensive basis all regions of the world and to become more user-friendly. After subsequent steps are *Global Air Navigation Plan for CNS/ATM Systems* achieved and the material matures, the Global Plan will be updated accordingly. Future work will focus on the following activities: a) gathering information on CNS/ATM systems initiatives in other regions of the world to expand the model in order to represent a worldwide result;

b) performing additional simulations to estimate the impact of specific technology enhancements on flight efficiency which result in changes to fuel usage and emissions. A more detailed examination of the effect of altitude on the emissions and fuel usage will be performed;

c) enhancing the parametric model as new information becomes available. Various parameters will be calibrated to better represent different regions of the world; and

d) enhancing the user interface of the parametric model so any decision-maker can use it easily to perform sensitivity analyses. This would enable the decisionmaker,

for example, to change the forecast demand input and compare the resulting fuel savings due to CNS/ATM initiatives or to change the schedule or the impact of one or several CNS/ATM initiatives and compare the resulting fuel savings.

Regional planning considerations

Regional planning groups should take environmental factors into consideration when developing CNS/ATM systems implementation plans. Although future plans could include developing a user-friendly, stand-alone modelling capability, the current model is run under the auspices of ICAO/CAEP's Working Group 4. Representatives of the PIRGs are encouraged to contact the ICAO Secretariat to initiate the process to evaluate the environmental benefits of planned CNS/ATM systems enhancements.

After initial contact with the Secretariat, arrangements will be made to gather the appropriate modelling data for a particular region to begin the modelling effort. The data as described above can be collected from existing databases, from direct interviews between representatives from the regional planning groups and the modellers, or by the development of regional-specific assumptions.

The results of the model can be useful in providing national decision-makers within the various regions with information upon which to base airspace architecture decisions and in providing the international climate change body with information on what the aviation industry is doing now to protect the environment in the future.

These high-level benefit estimates for 2020 are very similar to the 2018 benefits on which authorities reported in last year's update of the NextGen Implementation Plan. The two-year difference arises from a number of factors. The soft economy and reduced passenger demand prompted airlines to reduce schedules, often resulting in fewer delays throughout the NAS. Internal factors include challenges in deploying complex systems such as En Route Automation Modernization (a key enabler of many NextGen capabilities), refinements to modeling inputs and budget pressures. baseline delay estimates include benefits authorities expect from new and expanded runways, including those at Chicago O'Hare, Fort Lauderdale and Philadelphia airports. These contribute to the "no further progress" scenario. To determine near-term benefits, authorities focus estimates on time frames eight to 10 years in the future. Those time frames also correspond to the NextGen break-even point. The breakeven point is the year when cumulative benefits, to the FAA and NAS users, equal and then exceed the cumulative costs of implementation. Last year authorities estimated NextGen would break even in 2018; now authorities believe authorities will attain that milestone in 2020.

It takes a longer time horizon, however, to understand the full life cycle of most of mid-term and later projects. Indeed, some NextGen improvements will just be coming on line to full effect in 2020, with an expected 10 to 20 years of service life ahead of them. Looking out to 2030, then, and comparing benefits with the full cost of deploying and maintaining mid-term improvements, authorities estimate that the overall NextGen initiative has a benefit-to-cost ratio of more than two-to-one. In addition to incorporating new operations, NextGen will support the

introduction of new aircraft, engine and fuel technologies that will increase the environmental benefit that come from operations. Authorities believe that over time, the fuelsaving and environmental benefits from these new technologies will exceed those from operational changes. As in earlier updates to the Implementation Plan, these estimates reflect current view of budgets and schedules, based on congressional appropriations for FY 2012 and the FAA's FY 2013 budget request to Congress. estimates are system-wide aggregates and do not reflect improvements at specific localities or airports. Achieving NextGen benefits depends heavily on decisions by airspace users on whether and when to equip their aircraft with the avionics that will enable them to take advantage of the specific NextGen capabilities authorities deploy. Except for Automatic Dependent Surveillance–Broadcast Out avionics, which authorities mandate by 2020 for aircraft operating in most controlled airspace, operators' equipage decisions will depend on their ability to leverage NextGen improvements to improve their own bottom line.

Qualitatively, the argument for equipping is straightforward. Airspace users who equip will reduce their operating costs and travel time through greater efficiency on the airport surface, more-direct routes, precision navigation in departures and approaches, and collaborative decision making in all phases of flight. In some cases, those who equip sooner will benefit sooner. And all users will benefit if travelers experience more predictable flights with less time lost to delays. Quantitatively, equipage questions become complicated. Operators must consider the costs of equipment, installation, training and operations; incentives to equip; the timetable for FAA deployment of capabilities; users' confidence in benefit estimates, and other factors. Many of these decision criteria remain uncertain, leading many operators to take a wait-and-see approach to equipping. To keep abreast of cost estimates, the FAA needs the steady refinement of its benefit estimates enabled by analyzing a continuing stream of data from the demonstrations, trials, flight evaluations and simulations authorities conduct as a normal part of developing NextGen systems and procedures. Following are a few examples of FAA activities during the past year that contributed to analyses of benefits or the business case for NextGen:

- Optimization of Airspace and Procedures in the Metroplex study teams estimated substantial fuel saving in the Washington, D.C., and north Texas metroplexes, mainly from systematic application of multiple Optimized Profile Descents and reduced distances in flight. For Washington, the estimate is \$6.4 to \$19 million per year in fuel savings, and the prospective north Texas saving is \$10.3 to \$21.7 million. In addition, reduced radar vectoring will decrease pilotcontroller communications and the complexity of the controller workload. The

Washington and North Texas projects moved to the design and implementation phase in 2011.

- Atlantic Interoperability Initiative to Reduce Emissions (AIRE) demonstrations continued in 2011, delivering more data on benefits from real-time rerouting and other fuel-saving measures. By optimizing lateral tracks relative to winds aloft between Portuguese and U.S. airspace, 65 Air Europa A330 and Iberia A340 flights from Madrid to the Americas and the Caribbean were able to save an average of 274 gallons of fuel and reduce carbon dioxide emissions by 2,608 kilograms per flight. In a limited number of Air France Transatlantic Green Flights, Air France 777s saved an average of 70 gallons of fuel per flight through real-time lateral and vertical optimization.

Economic part

Problem of economic development of our Republic is production efficiency increase on the basis of acceleration of scientific and technical progress and economy of all types of resources.

The accelerated introductions of achievements of scientific and technical progress in production and operation of the aircraft equipment are covered by a specific circle of problems among which the extreme importance gets a choice of the most effective directions of research works, expediency of design of these or those models of new aircraft.

At existing speeds and heights it is impossible to carry out flight without stable and reliable information about flight parameters, modes of operation of engines and numerous onboard devices and units therefore the role of aviation devices and automatic systems constantly increases in safety of flights.

Information arriving from onboard systems and sensors of primary information, is processed by means of electronic onboard cars, and automatic devices give out teams for performance of operations on providing all modes of flight.

The salary of dispatchers of the Air traffic control is established

Salary of dispatchers of the Air traffic control according to the Industry, tariff agreement between central committee of labor union of an avia of workers both national airline "Uzbekistan Air Ways" and Situation on compensation of an avia of employees of national airline "Uzbekistan Air Ways".

The tariff agreement is the main for the conclusion of collective agreements, employment contracts (contracts) in structural units the enterprises National Airlines and all additional rights provided by it, privileges, guarantees, compensations, compensation and working conditions is minimum obligatory.

The presents the industry tariff agreement is concluded between the center it committee labor union an epithet to labor unions of an avia of workers of Uzbekistan management of National airline "Uzbekistan Air

Ways" for creation to partnership system in regulation of work of all relations, establishments of healthy and safe working conditions and realization of socially economic privileges, guarantees, compensations for workers and their security in questions of entertaining and the population and republic economy in aviation services is directed on ensuring stable work of civil aviation of the Republic of Uzbekistan and satisfaction of requirements.

The agreement establishes additional in comparison by the legislation of the right, a guarantee and compensation privilege, payment and a working condition all structural units and the enterprises of National airline and regulates obligations of the parties.

Calculation of a salary of the Head of flights

The annex No. 1 to the Industry tariff agreement between Central office of labor union of aviaworkers and Management of national airline agrees the Scale of charges of the coefficients, corresponding by the category on compensation of workers, Automated Systems, employees and heads of structural divisions of National airline is entered. According to a scale of charges the official salary of the worker of primary activity is defined by multiplication of tariff coefficient of the corresponding category on fixed a rate accepted in NAC "Uzbekistan Air Ways" for calculation of official salaries.

According to the annex No. 5 to the Industry agreement categories on compensation of employees of the Center are provided. "Uzaero navigation" of National airline "Uzbekistan Air Ways". According to the appendix No. 5 the official salary of the head of flights is charged proceeding from the 17th category on compensation, with application of coefficient 8,28 and raising in coefficient on compensation.

Table 1

Position	Category	Coefficient according to a scale of charges the appendix No. 1	The raising coefficient	The fixed rate accepted in NAC	Official salary
1	2	3	4	5	6
Head of flights	15	8,28	1,67	68655	949334

According to Situation on compensation of an avia of workers national airlines "Uzbekistan Air Ways" price-work and time wage of work is established: to heads, Automated Systems and employees official salaries, worker official salaries, hour tariff rates and price-work quotations.

According to Situation on compensation the following surcharges for specialists of the Air traffic control are established:

1) To the workers knowing a foreign language not below the 4th level on a scale of IKAO and applying them in work, extra charges to an official salary in the size of 15% from an official salary are established.

2) Taking into account carried-out amounts of works to establish the following class of services and points of Air traffic control of the Uz aero navigation Center;

I class:

Tashkent, Nukus, Samarkand territorial office.

VRTs - Navoi, Termez; Namangan

II class

Territorial offices (control offices with direct Air traffic control) on all the territory Uzbekistan.

Additional payment to a salary for intensive work by the head of flights is established, to the senior dispatchers and the dispatchers of the Uzaero navigation Center having the existing certificate of the aviation dispatcher, from calculation:

- Tashkent, Navoi, Termez – 20%;
- Samarkand – 15%
- Nukus – 10%
- Namangan – 5%

Thus, the total salary of the Head is displayed by flight in a tabular form (tab. No. 2), as follows:

Table 2

Position	Official salary according to the tab. No. 1	Extra charge for foreign language, 15%	Additional payment for intensity of 20% the Salary (bags) in a month	1
2	6	4	5	Head of flights
949334	142400	189866	1281600	

Thus, the salary of the Head of flights will make according to the table No. 1 and the table No. 2, and according to the industry tariff agreement and Situation on compensation of 1281600 bags in a month.

4. Labor safety

Safety requirements on labor protection for specialists of the Air traffic control

The Tashkent Center of the Automated System Air traffic control

Persons are allowed to work as the specialist of the Air traffic control not more young 19 years which have passed medical about

witnessing, induction on labor protection. After that the specialist of the Air traffic control passes primary examination on labor protection in examination committee of CUAN. Further it passes periodic instructing in labor protection once in six months with confirmation of it in a log-book of instructing on a workplace.

The specialist of the Air traffic control of the Air traffic control AUTOMATED SYSTEM Tashkent Center is obliged:

- to carry out the instruction on labor protection, Center employment policies and procedures
- "Uzaero navigation";
- fire safety regulations;
- not to allow on a workplace of persons not concerning to performed work;
- to have 1 group on electrical safety;
- nobility and carry out rules of personal hygiene, not to smoke in premises of Shopping Center AS ATC and not to use to and to operating time on which was trained;
- to fulfill requirements of signs of safety;
- to be able to use fire extinguishing means.

The specialist of the Air traffic control of the Air traffic control AUTOMATED SYSTEM Tashkent Center, allowed violations of requirements of the instruction on labor protection, is attracted to a disciplinary responsibility according to CUAN employment policies and procedures and if these violations are connected with causing material damage to the enterprise, bears also a liability in accordance with the established procedure.

Safety requirements before work.

To prepare a workplace.

In the course of pre replaceable instructing the specialist of the Air traffic control receives information on availability for service electro, radio and lighting means from Automated Systems of KRTOPI, ESTOP and specialists of the Departments of Internal Affairs which are handing over watch and taken measures for elimination of malfunctions, revealed by previous change.

The specialist of the Air traffic control checks serviceability of the equipment.

Safety requirements in operating time.

During the work with the radio engineering equipment to carry out only those operations which are provided by the instruction on its operation for specialists of the Air traffic control of the Air traffic control AUTOMATED SYSTEM Tashkent Center.

It is forbidden to open panels, hatches, telephone sets, sockets and electric sockets, to repair radio and electric equipment, both special, and household appliances.

In case of shortcomings of work of radio engineering means immediately to report on the shift engineer of RTP of the Air traffic control AUTOMATED SYSTEM Tashkent Center.

Movement on the territory of airfield has to be, as a rule, by car PPRP. In movement cases on foot, movement is made according to airfield marking, with observance of precautionary measures and constant discretion.

Not to run across rulezhny paths before driving planes and isn't at planes with working engines, ahead – 50 meters are closer, behind – 100 meters, and also in the plane of rotating screws are closer. Isn't in the sectors which haven't been specified in the admission of the worker.

Not to accept food on workplaces, not to place on panels of the Department of Internal Affairs and other processing equipment and in close proximity to them construction subjects.

Not to carry out functional duties of employees of other services.

Safety requirement in emergencies.

At emergence of the electric short circuits which have led to ignition of an electrical wiring or the equipment immediately to report RP, on the shift engineer of RTO.

At health deterioration during watch it is necessary to report immediately RP and to demand replacement, and RP organizes substitution and immediately calls the doctor on duty on ph. 34-52, 140-28-95.

At emergence of a fire to call the ASS team (by local phone: 69-81, 60-03, 60-11, 10-25 or PGS) and to take measures for elimination of the seat of fire.

Safety requirements upon termination of work.

To order a workplace.

At available shortcomings of equipment work, the specialist of the Department of Internal Affairs has to notify on this RP and dispatchers of taking-up change.

Safety requirements on labor protection for the employees of services of Shopping Center Uzaeronavigation performing works on personal computers and office equipment (the personal computer and FROM)

On the personal computer (PC) and the organizational equipment (OE) it is allowed to work the persons which have reached 18-year age.

The worker passes preliminary medical examination and not having contraindications. Further the worker passes induction on labor protection and primary instructing in labor protection on a workplace.

In the course of work the worker passes periodic instructing in labor protection of 1 time in 6 months. All types of instructing in labor protection are made out in magazines of registration of instructing and are confirmed by signatures of the worker.

Periodic medical examination is carried out once a year with obligatory participation of the therapist, the neuropathologist and the oculist.

The worker has to have 1 qualification group on electrical safety. The mode of work and rest are defined in Employment policies and procedures of employees of the Uzaeronavigation Center.

Factors of danger are:

Tension of electromagnetic fields.

Tension of the visual analyzer and attention function.

The compelled working pose, the monotonian Period.

Aren't allowed to work with the computer equipment of the woman from the moment of establishment of pregnancy and during feeding by a breast.

During the work on the personal computer and FROM the worker it is obliged:

- to carry out the instruction on labor protection, employment policies and procedures of workers, Center of Uzaeronavigation the instruction of the direct head, workers of labor protection and safety measures, a fire service;

- nobility and observe only that work on which was trained, instructing in protection and it is allowed by the head to work performance;

- to fulfill requirements of signs of safety;

- to report to the direct head about the noticed malfunctions of the personal computer and Completely acceptances of the appropriate measures by the head not to start work; - to be able to render the pre-medical help to injured workers, to use fire extinguishing means (the fire extinguisher, an internal fireplug, etc.), at emergence of a fire to cause a fire brigade 01, 16-54, 60-65, 140-28-70) and to participate and fire eliminations.

The worker who has allowed violation of requirements of instructions on labor protection, can be attracted to a disciplinary responsibility according to Employment policies and procedures of employees of the Uzaeronavigatsy Center and if these violations are connected with causing property damage to the enterprise, the worker bears also a liability in accordance with the established procedure.

Safety requirements before work.

The worker is obliged:

- to check external survey serviceability of sockets and food cords. ;

- to adjust illumination on a workplace, to be convinced of lack of patches of light on the display screen;
 - to wipe a napkin a screen surface from a dust (at the switched-off computer)
 - to be convinced of lack of diskettes in disk drives;
 - to check a nezagramozhdennost of ventilating openings in equipment cases;
 - at identification of damages to report on it on the direct head.
- Safety requirements in operating time.

The worker is obliged:

- to observe service regulations of the personal computer and FROM;
- to observe the established mode of work and rest;
- to watch lack of paper and other combustible materials on the working equipment.

It is forbidden to the worker;

- to start to work wet hands;
- to open the protective case of the system unit;
- independently to make replacement of safety locks;
- to leave the switched-on personal computer and Otpri an emergency shutdown of the electric power;
- to work at faulty personal computers and FROM (at emergence of a smoke, a smell, ashes, sparking, feeling of an electric current at a touch to metal cases of the equipment, etc.);
- to concern at the same time the monitor and keyboard screen;
- to touch the back panel of the system unit at included pitaniye;
- to put and put on the completing equipment which is a part of the personal computer and Otpostroyeniye subjects: paper clips, scissors, cups, drinking bowls, etc.;
- to clean the personal computer and FROM, being energized;
- independently to eliminate the appeared malfunctions.

To report on the appeared malfunctions on the immediate superior.

Duration of continuous work on the personal computer and Otbez of the regulated breaks shouldn't exceed 2 hours. The regulated breaks are established by duration of 15 minutes. The general total duration of working hours on the personal computer and FROM shouldn't exceed 4 hours.

Summary

It takes a longer time horizon, however, to understand the full life cycle of most of mid-term and later projects. Indeed, some NextGen and CNS/ATM improvements will just be coming on line to full effect in 2020, with an expected 10 to 20 years of service life ahead of them. Looking out to 2030, then, and comparing benefits with the full cost of deploying and maintaining mid-term improvements, authorities estimate that the overall NextGen initiative has a benefit-to-cost ratio of more than two-to-one.

Achieving this systems benefits depend heavily on decisions by airspace users on whether and when to equip their aircraft with the avionics that will enable them to take advantage of the specific NextGen capabilities authorities deploy. Except for Automatic Dependent Surveillance–Broadcast Out avionics, which authorities mandate by 2020 for aircraft operating in most controlled airspace, operators' equipage decisions will depend on their ability to leverage NextGen improvements to improve their own bottom line.

New system is transforming the National Airspace System (NAS) through a number of operational improvements. We implement each improvement through a series of capabilities, or increments, that provide individual benefits and combine to provide a transformative change in the way we operate the NAS. In this appendix, we have summarized our work plans, timelines and locations (when available) to deliver operational improvements.

Work is progressing to deliver related capabilities in eight implementation portfolios and two portfolios with supporting activities that address safety, environmental and energy considerations. See graphic above for a list of the portfolios. The capabilities in the implementation portfolios depend on several common services and new or existing infrastructure, which we manage in a Common Services and Infrastructure portfolio.

Development of capabilities in one portfolio often depends on or impacts development in other portfolios. A change in the schedule of a capability in the Common Services portfolio, for example, could also impact all the increments that capability supports. Development and implementation can also be affected by other internal and external factors, such as program interdependencies, realignment of priorities, concept validation work or funding. This means that we may have to adjust the timeline or the scope of a capability.

The capabilities displayed in the implementation portfolio timelines depict current plans through 2015. Several increments have been delayed from the time frame shown in last year's update to the NextGen Implementation Plan. However, detailed planning for capabilities beyond the 2015 time frame is ongoing. Additionally, some increments are in concept development and we have not yet determined when these

capabilities will be available. While these increments are shown in the implementation portfolio timelines as becoming available in 2016 or later, preliminary work to further develop those increments is ongoing. The FAA is using a segment planning approach, which offers additional insight into the development and implementation of capabilities in the 2016 time frame and beyond while facilitating lower-level program planning. While the degree of uncertainty is higher, the segment planning approach guides the agency's concept maturity work. Before we implement a NextGen capability in the NAS, we complete a lengthy and complex process of development. Once we have conceived a concept for developing a needed capability, the FAA matures and validates that concept through research, modeling, simulated and operational demonstrations, Human-in-the-Loop testing and other activities. In some cases, our pre-implementation work does not validate the proposed concept or benefit, that is, the proposed capability does not provide benefit to the NAS, and development stops.

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