5.0 The ATI Supply Chain

Among the most significant aspects of the strategic inflection point reached by the global ATI market – the nexus of this report – is the evolution of well-established and distinct industry supply chains, each having a critical role in ATI modernization. Section 5 focuses on the two most important from an air traffic infrastructure perspective. For the purposes of this report, the ATI supply chain refers to the two networks of businesses involved in providing products, systems, and services to customers listed below:

Figure 5 -1
ATI Supply Chains

ATI Supply Chain Segment	Top Five Tier 0 Customers
CNS/ATM Ground and Space Systems Supply Chain	• ANSPs • National governments • Airports • Militaries • Aircraft OEMs
CNS/ATM Avionics Supply Chain	• Airlines • Charter and business aircraft operators • Aircraft OEMs • MRO providers • Militaries

Source: NEXA Advisors Research

The CNS/ATM ground and space system supply chain overlaps with the CNS/ATM avionics supply chain, but both have distinct differences important to understand for those approaching the ATI market during the next decade.

5.1 General Aerospace and Defense (A&D) Industry Sector Considerations

The ATI sector is, for the most part, a collection of large-scale systems integrators and niche businesses that fall within the broader aerospace and defense industry. With only a few notable exceptions, the ATI sector as a whole is buffeted by the pressures and winds of change the A&D sector must endure.

The global aerospace sector has proven to be a strong and resilient industry segment, even with the shocks of the Great Recession of 2007-2008. Currently the general health of the global A&D sector is good. Since the mid-2000s, the sector has witnessed impressive growth, with the civil aviation segment emerging as the major contributor to this expansion. The US and European countries are the dominant markets for aerospace products, systems, and services, and act as market catalysts supporting this overall growth.

The US represents the biggest aerospace market in the world, followed by France, the UK, Germany, and Canada. In the near future, most developing nations, led by China, India, Mexico, Indonesia, and Brazil, are expected to emerge as potential marketplaces for aerospace products, systems and services.

It is a tale of two industries, however, with optimism for commercial aerospace driven by OEM business expansion and caution for defense. Below are the factors and drivers that generally affect performance and outlooks in the sector.

5.1.1 Economic and Political Factors

Oil Price Volatility

Central to commercial aerospace is the airline industry, whose economics drive much of the aerospace supply chain through new aircraft orders, engine sales, aircraft maintenance, and operations. Oil prices are important to airlines as fuel accounts for more than a third of their operating costs.

High oil prices create new urgency for ATI modernization, as the airline industry believes substantial fuel savings can be had once fleets are fully equipped to use new ground and space-based infrastructure. Volatility on top of high prices makes it difficult to plan and finance long-term infrastructure investment. Airlines are weakened financially by this unstable cost environment.

A growing number of analysts say oil-price trends can no longer be explained simply through supply and demand. While energy analysts still see those factors as the foundation of the oil market, they also view oil investor behavior as a factor in recent prices. Increasingly speculative behavior by a more diverse set of investors outside the oil industry — including hedge funds, pension funds, and investment banks—has made oil-market trends harder to predict. Speculative investments from financial firms contributed to record-high global oil prices seen in early 2008, and a sell-off by these speculators contributed to the subsequent massive price decline later in the year. As major political events rock the Middle East in 2012, analysts continue to worry about market speculation, which is seen in present high price volatility.

Government Monetary and Fiscal Challenges

The expression "government is broke" applies to many of the countries analyzed in this report. Some countries can no longer invest in needed infrastructure that has normally been the domain of the taxpayer. Claiming a peace dividend as militaries wind down in Iraq and Afghanistan, defense budgets are being slashed. Meanwhile, continued global economic challenges coupled with cost pressures will result in margin contraction for many parts of the aerospace sector. In particular, the defense sector is likely to undergo more streamlining of its cost structure, divestiture of non-core assets, and additions of gap filling, as well as transformation acquisitions.

A central theme of this report is that ATI modernization can proceed under partnership models that tap private sector funding, secured by revenues collected from users of the air traffic system. This new way of executing programs will provide a long-term boost to companies in the sector which take advantage of the new business model.

Environmental Pressures

Given the volatility in oil prices, commercial and government customers for A&D products are demanding greater fuel efficiency and alternative fuel options. With the advent of carbon emissions trading schemes in Europe and, increasingly, around the globe, the need to track and reduce carbon (and therefore fuel) use, demand for efficient new technologies will grow in importance. Product manufacturers and integrators will be rewarded as they develop and sell products that meet the needs of this new, greener demand from their customers.

ATI that is capable of performing to full potential has the capacity to reduce the carbon footprint of airlines by as much as 15 percent. Aviation accounts for only three percent of carbon emissions from the global transport sector; however, it is growing. Aviation-related carbon emissions often have a higher warming potential than ones emitted elsewhere. Recently, IATA committed to new emission reductions targets and fuel efficiency improvements over 2005 levels: a 1.5 percent annual fuel efficiency improvements through 2020; a 50 percent reduction in carbon emissions by 2050; and stabilizing aviation emissions from 2020, with carbon-neutral growth thereafter.

5.1.2 Market Factors

Growth in Commercial Aircraft Orders

The commercial aircraft sector is likely to enter a prolonged growth cycle in production in 2012 as a result of increasing demand for leisure and business travel, particularly in the Asia Pacific region. The growth in the commercial aircraft industry is expected to be driven by continued production and development of next-generation aircraft programs that aim to address increasing fuel costs.

The four manufacturers that dominate the world's market for major and regional airline jet transports had roughly 8,600 aircraft on their order books as of January 2012. That number is expected to grow as airlines in Asia Pacific, the Middle East, and Latin American regions try to keep pace with projected air travel growth, and those in North America and Europe upgrade their fleets to remain competitive and cut operating costs in the face of slower but steady growth.

Figure 5-2
Major Aircraft OEM Order Backlogs
Air Transport Only - As of January 2012

	Orders	Filled	Backlog
Airbus	11,363	6,943	4,420
Boeing	13,898	10,017	3,881
Bombardier	1,708	1,656	52
Embraer	1,908	1,660	248

Sources: Aircraft Manufacturers, NEXA research

In the last few years, new programs, such as the Airbus A320 NEO, the Boeing 737 MAX, the Mitsubishi Regional Jet (MRJ), the AVIC ARJ21, the Irkut MS-21 and, more recently, the Embraer ERJ product line (Figure 5-2), are planning customer deliveries in the future that will incorporate these new power plants.

In reality and despite potential operating cost reductions from these new technology aircraft, ATI modernization can derail orders and deliveries in many parts of the world. We believe that as much as 25 percent of the backlog in major OEM orders is at risk without strides in airspace procedures and capacity. The value of these at-risk orders exceeds $150 billion.

Growth in Air Traffic

Passenger demand for airline travel worldwide continues to show healthy increases, and the percentage of seats filled continues to grow as well, according to the International Air Transport Association. For example, IATA said that for the month of April 2012, total worldwide passenger demand grew by 6.1 percent from the same month a year earlier. That includes a 7.4 percent increase in international routes and a 3.9 percent growth in domestic itineraries. For the first four months of 2012, total demand rose by 7.1 percent, including 8.1 percent growth in international routes and 5.5 percent in domestic services. Airline capacity discipline has reached its full potential, and continued growth will require expansion in fleets and aircraft size.

For years, congested airspace, restricted flight paths, and dated CNS/ATM systems have undermined air traffic growth. This correlates with the broader aircraft and OEM business that drives much of the aerospace sector. As mentioned, a significant number of aircraft orders could be at risk of cancellation or deferral if airlines perceive that ATI-related congestion and delays could impede their ability to realize target profits with new aircraft. This is a major reason why Airbus and Boeing each are focusing corporate resources on the advancement of ATI modernization and the development of specific air navigation service solutions. Congestion in airspace also limits local economies. This is generally why capacity concerns reach the highest levels of policy making.

Continuing Globalization

The A&D industry is becoming more global due to heightened competition, growing travel demands, and security requirements in emerging markets. Globalization provides opportunities to lower costs and introduce technologically advanced products more rapidly, as these can be designed and manufactured anywhere, anytime, largely due to the internet and digital product definition, design, and manufacturing software. Globalization is also affecting product selections, in that military and commercial customers alike are requiring that value be “offset” by placing work in their countries of origin. This trend is likely to continue, as many countries are under pressure to keep their jobs at home, yet must balance this concern with the need to grow revenues and reduce labor costs. The industry trend toward globalization is also marked by new market entrants, some of which receive government financial support that may potentially invite World Trade Organization consideration in future years.

In the ATI arena, globalization is good for business. It speeds the process of standards and harmonization so essential to CNS/ATM architectures.

Global Consolidation, Merger & Acquisition Activity

A defining characteristic of the A&D sector over the recent past has been its consolidation. Causes derive from a combination of cost pressures, global opportunities and threats, shareholder demand for value, and need for access to key programs and technologies.

The A&D sector has traditionally pursued consolidation during down markets, most notably during the slump of the 1990s. In that downturn, the flip side of widespread consolidation was a decision by a large number of companies to exit, especially on the defense side. A few companies tried to migrate into commercial markets. The one strategy that did not succeed for A&D companies in the last downturn, however, was to "hunker down" and attempt to outlast the fall in demand by cutting costs and curtailing investment.

The industry has reduced to a few very large global players, a relatively small number of mid-tier companies still largely defined by their national roots, and a fragmented lower-tier of general or specialist suppliers. This shake-out has largely been driven by mergers and acquisition focused on key products and technologies.

In this respect, A&D is following the path of maturing industries. Industry consolidation follows a pattern through several phases over a definite period of time. For A&D, consolidation has been happening quickly. The largest Tier 0 and Tier 1 companies are building global capabilities around core capabilities; the mid-tiers are increasingly developing around technologies, services, or new markets; and the smaller companies are competing through agility or niche specializations.

All are impacted, to an extent, by the need to survive and thrive in this consolidating, merger-fueled environment:

- Buyers are required to pay premium prices due to the attractiveness of the A&D industry and the difficulty of finding suitable take-over targets.
- Potential targets are typically jockeying to position themselves for the future.
- Companies that cannot grow sufficiently, either organically or through acquisition, are diversifying into new offerings or markets.
- Companies that can grow are faced with post-merger integration challenges, requiring careful preparation, with attention to culture and people, technology and processes, and strong leadership.

M&A activity can be seen in the ATI arena. With the size of the market for CNS/ATM products, systems and services, one would expect to see continuing consolidation.

Transformational Technology Developments

The aerospace industry globally generates annual revenues of more than of $450 billion and employs millions of highly-skilled professionals. The sector is one of the most R&D-intensive, investing more than ten percent of its costs in research and development. Aeronautical technologies are a catalyst for innovation.

Due largely to a spillover effect from developments in many other sectors, the investments made in the aerospace industry are crucial to boosting competitiveness in other fields. It is well-known that some of the technology used in wind turbines comes from the aerospace industry.

Because the price of jet fuel continues to impact the ability for commercial airlines to make a profit, the introduction of new jet power plants which lower fuel consumption are an industry game changer. With a claimed fuel-efficiency savings in the range of approximately 15 percent, airlines are requesting that OEMs offer products incorporating these advances. New materials capabilities also bring such advances in aerospace structures.

The introduction of new space-based services also has a transformational impact. The Aireon space-based ADS-B program, along with developments led by Globalstar,

Company Name	HQ Country	Equipment	Systems and Integration	Support Services / Training	Facilities Management	Civil	Military	ATC/ATM Systems	ATI Communications	ATI Navigation	ATI Surveillance	Space Systems	Airborne Communications	Airborne Navigation	Airborne Surveillance	Airborne Other	Weather	Lighting	Other	Website
AACE Industries	USA	■				■				■				■					■	adriang.com/AACE-Industries/products.htm
AAI Corp. (Textron)	USA	■		■		■	■		■	■	■		■			■			■	www.aaicorp.com
Abacus Lighting	UK	■				■												■		www.abacuslighting.com
Accenture	Ireland		■	■		■	■												■	www.accenture.com
ACG Systems	USA	■		■		■	■						■			■			■	www.acgsys.com
ACSS, an L-3 Comms & Thales Co.	USA	■		■		■	■				■		■		■	■			■	www.l-3com.com
Adacel Systems	Australia	■	■	■		■	■	■	■	■	■					■			■	www.adacel.com
AdaCore	USA	■		■		■	■	■	■	■	■	■				■			■	www.adacore.com
ADB Airfield Solutions	USA	■	■			■				■								■		www.adb-airfield.com
ADS Aerospace Ltd.	UK	■				■							■			■				www.adsaerospace.com
Advanced Navigation & Positioning Corp.	USA	■				■	■	■		■	■			■	■					www.anpc.com
Advanced Technical Group, Inc.	USA	■		■		■	■				■				■	■			■	www.a-tg.com
Aeroflex Corporation	USA	■				■	■		■		■								■	www.aeroflex.com
Aerosup Inc.	USA			■		■				■						■			■	www.aerosup.com
Aerotronics, Inc.	USA	■		■		■							■	■					■	www.aerotronics.com
AGI	UK	■	■	■		■	■										■	■		www.agiltd.co.uk
AgiLynx Inc.	USA	■		■		■							■							www.agilynx.com
Ahr Aviation	USA	■		■		■							■							home.ahraviation.com
Air Comm Systems, Inc.	USA	■		■		■							■						■	www.aircommsys.com
Air Electro, Inc.	USA	■				■	■				■				■	■				www.airelectro.com
Airbus	France	■				■							■	■	■	■			■	www.airbus.com
Airbus Prosky	France			■		■		■					■						■	www.airbusprosky.com
AirCell, Inc.	USA	■				■							■							www.aircell.com
Airco Republic Electronics	USA	■				■	■							■		■				www.airco-international.com
Aircraft Engineering & Installation Services, Inc.	USA	■				■	■				■				■	■				www.aei.aero
Aircraft Specialists, Inc.	USA	■				■					■				■	■				www.asicharter.com
Aircraft Systems & Manufacturing, Inc.	USA	■				■								■	■	■				www.asminc.net
Air Sciences, Inc.	USA	■				■											■			www.airsci.com
Airod Sdn Bhd	Malaysia					■	■											■		www.airod.com.my/
Airservices Australia	Australia			■	■	■		■	■										■	www.airservicesaustralia.com
AirSport Avionics	USA	■				■					■				■	■				www.airsport-corp.com
Airtel ATN	Ireland		■			■	■		■											www.airtel-atn.com
Airways New Zealand	New Zealand			■	■	■		■	■										■	www.airways.co.nz
Alcatel-Lucent	France				■	■			■											www.alcatel-lucent.com
Alenia Aermacchi	Italy	■	■	■		■	■	■			■									www.aleniaaermacchi.it
Ales	Slovakia	■		■		■	■	■		■	■						■			www.ales.sk
Alifabs Design & Construction Ltd.	UK		■	■	■	■		■		■							■		■	www.alifabs.com
Allen Osborne Associates	USA					■														acquired by ITT Exelis
AMA Airfield Lighting Systems	India	■				■												■		www.amaindia.com/
Amphenol Fiber Systems International	USA	■				■	■		■				■							www.fibersystems.com
Antenna Research Assoc., Inc.	USA	■				■	■		■		■		■	■						www.ara-inc.com
APG Eastern Avionics Intl., Inc.	USA	■				■					■		■	■	■	■				www.apgavionics.com
Apptis Inc.	USA		■	■		■	■													www.apptis.com
ARINC Inc.	USA		■	■		■	■						■						■	www.arinc.com
Aselan Elektronik Sanayi Ve Ticaret A. A.S.	Turkey	■				■	■						■	■	■	■				www.aselsan.com.tr
ATAC Corporation	USA				■	■	■	■											■	www.atac.com
ATEC, Inc.	USA	■				■						■	■							www.atec.com
Athena Technologies Inc.	USA	■				■										■				acquired by Rockwell Collins
Austin Aerotech, Inc.	USA	■				■	■				■		■	■		■				www.austinaerotech.com
Austro Control	Austria	■		■	■	■		■												www.austrocontrol.at
AVCOM Avionics & Instruments, Inc.	USA	■				■					■		■	■	■	■				www.avcomtechnik.com
Aviation Advocacy	Switzerland			■		■														www.aviationadvocacy.aero
Aviation Data Systems	USA	■				■							■						■	www.avdat.com.au
AviBit Data Processing GmbH	Austria		■			■		■												www.avibit.com
Avidyne Corp.	USA	■				■	■				■		■	■	■	■				www.avidyne.com
Avionica, Inc.	USA	■				■	■						■		■					www.avionica.com
Avionicare Ltd.	UK	■				■	■	■			■		■		■	■				www.avionicare.com
Avionics & Aircraft Systems, Inc.	USA	■				■					■			■	■	■				www.avionicsaircraftsys.com
Avionics Mobile Services Ltd.	UK	■	■			■	■				■			■	■	■				www.avionics-mobile.co.uk
Avionics Place	USA	■				■							■	■	■	■				www.avionicsplace.com
Avitech AG	Germany	■	■			■	■		■	■										www.avitech.aero
AvReps Intl., Inc.	USA	■				■				■								■		www.av-reps.com
AZIMUT	Russia	■				■	■	■	■	■	■									www.azimut.ru/en/
B3 Solutions	USA	■				■													■	www.b3solutions.com
BAE Systems	USA	■	■	■		■	■	■	■	■	■		■	■		■			■	www.baesystems.com/
Barco	USA	■				■													■	www.barco.com
Barco Orthogon GmbH	Germany	■	■			■	■	■			■								■	www.barco-orthogon.com
Bechtel National	USA				■	■														www.bechtel.com
Becker Flugfunkwerk	Germany	■				■							■	■	■	■				www.becker-avionics.de
Beel Technologies Inc.	Canada	■				■					■									www.beeltech.com
Boeing ATM	USA		■	■		■		■	■	■	■		■						■	www.boeing.com
Boeing Company	USA	■				■							■	■	■	■			■	www.boeing.com
Bombardier	Canada	■				■							■	■	■	■			■	www.bombardier.com
Booz Allen Hamilton	USA			■		■													■	www.bah.com
Bosch Security Systems, Inc.	USA	■	■			■									■					www.boschsecurity.us
Broadcast Microwave Services, Inc.	USA	■				■	■		■				■							www.bms-inc.com
Brüel & Kjær EMS	Australia	■	■	■		■	■												■	www.bksv.com/EMS
Caledonian Airborne Systems	Norway	■				■	■						■		■					www.caledonian-airborne.com
California Radomes	USA	■				■								■	■	■				www.californiaradomes.com
Canard Aerospace Corp.	USA	■				■									■	■				www.canardaero.com
CAST Navigation, LLC	USA	■				■	■			■									■	www.castnav.com

Company Name	HQ Country	Equipment	Systems and Integration	Support Services / Training	Facilities Management	Civil	Military	ATC/ATM Systems	ATI Communications	ATI Navigation	ATI Surveillance	Space Systems	Airborne Communications	Airborne Navigation	Airborne Surveillance	Airborne Other	Weather	Lighting	Other	Website
CE Avionics, Inc.	USA	■				■					■				■	■				www.ceavionics.com
Cegelec	France	■		■		■												■	■	www.cegelec.com
Climatronics Corp.	USA					■											■			www.climatronics.com
CMC Electronics Inc.	USA	■				■	■									■				acquired by Esterline
Cobham Avionics	USA	■				■	■						■	■	■	■				www.cobham.com
Columbia Electronics Intl., Inc.	USA	■				■	■						■	■						www.columbiaelectronics.com
Columbia Weather Systems, Inc.	USA					■											■			www.columbiaweather.com
Comant Industries, Inc.	USA	■				■							■							acquire by Cobham
Computer Sciences Corp	USA		■	■		■	■	■											■	www.csc.com
Comsoft	Germany		■	■		■	■	■											■	www.comsoft.de
Cooper Crouse-Hinds	USA	■				■												■		www.cooperindustries.com
Corvallis Microtechnology	USA	■				■										■			■	www.cmtinc.com/
Crown Consulting	USA			■		■		■											■	www.crownci.com
CSSI	USA			■		■		■											■	www.cssiinc.com
CU Phosco Lighting	UK	■				■												■		www.cuphosco.com
Cubic Corp.	USA	■				■	■						■							www.cubic.com
Curtiss-Wright Controls	USA	■				■	■							■	■	■				www.cwcdefense.com
DAC International, Inc.	USA	■		■		■					■		■	■	■	■	■			www.dacint.com
Data Bus Products	USA	■				■	■						■							www.databusproducts.com
dB Systems, Inc.	USA	■				■	■			■	■				■			■		www.dbsant.com
Dittel Walter GmbH	Germany	■				■							■							www.dittel.com
DLE Luftfahrtservice	Germany	■				■										■				www.dle.de
DME Corp.	USA	■		■		■	■			■								■		www.dmecorp.com
DRS Technologies, Inc., Data Link	USA	■				■	■				■				■	■				www.drs.com
Ducommun, Inc.	USA	■				■	■				■	■			■	■				www.ducommun.com
Duncan Aviation	USA			■		■							■	■	■	■				www.duncanaviation.aero
DX Radio Systems, Inc.	USA	■				■							■	■						www.dxradiosystems.com
Dyersburg Avionics, Inc.	USA	■				■								■						www.dyersburgavionics.com
Dymeq Ltda.	Chile	■				■	■									■				www.dymeq.com
Dynamic Engineering	USA	■				■							■							www.dyneng.com
Dynamic Science, Inc.	USA			■		■		■											■	www.exodyne.com/dsi_home.php5
EADS	France	■	■	■		■	■	■											■	www.eads.com
EADS Astrium	France	■	■	■		■	■					■							■	www.astrium.eads.net
EADS Cassidian	Germany	■	■			■	■		■		■	■			■	■				www.eads.com
Earmark, LLC	USA	■				■							■							www.earmark.com
Egis Avia	France			■		■		■												www.egis-avia.com/
Elbit Systems Ltd.	Israel	■				■	■						■	■	■				■	www.elbitsystems.com
Elisra Group Systems	Israel	■		■		■	■						■	■						www.elisra.com
Embraer	Brazil	■				■	■						■	■	■	■			■	www.embraer.com
Embry Riddle Aeronautical U.	USA			■		■													■	www.erau.edu
Emcore Corp.	USA	■				■						■	■	■						www.emcore.com
EMS Aviation	Australia	■				■							■							acquired by Honeywell
ENSCO, Inc.	USA	■		■		■	■									■				www.ensco.com
Entry Point North	Sweden			■		■														www.entrypointnorth.com
ERA	USA	■	■	■		■	■	■	■		■			■	■				■	www.era.aero
Ericsson AB	South Africa	■				■							■							www.ericsson.com
Esterline	USA	■				■	■						■	■	■	■				www.esterline.com
Esterline CMC Electronics	Canada	■				■	■						■	■	■	■			■	www.esterline.com/avionicssystems
EUROCONTROL	Belgium		■			■		■	■	■	■								■	www.eurocontrol.int
European Satellite Services Provider	France			■		■						■	■	■						www.essp-sas.eu
Evans Consoles	Canada	■				■								■	■	■			■	www.evansonline.com
Execaire, Inc.	USA	■				■					■				■	■				www.execaire.com
Fernau Avionics	USA	■				■	■			■								■		www.moogfernau.com/
Finmeccanica	Italy	■	■	■		■	■	■	■	■	■	■	■	■	■	■			■	www.finmeccanica.com
Flatirons Solutions	USA			■		■	■	■											■	www.flatironssolutions.com
FlightSource International, Inc.	USA	■				■					■				■	■				aircraftcommerce.com
Format Aerospace, Inc.	USA	■				■					■				■	■				www.formataerospace.com
Freeflight Systems	USA	■				■	■							■		■				www.freeflightsystems.com
Frequentis	Austria	■	■	■		■	■	■	■	■	■		■						■	www.frequentis.com
Funkwerk Avionics GmbH	Germany	■				■		■			■				■	■				www.funkwerk-avionics.com
Furuno Electric	Japan	■				■									■				■	www.furuno.co.jp/en/
Gables Engineering, Inc.	USA	■				■	■				■		■		■	■				www.gableseng.com
Garmin International, Inc.	USA	■				■							■	■	■	■				www.garmin.com
GE Aviation	USA	■		■		■	■	■					■	■	■	■				www.geaviation.com
GE Capital Aviation Services	USA			■		■					■				■	■				www.gecas.com
General Dynamics C4 Systems	USA		■	■		■		■											■	www.gdc4s.com/
Global Weather Dynamics, Inc.	USA	■				■										■	■			acquired by Frequentis
Globalstar	USA		■			■						■							■	www.globalstar.com
Goodrich Corporation	USA	■				■	■				■	■	■		■	■				www.goodrich.com
Goodrich ISR Systems	USA	■				■						■	■							www.goodrich.com/isr
Gorman Aviation, Inc.	USA	■				■	■				■				■	■				www.gormanaviation.com/
GroupEAD	Spain			■		■													■	www.groupead.com
Gulfstream Aerospace, Inc.	USA	■				■	■				■				■	■				www.gulfstream.com
Harris Corporation	USA	■	■	■		■	■	■				■							■	www.harris.com
Herley Industries Inc.	USA	■				■	■						■							www.herley.com
Hi-Tec Systems	USA			■		■	■													www.hitecsystems.com
HNTB	USA				■	■														www.hitecsystems.com
Honeywell Aerospace	USA	■	■			■					■	■	■		■	■			■	www.honeywell.com
IAI Elta Systems Ltd.	Israel	■				■	■						■							www.iai.co.il
IBM Corporation	USA		■	■		■	■	■											■	www.ibm.com
ICF International	USA			■		■	■													www.icfi.com

Company Name	HQ Country	Equipment	Systems and Integration	Support Services / Training	Facilities Management	Civil	Military	ATC/ATM Systems	ATI Communications	ATI Navigation	ATI Surveillance	Space Systems	Airborne Communications	Airborne Navigation	Airborne Surveillance	Airborne Other	Weather	Lighting	Other	Website
ICG (International Communications Group)	USA	■				■							■							www.icg.aero
ICOM America, Inc.	USA	■				■							■							www.icomamerica.com
Icom UK Ltd	UK	■				■							■							www.icomuk.co.uk
IDS - Ingegneria Dei Sistemi SpA	Italy		■			■	■						■							www.idscompany.it
iJet Inc.	USA		■			■							■			■	■		■	www.ijetonboard.com
Indra	India	■	■	■		■		■	■	■	■					■			■	www.indracompany.com
INECO	Spain			■		■	■	■	■	■	■									www.ineco.com
Infotech Enterprises Limited	India	■				■	■								■	■				www.infotech-enterprises.com
Inmarsat	UK	■				■	■					■								www.inmarsat.com
Innotech Aviation Ltd.	Canada	■				■	■				■				■	■				www.innotechaviation.com
Innovative Concepts	USA	■				■							■						■	www.in-con.com
Innovative Solutions Intl., Inc.	USA	■				■	■						■							www.isicns.com
Intelcan	Canada	■	■	■		■	■	■	■	■	■									www.intelcan.com
Interscan Navigation Systems	Australia	■	■			■				■	■								■	www.interscan.com.au
Interstate Electronics Corp.	USA	■				■	■			■				■						www.iechome.com/
Intro Corp.	USA	■				■					■				■	■				www.introcorp.com
Intronics Power Inc.	USA	■				■	■			■								■		www.intronics.com
IPITEK	USA	■				■	■						■	■						www.ipitek.com
Iridium	USA		■			■	■				■	■							■	www.iridium.com
ITT Exelis	USA	■	■	■		■	■	■			■								■	www.exelisinc.com/
Jeppesen Sanderson	USA	■	■	■		■	■							■			■		■	ww1.jeppesen.com
Jet Source	USA	■				■										■				www.jetsource.com
Jotron PHontech AS	Norway	■				■	■						■							www.jotron.com
JRC	Japan	■				■							■	■	■					www.jrc.co.jp/
Kellogg Brown & Root	USA			■		■	■												■	www.kbr.com
Kings Avionics, Inc.	USA	■				■							■							www.kingsavionics.net
Kongsberg Defence & Aerospace	Israel	■				■	■						■							www.kongsberg.com
L-3 Communications Avionics Systems, Inc.	USA	■				■	■				■		■		■	■	■			www.l-3com.com
L-3 Vertex Aerospace	USA	■				■	■									■				www.l-3vertex.com
LAIC Aktiengesellschaft	Switzerland		■	■		■		■												www.laicatc.com
LCD Lighting, Inc.	USA	■				■	■				■				■	■				www.light-sources.com
LEMZ R&P Corp.	Russia	■	■			■	■	■	■	■	■						■			www.lemz.ru
Lockheed Martin	USA	■	■	■		■	■	■	■	■	■	■				■			■	www.lockheedmartin.com
Manairco, Inc.	USA	■				■				■								■		www.manairco.com
Megahertz Avionics, Inc.	USA	■				■					■				■	■				www.megahertzavionics.com
Meteorlogix	USA					■											■			acquired by Telvent
Metron Aviation	USA		■	■		■		■											■	www.metronaviation.com
Micro Nav Ltd	UK	■		■		■	■	■			■								■	www.micronav.co.uk
Microkim Ltd.	Israel	■				■							■							www.microkim.com
Midwest ATC Services	USA		■	■		■		■									■		■	www.atctower.com
Millennium Intl.	USA	■				■					■				■	■				www.avionics411.com
MITRE	USA			■		■	■	■	■	■	■		■	■	■	■			■	www.mitre.org
Morcom Intl. Inc.	USA	■				■	■		■				■				■			www.morcom.com
Muirhead Avionics	UK	■				■							■							www.muirheadavionics.com
NAT Seattle, Inc.	USA	■				■							■							acquired by Cobham
NATS (UK)	UK		■	■	■	■	■	■	■	■	■	■				■			■	www.nats.co.uk
NAV CANADA	Canada		■	■	■	■		■	■	■	■	■				■			■	www.navcanada.ca
NEXA Capital Partners	USA			■		■													■	www.nexacapital.com
NextGen Equipage Fund	USA			■		■													■	www.nextgenfund.com
Noblis	USA			■		■		■									■		■	www.noblis.org
Normarc	Norway	■				■	■		■	■	■								■	www.nfis.no/Normarc_FIS/Home.html
North Hills Signal Processing	USA	■				■							■							www.northhills-sp.com
Northern Airborne Technology Ltd.	Canada	■				■	■						■							www.northernairborne.com
Northern Lights Avionics, Inc.	USA	■				■										■				www.northernlightsavionics.com
Northrop Grumman	USA	■	■	■		■	■	■	■		■	■		■		■	■		■	www.ngc.com
NovAtel	Canada	■				■				■	■								■	www.novatel.com/
NTT Data Corporation	Japan		■			■			■											www.nttdata.com
Oracle	USA			■		■													■	www.oracle.com
Orbits Lightwave, Inc.	USA	■				■	■				■	■			■		■			www.orbitslightwave.com
Parker Hannifin Corp.	USA	■				■	■									■				www.parker.com
Paroscientific, Inc.	USA					■											■			www.paroscientific.com
Parsons Brinckerhof	USA				■	■													■	www.pbworld.com
Pentek	USA	■				■	■				■									www.pentek.com
PM Research, Inc.	USA	■				■	■						■							www.papa-mike.com
Priester Aviation	USA	■				■					■				■	■				www.priesterav.com
Racal Avionics	UK	■				■	■													www.racal-ltd.com
Radio Research Instrument Co., Inc.	USA	■				■	■				■						■			www.radiores.com
Raytheon	USA	■	■	■		■	■	■	■	■	■									www.Raytheon.com
REMF Avionics	France	■				■	■						■							www.avionics-remf.com
Riegl Laser Measurement Systems	USA	■				■					■									www.rieglusa.com
RMS Technology, Inc.	USA	■		■		■										■				www.rmstek.com
Robinson Aviation Services	USA			■		■													■	www.robinsonaviation.com
Rockwell Collins	USA	■	■			■	■						■	■	■	■	■		■	www.rockwellcollins.com
Rohde & Schwarz GmbH & Co. KG	Germany	■				■	■						■							www2.rohde-schwarz.com
Ross Engineering Corp.	USA	■				■				■								■		www.rossengineeringcorp.com
RVA, Inc	USA	■		■		■		■						■	■					www.rvainc.net
Saab Aviocomp Rias	Netherlands	■				■	■							■	■					jetsupport.nl
SAAB Sensis Corp	USA		■	■		■	■	■			■				■					www.saabsensis.com
Sabena Technics	France	■				■					■				■	■				www.sabenatechnics.com
Safe Flight Instrument Corp.	USA	■				■	■									■				www.safeflight.com
Sagem Defense Securite	France	■				■	■							■	■	■				www.sagem-ds.com

Company Name	HQ Country	Equipment	Systems and Integration	Support Services / Training	Facilities Management	Civil	Military	ATC/ATM Systems	ATI Communications	ATI Navigation	ATI Surveillance	Space Systems	Airborne Communications	Airborne Navigation	Airborne Surveillance	Airborne Other	Weather	Lighting	Other	Website
SAIC	USA		■	■		■	■	■											■	www.saic.com
Sandel Avionics	USA	■				■					■				■	■				www.sandel.com
Sandia Aerospace	USA	■				■								■	■					www.sandia.aero
Scandinavian Avionics AS	Denmark	■		■		■	■						■	■	■					www.scanav.com
SCHOTT North America, Inc.	USA	■				■	■			■				■		■		■		www.schott.com
SeaTec LLC	USA			■		■		■											■	www.seatecsite.com
Selex	Italy	■	■	■		■	■	■	■										■	www.selexelsag.com
Sensor Systems, Inc.	USA	■				■	■			■			■	■					■	www.sensorantennas.com
Serco	USA			■	■	■	■	■	■	■	■								■	www.serco-na.com
Shaw Group	USA				■	■													■	www.shawgrp.com
Siemens, Aerospace and Defense	Germany	■	■	■		■	■	■	■	■	■								■	www.plm.automation.siemens.com
Signatec Inc.	USA	■				■	■						■				■			www.signatec.com
SITA	Belgium		■	■		■							■						■	www.sita.aero
Southeast Aerospace	USA	■				■	■				■		■	■	■	■				www.seaerospace.com
Southwest Research Institute	USA	■		■		■	■						■							www.swri.org
Space Machine & Engineering Corp.	USA	■				■					■									www.space-machine.com
Specmat Technologies Inc.	USA	■				■								■		■				www.hr-smith.com
Spectra Precision	USA	■				■								■	■					www.ashtech.com
Spectralux Avionics	USA	■		■		■							■							www.spectralux.com
Squitter Electronics, Inc.	USA	■				■											■			www.squitter.com
SRA, International	USA	■	■	■		■	■	■				■			■	■				www.sra.com
Stambaugh Aviation, Inc.	USA	■		■		■					■				■	■				www.stambaughaviation.com
Stevens Aviation, Inc.	USA	■				■					■			■	■	■				www.stevensaviation.com
STR-SpeechTech Ltd. (STR)	Canada	■				■	■		■											www.speechtech.com
Technisonic Industries, Inc.	Canada	■				■	■						■							www.til.ca
TECOM Industries, Inc.	USA	■				■	■					■	■	■		■				www.tecom-ind.com
Teledyne Brown Engineering, Inc.	USA	■		■		■	■			■		■					■	■		www.tbe.com
Teledyne Controls	USA	■				■	■						■							www.teledynecontrols.com
Teledyne KW Microwave	USA	■				■				■	■									www.teledynekwmicrowave.com
Telephonics	USA	■	■			■	■	■		■			■	■	■					www.telephonics.com
Tellumat (Pty) Ltd	South Africa	■		■		■	■	■	■	■	■		■						■	www.tellumat.com
Tetra Tech	USA	■		■		■				■	■									www.amti.com
Textron	USA	■		■		■	■												■	www.textron.com
Thales ATM Navigation GmbH	Germany	■				■	■							■	■	■				www.thalesgroup.com
Thales ATM, Inc.	USA	■	■			■	■	■			■								■	www.thalesgroup.com
Thales Group	France	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■		■	www.thalesgroup.com
TIMCO Engineered Systems, Inc.	USA	■				■	■				■				■	■				www.timco.aero
Toshiba Lighting and Technology	Japan	■				■												■		www.tlt.co.jp/tlt/index_e.htm
Trimble Navigation Ltd.	USA	■				■	■							■						www.trimble.com
TSL	USA	■				■	■	■			■		■		■	■	■			www.tslinc.com
Ultra Electronics Airport Systems	UK	■	■		■	■										■			■	www.ultra-as.com
Universal Avionics Systems Corp.	USA	■				■		■					■	■	■	■				www.uasc.com
Universal Weather and Aviation, Inc.	USA	■	■			■											■			www.universalweather.com
URS/Apptis	USA		■	■		■	■	■	■	■									■	www.apptis.com
Vaisala, Inc.	USA	■				■		■									■			www.vaisala.com
ViaSat, Inc.	USA	■		■		■	■					■	■							www.viasat.com
Voltarc Technologies, Inc.	USA	■				■				■								■		www.light-sources.com
Warren-Knight Instrument Co.	USA	■				■	■							■			■			www.warrenknight.com
Washington Consulting Group	USA			■		■		■											■	www.washcg.com
Western Avionics	Canada	■				■				■								■		www.westernavionics.com
WIDE	Korea	■				■		■											■	www.widecorp.com
WSI	USA	■		■		■		■				■					■		■	www.wsi.com
Young Co., RM	USA	■				■											■			www.youngusa.com
Zeiss, Carl	Germany	■				■										■				www.zeiss.com
Zodiac Data Systems	France	■				■	■			■		■		■					■	www.zds-fr.com/en/

promise new and significant economic benefits to operators. The SESAR Joint Undertaking, the technological component of the so-called Single European Sky, which aims to reform the current ATM system, is also driven by technological innovation.

Finally, the growth in UAVs promises to make significant and transformational impacts on military and even commercial markets.

5.1.3 Industry Sector Factors

Program Management Challenges

In recent years, virtually every segment of the A&D industry has suffered calamitous difficulties in the execution of major programs. No segment—neither large commercial aircraft, nor military spacecraft, nor naval surface combatants—has been immune from costly program failures. Many analysts attribute these failures to management errors, lack of self-discipline among customers, systems integration issues, or shortages of skilled labor. But we believe this spate of failures has a systemic cause, namely, the increasing obsolescence of traditional approaches to program and risk management, given the evolving structure of the A&D industry.

Intensifying Cost Pressures

Aerospace companies must position themselves for substantial changes to avoid the "death spiral" of rising costs and decreasing demand. Expensive defense programs that face large cost overruns and scheduling delays are at risk. Contractors must develop a demonstrable affordability strategy not only to survive, but also to find opportunity amid new defense spending priorities. Getting on a path to affordability, however, requires a fundamental rethinking of operating models and economics if companies are to successfully operate at lower production rates. All elements of cost—direct labor, material, and overhead—must be addressed in a comprehensive manner to create more affordable alternatives for customers.

5.1.4 ATI Companies and Principal Products, Systems, and Services

The adjacent table lists the principal industrial players in the global ATI sector. Most fall squarely within the definition of aerospace and defense. Most also consider their ATI products, systems and services a single line of business which accounts for a percentage of the company's total revenues. Each is listed by the following attributes:

- Sector tier(s).
- Headquarter country.
- Principal activities: equipment manufacturing, systems and integration, support services and training, and facilities management.
- Civil and/or military and defense offerings.
- Ground ATI/ATM focus: systems, communications, navigation, surveillance, and space.
- Airborne focus: communications, navigation, surveillance, or other.
- Weather, lighting or other specializations.
- Website.

Key Points:

- The ATI supply chain falls within the broader aerospace and defense industry, as the Tier 1 large scale integrators show.
- Optimism for commercial aerospace growth is offset by caution for global defense contraction.
- Major economic and political factors that raise concerns for ATI are led by global debt levels and government fiscal challenges.
- Growth in commercial aircraft orders can be significantly dampened if new ATI is not quickly installed in many parts of the world.

5.2 Supply Chain Model

A supply chain is the network of businesses involved in the ultimate provision of products and services required by an end customer. It includes the organizations, people, technology, activities, information, and resources involved from the movement and storage of component materials through to the delivery and consumption of finished goods, systems, and services.

5.2.1 Mapping

Supply chain maps are representations of the flows of information, processes, and money between companies both upstream and downstream in the supply chain.

- "Upstream" refers to those suppliers that supply an organization with goods or services to move the capability further downstream.
- "Downstream" refers to the organizational or individual buyers at the next stage of the process, ending with end customers.

The aerospace supply chain and its sector-specific components share a common taxonomy that groups suppliers at different levels of the chain into tiers based on their size and proximity to the end customer in the flow of goods and services. This taxonomy begins with the end customer at Tier 0 and continues as follows:

Tier 0 (End Customers and Stakeholders)

These are the downstream organizations and groups, and at times stakeholders, who receive value in exchange for the procurement of products, systems and services from within the specific supply chain identified.

Tier 1 (Integration Suppliers)

Tier 1 is comprised of commercial integration suppliers of products, systems, and services to the Tier 0 customers and indirectly, stakeholders. The Tier 1 commercial suppliers take responsibility for integration of a wide range of upstream component products, systems, and services that produce downstream benefits.

Tier 2 (System Suppliers)

The Tier 2 system suppliers produce component products, systems, and services that the Tier 1 integration suppliers need to complete their deliverables. In this study, the companies provisioning space-based systems, are considered Tier 2.

Tier 3 (Component Suppliers)

This group is made up of the companies that provide subsystems and components to the Tier 2 suppliers. In some cases, companies generally considered to be in Tier 2 may also play roles as Tier 3 suppliers. These can also include specialist software developers or software program companies.

Tier 4 (Core Technology and Materials Suppliers)

This group also includes the R&D units of Tier 1, 2, and 3 companies as well as commercial entities producing sub-components, sub-systems, raw materials, and related Tier 4 services to support all downstream tiers.

Suppliers can participate in multiple tiers at the same time.

The supply chain taxonomy has shifted in the last decade or so by several key drivers:

- **Industry verticalization and cross-tier consolidation**: The tiers have seen certain players move up or down the tier structure, and at times (or as a practice) occupy two tiers.
- **Technology advances:** Increased technological complexity of modern aircraft avionics have given rise to the need for new approaches for installation, service delivery, training, and the like.

The largest Tier 1 CNS/ATM providers have been busy trolling the lower tiers to acquire businesses with new technologies, capabilities, and customers. Coming the other way, this also extends to ANSPs (Tier 0 customers), some of whom have chosen to compete in automation markets for CNS/ATM businesses, such as the traditional automation venues of Raytheon, Lockheed Martin, and others (e.g. Airservices Australia, NAV CANADA, etc.).

The increasing complexity of modern aircraft, particularly with regards to the use of computerized and automated devices to monitor and control large and small components, creates new certification challenges. Aircraft today, from Airbus and Boeing aircraft to the newest general aviation aircraft, often are referred to as systems of systems, and their OEMs — as integrators of those systems — are described as prime contractors rather than Tier 1 suppliers. Designations of subsequent levels of suppliers likewise are revised (with Tier 2 suppliers designated Tier 1, and so forth). Both the current and former taxonomies are evident in literature about the aerospace supply chain and may cause some confusion. Which version is in use can be determined by starting with the identification of the tier (prime contractor or Tier 1) that delivers the completed good or service to the end customer. (The term OEM itself can be confusing. Widely used to refer to aircraft makers, it also is used in reference to airworthiness oversight as a term for the original manufacturer of any component — power plants, landing gear, flight controls, CNS avionics, etc.).

Key Points:

- Tier 1 suppliers, generally large scale integrators, have the size and means to dominate the ATI business in mature economies; however, this is not the case in many smaller markets.
- Tier 0 customers are increasingly entering the traditional Tier 1 space. Examples include Airservices Australia and NAV CANADA.
- The largest Tier 1 CNS/ATM providers have used M&A resources to acquire new capabilities, technologies and customers.

5.3 CNS/ATM Ground and Space Systems Supply Chain

Figure 5-3

Supply Chain for Ground and Space-Based ATI Providers:
Significant Global ATI Developments and Challenges, and Dominant Players

	Upstream			Downstream		
				Customers and Stakeholders		
	Tier 3	*Tier 2*	*Tier 1*	*Tier 0 Direct*		*Tier 0 Indirect*
	CNS/ATM Subsystems & Components CNS/ATM Software Pro-grams/services Training and Support Logistics	CNS/ATM Automation Systems Info/Comm Integration Services Space Infrastructure	CNS/ATM Ground and Space Based Infrastructure Providers	ANSPs, FAA, Eurocontrol Airports Sovereign States	Passenger and Cargo Airlines Domestic and International Regulators Infrastructure Funds and Banks	Passengers Taxpayers and Legislators Other Stakeholders
Key ATI Develop-ments Affecting Supply Chain	• Higher level component integration • Hardware, software and system certification, complexity and cost	• Emergence of space based CNS platforms • New operating models for major CNS systems • Consolidation • M&A activity • Introduction of project finance into contract bidding and program schedules	• **Deficits and status of government infrastructure and finance** • **Increased reliance upon space based CNS platforms** • **Acceleration in facility consolidation** • **Integration scale between NextGen CNS ground/air and space systems** • **Tier 0 customer migration into Tier 1 systems, products and services** • **Use of innovative infrastructure finance tools, structures and sources**	• Increasing reliance upon user fees • Capacity limitations in most congested facilities • Complexity of new systems • Facility consolidation and political fallout	• Oil price volatility • Equipage mandates • Harmonization and overlap of new and old systems	• Travel delays attributable to crumbling or outdated infrastructure • Environmental impacts
Key ATI Challenges Facing Supply Chain	• Software certification	• Subsystem and software certification • Commercial data links and suitability for flight critical applications	• **Acceleration in technological complexity** • **Future certification of coupled ground/air systems** • **NextGen standards continue evolving** • **Project financing**	• ANSP readiness to address NextGen and avionics • Revenue securitization • User fees	• Closing the airline business case for NextGen/SESAR • Cost of modernization and financing	• Financing sources
Dominant Players	• Metron • NavCanada	• Space infrastructure: Iridium, Globalstar, Inmarsat, Intelsat. • Ground infrastructure: Raytheon, Lockheed Martin, Harris	• **Raytheon** • **Lockheed Martin** • **Thales ATM** • **Northrop Grumman** • **ITT Exelis** • **Harris** • **Finmeccanica** • **Siemens**	• NextGen leading: EUROCONTROL, NavCanada, FAA, UKNats	• NextGen Leading: UA/CO, AK, JB, Fedex, UPS • SESAR Leading: LH, AF. • Financing: NextGen Fund, LLC	• Proactive: CANSO, RTCA, Eurocae
Emerging Players			• **Iridium/Aireon** • **Metron** • **Saab Sensis** • **Airbus Prosky** • **Boeing ATM**			

Source: NEXA Advisors analysis

This segment of the supply chain represents hundreds of companies offering products, equipment, systems, and services that constitute the traditional CNS/ATM market place.

Tier 0 customers in this segment are led by ANSPs, the FAA, EUROCONTROL, their sovereign states, and certain airports. Indirect Tier 0 customers and stakeholders include passenger and cargo airlines, regulators, and financial institutions. Increasingly, Tier 0 indirect customers and stakeholders, such as passengers and users of cargo business, taxpayers, and legislators, are having more say in terms of overall segment performance and outcomes.

5.3.1 Supplier Tiers

We discuss major considerations of the top three tiers of the CNS/ATM ground and space systems supply chain. See Figure 5-3 for a summary of this supply chain and its integrated relationships.

Tier 1

The world's Tier 1 CNS/ATM ground and space systems integration suppliers are more often significant divisions of aerospace companies having proven capabilities in large scale integration.

- **Raytheon**: (NYSE: RTN) Raytheon Company is a major American defense contractor and industrial corporation with core manufacturing concentrations in weapons and military and commercial electronics and systems. Raytheon is the world's largest producer of guided missiles. Established in 1922, the company reincorporated in 1928 and adopted its present name in 1959. The company has 72,000 employees worldwide and annual revenues of approximately $25 billion. More than 90 percent of Raytheon's revenues are obtained from military contracts, and today it is the fifth-largest military contractor in the world and the fourth largest defense contractor in the US, by revenue. Raytheon Headquarters was moved from Lexington, Massachusetts to Waltham, Massachusetts in 2003.

  With a sixty-year history in the CNS/ATM sector, this company designs, manufactures, and services a full line of modern CNS/ATM systems and products for civil and military applications around the world. Raytheon provides modern open architecture air traffic management systems, GPS-based navigation and landing systems, and modern solid state digital primary and secondary surveillance systems. Raytheon's range of products and services scale from small airport systems to gate-to-gate national air traffic management systems. Raytheon systems are operationally controlling air traffic in more than 50 countries and on every continent, with operational systems in such large airports as Houston, Miami, Boston, Hong Kong, Frankfurt, and Amsterdam. Raytheon has an extensive software development capability and is an industry leader in Software Engineering Institute (SEI) and ISO Software Institute awards and capabilities. Raytheon provides complete ATM capability, including ATM systems to control aircraft; develops precision landing systems to help land aircraft; and provides training and maintenance for ATM systems and air traffic controllers. It has a wide breadth of equipment, systems integration, services, support, and experience in air traffic management. The air traffic automation systems portion of Raytheon's business includes the AutoTrac™ family of open architecture ATM systems with fully integrated surveillance and flight data processing systems, including AutoTrac III, a next generation ATM system.

- **Lockheed Martin**: (NYSE: LMT) Lockheed Martin is a US aerospace, defense, security, and advanced technology company with worldwide interests. It was formed by the merger of Lockheed Corporation with Martin Marietta in March 1995 and is headquartered in Bethesda, Maryland, in the Washington metropolitan area. Lockheed Martin employs 123,000 people worldwide and is one of the world's largest defense contractors. Today, 74 percent of Lockheed Martin's revenues came from military sales, and it received eight percent of the total funds paid out by the Pentagon for equipment. Lockheed Martin operates in four business segments. These comprise, with respective percentages of 2009 total net sales of $45.2 billion, Aeronautics (27 percent), Electronic Systems (27 percent), Information Systems & Global Solutions (27 percent), and Space Systems (19 percent). In 2010, US government contracts accounted for $38.4 billion (85 percent), foreign government contracts $5.8 billion (13 percent), and commercial and other contracts for $900 million (two percent). In both 2009 and 2008, the company topped the list of US federal contractors.

This company has a significant US presence in CNS/ATM and is gaining an increasing footprint throughout the world. More than 60 percent of the world's air traffic and 80 percent of the world's managed oceanic airspace are guided by Lockheed Martin systems. Oceanic routes managed by the US FAA use the Lockheed Martin Ocean 21 system as part of the advanced technologies and oceanic procedures (ATOP) initiative. FAA oceanic air traffic controllers depend on this system to reduce air separation between flights and enable airlines to reduce fuel and emissions on many oceanic flights. In the NextGen arena, Enroute Automation Modernization (ERAM) is an FAA initiative for which Lockheed Martin is the prime contractor. ERAM is replacing the FAA's enroute air traffic control automation system, housed at the 20 FAA Air Route Traffic Control Centers to control aircraft flying at altitudes above 10,000 feet. ERAM accommodates increased air traffic and is capable of housing new innovations. As the platform for NextGen initiatives, ERAM uses open, standards-based software in a highly secure system architecture, and will serve as the backbone of the NAS, processing flight radar data, providing communications support, and generating display data to air traffic controllers. Using ERAM, controllers at the Air Route Traffic Control Centers will be able to track 1,900 aircraft at a time, instead of the current 1,100. Among key ERAM technologies is an end-to-end, four-dimensional trajectory model that predicts the path of each aircraft in time and space.

- **Thales Group:** (Euronext: HO) Thales Group is a French multinational company that designs and builds electrical systems and provides services for the aerospace, defense, transportation, and security markets. The headquarters are in Neuilly-sur-Seine (in the suburbs of Paris), and its stock is listed on the Euronext Paris. The company changed its name to Thales from Thomson-CSF in December 2000 shortly after the £1.3 billion ($1.59 billion) acquisition of Racal Electronics plc, a UK defense electronics group. It is partially state-owned by the French government and has operations in more than 50 countries. It has 68,000 employees and generated €13.03 billion ($15.99 billion) in revenues in 2011. The group is ranked as the 475th largest company by Fortune 500 Global, and is the 11th largest defense contractor in the world with 60 percent of its total sales to the military.

  Thales Air Traffic Management, a business unit, uses the product designation TopSky/ATM Solutions, an automation product portfolio consisting of TopSky/ATC, TopSky/Tower, TopSky/ATFM, TopSky/Simulation and TopSky/AIM. Thales states that these products can integrate many recent technological developments, such as ADS-B data arising from both the SESAR and NextGen modernization programs, with radar data. Thales is also heavily involved in the SESAR Joint Undertaking.

- **Harris Corporation**: (NYSE: HRS) Harris is an international communications and information technology company serving government and commercial markets worldwide. Headquartered in Melbourne, Florida, the company has approximately $6 billion in annual revenue and more than 16,900 employees — including nearly 7,000 engineers and scientists.

  Harris has staked out CNS/ATM as an important market and is currently a major LSI for the US FAA. The FAA FTI network provides critical voice, data, and video communications for agency operations and mission support functions. FTI connects over 4,500 national and international FAA and DOD facilities, manages 22,000 services, and supports some 50,000 users. Harris also provides CNS/ATM solutions in Voice Switching and Control System (VSCS), VSCS Training and Backup Switch (VTABS), the Alaskan NAS Interfacility Communications System

(ANICS), Weather and Radar Processor (WARP) Maintenance and Sustainment, the Alaskan Satellite Telecommunications Infrastructure (ASTI) Liberty-STAR Voice Communications System, and the Crash Alarm and Red Telephone (CART).

- **Northrop Grumman:** (NYSE: NOC) Northrop Grumman is an American global aerospace and defense technology company formed by the 1994 purchase of Grumman by Northrop. The company was the fourth-largest defense contractor in the world as of 2010, and the largest builder of naval vessels. Northrop Grumman currently employs over 72,500 people in the US. Its 2011 annual US revenue was reported at $25.6 billion. Approximately 80 percent of its revenues are from military customers. Northrop Grumman ranked 72nd on the 2011 Fortune 500 list of America's largest corporations and ranks in the top ten military-friendly employers. It is headquartered in Falls Church, Virginia.

  Northrop provides significant equipment, systems, and services to the US military as well as foreign militaries in air traffic control and related command and control systems. Northrop Grumman has been a major provider of voice and data switches and related logistics support services to the FAA over the past 30 years, with more than 2,000 systems delivered both domestically and internationally. Denro Systems, a division of Northrop, provides communications switching and recording equipment and services for the FAA's ATC towers, terminal radar approach control facilities, and automated flight service stations.

- **Finmeccanica**: (BIT: FNC) Finmeccanica S.p.A. is an Italian conglomerate, and is the second largest industrial group as well as the largest of the hi-tech industrial groups based in that country. It operates in seven sectors: Aeronautics, Helicopters, Space, Defense and Security Electronics, Defense Systems, Energy, and Transportation. The company has offices in over 100 countries. It is partially owned by the Italian government, which holds about 30 percent of Finmeccanica's shares. In July 2003, Finmeccanica and BAE Systems announced their intention to set up several joint venture companies, collectively known as Eurosystems. In March 2007, BAE Systems sold its 25 percent share of SELEX Sensors and Airborne Systems to Finmeccanica for €400 million ($490 million). SELEX S&AS now operates as SELEX Galileo following a merger with Galileo Avionica S.p.A., another Finmeccanica company, in January 2008. In 2011, Finmeccanica had revenues of approximately $18.7 billion and about 72,000 employees worldwide.

  SELEX Systems Integration, Inc., a Finmeccanica Company, is a supplier of advanced, ground-based CNS/ATM systems to the air transportation industry. Its systems are used by commercial and military agencies to support aircraft operations during all phases of navigation, landing, and surface movement. SELEX designs, manufacturers, implements, and supports its systems around the world.

While there are approximately 60 companies that perform large scale systems integration in the CNS/ATM ground systems segment, the above companies are the largest and most capable of the group.

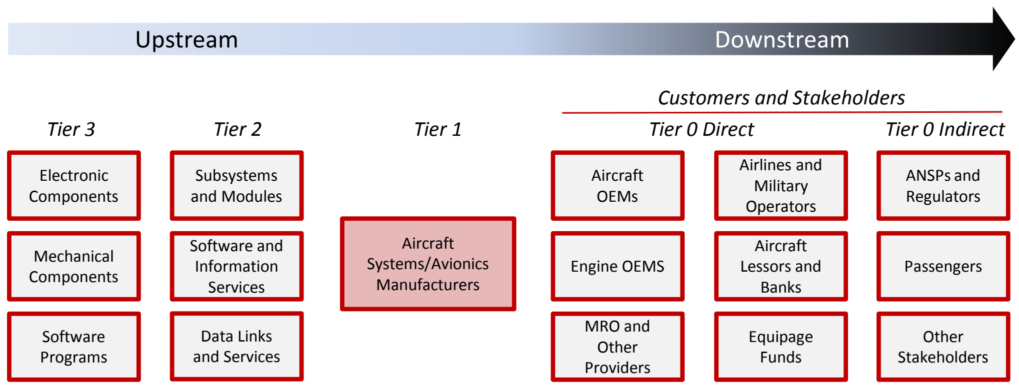
5.3.2 Key Developments and Challenges Affecting CNS/ATM Ground and Space Systems Supply Chain

The key developments affecting the CNS/ATM ground and space-based infrastructure providers evolve around shifting customer conditions and priorities, competition and technology.

ANSPs are beginning to place increased reliance upon space-based CNS platforms. GPS is central to the cause, as will be Galileo and other satellite navigation systems. Space-augmented GPS using WAAS and EGNOS is a further example. Major plans are underway to implement ADS-B surveillance for oceanic and underserved continental

Figure 5-4

Supply Chain for Commercial Aircraft Systems/Avionics Manufacturing and Support Providers: Significant Global ATI Developments and Challenges, and Dominant Players



	Tier 3	Tier 2	Tier 1	Tier 0 Direct	Tier 0 Direct	Tier 0 Indirect
Key ATI Develop-ments Affecting Supply Chain	• Higher level component integration • Lower power and higher reliability design opportunities • Miniaturization • Improved reliability • Lower component costs- automotive supply chain volumes	• New/cost effective satellite services, models and options • Connectivity between subsystems • Advanced navigation subsystems • NextGen-specific subsystems • Real time (non-ATC) operations centers • Commercial data link services	**• Integration scale between NextGen CNS ground/air systems** **• Transition to higher bandwidth connectivity for safety and non-safety critical systems** **• Next generation electronic flight bags** **• Open platform architectures and software apps**	• NextGen Capabilities • Connectivity at the CNS and ATM levels • Reduction in AOG due to improved serviceability of aircraft systems • Streaming maintenance data • 3rd party operator outsourced services	• Cost-effective retrofit programs • Improved asset utilization and ROA • Fuel savings • Flight schedule and network restoration • Remote refresh • AOG reduction • Improved residual aircraft asset values • Special purpose aircraft systems and avionics financing companies	• Ability to deliver ground ATC infrastructure to timely match aircraft capabilities • Performance trends that restore operator schedule & reliability • Connectivity and FOQA • RT black boxes • In flight entertainment
Key ATI Challenges Facing Supply Chain	• Certification of highly integrated miniature components • Economic returns of highly integrated components • Intellectual property and disputes	• Subsystem and software certification • Commercial data links and suitability for flight critical applications	**• Absorption of data links and information services into product mix** **• NextGen standards continue evolving** **• Future certification of coupled ground/air systems**	• ANSP readiness to address NextGen and avionics • Lack of GPS templates • New types of inventory pools	• Closing the airline business case for NextGen/SESAR • Predominant equipage • New equipage securitization models	• Air/ground functional integration • Need to time aircraft retrofit programs with advanced ground ATC capabilities
Dominant Players		• Sensors: L-3 • Comm: Iridium	**• Rockwell Collins** **• Honeywell Aerospace** **• L-3/ACSS** **• Thales** **• Esterline** **• Garmin** **• Canadian Marconi**	• In order: Airbus, Boeing, Embraer, Bombardier • Rolls Royce, GE Engines, Pratt & Whitney	• NextGen Leading: UA/CO, AK, JB • SESAR Leading: LH, Etc. • Financing: NextGen Fund, LLC • Emerging infrastructure banks	• Proactive: CANSO, ICAO, FAA, NavCanada, UKNats, Eurocontrol • RTCA • Eurocae
Emerging Players		• Accord Technologies • Novatel	**• iJet Technologies, Inc.** **• Universal Avionics**	• MRO integrators		

Source: NEXA Advisors Analysis

regions with the Iridium/Aireon system, financially backed by NAV CANADA and other ANSPs.

- Potential exists for ANSPs everywhere to consolidate major air traffic facilities using new technologies and communications infrastructure capabilities that until this past decade were not practical. While automation systems and capabilities improve, the politics of labor have led to complications and practical limitations in what can be made redundant.

- The financial status of the principal Tier 0 customers able to invest in ground and space-based CNS/ATM infrastructure is beginning to hurt plans for investment. Stability of funding and revenue is a hallmark of infrastructure finance. Increasingly, creative financing structures utilizing PPPs and securitized contract or user revenues are being seen. The use of innovative infrastructure finance tools will have a positive effect on modernization and is noted in this study as a positive development.

- Integration scale and the inter-relationships between aircraft and ground/space CNS/ATM is further complicating long-term infrastructure investment decision-making. This study finds that airlines, frustrated by rates, charges, and large demands placed upon them to invest in modern CNS/ATM cockpit avionics, are asking tough questions of the ANSPs servicing their airspace.

- Competition for the business of ground and space-based air traffic infrastructure is emerging from Tier 0 customers. For example, NAV CANADA is competing against traditional industry players and is teaming with US companies to bid on FAA opportunities such as TFDM (Tower Flight Data Manager.).

5.4 CNS/ATM Avionics Supply Chain

This segment of the supply chain represents a large number of avionics and related service offerings that constitute the traditional marketplace. Tier 0 customers in this segment are led by commercial air transport, business aviation, and general aviation aircraft manufacturers. Indirect Tier 0 customers and stakeholders include jet and turboprop engine manufacturers, MRO providers, airlines, militaries, and other operators. Increasingly, Tier 0 indirect customers and stakeholders include aircraft lessors and banks, equipage funds (NextGen Fund), and the like. These stakeholders are having more influence in CNS/ATM investment decision-making.

5.4.1 Supplier Tiers

See Figure 5-4 for a summary of the CNS/ATM avionics supply chain, and key issues and developments affecting it.

Tier 1

The Tier 1 avionics suppliers are dominated by several manufacturers, notably Rockwell Collins, Honeywell, and Thales. However, other manufacturers, such as L-3 Communications, Esterline, and Garmin have made inroads as innovative, agile suppliers to aviation segments such as business jets, and aspire to more deeply penetrate the air transport segment.

Customers and stakeholders for this supply chain are dominated by the airlines, and by OEMs of transport category aircraft including Airbus and Boeing, which account for the vast majority of the Western air carrier fleet. Other Tier 1 suppliers are the regional jet manufacturers Bombardier and Embraer, the regional turboprop consortium ATR, and makers of niche aircraft such as Gulfstream and Dassault. Increasingly, the engine OEMs are becoming important as so much cost and value are tied to the power systems, and digitalization of the cockpit brings new opportunity and perspective to these suppliers.

- **Honeywell Aerospace**: (NYSE: HON) Honeywell Aerospace is the world's largest manufacturer of aircraft engines and avionics, as well as a producer of auxiliary power units (APUs) and other aviation products for commercial air transport aircraft. Headquartered in Phoenix, Arizona, it is a division of the Honeywell International conglomerate, and generates approximately $10 billion in annual revenue (of Honeywell International's roughly $37 billion) from an even mix of commercial and defense revenues. Today Honeywell produces space equipment, turbine engines, auxiliary power units, brakes, wheels, synthetic vision, runway safety systems and a broad range of CNS/ATM avionics. Honeywell is deeply involved in the US NextGen program and Europe's SESAR program for advancing avionics.

  In commercial air transport, Honeywell has a history of providing reliable avionics and mechanical products for airlines. Its avionics can be found on virtually every type of commercial aircraft in use in most regions of the world. Honeywell continues to apply advanced technological expertise to develop CNS/ATM-based avionics solutions that increase pilot and crew efficiency, maximize aircraft performance, decrease operating and maintenance costs, and reduce fuel consumption.

- **Rockwell Collins**: (NYSE: COL) Rockwell Collins, Inc. designs, produces, and supports communications and aviation electronics for commercial and military customers worldwide. With revenues of approximately $4.8 billion and 21,000 employees, it operates in two segments, Government Systems and Commercial Systems. The Government Systems segment provides communications systems and products to enable the transmission of information, including satellite communications; navigation products and systems, such as radio navigation products, global positioning system equipment, handheld navigation devices, and multi-mode receivers; subsystems for the flight deck that include flight controls and displays, information/data processing and communications, navigation, safety, and surveillance systems; cockpit display products consisting of multipurpose flat panel head-down displays, wide field of view head-up and helmet-mounted displays; and simulation and training systems comprising visual system products, training systems, and services.

  The Commercial Systems segment supplies aviation electronics systems, products, and services, including integrated avionics systems, integrated cabin electronics systems, navigation systems and products, situational awareness and surveillance systems and products, electro-mechanical systems, simulation and training systems, on-board information management systems and connectivity solutions, airborne and ground applications and services, and ground infrastructure and services. The company also provides maintenance, repair, parts, and after-sales support services. It serves various customers, including the US DOD, the US Coast Guard, civil agencies, defense contractors, foreign ministries of defense, manufacturers of commercial air transport, business and regional aircraft, commercial airlines, and fractional and other business jet operators. Rockwell Collins is headquartered in Cedar Rapids, Iowa.

  Rockwell Collins has been at the nexus of CNS/ATM developments for years. The company has a wide range of available CNS technology for commercial aircraft, with leading-edge cockpit electronics for OEMs, such as its Proline Fusion avionics system. Recently, Rockwell Collins completed one of the most monumental CNS projects to date — the $750 million KC-135 GATM (global air traffic management) project. A total of 417 US Air Force KC-135 refueling tankers, most of them approaching 50 years in age, were upgraded with new avionics electronics to allow CNS operations.

- **L-3 Communications**: (NYSE: LLL) L-3 Communications Holdings, Inc. is a company that supplies command and control, communications, intelligence, surveillance), and reconnaissance (C3ISR) systems and products, avionics, ocean products, training devices and services, instrumentation, space, and navigation products. It has revenues of approximately $15 billion and employs 51,000 people. Its customers include the Department of Defense, Department of Homeland Security, US government intelligence agencies, NASA, aerospace contractors, and commercial telecommunications and wireless customers. L-3 is headquartered in New York City and was formed from the purchase of ten former Lockheed Corporation business units when Lockheed merged in 1996 with Martin Marietta.

  ACSS is a joint venture company of L-3 Communications and Thales. ACSS is responsible for the design, manufacture, and support of commercial avionics products, and handles sales to regional airline, business aviation, general aviation and military customers. Thales Avionics is the exclusive sales and support agent of ACSS products to commercial air transport customers operating Airbus and Boeing aircraft. Today ACSS is a leader in safety-related avionics systems that increase safety, situational awareness, and efficiency for commercial and military flight operators. Products include TCAS traffic alert and collision avoidance systems; MASS, a family of Mode S transponders; and TAWS. The ACSS portfolio also includes a set of ADS-B solutions called Safe-Route™. More than 75,000 ACSS products are operating in commercial, corporate, and military aircraft. ACSS is very active in CNS/ATM forums and is expected to provide innovative product and systems solutions over the coming decade to airlines and military customers.

- **Thales Group:** (Euronext: HO). See the description of this company in Section 5.3.

- **GE Aviation**: (NYSE: GE) A subsidiary of General Electric, GE Aviation is one of the world's largest producers of commercial air transport systems, with emphasis on large and small jet engines for commercial and military aircraft. It provides aviation services, supported by continuing investments in research and development. GE Aviation is a major provider of integrated CNS/ATM systems for commercial and military aircraft. Through expertise in avionics, electrical power, actuation and landing gear, structures, and propellers, GE offers a range of systems critical to aircraft performance and customer services tailored to maximize aircraft availability. Products include power supplies, data acquisition systems, cockpit lighting, engine health and usage monitoring systems, and flight management systems. GE Aviation is a leader in performance-based navigation in CNS/ATM. Airlines globally are beginning to adopt PBN strategies to save fuel, reduce emissions, reduce flight time, improve safety, and fight airspace congestion.

- **Esterline**: (NYSE: ESL) Esterline Technologies Corporation designs, manufactures, and markets engineered products and systems for aerospace and defense customers in the US and internationally. Total revenues are approximately $1.9 billion, and the company employs about 12,100 personnel. The company operates in three segments: Avionics and Controls, Sensors and Systems, and Advanced Materials. The Avionics and Controls segment provides global positioning systems, head-up displays, enhanced vision systems, and electronic flight management systems for control and display applications. It also develops, manufactures, and markets technology interface systems, including lighted push-button and rotary switches, keyboards, lighted indicators, panels, and displays; and control sticks, grips, and wheels, as well as switching systems. In addition, this segment offers keyboards, keypads, and input devices that integrate cursor control devices, bar-code scanners, displays, video, and voice activation; instruments for point-of-use and point-of-care in vivo diagnostics; and military personal communications equipment. The Sensors and Systems segment manufactures precision temperature, pressure, and speed sensors; electrical interconnection systems; and electrical power switching, control and data communication devices, and other related systems. The Advanced Materials segment manufactures elastomer products for a range of commercial aerospace, space, marine, and military applications. Esterline Technologies Corporation was founded in 1967 and is headquartered in Bellevue, Washington.

  A division of Esterline that contributes extensively to CNS/ATM is CMC Electronics, which designs, manufactures, and supports commercial air transport customers. The company is a major supplier to the aerospace and high-technology industries, airlines, military agencies, and government customers around the world. Its product line includes cockpit systems integration, navigation and

FMS, displays and vision systems, advanced voice and data communications, and hybrid microelectronics.

5.4.2 Key Developments and Challenges Affecting the CNS/ATM Avionics Supply Chain

The key developments and challenges affecting the CNS/ATM avionics supply chain identified in this report are as follows:

- **CNS systems complexity.** As airlines transition to the latest generation of software-driven aircraft while continuing to fly older models with outdated electronics, industry concern is rising that avionics issues are a growing source of AOG (aircraft on ground) dispatch problems. Airlines contend that avionics are among the top five contributors to AOG, with most associated with indicating systems, navigation, communication, electrical power, and autoflight. Hardware and software modifications have increased reliability, but that has led to increased system and component complexity, requiring even more trained technicians and expensive test equipment. Among the issues is a perceived lack of technical data sharing between avionics OEM repair facilities and their customers.

- **Innovation challenges.** Air transport avionics is conservative, much like other aspects of air transport design and operations that potentially impact safety. Avionics is a conservative field governed by stringent reliability and certification requirements. This slows the pace of innovation in air transport avionics and the adoption of advances in consumer electronics and other fields to commercial airline cockpits. Two examples are GPS-based navigation systems and computer tablets, which were available for consumer use and terrestrial commercial transport applications long before airworthiness regulators permitted their use as primary aids in airline cockpits. Innovation occurs mostly at Tier 2 of the supply chain. Consolidation of the air transport supply chain has combined with defense cutbacks to push the risk and motivation for civil avionics innovation to Tier 2 suppliers. Under pressure to cut development and life-cycle costs, OEMs have pushed these suppliers to design and provide more integrated systems. At the same time, avionics suppliers are focusing more attention on developing their air transport avionics businesses to offset current and projected declines in defense work.

- **Consolidations and Acquisitions**. Avionics manufacturers have undergone their own consolidation. Honeywell's predecessor companies include Sperry, Bendix, King, and AlliedSignal. Rockwell Collins has acquired such businesses as Hughes-Avicom, Communication Solutions, and Evans & Sutherland. Thales now includes the former French firms Alcatel and Dassault Electronique and the UK company Racal Electronics.

- **Supply Tier Consolidation.** The relationship of suppliers and OEMs has undergone major changes in the last decade or so as the cost and complexity of aircraft has increased. In their drive to satisfy the demands of their airline customers to control cost increases for their products (and those of their stakeholders to control manufacturing costs and increase profits), OEMs have changed their way of designing and winning certification of aircraft. A common past practice was for the OEM to control nearly all of the design and certification processes, dictating specifications to a component or system supplier and largely taking on the time and cost burden of integrating those elements into the aircraft.

  Since the early 1990s, OEMs increasingly have enlisted Tier 2 suppliers as risk-sharing partners in aircraft development programs, requiring them to design, develop, and (in some cases) gain certification of integrated systems and to bear a higher share of the cost burden of the aircraft development and production program. The tradeoffs for suppliers were an increased volume of work, since they would provide all the prescribed components for an aircraft program and a share of the profit (or loss) of that program.

At the same time, OEMs shifted away from allowing airline customers to specify the systems, such as avionics, to be used on their aircraft (a practice that increased the OEM's design and production costs). Instead, they offered new aircraft lines with sets of standard equipment, such as integrated communications and navigation avionics suites (the most pertinent components for the purposes of this study). Embraer offers a typical example. When it developed its 40-50 passenger EMB145 regional jet in the 1980s and 90s, it used about 350 suppliers. Only four of those were risk-sharing partners. For development of the EMB170/190 aircraft in the late 1990s, it used 38 suppliers, 16 of which were risk-sharing partners. Airbus enlisted about 30 risk-sharing partners for work on its 500-800 passenger A380, which it says allows it to offload about 30 percent of program cost. That trend is intensifying as civil avionics shift toward greater use of integrated, modular architectures and high-speed networks and systems (i.e., fly-by-wire) in aircraft like Airbus' A350, Boeing's 787, Bombardier's C Series and Sukhoi's Superjet 100 regional jet.

6.0 ATI Industry & Market Forecast

In this section, the Nexa Study Team authors integrate the research and analysis of the previous topics to develop investment forecasts for infrastructure and aircraft equipage needed to implement ATI for the ten-year forecast period (2012-2021). ATI includes ANSP ground and satellite-based programs, as well as aircraft equipage to participate in ANSP programs. The forecasts project the investment requirements for ANSPs to upgrade or implement programs related to communication, navigation, surveillance, ATM, automation, weather, facilities, and mission support. The ANSP investment requirement is also segmented by function for equipment, systems, and services (including outsourced services and training) through 2021. Aircraft equipage includes the necessary avionics for CNS.

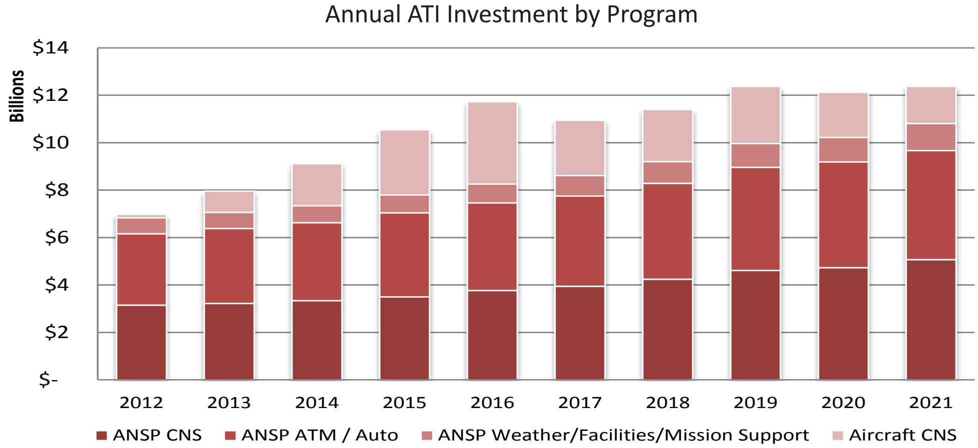
These ATI market forecasts project estimates based on what world governments and commercial aircraft operators need to procure over the next decade to keep pace with emerging ATI modernization requirements.

Mature ANSPs (including the US, Canada, Western Europe, Australia, Japan, and New Zealand) are expected to account for 68 percent of aircraft movements and 68 percent of ATI investment requirements over the forecast period. These mature ANSPs face mandatory deadlines for implementation of advanced surveillance and communications programs. For example, Europe has a 2015 deadline for digital data communications under EUROCONTROL's Link 2000+ program. ADS-B Out surveillance has been mandated for 2013 in Australia, 2017 in Europe, and 2020 in the US, and is already mandated in portions of Canadian airspace.

Developing ANSPs face an investment requirement that will accelerate over the next decade and continue well beyond. Some of these ANSPs may benefit from the ability to proceed with next-generation upgrades over incremental conventional technologies to deploy advanced, space-based solutions. Space-based ADS-B receiver technologies, for instance, would offer developing ANSPs turn-key aircraft surveillance programs with minimal ground infrastructure requirements or investment.

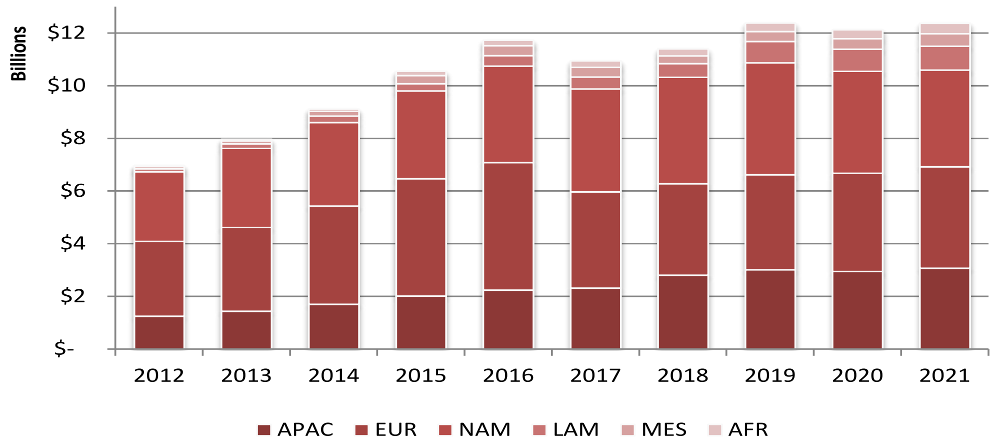
Transitioning air traffic control and management to next-generation infrastructure and the supporting systems is very costly. Therefore, budgetary constraints restrict what and where a nation can afford to invest. The forecasts analyze the gap between requirements and constraints due to the shortage of capital. Therefore, we present the ATI forecasts via two perspectives:

Figure 6-1
Annual ATI Investment by Program



Source: NEXA Forecast 2012-2021; $US Billions

Figure 6-2
Annual ATI Investment By World Region



Source: NEXA Forecast 2012-2021

- **Unconstrained** by availability of capital — assuming no project funding restrictions exist.
- **Constrained** by availability of capital — applying funding constraints by country and region of the world.

Adding these perspectives can assist in understanding the critical role that non-traditional funding sources can and will play in future ATI investment.

The Study Team then segmented the unconstrained global ANSP investment requirement into three **functions**: equipment, systems, and services.

- Equipment upgrade and replacement is projected to require $32 billion through 2021 (39 percent of the total ATI investment requirement). Infrastructure consists of basic hardware to support ATI modernization and sustainment programs, including ADS-B ground stations, runway lighting, and equipment to support GPS, WAAS, EGNOS, PBN, RNAV, and RNP procedures.
- Systems that make the hardware function are projected to require a $46 billion (55 percent of total ATI) investment by ANSPs over the next decade. These systems include trajectory-based operations that allow for more direct flight paths, collaborative air traffic management and decision-making, and improved traffic flow management systems
- Services are projected to require an unconstrained investment by ANSPs of $5 billion (six percent of total ATI) over the next decade; these include training, weather services, and systems engineering, research, and development. The mature ANSPs will invest heavily in systems engineering and R&D programs, while the developing ANSPs are more likely to purchase off-the-shelf solutions and focus on training support programs.

We also analyze the effects on the forecasts of transformational **technologies and programs,** such as space-based CNS systems, and how those technologies may alter airspace user behavior. The ATI program areas studied here include:

- Communications, navigation, surveillance (CNS).
- Air traffic management (ATM) within automation.
- Weather, facilities, and mission support.

ANSPs will need to invest $86 billion to meet the demand for air travel and to capture the full economic benefits generated through air-travel's stimulation of commerce, trade, and tourism.

Communications, navigation, and surveillance capabilities account for $39 billion (38 percent) of the anticipated ATI investment (Figure 6-1). In our forecast, ATM is grouped with automation initiatives, since automation is a central element of ATM. The projected ANSP unconstrained investment requirement for ATM/automation over the next decade exceeds $38 billion, or 36 percent of the required ATI investment. The other ATI investment requirement categories are weather systems, facilities, and mission support. Collectively, they will require $8 billion (eight percent of the total ATI investment).

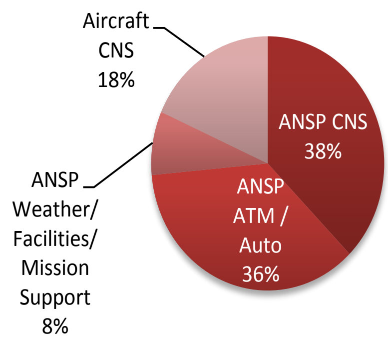
The **aircraft equipage** forecasts detail the investments required for airlines to take advantage of advanced CNS and ATM programs. The forecasts estimate commercial aircraft equipage investment by aircraft **type** (twin-aisle, single-aisle, regional jet, and turboprop), by **program** (communications, navigation, and surveillance), and by **world region** (North America, Europe, Asia Pacific, Middle East, Africa, and Latin America).

The ATI investment required of commercial airlines through 2021 will follow the ANSP investment profile. More than $19 billion, or 18 percent of the total unconstrained ATI investment forecast, will be required by airlines to install avionics such as ADS-B, satellite-based navigation, and digital communications.

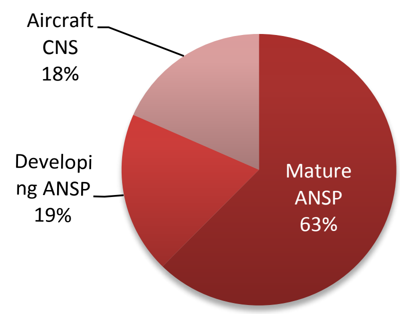
Taken together, the Study Team projects that over the next decade the six regions and respective airlines of the world will face an unconstrained investment requirement of $105 billion to transition to a global satellite-based CNS/ATM infrastructure, while continuing the maintenance legacy systems (Figure 6-2). *Note: All assumptions and detailed forecasts can be found in accompanying materials.*

Figure 6-3

ATI Investment by Program



Mature ANSP, Developing ANSP, and Aircraft Investment



Source: NEXA Forecast 2012-2021

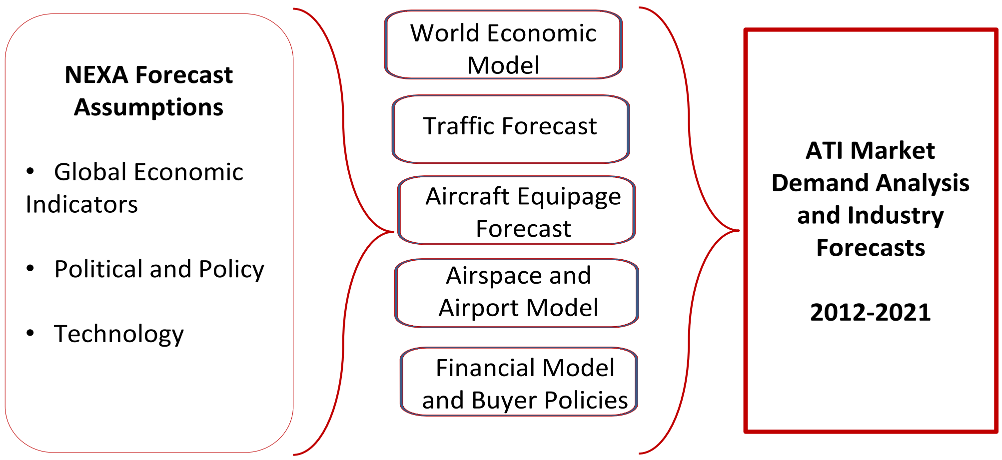
The following provides a brief overview of each of the sections:

Section 6.1 describes the methodology used to model appropriate forecasting metrics and explains key underlying assumptions. Key assumptions apply to global aircraft fleet forecasts, ANSP investment forecasts, and equipage of global commercial aircraft.

Sections 6.2 forecasts ANSP unconstrained ATI investment requirement. The total required investment for all world regions is based on analogies to current investment trends, as well as assessments of regional readiness.

Figure 6-4

NEXA Model



Source: NEXA Forecast 2012-2021

Section 6.3 forecasts global commercial aircraft equipage requirements, across four relational dimensions:

- Type of aviation operation.
- Technology programs.
- Geographical location – by region/country.
- Time – annual forecasts (2012-2021).

Section 6.4 adjusts the unconstrained forecasts, taking into consideration the scarcity of investment capital and the predilection of certain countries to adopt new ATI financing models.

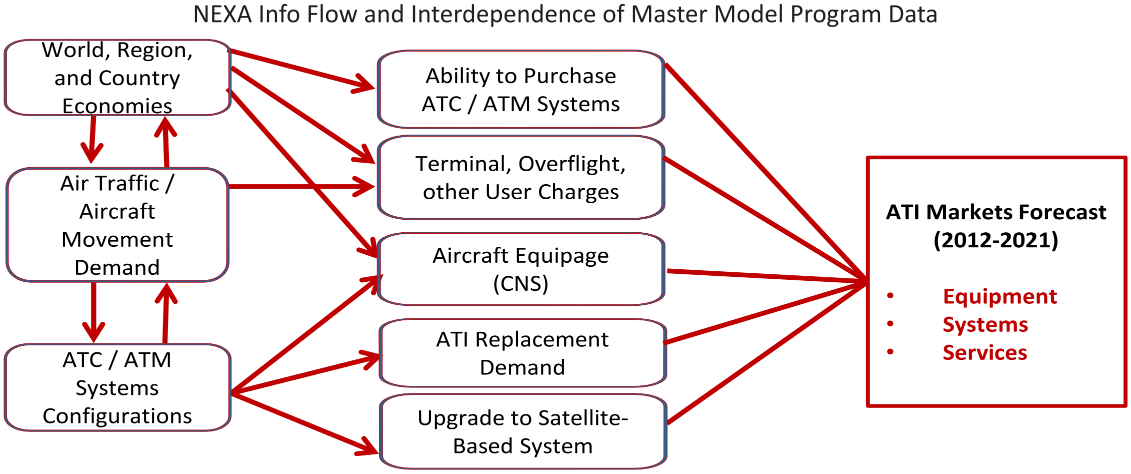
Section 6.5 discusses the critical issue of funding and identifies the shortfalls in global abilities to fund the transition to satellite-based air traffic management. This section explores sovereign, institutional, private, and ANSP sources of finance.

6.1 ATI Forecast Model - Methodology and Assumptions

The Study Team developed an econometric forecasting model to determine the size, composition, and probity of the anticipated ATI markets in the 60 countries discussed earlier and world regions. The country forecasts were then adjusted to reflect the ATI requirements of the entire region.

Figure 6-5

NEXA Info Flow and Interdependence of Master Model Program Data



Source: NEXA Advisors

Figure 6-6
ICAO Regional Fleet Growth Rates

Region Key	Region	Average Annual %			20 Year Growth		
		Passenger	Cargo	Other	Passenger	Cargo	Other
AFR	Africa	2.8%	3.7%	6.1%	56%	74%	122%
APAC	Asia/Pacific	5.0%	5.3%	9.1%	100%	106%	182%
EUR	Europe	3.0%	1.7%	6.5%	60%	34%	130%
LAM	Latin America	3.8%	4.3%	6.0%	76%	86%	120%
MES	Middle East	4.1%	5.8%	4.8%	82%	116%	96%
NAM	North America	1.8%	1.6%	2.8%	36%	32%	56%
WORLD	World	3.1%	2.7%	4.3%	62%	54%	86%

Source: ICAO

6.1.1 Econometric Model Overview

A schematic of the econometric forecast model is shown in Figure 6-4. The model parameters include numerous quantitative and qualitative factors that form the underlying assumptions of the mathematical and logical relationships supporting the forecasts. The information flow of each factor in the model is detailed in Figure 6-5.

Quantitative parametrics included published air traffic forecast data; propensity to travel; flight statistics such as key routes, movements by country and by scheduled passenger operator; aircraft fleet profiles by operator type (including scheduled and non-scheduled, passenger and cargo); economic data for the 60 countries on which this study focuses and the regions (such as population, population growth, GDP, GDP per capita, inflation, national debt, historic and projected government budgetary figures); and existing CNS and ATM equipment, systems, and services.

Sources included ICAO, IATA, transport aircraft manufacturers, the World Bank, the European Bank for Reconstruction and Development (EBRD), the International Monetary Fund (IMF), OAG schedules and fleet databases, and studies by the FAA, EUROCONTROL, SESAR, CANSO, and others.

Qualitative parametrics include, for each country and six regions, general infrastructure development, aeropolitical environment, technology development, political stability, and government policies that impact CNS and ATM deployment (for example, policies prioritizing military vs. civilian use of airspace).

In the model, information flows from the world/region/country economic data to the air traffic and aircraft movement forecast and the ability of buyers to acquire equipment, systems, and services. Increased demand for air traffic leads to stimulated economic development. Air traffic demand flows to aircraft movements, which flow to the ATI requirements and configurations needed to meet the air traffic demand. The demand for ATI, in turn, flows to replacement of terrestrial systems and upgrade to new capabilities. The demand for replacement and upgrade results in the Study Team's forecast of the ATI unconstrained investment requirement. Funding for ATI is a function of public policy, economic factors, and the collection of user-fees by ANSPs to provide revenue streams. These revenue streams can be monetized to attract private funding sources.

6.1.1.1 World Economic Indicators

As discussed in Section 2, the most powerful driver in commercial air transportation is worldwide economic activity. Economic performance directly affects the financial conditions of national governments and national industries in the public and private sectors. Economic development leads to increased demand for air transportation services and, as a result, air navigation services. While the aviation industry is highly cyclical, the trend has been for continuous growth since the 1950s. The greater the demand for air navigation services, the greater the need for governments to upgrade ATI and to find the financial resources for those upgrades.

6.1.1.2 Air Traffic Forecasting Model

Air traffic volume is a key factor in determining the required ATI investment in CNS and ATM equipment, systems, and services for each nation. International traffic flows, especially to the EU and US where equipage has been mandated, will drive aircraft equipage in those areas and elsewhere in the world. Domestic and regional traffic flows also determine ATI investment requirements in the local markets. For this analysis, the Study Team worked with ICAO reports and incorporated the aggregated national, regional, and corridor forecasts of passenger, freight, and aircraft types.

6.1.1.3 Buyer Policies and Financial Model

The buyers of CNS and ATM equipment, systems, and services are national governments, privatized or corporatized air navigation service providers, private-sector companies that provide air navigation services to national and local governments, entities that provide terminal-area services within national air traffic control systems, military services, and suppliers that integrate and sell turn-key CNS and ATM solutions. The propensity to purchase CNS and ATM equipment, systems, and services depends on how progressive these entities are and their willingness and ability to obtain the requisite financial resources to modernize ATI.

The Study Team's financial model accounts for buyer policies, the concepts of CNS and ATM modernization costs versus benefits and, to some extent, impacts on each nation's economic performance and national security.

6.1.1.4 ATI Industry and Market Forecast Model

The transition from traditional, ground-based ATC to advanced CNS and ATM will have a significant impact on airspace management and capacity. The Study Team assumed that the EU and US will implement advanced communications and surveillance systems within the term of the forecast period (through 2021). ANSPs and commercial airlines are already utilizing advanced systems, such as multilateration and ground- and space-based augmentation of GPS signals, which support advanced navigation, such as RNAV and RNP. (See Section 4 for a discussion of the underlying technologies.) That use is assumed to increase and accelerate within the term of the forecast. Full global implementation of satellite-based navigation is assumed to fall outside the forecast period.

The key ATI investment areas studied here include communications, navigation, surveillance (CNS), air traffic management (ATM) within automation, weather, facilities, and mission support (Figure 6-7). Communications between air traffic control officers (ATCO) and pilots both on the ground and en route are currently conducted largely over voice radio channels, with very little communicated through digital formats.

Advanced communications programs, including Link 2000+ in Europe and DataComm in the US, would transfer much routine ATCO-pilot communications to digital channels and formats. Advanced navigation programs combine positioning and timing signals from global and regional satellite constellations or networks of terrestrial signal-augmentation transceivers with more precise aircraft avionics to provide pilots with more accurate guidance for takeoff, en route navigation, approach, and landing. ADS-B programs provide for surveillance of aircraft both in the air and on the ground. Automation provides the tools for advanced air traffic management, including the timing and direction of aircraft on the surface and en route, aircraft separation to prevent collisions, and the management of traffic flow.

Figure 6-7
Key ATI Investment Areas

Communications • Communication between pilots and controllers	**Navigation** • Precision takeoff • En route navigation • Precision approach and landing guidance
Surveillance • En route aircraft tracking • Surface aircraft tracking • Space based aircraft tracking	**Air Traffic Mgmt. & Automation** • Direction of aircraft on the surface and en route • Aircraft separation to prevent collisions • Traffic Flow Management
Weather • Integrated weather observations and projections	**Facilities & Mission Support** • Facility construction and maintenance • R&D support • Training programs

Source: NEXA Advisors

Weather programs include the integration of real-time weather into aircraft navigation and surveillance. Facilities and mission support provide the physical location for air traffic management and the supporting programs, including research and development, validation, testing, and calibration. Training services are an important part of mission support programs.

Equipment, systems, and services categories were selected to best classify CNS and ATM market opportunities and trend. These forecasts are analyzed and presented on a global, regional, and country basis.

Key Points:

- The transition from ground-based air traffic control to satellite-based CNS/ATM will require virtually all ATI to be upgraded or replaced to meet air traffic demand over the next several decades.
- The forecast parameters include numerous quantitative and qualitative factors that form the underlying assumptions to the mathematical and logical relationships supporting the forecasts. These factors include:
  - ◊ Global economic indicators
  - ◊ Air traffic levels
  - ◊ ATI procurement policies
- Key ATI investment areas studied here include communications, navigation, surveillance (CNS), air traffic management (ATM) within automation, weather, facilities, and mission support.

6.1.2 ANSP and Commercial Aircraft ATI Industry and Market Forecast

The key identified assumptions underlying the Study Team forecast models that are expected to impact global ATI development over the next decade. *Note: All data was publicly available and/or provided directly by proprietary sources.*

6.1.2.1 World Economic Assumptions

Moving from ground-based air traffic control to satellite-based CNS and ATM will require virtually all ATI to be upgraded or replaced to meet air traffic demand over the next several decades. Each country and region has unique requirements for CNS and ATM equipment, systems, and services to support air traffic. Libya, for example, is working to rebuild its air transport sector in the wake of devastating armed conflict, but labor unrest and military control of air traffic has hampered reconstruction efforts.

World economic assumptions are important underlying factors in the Study Team's development of the CNS and ATM Industry and Market Forecasts. Figure 6-8 summarizes the leading economic indicators for selected countries used in the forecasts. Other assumptions:

- The current global economic crises will be resolved over the next several years, and robust growth will return to air transportation within the next five years.

Figure 6-8

Region	Country	GDP Purchasing Parity (billions) 1/	GDP Growth Rate 2/	GDP Growth Forecast Avg Annual 3/	GDP/Capita 4/	Public Debt % GDP 5/	Inflation Rate 6/	Population (million) 7/	Pop Growth 8/
NAM	USA	$14,660	3.7%	4.0%	$47,200	62.9%	1.6%	313.2	1.0%
NAM	Canada	$1,330	3.1%	4.8%	$39,400	84.0%	1.8%	34.0	0.8%
EUR	Germany	$2,940	3.5%	2.8%	$35,700	83.4%	1.1%	81.5	-0.2%
EUR	Russia	$2,223	4.0%	15.5%	$15,900	9.0%	6.9%	138.7	-0.5%
EUR	United Kingdom	$2,173	1.3%	6.2%	$34,800	76.1%	3.3%	62.7	0.6%
EUR	France	$2,145	1.5%	3.9%	$33,100	8.2%	1.7%	65.3	0.5%
EUR	Italy	$1,774	1.3%	2.9%	$30,500	119.1%	1.6%	61.0	0.4%
EUR	Spain & Canary Islands	$1,369	-0.1%	3.6%	$29,400	60.1%	2.0%	46.8	0.6%
EUR	Turkey	$961	8.2%	7.7%	$12,300	43.0%	8.6%	78.8	1.2%
EUR	Netherlands	$677	1.7%	3.4%	$40,300	62.7%	1.3%	16.8	0.4%
EUR	Switzerland	$325	2.6%	6.4%	$42,600	38.4%	0.7%	7.6	0.2%
EUR	Ukraine	$305	4.2%	NA	$6,700	42.3%	9.4%	45.1	-0.6%
EUR	Norway	$255	0.4%	4.6%	$54,600	49.7%	2.5%	4.7	0.3%
EUR	Romania	$254	-1.3%	11.3%	$11,600	33.8%	6.1%	21.9	-0.3%
EUR	Ireland	$172	-1.0%	0.8%	$37,300	94.9%	-0.9%	4.7	1.1%
EUR	Bulgaria	$97	0.2%	7.2%	$13,500	16.2%	2.4%	7.1	-0.8%
AFR	South Africa	$524	2.8%	6.8%	$10,700	33.4%	4.1%	49.0	-0.4%
AFR	Egypt	$498	5.1%	8.1%	$6,200	81.4%	11.1%	82.1	2.0%
AFR	Nigeria	$378	8.4%	11.1%	$2,500	17.8%	13.7%	155.2	1.9%
AFR	Libya	$91	4.2%	4.1%	$14,000	3.5%	2.5%	6.6	2.1%
AFR	Ethiopia	$86	8.0%	10.0%	$1,000	48.3%	8.1%	90.9	3.2%
AFR	Kenya	$66	5.0%	14.1%	$1,600	47.7%	4.0%	41.1	2.5%
AFR	Ghana	$62	5.7%	14.0%	$2,500	34.0%	10.7%	24.8	1.8%
AFR	Tanzania	$58	6.5%	7.4%	$1,400	34.4%	7.2%	42.7	2.0%
APAC	China	$10,090	10.3%	14.3%	$7,600	16.3%	3.2%	1,336.7	0.5%
APAC	Japan	$4,310	3.9%	3.5%	$34,000	199.7%	-0.7%	126.5	-0.3%
APAC	India	$4,060	10.4%	12.2%	$3,500	50.6%	12.0%	1,189.2	1.3%
APAC	Korea, South	$1,459	6.1%	9.5%	$30,000	22.6%	3.0%	48.8	0.5%
APAC	Indonesia	$1,030	6.1%	13.6%	$4,200	25.7%	5.1%	245.6	1.1%
APAC	Australia	$882	2.7%	6.6%	$41,000	28.8%	2.8%	21.8	1.2%
APAC	Thailand	$587	7.8%	9.8%	$8,700	43.1%	3.3%	66.7	0.6%
APAC	Pakistan	$465	4.8%	10.2%	$2,500	50.6%	13.9%	187.3	1.6%
APAC	Malaysia	$414	7.2%	7.4%	$14,700	53.1%	1.7%	28.7	1.6%
APAC	Philippines	$351	7.3%	7.7%	$3,500	52.4%	3.8%	101.8	1.9%
APAC	Singapore	$292	14.5%	7.4%	$62,100	105.8%	2.8%	4.7	0.8%
APAC	Vietnam	$277	6.8%	14.7%	$3,100	57.1%	9.0%	90.5	1.1%
APAC	Bangladesh	$259	6.0%	9.2%	$1,700	35.4%	8.1%	158.6	1.6%
APAC	Kazakhstan	$196	7.0%	17.1%	$12,700	15.5%	7.1%	15.5	0.4%
APAC	New Zealand	$118	1.5%	7.0%	$27,700	27.5%	2.3%	4.3	0.9%
APAC	Afghanistan	$27	8.2%	11.9%	$900	NA	0.9%	29.8	2.4%
APAC	Myanmar	$76	5.3%	5.7%	$1,400	NA	7.7%	54.0	1.1%
LAM	Brazil	$2,172	7.5%	8.8%	$10,800	54.7%	5.0%	203.4	1.1%
LAM	Mexico	$1,567	5.5%	6.5%	$13,900	36.9%	4.2%	113.7	1.1%
LAM	Argentina	$596	7.5%	4.5%	$14,700	45.1%	22.0%	41.8	1.0%
LAM	Colombia	$435	4.3%	7.0%	$9,800	45.3%	2.3%	44.7	1.2%
LAM	Venezuela	$345	-1.9%	2.2%	$12,700	24.9%	28.2%	27.6	1.5%
LAM	Peru	$276	8.8%	8.3%	$9,200	23.9%	1.5%	29.2	1.0%
LAM	Chile	$258	5.3%	4.1%	$15,400	9.2%	1.4%	16.9	0.8%
LAM	Uruguay	$48	8.5%	9.3%	$13,700	56.3%	6.7%	3.3	0.2%
LAM	Bolivia	$48	4.2%	10.5%	$4,800	38.1%	2.5%	10.1	1.7%
LAM	Panama	$44	7.5%	10.2%	$13,000	43.3%	3.5%	3.5	1.4%
LAM	Trinidad & Tobago	$26	1.1%	8.9%	$21,200	29.8%	10.5%	1.2	-0.1%
LAM	Jamaica	$24	-1.1%	5.8%	$8,300	126.2%	12.6%	2.9	0.7%
MES	Iran	$819	1.0%	7.8%	$10,600	16.3%	10.1%	77.9	1.3%
MES	Saudi Arabia	$622	3.7%	9.2%	$24,200	16.6%	5.4%	26.1	1.5%
MES	U.A. Emirates	$247	3.2%	7.7%	$49,600	51.2%	0.9%	5.1	3.3%
MES	Oman	$76	4.2%	7.1%	$25,600	4.0%	3.2%	3.0	2.0%
MES	Lebanon	$59	7.5%	6.9%	$14,400	133.8%	4.0%	4.1	0.2%
MES	Jordan	$35	3.1%	9.3%	$5,400	61.2%	5.0%	6.5	1.0%
MES	Bahrain	$30	4.1%	6.4%	$40,300	60.1%	2.0%	1.2	2.8%

Notes: All Data from CIA World Fact Book for 2011/2012, except as noted

1/ Based on World Bank Purchasing Power Parity 2011

2/ GDP 2011 growth on an annual basis adjusted for inflation and expressed as a percent.

3/ International Monetary Fund, World Economic Outlook Database, September 2011

4/ 2011 GDP on a purchasing power parity basis divided by population

5/ Public Debt is cumulative total of all government borrowings less repayments that are denominated in a country's home currency as percent of 2011 GDP

6/ Annual percent change in consumer prices compared with the previous year's consumer prices.

7/ Estimate from the US Bureau of the Census based on statistics from country population censuses

8/ Average annual percent change in the population, resulting from a surplus (or deficit) of births over deaths and the balance of migrants entering and leaving a country

Figure 6-9

Region	Country	2011 Total Movements 1/	2011 International Movements 2/	2011 International Movement & of Total Movements	% Change International Movements 2006-2011	Number Airports 3/
NAM	United States	10,057,557	1,336,868	13.3%	2%	15,079
NAM	Canada	1,285,078	504,633	39.3%	11%	1,404
EUR	United Kingdom	1,669,660	1,314,222	78.7%	5%	505
EUR	Germany	1,589,615	1,305,888	82.2%	4%	549
EUR	Spain & Canary Islands	1,262,438	840,092	66.5%	24%	154
EUR	France	1,141,640	855,435	74.9%	3%	475
EUR	Italy	991,668	694,718	70.1%	7%	132
EUR	Russia	691,240	319,984	46.3%	71%	1,213
EUR	Turkey	501,754	308,393	61.5%	112%	99
EUR	Netherlands	424,535	424,167	99.9%	5%	27
EUR	Switzerland	416,446	404,717	97.2%	16%	65
EUR	Norway	408,170	174,145	42.7%	19%	98
EUR	Ireland	190,497	184,117	96.7%	-7%	39
EUR	Ukraine	126,133	104,278	82.7%	63%	425
EUR	Romania	118,573	101,212	85.4%	46%	54
EUR	Bulgaria	48,478	44,883	92.6%	36%	210
AFR	South Africa	251,959	96,000	38.1%	18%	578
AFR	Egypt	165,042	134,090	81.2%	84%	86
AFR	Kenya	107,571	62,307	57.9%	84%	191
AFR	Nigeria	90,413	25,610	28.3%	37%	54
AFR	Tanzania	54,678	26,109	47.8%	84%	124
AFR	Ethiopia	53,847	38,758	72.0%	133%	61
AFR	Libya	37,817	25,968	68.7%	41%	137
AFR	Ghana	30,432	19,180	63.0%	60%	11
APAC	China	2,819,030	569,073	20.2%	45%	502
APAC	Japan	989,733	299,978	30.3%	8%	176
APAC	India	863,258	250,874	29.1%	70%	352
APAC	Australia	727,077	153,603	21.1%	37%	465
APAC	Indonesia	626,577	146,766	23.4%	86%	684
APAC	Malaysia	415,925	217,004	52.2%	81%	118
APAC	Korea, South	383,466	242,853	63.3%	36%	79
APAC	Philippines	283,083	89,556	31.6%	68%	254
APAC	Singapore	280,421	280,421	100.0%	42%	8
APAC	Thailand	369,025	230,966	62.6%	26%	105
APAC	New Zealand	251,362	61,324	24.4%	16%	122
APAC	Pakistan	97,555	53,440	54.8%	18%	148
APAC	Vietnam	187,278	84,364	45.0%	58%	44
APAC	Kazakhstan	57,698	29,027	50.3%	64%	97
APAC	Bangladesh	55,219	35,833	64.9%	78%	17
APAC	Myanmar	40,030	15,063	37.6%	78%	76
APAC	Afghanistan	30,255	15,194	50.2%	290%	53
LAM	Brazil	1,092,441	113,268	10.4%	63%	4,072
LAM	Mexico	603,676	244,317	40.5%	-2%	1,819
LAM	Colombia	284,447	73,187	25.7%	68%	990
LAM	Argentina	170,139	88,514	52.0%	39%	1,141
LAM	Peru	126,793	52,966	41.8%	91%	211
LAM	Chile	125,648	47,627	37.9%	36%	366
LAM	Panama	103,303	82,592	80.0%	95%	118
LAM	Venezuela	95,230	39,770	41.8%	10%	409
LAM	Bolivia	67,293	10,685	15.9%	3%	881
LAM	Trinidad & Tobago	41,766	26,306	63.0%	-10%	6
LAM	Jamaica	40,216	31,755	79.0%	-8%	27
LAM	Uruguay	32,330	32,330	100.0%	103%	58
MES	U.A. Emirates	411,250	410,889	99.9%	79%	41
MES	Saudi Arabia	267,162	156,589	58.6%	131%	217
MES	Iran	161,623	45,140	27.9%	21%	319
MES	Bahrain	84,120	84,120	100.0%	57%	4
MES	Oman	63,123	58,816	93.2%	46%	130
MES	Jordan	62,520	61,033	97.6%	80%	18
MES	Lebanon	53,986	53,986	100.0%	97%	7

Notes:

1/ NEXA analysis of OAG Schedules Data, October 2011

2/ Movement = international departure+international arrival+ domestic single flight, October 2011

3/ CIA World Factbook = total number of airports or airfields recognizable from the air
The runway(s) may be paved (concrete or asphalt surfaces) or unpaved (grass, earth, sand, or gravel surfaces)
and may include closed or abandoned installations. Airports or
airfields that are no longer recognizable (overgrown, no facilities, etc.) are not included.
Not all airports have accommodations for refueling, maintenance, or air traffic control.

- International trade barriers will continue to be reduced, driven largely by the growth of global access to internet, regional trade agreements, and WTO initiatives. The consequence will be an increased demand for air travel. Air traffic growth is estimated for each region and the selected countries included in the forecast.

- GDP, the most important measure of the economic status of nations, assumes historic values compiled by the World Bank. Purchase power parity normalizes GDP for the impacts of exchange rates. Historic and forecast GDP growth rates provide an indication of the strength of the underlying economy. The economic activity creates the propensity for infrastructure development in general, and CNS and ATM infrastructure development specifically, and contributes to the ability of a government to finance the required modernization. GDP per capita is an indication of the country's wealth and ability of the local airlines and air passengers to pay additional user charges and/or taxes to fund ATI modernization costs.

As has been discussed, the growing public debt in developed countries will impact the cost and ability of governments to finance ATI modernization. There is a new economic grouping, Heavily Indebted Industrial Countries (HIIC), which includes the US, UK, Europe, and Japan. HIICs are displaying the kinds of investment risks traditionally associated with developing markets. The US has a public-debt-to-GDP ratio of 63 percent, which is relatively low compared to other developed countries — including the UK's ratio (76 percent), and Japan's ratio of 200 percent — but is expected to continue to grow as the government invests in economic recovery.

Key European countries have extraordinary public-debt-to-GDP ratios, including Italy at 119 percent, Ireland at 95 percent, and Germany at 83 percent. Many developing countries have much lower public-debt-to-GDP ratios, which is partially due to the IMF and World Bank programs to assist Heavily Indebted Poor Countries (HIPC). The countries in our study that are part of the HIPC program include Bolivia (with a public-debt-to-GDP ratio of 38 percent), Ethiopia (48 percent), and Ghana (34 percent).

Population and population growth are also indicators of potential demand for air travel and therefore are considered a factor in government's decisions to invest in ATI. A rapidly growing population, such as that of the United Arab Emirates with an annual growth rate of 3.3 percent, helps to justify government expenditures on infrastructure to support aviation services.

Key assumptions regarding global economic factors include:

- Oil prices will continue to fluctuate and trend upward, resulting in downward pressure on economic growth. In the short term, the aviation industry is developing strategies, such as hedging and direct refinement, to mitigate the impact of high oil prices. (Delta Air Lines recently acquired an oil refinery from Phillips 66 in an attempt to save money on rising fuel costs. Delta will convert the existing refinery infrastructure to optimize for jet fuel production.) Through 2021, the transition to more fuel-efficient aircraft will reduce the consumption of oil. Airlines are adopting procedures to reduce flight, taxi, and holding times to minimize the time engines are operating and thus cut fuel consumption. Investment in NextGen technologies is of tremendous importance to ultimately reducing fuel consumption.

- Exchange rates and interest rates will vary as functions of inflation, economic growth, and national debt computations of individual countries. The consequences of interest rates and inflation are the ability of the country to finance long-term CNS and ATM equipment purchases in its own currency.

While the US domestic market remains the largest single aviation market in the world, air service in other world regions is growing faster.

- The strengthening economies of China and India are resulting in new purchasing power for their middle classes. For example, the success of the Malaysia-based low-fare carrier Air Asia in Southeast Asia is built on the demand for travel among the emerging middle class in that region.

- Certain countries — including the BRIC countries (Brazil, Russia, India, and China) and the new growth markets of Indonesia, Mexico, South Korea, and Turkey — will continue to transition their economies to liberalized "capital market" models and open them to modernization and foreign investment. The consequence will be further justification in these countries for rapid CNS and ATM modernization.

- Because governments are facing budget constraints and limitations on funding from general funds, the transition to satellite-based CNS and ATM to modernize ATI will be financed by increased user fees paid by operators, primarily airlines, and new taxes on air passengers and air freight. The consequence of increased fees and taxes will be a decrease in the demand for air travel. This is expected to be offset by improved operational efficiency for operators and time savings to passengers generated by the improvements realized from modernization.

6.1.2.2 Political and Policy Assumptions

In analyzing the selected countries to forecast ATI, the Study Team assessed the countries in Figure 6.9 as to the volume of aircraft movements, the volume of international aircraft movements, the annual rate of growth for international aircraft movements, and the number of airports in the country.

The first level of analysis was to assess the number of airports in a country. The more airports available for air service, the greater the potential demand for air travel. The CIA World Factbook provides a listing by country of the airports and airfields recognizable from the air. These runways may be paved (concrete or asphalt surfaces) or unpaved (grass, earth, sand, or gravel) and may include closed or abandoned facilities. The airports may not have accommodations for refueling, maintenance, or air traffic control. Despite these limitations, this metric provides the universe of opportunities for air service in a country which could be tapped, assuming technology and investment funds for ATI were available.

The next set of metrics refers to the number of air movements in or to/from a country. A movement is defined as an international departure, an international arrival, or a single domestic flight that has both its origin and destination in the subject country. Countries with a large number of airports and growing aircraft movements are likely to invest in ATI to better manage their aviation industries.

Key assumptions regarding political, environmental, and policy matters related to investment in ATI include:

- National security will continue to override or guide airspace modernization decisions in many nations offering significant market opportunities. Thus, dual-use airspace architecture will influence the mix of terrestrial-based airspace systems and satellite surveillance and communications facilities in these countries.

- Globalization and the continued liberalization of air service agreements through "Open Skies" initiatives will continue. These agreements continue to evolve on a multilateral rather than bilateral basis. Examples are the pursuit of such initiatives by the members of the Association of Southeast Asian Nations and regional blocs in Africa. Air service liberalization and "open skies" initiatives over the term of the forecast will serve to increase the demand for air travel between regions.

- Aeropolitical agreements that limit domestic market access (cabotage) and foreign ownership of airlines that prevent cross-border mergers and acquisitions are expected to continue to be factors over the forecast period. Global alliances among airlines will allow airlines to leverage limited resources and to work within the legal/regulatory confines to serve global passenger demand and to achieve economies of scale, scope, and production.

- The creation of centralized CNS and ATM by region will continue. There will be a "denationalization" process. That is, the process of liberating airspace management and control from rigid country-based structures to flexible trans-border organizations to manage the region's air space will continue to evolve.

- Space-based aircraft tracking systems, such as the Aireon ADS-B program, will help developing ANSPs "leap frog" implementation of surveillance and navigation programs through advanced technology.

- Global harmonization of air safety regulations and air navigation services will continue and rapidly increase in and among North America, Europe, and Asia/Pacific. The costs to achieve harmonization are difficult to measure, but the consequences of a lack of harmonization are considered in the Study Team forecasts.

- Political pressures will increase over the term of the forecast to decommission existing redundant terrestrial ATC facilities, including secondary surveillance radar, and navaids, due to budgetary constraints and cost considerations.

6.1.2.3 Technological Assumptions

Key assumptions regarding the technological issues of satellite-based CNS systems include:

- The transition from terrestrial-based CNS to satellite-based systems for continuously tracking and communicating with aircraft, especially over remote areas, will allow for the development of procedures to increase capacity in national, oceanic, and remote-area airspace systems.

- Advanced ATM will incorporate optimal aircraft routings to minimize flight duration and length and thereby reduce fuel consumption.

- Space-based aircraft tracking and surveillance will emerge during the second half of the forecast period. It will provide coverage for oceanic, mountain, desert, and jungle routes and will be "leapfrog" technology for developing ANSPs whose capabilities are limited by traditional ATI.

- The global ATM community will use GNSS as the primary navigation means, while wide- and local-area augmentation systems implementation with specific aviation applications (WAAS, EGNOS, etc.) will gain wider acceptance across new regions.

- Satellite-based aircraft tracking systems will eliminate some traditional air routes and services.

- Surface management at airports will be vastly enhanced through surface radar developments, ADS-B, and multilateration, as well as proprietary vehicle tracking systems, allowing for more efficient and safer ground operations and aircraft movements, and increased predictability in estimated departure and arrival times.

- Digital data communications equipment will proliferate as routine messaging is shifted away from voice radio systems to more efficient digital messaging and highly secure texting.

- Weather systems will be integrated into automation solutions for both ground and airborne CNS and ATM.

- The market for traditional land-based systems — including radar, instrument landing systems (ILS), and VHF omni-directional range/distance measuring equipment (VOR/DME) — will continue to decline globally as satellite-based navigation and surveillance systems are implemented, but hybrid systems will continue in use throughout the forecast period.

6.1.2.4 Exclusions

The analysis for aircraft movements and equipment upgrades contained herein is focused on commercial airline operations and does not include military, helicopter, corporate aviation, or light general aviation aircraft, (including ultra-lights or experimental aircraft). If one were to incorporate these constituents, forecasted investment requirements would likely increase substantially.

6.1.2.5 Risks to Forecast

Analyses and conclusions are based on historical relationships between market conditions and air traffic demand. Any changes in these underlying relationships, such as assumptions relating to economic factors, political environment, and technological developments, would potentially and significantly impact these forecasts. In some cases, the analysis makes certain judgments based on years of aviation industry experience. The conclusions drawn in this study represent the Study Team's best understanding of the issues and factors. Should any of the assumptions change, the Study Team's conclusions and recommendations may, in turn, alter substantially. These forecasts are intended to be for general guidance only.

There are risks to any forecast. Key sensitivities potentially impacting the results of the forecasts presented in this study are:

- Disruptive technologies could emerge that devolve standards and divert resources. For example, China's 35-satellite BeiDou-2/Compass navigation system — its alternative to the US GPS system — could divide the world in a fashion similar to the partition of global mobile telephone users between the US terrestrial-based cellular phone network and the phone networks used by other world regions.

- If space-based ADS-B receivers are not launched, developing ANSPs would lose an option for leap-frogging traditional CNS technology, and the pace of ATI modernization in these markets would be slowed.

- If the trends towards globalization and liberalization are slowed or reversed due to protectionist policies resulting from exogenous factors, including terrorism, war, or epidemics, ATI modernization would be impacted.

Key Points:

- This forecast accounts for policy restrictions, CNS/ATM modernization costs vs. benefits, and impacts on each nation's economic performance and national security.

- Critical inputs into the forecast methodology include:
    - ◊ Type of aviation operation: commercial (passenger and freight).
    - ◊ Class of technology: communications, navigation, surveillance, technology, weather, facility requirements, and mission support programs.
    - ◊ Geographical location: by the six regions defined in this study.
    - ◊ Time: annual forecasts (2012-2021).

- The analysis does not include military, helicopter, corporate aviation, or general aviation aircraft.

6.2 ANSP ATI Investment - Unconstrained

The Study Team forecasts a total global ATI investment requirement of $105 billion through 2021, with $86 billion required of ANSPs to support CNS, ATM/automation, weather, facilities, and mission support. This represents 81 percent of the required global ATI investment, with the remaining 19 percent ($19 billion) expected to be invested by commercial operators to equip aircraft to operate in the new ATM environment.

The ANSP investment requirement for CNS is projected to be $39 billion, with $31 billion

Figure 6-10

ATI Investment

Program		Projected ATI Requirement	Share Global Movements	Share ANSP Investment
Communications, Navigation, & Surveillance				
Mature ATIs 1/	$	30,732,009,806	70%	36%
Developing ATIs	$	8,961,298,566	30%	10%
Total CNS Investment Requirement	$	39,693,308,372	100%	46%
ATM/Automation				
Mature ATIs 1/	$	29,079,132,949	70%	34%
Developing ATIs	$	8,841,383,847	30%	10%
Total ATM/Automation	$	37,920,516,797	100%	44%
Other Programs (Weather, Facilities, & Missions Support)				
Mature ATIs 1/	$	6,018,485,360	70%	7%
Developing ATIs	$	2,530,274,596	30%	3%
Total Other Programs	$	8,548,759,956	100%	10%
Total ATI Equipage ANSPs	**$**	**86,162,585,125**		**100%**

Source: NEXA Advisors

required of mature ANSPs and $9 billion of developing ANSPs. ATM/automation is the second largest ATI investment requirement, accounting for $38 billion through 2021. The mature ANSPs face an ATM/automation investment requirement of $29 billion, while developing ANSPs will have an investment requirement of $9 billion in this category. The third group of ATI programs includes weather, facilities, and mission support. These programs will require far less investment, a total of $9 billion for mature and developing ANSPs combined (Figure 6-10).

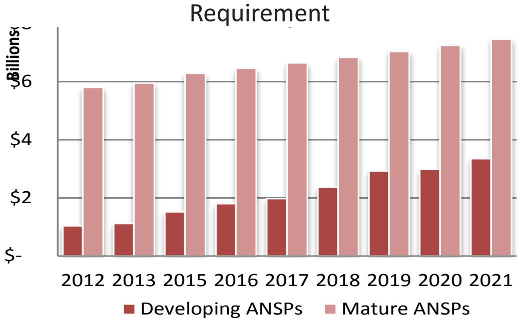
As discussed in other sections, mature ANSPs are expected to maintain a steady stream of investment over the forecast period, with a total value of $66 billion through 2021, representing 68 percent of ATI investment requirement. Developing ANSPs are expected to account for $20 billion over the forecast period, with annual investment growing more prominently over the term of the forecast (Figure 6-11). The Study Team assumes that space-based ADS-B receivers will be available in 2018 and enable developing ANSPs to gain rapid and less expensive capability and flexibility than traditional CNS and ATM infrastructure offers. As a result, developing ANSPs are expected to invest relatively less in terrestrial ATI.

6.2.1 ANSP ATI Investment Overview

The Study Team forecasted the ANSP investment requirement for five ATI program areas: communication, navigation, surveillance, ATM/automation, and weather/facilities/mission support. An ANSP generally develops a multi-year plan for capital investments needed to manage air navigation services. Their common elements are the identification of key initiatives, the components of those initiatives, the time-line for their implementation, and (in some cases) details

Figure 6-11

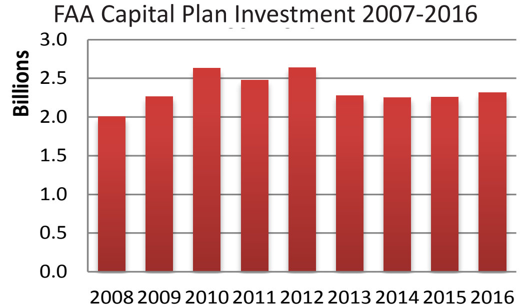
Mature vs. Developing ANSP ATI Investment Requirement



Source: NEXA Forecast 2012-2021

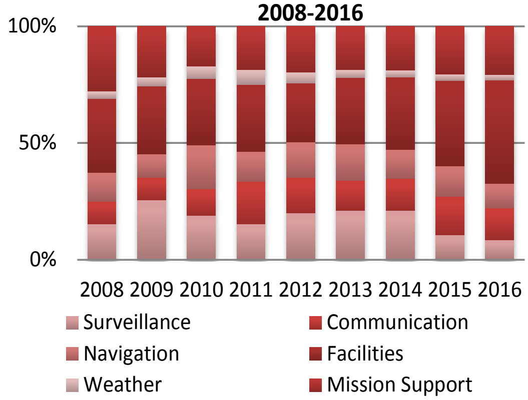
Figure 6-12

FAA Capital Plan Investment 2007-2016



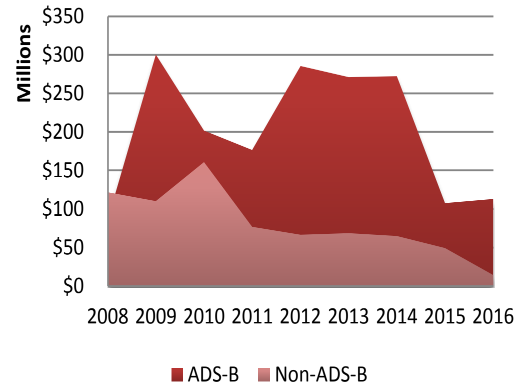
Source: NEXA Forecast 2012-2021

Figure 6-13
FAA Capital Investment Plan
2008-2016



Source: NEXA Advisors Forecast

Figure 6-14
FAA CIP Surveillance: ADS-B vs. Other



Source: NEXA Forecast

on the specific equipment and unit numbers required for successful deployment. This report contains specific details for 60 countries in the Appendix.

In developing its forecasts, the Study Team began with a detailed analysis of the capital expenditure plans of numerous ANSPs. Then, to establish a baseline for its forecasts, the Study Team selected the FAA Capital Investment Plan (CIP) for the period covering 2008 through 2016. There were two reasons for starting here, including:

- The FAA operates what is arguably the world's most complex and sophisticated air traffic system.
- The availability of annual iterations of multi-year CIPs supports an understanding of the evolution of advanced ATI programs through the stages of definition, R&D, procurement, deployment, and sustainment.
- The degree of FAA activities tied to drivers of workload, such as movements and handles, permits the adjustment of its expenditures to better align with the traffic levels and complexity of many of the world's other ANSPs, as well as forecasts of their investment requirements.

The FAA CIP describes planned investment in the US national airspace for a period of five years. It includes programs that transition to new technology as well as those that maintain legacy systems until the transition is complete. In the FAA plans, communications, navigation, and surveillance programs require the greatest investment, followed closely by air traffic management/automation. Programs for weather, facilities, and mission support are relatively smaller. Later in this section there is a discussion of the key elements of each program generally included in an ANSP's capital plans.

6.2.2 Forecast Methodology

The Study Team forecasted the investment requirements for ANSPs based on an analysis of FAA CIPs for the years 2008-2016.

Each of the four categories (CNS, ATM/automation, weather, and facilities/mission support) was analyzed and quantified to develop an average investment per program over the period covered by those five-year plans (occurring within 2008-2016) to normalize for the different stages of programs in those categories (Figure 6-13). Surveillance programs from an FAA CIP perspective peaked in 2009 (Figure 6-14). ATM/automation's share of the CIP increases through 2016 as programs develop.

The US investment in surveillance has shifted to ADS-B-based programs as investment in non-ADS-B surveillance programs, including radar, has declined. The funding for non-ADS-B programs is primarily for maintenance of radar systems to back up ADS-B once fully mandated in 2020. In forecasting surveillance investment globally, mature ANSPs are assumed to increase ADS-B investment over the forecast period through the use of mandates and reduce investment in non-ADS-B surveillance programs. An exception is Japan, which continues to rely heavily on radar networks, in addition to ADS-B, for surveillance.

Key Points:

- The Study Team forecasts a total global ATI investment requirement of $105 billion through 2021.
- $86 billion (82 percent) will be required to support ATM modernization:
    - ◊ CNS: $40 billion
    - ◊ ATM/Automation: $38 billion
    - ◊ Weather/Facilities/Mission Support: $9 billion
- $19 billion (19 percent) is expected to be invested by commercial operators to equip aircraft.

6.2.2.1 Capital Investments for Selected Countries

The Study Team estimated the capital investments for each country in this report based on an assumption that the country's investment in ATI is scalable relative to the number of aircraft movements handled by its ANSP, as well as its position under overflight routes. Each country's total aircraft movements were compared to the US total aircraft movements, and that factor was applied to the FAA investment plans to project the target investment requirement for each country. That target was then adjusted using CANSO groupings of ANSPs to better align with the size, complexity, and infrastructure requirements of their peers.

CANSO's Global ANS Performance Report 2011 included five years of data submitted by participating ANSPs. CANSO grouped ANSPs by IFR traffic levels, including oceanic services. The groupings were not a sole data point as to the effectiveness of the ANSP, but rather offered a simple ranking based on activity level (Figure 6-15).

Figure 6-15

CANSO ANSP Grouping and NEXA Factor

Group A **>1 million IFR Flight Hours** ***NEXA Factor: 100%***	**Group B** **250k - 1 MM IFR Flight Hours** ***NEXA Factor: 90%***
USA Canada India UK Germany Spain Mexico	Portugal Sweden New Zealand Thailand Romania South Africa Ireland
Group C **100k-250k IFR Flight Hours** ***NEXA Factor: 80%***	**Group D** **0-250k IFR Flight Hours** ***NEXA Factor: 70%***
UAE Czech Republic Montenegro Denmark Hungary Netherlands Cyprus Finland	Slovak Republic Latvia Netherlands Antilles Estonia Slovenia Georgia

Source: CANSO Global ANS Performance Report 2011

The Study Team assumed that the ANSPs in Group A, which includes the FAA, would have a steady level of air traffic activity and therefore an ATI investment requirement at 100 percent of the target developed by the Study Team. The investment requirement for countries in Group B would be 90 percent of the target level developed by the Study Team, while those in Group C would have an investment requirement of 80 percent. The requirement for those in Group D would be 70 percent of the target level. Not all ANSPs provided data for all metrics of the CANSO study. For countries not on the CANSO listing, the Study Team estimated the grouping based on aircraft movements in Figure 6-9 and other factors. Each country's projected requirement for ATI was calculated and grouped into regions (Figure 6-16).

Based on the research supporting this study, the Study Team developed factors to allocate capital investment to reflect the differences in CNS and ATM by world region (Figure 6.16). The two main expenditures for all regions are in the categories of CNS and ATM/automation. A subtotal for CNS is calculated

Figure 6-16

ATI Investment Allocation by Function and Region

FAA	Comm.	Navigation	Non-ADS-B Surveillance	ADS-B	ATM / Automation	Weather	Facilities	Mission Support	Projected ATI Expenditure	Total for CNS	ATM / Automation
US (FAA) CIP Budget FY2012 ($ MM)	$244.0	$269.4	$49.7	$285.1	$814.9	$81.7	$35.0	$116.6	$1,896.4	$848.2	$814.9
% Allocation of Total ATI Expenditure	13%	14%	3%	15%	43%	4%	2%	6%	100%	45%	43%
By World Region											
AFR	13%	20%	5%	20%	30%	4%	4%	4%	100%	58%	30%
APAC	13%	14%	3%	20%	38%	5%	3%	4%	100%	50%	38%
Japan	*13%*	*14%*	*20%*	*3%*	*38%*	*5%*	*3%*	*4%*	*100%*	50%	38%
EUR	15%	12%	3%	18%	45%	3%	1%	3%	100%	48%	45%
LAM	10%	10%	3%	17%	50%	4%	2%	4%	100%	40%	50%
MES	16%	18%	5%	18%	32%	4%	2%	5%	100%	57%	32%
NAM (Canada)	13%	14%	2%	16%	43%	4%	2%	6%	100%	45%	43%

Notes

FAA CIP budget was adjusted to take out programs that are U.S. specific and therefore not globally relevant.

These projections of capex by function and region are based on NEXA analysis of the 60 countries chosen for this study.

Japan does not plan to adopt ADS-B and is investing in radar.

North America includes US and Canada, however since the capex forecasts are baselined against FAA CIP, the forecast capex for the North America region is comprised only of Canada.

ATM/Automation and CNS are primary expenditures for each region, highlighted for comparison purposes.

Source: NEXA Forecast 2012-2021

in the data table and highlighted, by region, for comparison purposes.

The FAA allocates 45 percent of its Capital Investment Plan to CNS, with ATM/automation spending accounting for 43 percent. Europe allocates roughly the same as the US for CNS (48 percent) and ATM/automation (45 percent).

It is assumed that Africa and the Middle East will accelerate CNS due to factors such as proximity to the EU and trends in airline capacity growth. They are expected to take advantage of space-based ADS-B applications and to allocate a majority of investment to CNS (Africa: 58 percent, Middle East: 57 percent).

The Asia Pacific region is diverse, with developed ANSPs (Australia, Japan, and New Zealand), developing ANSPs (such as those in China and India), and some that might be considered under-developed (such as Vietnam). The regional averages therefore have wide deviations when analyzed on a country basis. The Study Team assumed that the overall region will allocate approximately half of its investment to CNS, with a strong emphasis on regional and space-based ADS-B.

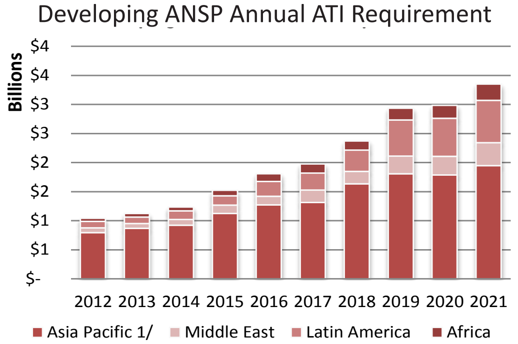
Latin America lags behind other regions in the development of infrastructure to support air traffic, and with rapidly growing fleets, therefore has the greatest need to develop ATM and automation of air traffic control. It is assumed to allocate the largest share of investment to ATM/automation (40 percent).

6.2.2.2 World Region Forecasts

For the mature ANSPs (US, Canada, the EU, Australia, New Zealand, and Japan), ATI investment levels are assumed to be maintained at 2012 levels. We then applied ICAO traffic growth rates for the regions to develop the ATI investment requirement for the balance of the forecast period. ATI for mature

Figure 6-17

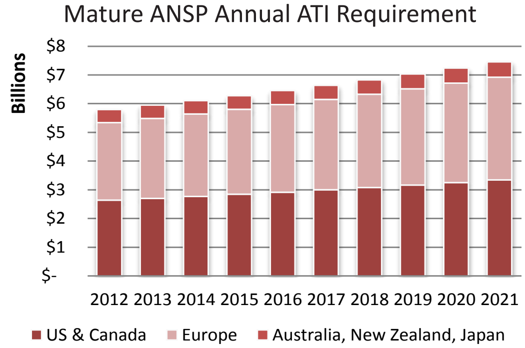
Developing ANSP Annual ATI Requirement



Source: NEXA Forecast 2012-2021

Figure 6-18

Mature ANSP Annual ATI Requirement



Source: NEXA Forecast 2012-2021

ANSPs is projected to be steady throughout the forecast period as CNS programs develop and ATM programs are implemented. Investment in ADS-B programs for mature ANSPs was assumed to grow at an annual average rate of five percent, while non-ADS-B surveillance programs were assumed to decline ten percent annually.

Due to the overall size of the aviation market in North America and Europe, these two regions will continue to require larger investments than Australia, Japan, and New Zealand. Together, North America and Europe account for 60 percent of global aircraft movements.

For developing ANSPs, the Study Team assumed that the projected capital investment requirement is a forecast each region would reach by the end of the period. We then developed annual investment requirement levels to reach that forecast by the end of 2021.

The pace of investment in the Asia Pacific region (excluding Australia, Japan, and New Zealand) is expected to increase through 2021, driven by spending by China and India. Space-based aircraft tracking systems are expected to accelerate investment in surveillance and navigation programs in developing ANSPs (Figure 6-17). Similar to the way the availability of mobile telephones supplanted land-line phones and transformed telecommunications markets in developing countries, space-based aircraft tracking systems will offer developing ANSPs a cost-effective means of adopting a global CNS standard, enhancing safety for all ANSPs. Space-based aircraft tracking systems are expected to be operational by 2017. CNS programs based on these capabilities should be implemented by developing ANSPs shortly thereafter and continue beyond the forecast period.

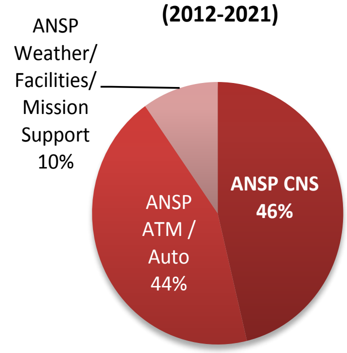
Key Points:

- ATI for mature ANSPs is projected to be steady throughout the forecast period. North America and Europe will continue to require larger investments than Australia, Japan, and New Zealand.
- Africa and the Middle East will accelerate CNS upgrades due as proximity to the EU and trends in airline capacity growth.
- Latin America lags in the infrastructure to support growing air traffic and, with rapidly growing fleets, has the greatest need to develop ATM capabilities quickly.
- The Asia Pacific region is diverse, with both mature and developing ANSPs driving investment.

6.2.3 ANSP ATI Forecast by Program

The Study Team developed investment requirement forecasts for each program: CNS, ATM/automation, weather, facilities, and mission support. The forecasts are based on the assumptions outlined in previous sections. CNS is projected to account for 46 percent of the required investment by ANSPs, followed by ATM/automation with 44 percent. The remaining programs (weather, facilities, and mission support) account for ten percent of the ANSP required investment (Figure 6-19).

Figure 6-19
ANSP ATI Requirement by Program
(2012-2021)



Source: NEXA Forecast 2012-2021

6.2.3.1 Communication, Navigation, and Surveillance

CNS programs are projected to require a $39 billion investment through 2021. Almost $4 billion investment a year would be needed to support required CNS projects around the world. The mature ANSPs dominate the investment requirement for CNS (78 percent), followed by developing ANSPs in the Asia Pacific region (15 percent). African, Middle East, and Latin American ANSPs combined account for seven percent of the CNS investment requirement over the next decade (Figure 6-21).

Developing ANSPs will invest $9 billion with more in surveillance (53 percent) than navigation and communications based on the anticipation that space-based aircraft tracking through satellite-based ADS-B receivers will provide the technology for these ANSPs to accelerate equipage. The Aireon satellite-based ADS-B receivers program is scheduled to be fully operational by 2018, thus the investment for developing ANSPs accelerates later in the decade (Figure 6-22).

Mature ANSPs will also invest more in surveillance (43 percent) and will invest earlier in the forecast period due to mandates in the EU, the US, and Australia (Figure 6-23).

Communications

Communication between pilots and ATCOs, between air traffic control facilities, and among those facilities and airspace users is an essential element of ATC. Pilots and ATCOs currently use radios for communication. Because en route control sectors cover areas that extend beyond direct radio range, remotely located radio sites are used to provide extended coverage. The ATCO activates radios at these sites, and ground telecommunication lines carry the information exchange to and from air traffic control facilities. If ground links are not available, communication satellite links are sometimes used to connect pilots and ATCOs. Backup systems are available to provide continued ability to maintain communications when the primary systems fail. Where no radio or satellite coverage is available or selected, pilots and ATCOs communicate through regularly scheduled position reports when aircraft come within communications range.

Communications-focused ATI improvements include various efforts to support greater use of digital communications in air navigation services.

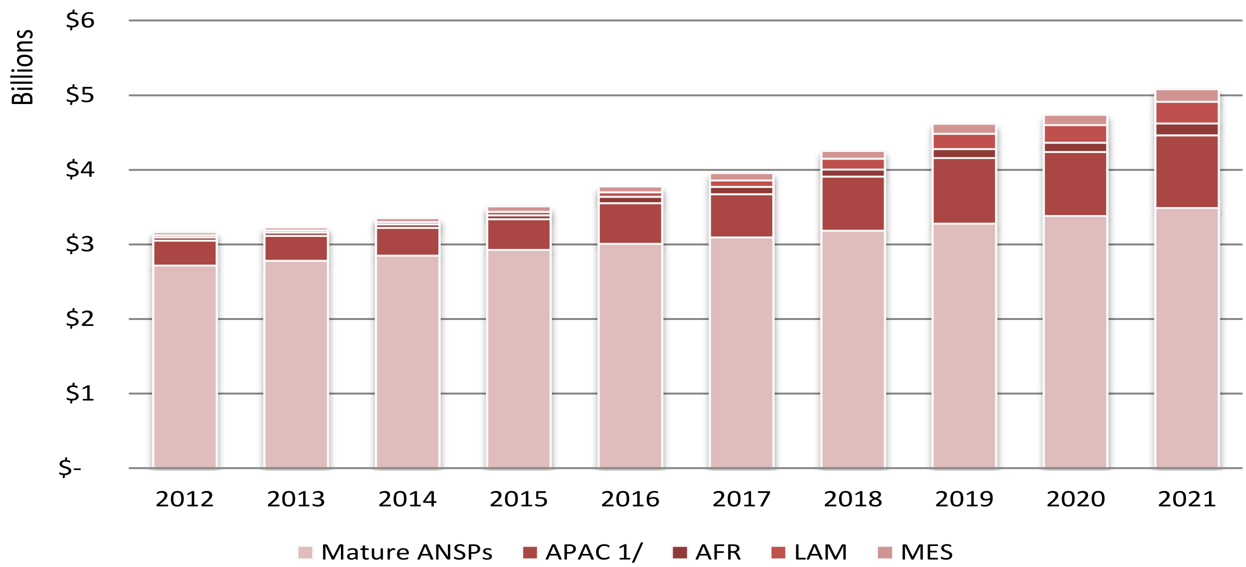
EUROCONTROL has launched Link 2000+, a pan-European program to coordinate the implementation of CPDLC. It is introducing incentives, such as route charge reductions, to encourage operators to equip their aircraft earlier. The goal is for 75 percent of flights to be equipped with Link 2000+ by 2015.

The FAA is developing digital communications with data- link capability under its DataComm program. Initially, DataComm would be used for such routine messages as air traffic clearances, advisories, flight crew requests, and reports. As the technology matures, the FAA may be able to upload an entire flight route directly to an aircraft's flight management system. The FAA is expected to select the vendor to develop the surface network by 2013, and the Study Team assumed, for the purposes of this forecast, that DataComm will reach predominant usage by 2021.

Europe is developing the PENS network to support seamless exchange of voice and data communications among European air navigation service providers. In addition, major radio modernization programs are underway throughout the world. China, the Netherlands, Nigeria, Norway, and Qatar have undertaken such initiatives, and Australia has completed one. Iceland's ANSP, ISAVIA, and Icelandair have tested VoIP ATCO-to-pilot communications.

At a broader level, different ATC facilities have regular, and at times urgent, requirements to communicate with each other and with airspace users to coordinate and manage tactical and strategic operations. Such communications are hindered by disparate and incompatible systems and messaging formats in use among those communities. Efforts to improve the capability, interoperability, and efficiency of communications and information management are included broadly under the banner of SWIM, which is also the title of an FAA program with similar objectives. That program proposes to establish digital information management and

Figure 6-20
Global CNS Investment - By Year



Source: NEXA Forecast 2012-2021; $US Billions

Figure 6-21
10-Year CNS Investment - By Region

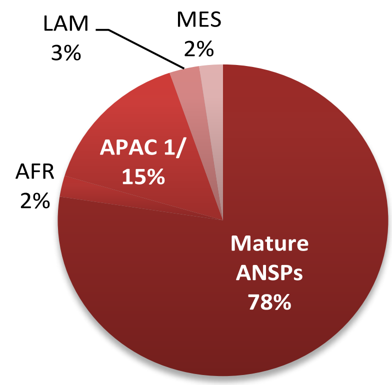


Figure 6-22
CNS Investment- Developing ANSPs

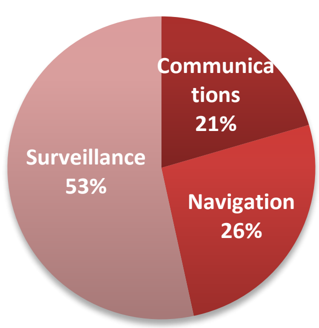
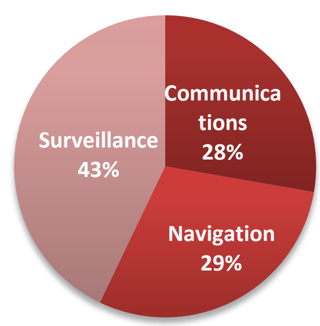


Figure 6-23
CNS Investment - Mature ANSPs



Mature ANSPs include US, Canada, Europe, Australia, New Zealand, and Japan. 1/APAC excludes Australia, New Zealand, and Japan.

data-sharing policies, standards, and capabilities.

In 2005, ICAO's Global ATM Operational Concept adopted the SWIM concept to support greater integration of ATM. SWIM also is a key element of the Aviation Safety Block Upgrades scheme that ICAO is proposing for adoption by its member nations. The improved coordination envisioned for SWIM initiatives would allow ANSPs to transition from tactical conflict management of air traffic to strategic, trajectory-based operations.

Navigation

There are two major types of navigational aids: Those used for en route navigation and those used for approach and landing guidance.

The en route aids have traditionally been radio transmitters that provide pilots with a heading and/or distance from their location to a transmitter. The ground-based system commonly used for en route navigation is VOR/DME. There are roughly 3,700 VORs in the world. There are more than 1,000 US-defined Victor and Jet airways, which are published, straight-lines routes from VOR to VOR. These simplify route planning, provide predictability for ATCOs, and allow pilots to follow their planned routes accurately under all visibility conditions. However, the routings are often circuitous and result in higher fuel consumption.

The advent of more advanced navigation systems may lead to decommissioning of VORs and associated DMEs if national authorities (which may include others outside of ANSPs) decide that they are not needed as backups for navigation satellite systems. For instance, the FAA is scheduled to decide in 2015 whether to continue operating VORs as a backup for GPS or remove them all by 2025. Nations that retain VOR networks as a backup may face a requirement to replace many units or implement programs to extend their service lives.

GNSSs, including the GPS (US), Glonass (Russia), Galileo (Europe), and BeiDou-2/Compass (China) constellations, support more direct routings, as would regional systems like Japan's Multi-Functional Satellite Augmentation System (MSAS) Quasi-Zenith Satellite System, and India's GPS-Aided and Geo-Augmented Navigation (Gagan) System. These systems allow pilots to program and fly routes to a variety of virtual geographic coordinates rather than to fixed VOR locations, resulting in more direct routings and less fuel consumption.

Approach and landing guidance systems and associated equipment support low-visibility operations by providing radio signals and approach lights to help pilots land safely in limited visibility. The most widely-used precision landing aids are ILSs that guide pilots to runway ends by depicting a glide path on cockpit instruments using a pair of radio beams — one for lateral and the other for vertical guidance. ILSs are essential to airlines for maintaining schedule reliability during adverse weather conditions.

Augmented signals from navigation satellites also support precision landing guidance. There are two general types of systems that are most pertinent to ANSP investment requirements.

- Space-Based Augmentation Systems (SBASs)
- Ground-Based Augmentation Systems (GBASs)

SBASs use networks of precisely located ground stations to calculate corrections to the main navigation satellites' signals and broadcast those corrections to aircraft. Examples of space-based augmentation systems include the WAAS, EGNOS, India's Gagan, Japan's MSAS and QZSS, and Russia's System for Differential Correction and Monitoring (SDCM). China also has proposed its own satellite navigation augmentation system.

The FAA's WAAS uses a network of ground monitors to calculate corrections that properly-equipped aircraft can use to fly thousands of available precision approach procedures.

GBAS uses radio signals from precisely located ground stations to transmit local corrections of navigation satellite signals to aircraft in the area. The FAA's Local Area Augmentation System (LAAS) is an example; it is located at or near an airport and calculates corrections to support precision approach services to all runways at that airport in weather conditions approaching zero visibility. GBAS is a critical component of Australia's next-generation ATM infrastructure and is expected to improve safety and help reduce fuel burn and airport delays.

There are three categories of precision approach:

- Category I (Cat I)
- Category II (Cat II)
- Category III (Cat III)

Category I is the most common. It guides the pilot to the runway end, but it requires that the pilot be able to see the runway when the aircraft is no less than 200 feet above the field elevation and the horizontal visibility is one-half mile or more. The Category II and III approaches allow aircraft to descend to lower minimums (i.e., require less vertical and horizontal visibility). Currently, ILS is the primary system used for precision approaches. Cat II and III ILS have redundancy and reliability levels that reduce the risk of equipment failures and allow lower minimums.

Alternatives for precision approach guidance are the SBAS and GBAS. As these alternatives come into broader use, an ANSP may consider decommissioning ILS units, but a number are likely to remain in service to provide back-up capabilities. As an example, the FAA plans to decide in 2014 whether to begin decommissioning Cat I ILS units, and to decide in 2020 whether to decommission all remaining Cat I ILSs. There are estimated 3,600 ILSs in service around the world.

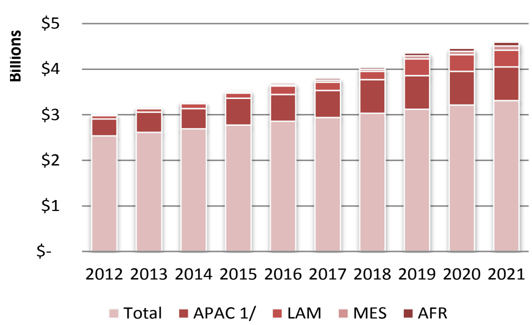
Cat I and Cat II/III ILSs often are paired with systems that light the approach path and measure visibility for a specific position and distance along the runway. The lighting obviously helps the pilot see the runway and transition from instrument to visual flight for landing before reaching runway minimums. The visibility measurements allow ATCOs to advise a pilot whether runway visibility is above or below minimums. Such systems will need to be sustained and remain in operation for precision approach guidance regardless of any decision to decommission ILSs.

Other aids to landing aircraft include lights to identify runway ends and to provide indications outside the cockpit of the aircraft's approximate position on the glide path to the runway. Examples are runway end identification lights (REILs), vertical approach slope indicators (VASIs), and precision approach path indicators (PAPIs) — which in the US are replacing the older technology VASIs. These are expected to remain in service throughout the roadmap timeframe.

Approach systems also include beacons that indicate an aircraft's distance from the runway end. Discussions are under way to replace these beacons – typically installed in three-unit sets (outer, middle, and inner

Figure 6-24

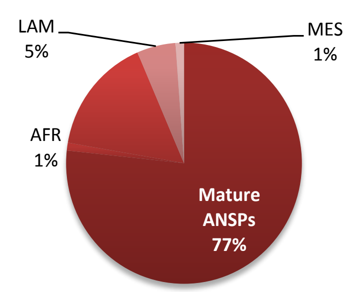
Annual ATM/Automation Investment



Source: NEXA Forecast 2012-2021

Figure 6-25

10-Year ATM/Automation Investment by Region



Source: NEXA Forecast 2012-2021

beacons) – with low-power versions of DMEs that are paired with VORs.

The industry trade association Airlines for America (A4A), for instance, has called for such replacements to reduce the cost of maintaining legacy instrument landing systems. The Study Team assumes that this replacement will take place, accelerating toward the end of the forecast period.

More precise procedures enabled by SBAS, GBAS, and improved aircraft avionics should encourage the phase-out of non-precision, non-directional beacons (NDB) throughout the forecast period. NDBs, of which there are roughly 6,600 in service throughout the world, allow a pilot to determine direction from a transmitter, but do not provide distance information. The FAA, for instance, plans to decommission its NDBs by 2016.

RNAV allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons. This can conserve flight distance, reduce congestion, and allow flights into airports without beacons. RNP is a navigation system that uses satellites and 3D calculations to devise the best route into an airport.

RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. A navigation specification that includes a requirement for on-board navigation performance monitoring and alerting is referred to as an RNP specification. One without such requirements is referred to as an RNAV specification. The use of RNP systems may therefore offer significant safety, operational, and efficiency benefits. While RNAV and RNP applications will co-exist for a number of years, it is expected that there will be a gradual transition to RNP applications as the proportion of aircraft equipped with RNP systems increases and the cost of transition reduces.

Non-precision approaches provide guidance to pilots preparing to land on a runway in limited visibility; however, they only provide lateral, not vertical, guidance. These approaches do not allow descent to the same minimum altitudes possible with a precision approach. VORs support many of the non-precision approaches, and GPS and WAAS also support non-precision approach operations. If the FAA decides to decommission VORs, GPS and WAAS will become the primary means for providing this service. The FAA has more than 4,000 GPS-WAAS non-precision approach procedures in place.

Surveillance

ANSPs use surveillance to track aircraft en route, while approaching and departing terminal areas, and on the ground. In much of the world, this surveillance is performed with a combination of primary radar, which tracks the return of radar transmissions off an aircraft's metallic surfaces and requires no cooperation from the aircraft, and secondary radar, which combines primary radar returns with electronic signals from equipment fitted and activated on aircraft.

Equipment on such "cooperating" aircraft may include Mode S and C transponders that provide aircraft identification, altitude, heading, and speed, and ADS-B transmitters. In remote areas, such as over oceans, radar coverage is unavailable. In these cases, surveillance is performed through regularly scheduled position reports from aircraft or through subscriber services like ADS-C. Radar coverage also can be limited in mountainous terrain. Satellite-based surveillance offers the ability to cover much of the world that cannot be served by radar, and the next generation, using satellite-based ADS-B receivers, could provide surveillance coverage of the entire globe depending on the orbital planes of their host satellites.

Automation systems process a variety of inputs, (including radar and transponder information), which is integrated and fed into ATCO displays. Air route traffic control centers use en route radar, and terminal facilities use several models of airport surveillance radar and possibly precision approach radars.

Multilateration, which is also being used for ground surveillance programs, has already been deployed in Japan and is being considered as the long-term solution for en route surveillance because of the appealing benefits and low costs, both for JCAB and air carriers.

ATCOs at airports use radar to monitor and control the movement of aircraft and ground vehicles on the surface. The surveillance capability of such radar can be combined with data from ADS-B and other technology; this category of surveillance is generally called Surface Movement Guidance and Control Systems (SMGCS). This helps ATCOs manage aircraft on the ground and warns of potential runway collisions. Advanced SMGCS, such as the FAA's ASDE-X, uses several technologies to improve detection of aircraft and provides a clear display of the positions of surface traffic. A technology entering service with SMGCS applications is high-definition television cameras to track aircraft and vehicles and identify details on specific problems (such as the presence of hazardous-materials placards on a ground vehicle involved in an airport collision).

High definition cameras also are involved in another surveillance area: the development of capabilities to separate traffic and guide approaches and departures for an airport from a remote, centralized location. Cameras mounted at an airport provide an ATCO at a remote site with a panoramic view of the terminal area that, combined with radar and other data, would support the safe separation of traffic. ANSPs in Sweden, Australia, and Slovenia are among those investigating remote-tower operations. The Study Team does not expect these operations to be employed to a degree that affects this forecast.

Key Points:

- Investment required for CNS programs is projected to exceed $39 billion through 2021, approximately half of all ground-based ATI spending.
- North America and Europe will drive next-generation communication investment in order to improve efficiencies for both operators and ATCOs.
- Satellite-based navigation is a growing component of air traffic control, and GBAS/RNAV/RNP adoption will accelerate this, but also require large-scale investment by both ANSPs and operators.
- Both advanced and developing regions will invest heavily in surveillance technologies, including burgeoning space-based options like Aireon, both as a safety and revenue-generation driver.

6.2.3.2 ATM & Automation

ATM was forecasted together with automation. Programs covered include airspace management, air traffic advisory services, flight information services, traffic flow management, and alerting services. Required investment in ATM/automation is projected to be $38 billion over the next decade, with an average annual global investment requirement of $3.8 billion. Mature ANSPs are expected to dominate the investment requirement throughout the forecast period, at $29 billion investment. While developing ANSPs' requirement is projected to be only $9 billion within the forecast period (through 2021), these ANSPs are expected to increase investment in ATM and automation and continue to invest well into the following decade.

The antiquated nature of much ATI, widespread use of military/national security airspace restrictions, and the shortage of runway and passenger-facility capacity at airports in key areas of demand have compelled airline, airport, and ATC managers to improve and expand their abilities to manage the flow of air traffic.

Automation is a core element of ATM. In addition to giving ATCOs continuously updated displays of aircraft position, identification, speed, altitude, and trajectory, automation systems can identify conflicts in proposed routes of different aircraft, highlight projected congestion on airways, approaches, and airports and, in the most sophisticated applications, suggest options for streamlining aircraft movements.

The motivation to develop, refine, and deploy these ATM capabilities is intensified by political pressures on aviation to reduce its impact on the environment and the desire of airlines to control and reduce fuel costs as oil prices rise. Efforts to meet those expectations, such as broader use of continuous descent approaches, tailored arrivals, and other trajectory-based operations techniques, depend to a great degree on the ability to improve air traffic management.

Numerous ANSPs are working separately and with their airline customers to enhance ATM capabilities.

- The Netherland's ANSP, LVNL, is working with KLM to develop a speed and route advisor tool, based on tests at Amsterdam's Schiphol Airport that showed eight in ten participating aircraft arrived within 30 seconds of the planned landing time. NASA is developing a similar tool to support the FAA's tailored arrivals program.

- Airways New Zealand is using a collaborative flow manager to work with airlines to minimize arrival and departure delays.

- ATNS (South Africa) has installed an advanced air traffic flow management system at its Central Airspace Management Unit at Johannesburg to support strategic planning and tactical management of traffic in the region. Airservices Australia plans to use the system at its National Operations Center and in regional ATC centers.

- DSNA (France) is using a decision-support tool to plan arrival and departure sequences at Charles de Gaulle Airport in Paris.

- EUROCONTROL in early 2011 introduced the "point merge" technique for merging arrival flows at Oslo Airport. The technique is based on a specific precision area navigation (P-RNAV) route structure and is designed to enable continuous descent approaches even under high traffic load. Applications are under consideration for Paris, Dublin, Rome, Brussels, and Geneva.

Demand for these and other ATM techniques and automation tools, such as electronic flight strips and conflict detection and tactical support, is expected to grow throughout the forecast period as more precise navigation finds greater use, and ANSPs upgrade air route traffic control centers and terminal-area operations. An additional driver of growth in ATM and automation is the increasing demands of airlines and other airspace users for ANSPs to improve productivity and efficiency.

Key Points:

- ATM/Automation investment is driven by air traffic capacity limitations, security concerns, and environmental factors.

- Required investment in ATM/automation is projected to be $38 billion over the next decade.

- Near term investment will likely come from the most advanced countries with the highest traffic density issues.

6.2.3.3 Weather, Facilities, and Mission Support

Programs for the integration of weather into CNS and ATM, the facilities to support ATI, and mission support are projected to require significantly less investment than CNS and ATM. Combined, these programs account for $9 billion or ten percent of the ANSP ATI investment requirement over the next decade (Figure 6-26). Weather is projected to account for roughly one-third of the investment requirement, with facilities and mission support accounting for the balance (Figure 6-27). Once again, mature ANSPs dominate the investment requirement at $6 billion (Figure 6-28).

Weather

Timely and accurate weather observations and forecasts are essential to aviation safety and to the optimum use of aviation capacity. Pilots need to know the direction and speed of winds aloft so that they can take advantage of tailwinds and minimize the effect of headwinds. They also need to know if there will be obstructions to visibility that restrict landings at their destination airport, whether the runway is wet or dry, and how that will affect braking action.

Traffic flow managers and pilots use weather observations and forecasts to determine when they need to plan alternative routes to avoid severe weather. Pilots must avoid thunderstorms with hail and heavy rain, turbulence, and icing because they can damage the aircraft and potentially injure passengers.

ANSPs that provide weather monitoring services (or the government agencies that provide such support for them) generally employ two categories of weather systems: weather sensors and weather processing/dissemination/display systems.

Weather sensors include weather radars and surface observation systems that measure atmospheric parameters, such as surface temperature, prevailing wind speed and direction, relative humidity, and cloud bases and tops, as well as wind shear and microbursts. In more developed ANSPs, these weather sensors provide real-time information to air traffic facilities and to centralized weather-forecasting models.

Weather processing/dissemination/display systems organize and process the sensor's observed data. Data from multiple sensors feed forecast models whose output can be disseminated and integrated in national and local processing and display systems to interpret broad weather trends affecting aviation operations. This information can then be sent to ATCOs, traffic flow managers, dispatchers, pilots, airlines, and other airspace users.

Several factors are expected to support investment in weather systems through the forecast period. These include the aforementioned drive to improve and expand ATM capabilities, which depend to a large degree on accurate weather sensing and forecasting, advances in the technology and techniques to monitoring and modeling the weather, and the expectation that ANSPs comply with ICAO standards and international best practices that will increase as ICAO undertakes more vigorous compliance audits of member nations.

Figure 6-26
10-Year Weather, Facilities, Mission Support Investment

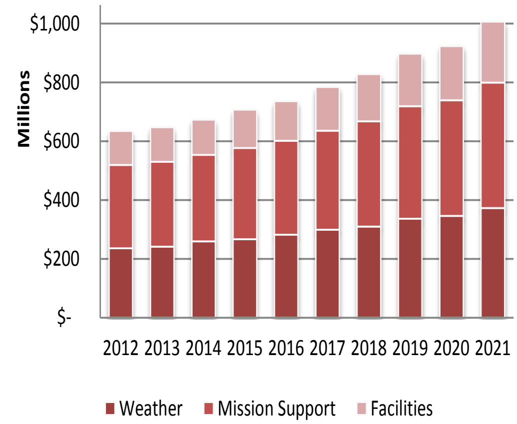


Figure 6-27
ANSP ATI Investment: Weather, Facilities, Mission Support

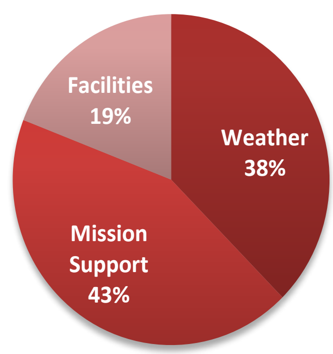
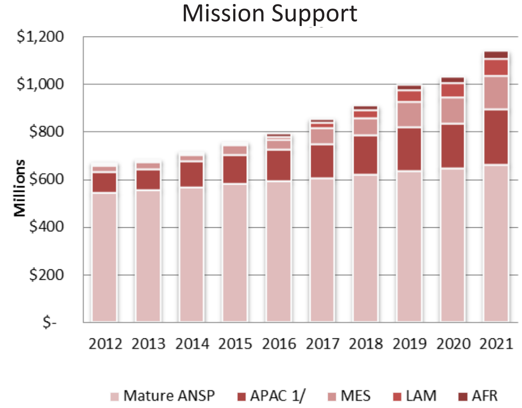


Figure 6-28
ANSP 10-Year ATI Investment: Weather, Facilities, Mission Support



Source: NEXA Forecast 2012-2021

Facilities and Mission Support

Facilities capital budgets include programs that both maintain existing facilities and transition to new facilities. Mission support provides the technical support, such as engineering, to develop new concepts for managing the system and transitioning from old technology to the satellite-based technology of new ATM systems.

ANSPs maintain and operate thousands of staffed and unstaffed operational facilities around the world that must be regularly upgraded and modernized. However, the extent of this infrastructure varies widely from country to country. The US has 21 air route traffic control centers, which house hundreds of employees and the equipment they use to control aircraft flying in the en route airspace. Many nations have a single center, which may be co-located with the approach control facility and tower for the country's main airport. Some countries have no air route traffic control center or approach control facilities. Some have no control towers.

Unstaffed facilities include those that support CNS equipment and weather sensors, much of which is housed in shelters and buildings that have exceeded their service lives and need renovation. Many unstaffed buildings and structures are in remote and/or hostile locations and are subject to damage from extreme weather, natural disasters, pilferage, and terrorism. These conditions result in a steady requirement for maintenance and improvement. As an example, the FAA invests more than $50 million a year to upgrade and improve air route traffic control centers facilities.

A trend that may impact the forecast is the consolidation of major facilities by larger ANSPs as part of efforts to control costs and improve efficiency. In 2011, Russia consolidated several facilities under its Khabarovsk center, and India plans to consolidate its air route traffic control centers, eventually paring the number to four.

As part of mission support, many ANSPs have support contracts and automated management tools to help employees plan and manage modernization of existing systems, develop detailed transition plans to install new equipment, and oversee installation of that equipment.

They also may have technical support programs that provide field engineers to oversee site preparation and installation of new equipment and sustainment of existing facilities. Mission support also includes the validation, testing, and calibration of new procedures. These tasks are often outsourced to specialists.

Key Points:

- Weather, facilities, and mission support are key areas that require commensurate maintenance and upgrades along with modernization efforts.
- These programs account for $9 billion or ten percent of the ANSP ATI investment, with a large majority coming from the most mature ANSPs.
- Consolidation of facilities and privatization or other efficiencies in services may impact requirements for investment or pending shortfall in capital funding.

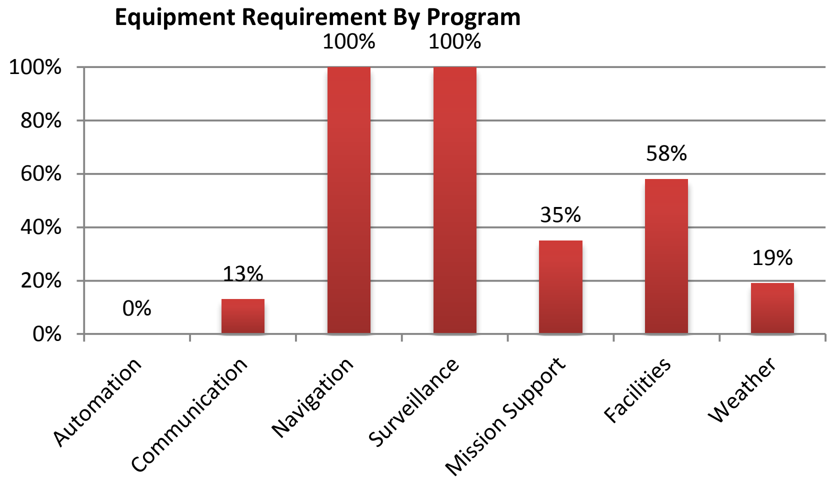
6.2.4 ANSP ATI Forecast by Function

The Study Team forecasted the ATI investment requirement through 2021 by function, that is, equipment, systems, and services. The largest share will be in systems, followed by equipment and services, as shown in Figure 6-32. This section will discuss each function and the related investment.

6.2.4.1 Equipment

Required ANSP investment in equipment purchases is projected to total $33 billion over the next decade and to increase across all regions (Figure 6-29). This will be driven by increased demand for air transportation, advances in technology, and the high maintenance costs of legacy equipment. North America will continue to outpace other regions, given its need to manage a high volume of flights. The other mature ANSPs (Australia, Europe, Japan, and New Zealand) are also expected to invest heavily in ATI

Figure 6-29
ANSP Investment: Equipment



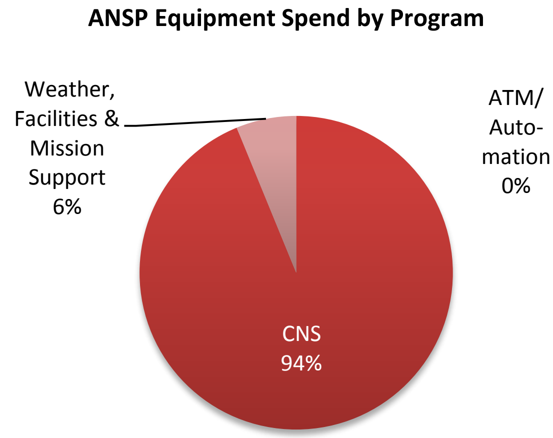
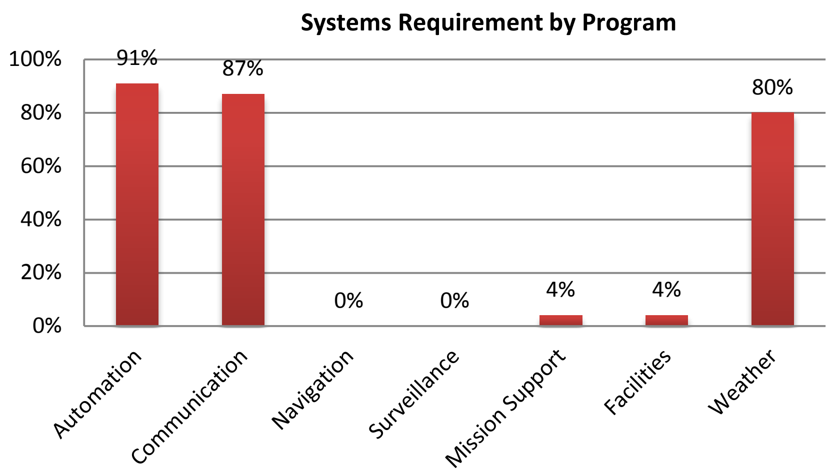


Figure 6-30
ANSP Investment: Systems



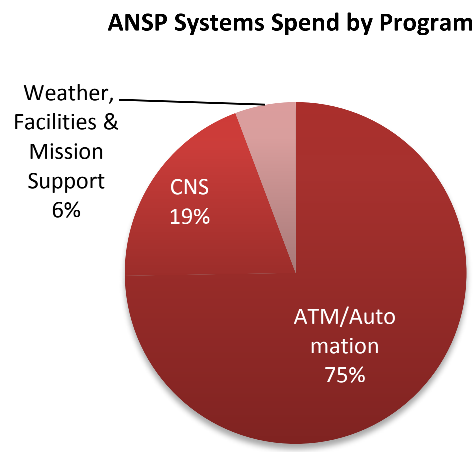
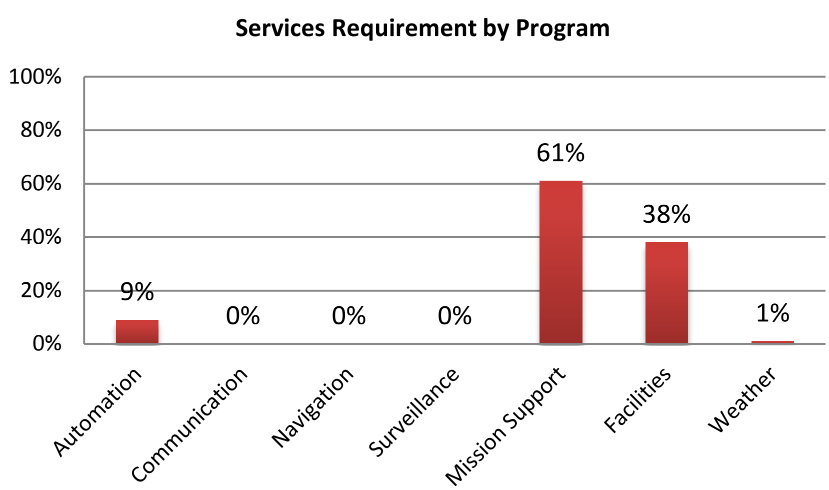
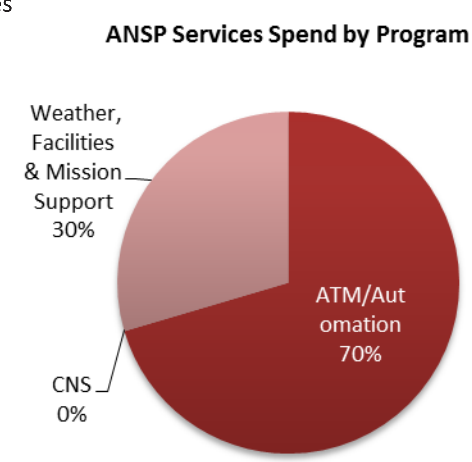


Figure 6-31
ANSP Investment: Services





Source: NEXA Forecast 2012-2021

equipment to manage increasing volumes of air traffic. Developing ANSPs are expected to accelerate investment in equipment through 2021 as new off-the-shelf solutions are developed.

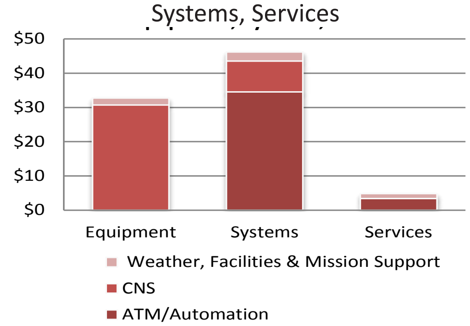
ATM/automation does not have any equipment requirement because, by definition, automation takes inputs from the other programs to provide ATM. CNS accounts for 94 percent of the equipment requirement.

Surveillance accounts for over half of the CNS investment in equipment ($18 billion) and includes ground stations supporting ADS-B and receivers in satellites. Radar units will need to be maintained by mature ANSPs until they complete the transition to ADS-B (and after that, if radar is selected as the backup system.) For developing ANSPs, radars will need to be installed for backup to ADS-B. Communications is projected to require over S1 billion in investment over the decade. The equipment for communications includes air-to-ground infrastructure and various switches.

Forecasted navigation investment is also entirely equipment-based and accounts for $11 billion. Navigation programs include precision takeoff, en route navigation, precision approach, and landing guidance. The management of takeoff, en route, approach and landing is included in the systems and services related to ATM and automation. Facilities and mission support investment in equipment is projected to be $2 billion. The required equipment investment in weather is projected at $600 million.

Figure 6-32

ANSP ATI Investment by Function: Equipment, Systems, Services



Source: NEXA Forecast 2012-2021

6.2.4.2 Systems

ANSP investment in systems to run the equipment is projected to be $46 billion over the next decade (Figure 6-30):

- The required ATM/automation investment in systems is projected to be $34 billion (75 percent of the systems total) and includes systems to provide direction of aircraft on the surface and en route, aircraft separation to prevent collisions, and traffic flow management.
- The communications investment requirement in systems is projected at $9 billion (20 percent of the systems total).
- The required investment for weather systems is over $2 billion (five percent of the systems total).

Navigation and surveillance are equipment intensive, with no systems. Likewise, facilities and mission support have a very small contribution to the required systems investment.

6.2.4.3 Services

In addition to hardware and the systems to run the hardware, there are specific services that support ATI. Automation and mission support are service-focused and each account for half of the required investment in services. Some common services in this category would include:

- ADS-B services
- Aviation safety analysis system
- Regulation and certification of infrastructure system safety (RCISS)
- Aeronautical information management
- System engineering and R&D support
- Operational testing and evaluation
- Information technology and security
- Facilities decommissioning services
- Training

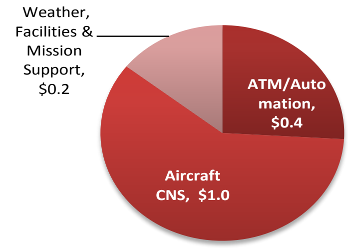
For example, with dozens of ADS-B ground stations spread among its archipelago, Indonesia and Australia have formally agreed to an exchange of enhanced flight data across FIR boundaries between the two countries. ANSPs are projected to invest almost $5 billion in services. Automation has the largest share with $3 billion followed closely by facilities and mission support with $1.5 billion. Weather is expect to acquire $31 million is services, such as Doppler radar data feeds (Figure 6-31).

6.2.4.4 Training

ICAO publishes guidelines for training standards for ANSPs in member states, private organizations, colleges, and universities. Within ANSPs, there are significant variances in training programs. Annex One of the Chicago Convention outlines personnel licensing procedures, but the procedures are at a high level, leaving room for interpretation and those variances. Differing levels of service from ANSPs cause communication and procedural inefficiencies. In general, ATCOs must complete three or four years of training on positions, in sectors, and other situations before they are fully certified. ANSPs also may conduct periodic training and re-training to address major changes in procedures or policies. New programs supporting advanced CNS/ATM will require ongoing training. In 2007, LEK Consulting analyzed the training requirements on behalf of the FAA. ANSPs will need training programs for management and air traffic ATCOs on implementation and procedures. The Study Team estimates that training will require a $700 million investment by ANSPs through 2021. Mature ANSPs are expected to focus on transition training and developing a customer service approach, in addition to meeting current training requirements. Developing ANSPs will need to establish baseline training for ATM, in addition to training on the functionality of new CNS capabilities.

Figure 6-33

CNS/ATM Training Requirements



Source: NEXA Forecast 2012-2021

Key Points:

- As discussed in this section, the requirement for investment in ATI is expected to be $105 billion through 2021.
- Lengthy modernization program delays can be expected if governments are the sole source of funds, as many around the world are facing severe budgetary constraints.
- A squeeze on government funding will force a movement toward "user pay" strategies, including new overflight fees from evolving capabilities such as ADS-B surveillance and traditional user fees, such as overflight, en route, take-off, and landing fees.

6.3 Commercial Aircraft Equipage Investment — Unconstrained

Aircraft will need to be equipped to operate in the controlled airspace managed by ANSPs. The Study Team developed forecasts for commercial aircraft in scheduled and nonscheduled operations for both passenger and cargo service, and then projected the required equipage investment for these aircraft. The projected global aircraft investment over the next decade will be $19 billion for CNS, including equipment, plus $1 billion in required training associated with the use of new capabilities.

6.3.1 Forecast Methodology

The Study Team developed a commercial aircraft fleet forecast by starting with the 2011 aircraft fleet, as provided by the OAG fleet database, and comparing and reconciling it with ICAO's fleet forecast (Figure 6-35). The 2011 fleet was segmented into the following categories: twin-aisle; single-aisle greater than 100 seats; regional jets with fewer than 100 seats, and turboprop aircraft. ICAO's fleet forecast growth factors were applied to the 2011 baseline fleet to project the total fleet by year, by aircraft class, and by world region. The Study Team modeled new deliveries by aircraft type and world region based on forecasts provided by the aircraft manufacturers (Airbus, Boeing, Bombardier, and Embraer). New aircraft deliveries were allocated to growth and replacement of retiring aircraft.

The projected fleet for 2012 through 2021 was then segmented into the four equipage classes. Equipage factors were assigned to aircraft type, world region, and equipage class. The methodology for this part of the forecast is discussed further under aircraft equipage forecast. Finally, the Study Team assigned equipage costs to each CNS program for aircraft by aircraft type, world region, and equipage class. The fleet and equipage forecast that supports the aircraft investment forecast is described in the next sections.

Figure 6-34
CNS Aircraft Investment Requirements by Region: 10-Year Total

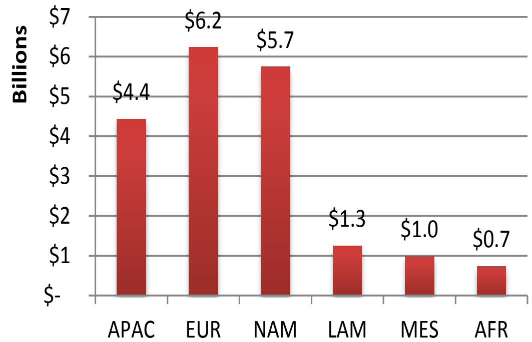
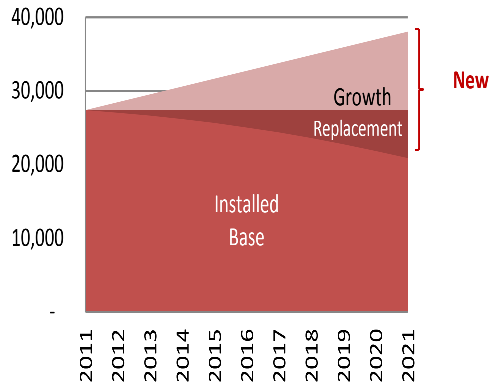


Figure 6-35
NEXA Global Fleet Forecast 2012-2021



Source: NEXA Forecast 2012-2021

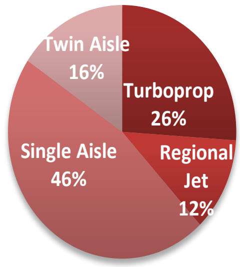
6.3.2 Global Fleet Forecast (2012-2021)

The global commercial aircraft fleet is projected to grow from 27,000 aircraft in 2011 to 38,000 in 2021. The fleet includes scheduled and non-scheduled operations and both passenger aircraft and freighters (Figure 6-36).

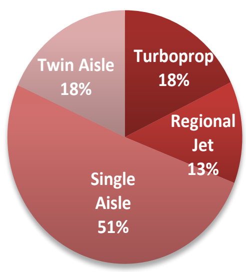
The Study Team foresees a shift through the forecast period toward single-aisle aircraft seating more than 100 passengers, which are forecast to increase from 13,000 aircraft in 2011 to 20,000 aircraft by 2021. Twin-aisle aircraft are expected to increase from 4,200 aircraft in 2011 to 7,000 aircraft by 2021. Regional jets, including the EJETS and the CRJ900/1000, are expected to increase from 3,300 aircraft in 2011 to 5,000 aircraft by 2021. The turboprop aircraft fleet is expected to decline from 7,300 aircraft in 2011 to 6,800 aircraft by 2021 because of lack of new production.

Figure 6-36

Global Fleet 2011 (27,000 Aircraft)



Global Fleet 2021 (38,000 Aircraft)



Source: NEXA Forecast 2012-2021

6.3.3 Equipage Classes

The forecasted fleet is grouped into four classes:

- Class 1: Forward fit
- Class 2: Upgradeable
- Class 3: Retrofitable
- Class 4: Non-retrofitable.

The classifications are based on the avionics installed in the aircraft and the requirements for the aircraft to participate in CNS and ATM programs developed by the ANSPs.

Forward Fit (Class 1) aircraft are those expected to be delivered with the required avionics and systems to utilize advanced CNS/ATM capabilities. Aircraft scheduled for delivery after 2014 are assumed to be equipped with ADS-B, data communications, advanced navigation equipment,and include new-design aircraft (such as the 787, A350, and Bombardier C-Series), which will have the required capabilities before delivery. Current designs (such as the A320NEO, the 737MAX, and the large regional jets) are assumed to be redesigned to have the required capabilities as standard equipment for new deliveries from 2014 forward.

Upgradeable (Class 2) aircraft are assumed to be digital (or compliant with ARINC 758 – both the early specifications and the 758-2 protocols adopted in 2005). These aircraft are those manufactured between 2002 and 2014. The upgrade for these aircraft is often simply the activation of service bulletins, replacement of a digital card, and some basic wiring. Upgradeable aircraft are expected to have upgrade kits available, especially for ADS-B Out and DataComm. Many of these aircraft have latent systems that can be activated by replacement of a card in the avionics system and the purchase of service bulletins.

Retrofitable (Class 3) aircraft included those manufactured between 1981 and 2002 that are compliant with ARINC 724 and 724-B protocols. These aircraft are analog-based but have some digital capabilities. Retrofits require replacement of analog hardware and transponders, rewiring of equipment, and activation of service bulletins. Retrofitable aircraft would need new equipment, including upgraded transponders, GPS transceivers, data display such as an electronic flight bag (EFB), RNAV/RNP, SWIM, and data communications equipment.

Non-Retrofitable (Class 4) aircraft were manufactured more than 30 years ago, and replacement of hardware and systems on them would be exceedingly expensive, if at all possible. Non-retrofitable aircraft are assumed to be too old and costly to retrofit for compliance and therefore are expected to be retired or put into domestic service in world regions where ADS-B and digital communications are not mandated.

Figure 6-37 presents the four equipage classes and the requirements by class for compliance with advanced CNS and ATM capabilities. The primary equipage categories included ADS-B Out/In, FMS, type of data display (analog versus digital), type of data radio (analog versus VHF data radio), communications management system, AOC (plain old

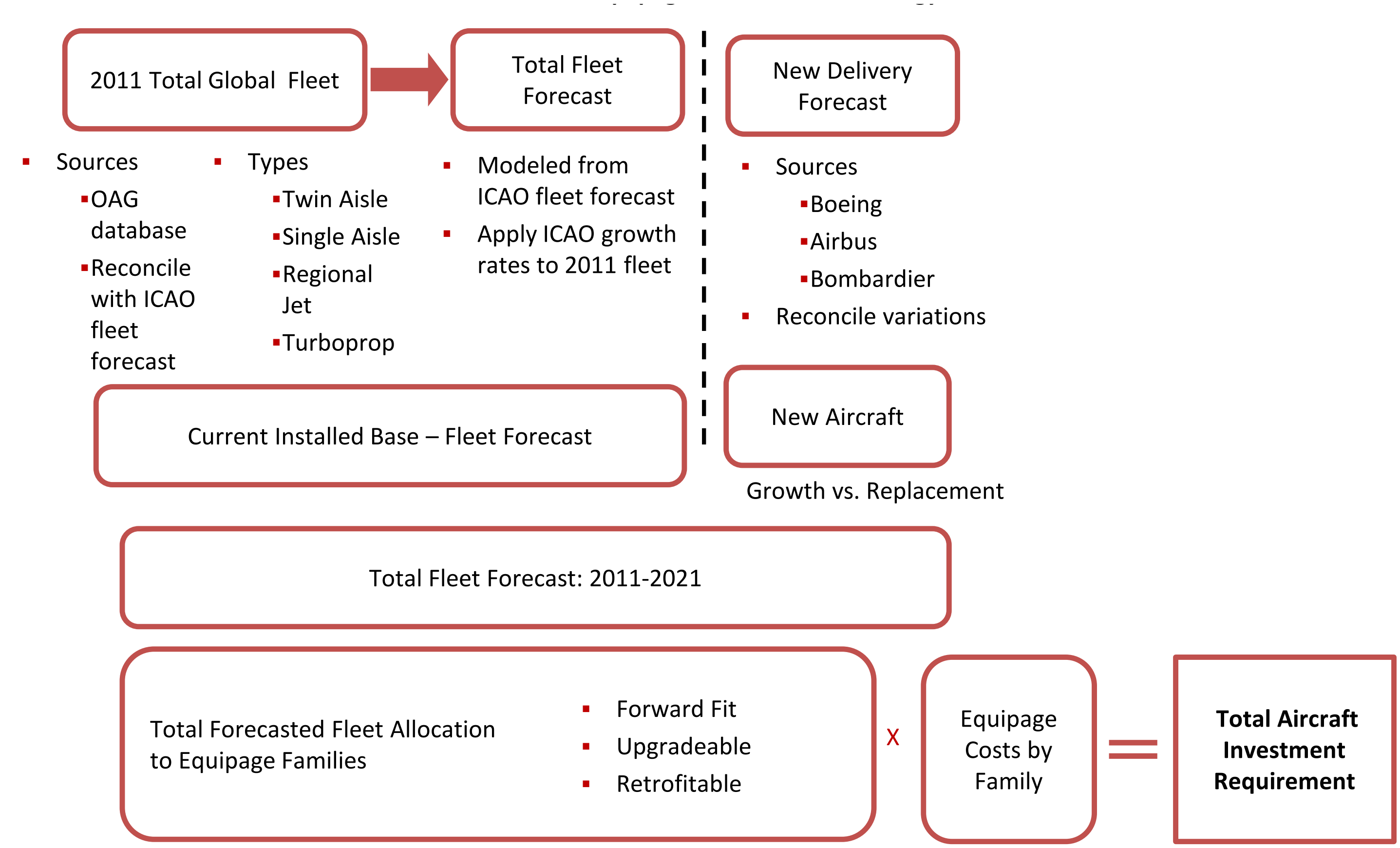
Figure 6-37

Equipage Families	Class 4 – Not Upgraded	Class 3 - Retrofitable		Class 2 - Upgradeable		Class 1 – Forward Fit
ARINC Reg		ARINC 724/724B	ARINC 724B	ARINC 758 (EARLY)	ARINC 758 (CURRENT)	
Production Year	<1980	1981-1993	1994-2000	2001-2002	2003-2013	2014- Forward
Example Aircraft	B-727, A-300 DC9/MD80, Most Turboprops	B747,B777, All RJs	A320 , B737	B-767-100, A-340,A320	B-737-7/8/9, A-320 B777	B-787; A380; A320 Neo; B737
Current Avionics						
ADS-B Out	None	None	None	None	None	Transponders and GPS Positioning
ADS-B In	None	None	None	None	None	Display and wiring
FMS	None	Dedicated FMS	Latent FANS 1/A* AIMS I	Latent FANS 1/A* AIMS II	Latent /Active FANS 1/A*	Dedicated FMS / FANS
Data Display	ACARS Display Unit	ACARS Display Unit	MCDU (A739)	MCDU (A758 CMU + APM)	MCDU (A758 +APM)	MCDU
Data Radio	2-3 analog radios	2-3 Analog Radios	Analog Radio	Analog Radio	1-3 VDR radios	1-3 VDR radios
Comm Managt	ACARS MU	ACARS MU	ACARS MU	CMU-900-101	CMU-900-151	CMU
AOC	POA	POA	AOA	POA	AOA or SATcom POA	AOA or SATcom
DCNS Migration Plan	To CMU/VDR or ATN Work Package 1	Implement FANS 1A+ or ATN Work package 1	Implement FANS 1A+ or ATN Work package 1	Implement FANS 1A+ or ATN Work package 1 Implement AIMS II	Implement FANS 1A+ or ATN Work package 1	AOA or SATcom POA
DCNS Upgrade	Expensive upgrade	Upgradable to CMU dedicated	FANS upgradable with Service Bulletin or Mod 2 modification	Needs hardware and software	Needs software and some hardware	None

Source: NEXA Analysis

Figure 6-38

Aircraft Equipage Forecast Methodology



Source: NEXA Forecast

ACARS [POA] or AOA, or SatComm), DCNS migration plan, and the required upgrades.

Key Points:

- The global commercial fleet is expected to grow to over 38,000 aircraft by
- 021, driven by delivery increases in single-aisle aircraft.
- For the purposes of these forecasts, all existing and forecasted new aircraft were grouped into four classes:
    - ◊ Class 1: Forward Fit – delivered with the required capabilities.
    - ◊ Class 2: Upgradeable – younger aircraft, software/other upgrades.
    - ◊ Class 3: Retrofitable – older aircraft, large scale replacement of equipment.
    - ◊ Class 4: Not-Retrofitable – too old/costly.
- Forecasted avionics upgrades include ADS-B Out/In, upgraded digital communication, SWIM and advanced GPS WAAS/EGNOS-configured RNAV/RNAP navigation.

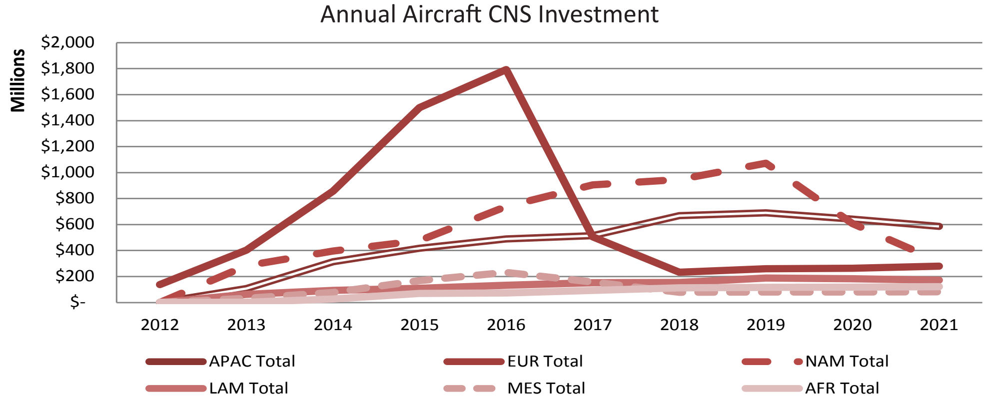
6.3.4 Aircraft Equipage Investment

The Study Team made assumptions about the scope and timing of aircraft equipage based on aircraft type, equipage class, and world region. These assumptions are set out in Figures 6-38 and 6-39. Equipage for each region was based on the large macro analysis of the ANSPs and 60 selected countries.

The Study Team developed broad equipage cost factors based on materials provided by the Aerospace Industries Association, the FAA, EUROCONTROL, OEMs, airlines themselves, and other industry organizations. The Study Team adjusted these cost estimates from other organizations to reflect typical discounts from catalog pricing and market pricing once the programs become operational. Figure 6-41 provides the Study Team's assumed average equipage costs per program by aircraft type, although it should be noted that the deviation in actual costs will vary widely. Analyzing the equipage cost by aircraft type and equipage class provides an indication as to the timing for equipping aircraft.

New aircraft delivered after 2014 are assumed to be forward fit, with the avionics and systems to support CNS. The installed base is the 2011 fleet that is projected to remain in operation through 2021. These aircraft will need to be upgraded or retrofitted for CNS.

Figure 6-39
Annual Aircraft CNS Investment



Source: NEXA Forecast 2012-2021; scheduled and non-scheduled commercial aircraft; jet, regional jet, turboprop; $US Millions

For all world regions, Class 1 Forward Fit aircraft are assumed to be delivered with digital communications avionics and systems (DataComm/Link 2000+ and SWIM), ADS-B Out, and navigation systems (RNAV & RNP).

Class 2 upgradable aircraft are assumed to be equipped with ADS-B Out and digital data communications, with some being equipped for advanced navigation based on the world region.

The Class 3 retrofitable aircraft are expected to require upgrade investment of over $1 million per aircraft for twin-aisle/single-aisle aircraft and approximately $600,000 for regional jets and turboprops. Given the prohibitive cost of older aircraft, this class is assumed to be fully equipped for the mandated/accepted programs (ADS-B and digital data communications) but only marginally equipped for navigation systems. Installing RNAV/RNP technology in the Class 3 aircraft is both difficult and costly. These aircraft are also not likely to be equipped with ADS-B In technology unless it is mandated.

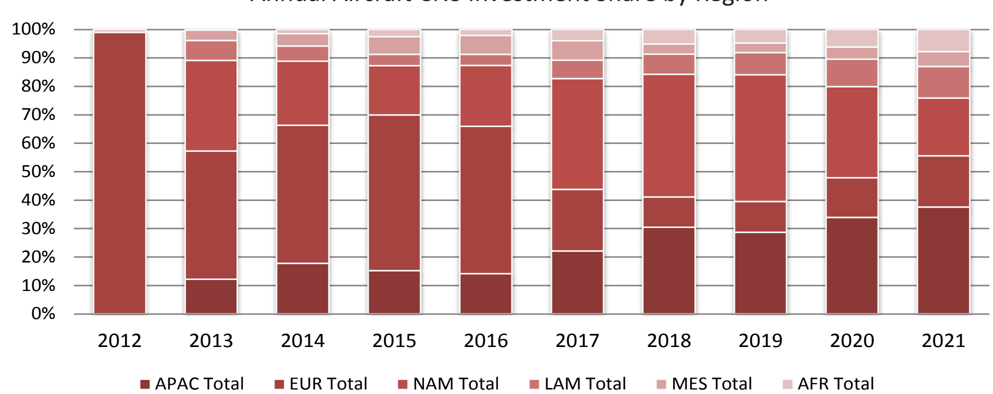
In addition to installing equipment onto aircraft, operators will need to train flight crews, controllers, dispatchers, and maintenance staff on the new equipment and CNS programs. The Study Team estimates training to be five percent of the total equipage cost ($1 billion).

From a regional perspective, Europe leads the equipage investment requirement due to the mandates for Link 2000+ and ADS-B (Figure 6-39). North America's investment requirement is projected to be slightly less, at under $6 billion, given the US ADS-B mandate is not until 2020 and DataComm is forecasted for predominant adoption later in the forecast period. The Asia Pacific region, at $4 billion, is the third largest due to the number of twin-aisle aircraft (33 percent of the fleet) in the region that fly oceanic routes to North America and Europe where key CNS-related equipage mandates have been established. Projected equipage for Latin America, Africa, and the Middle East combined will require $3 billion, roughly half the requirement for Europe or North America. These regions have smaller fleets and fewer oceanic twin-aisle aircraft.

The aircraft equipage investment requirement accelerates throughout 2021 as ADS-B and data communications programs become mandated and developing ANSPs are able to develop ATM programs using space-based ADS-B. Airlines in Africa, the Middle East, and Latin America are expected to accelerate equipage of twin-aisle aircraft to serve Europe and US markets. Single aisle aircraft and regional jets are expected to lag in equipage and will not equip until outside the forecast period. Airlines in Europe are projected to be early adopters of new equipage required to utilize advanced CNS and ATM capabilities, with 100 percent of the investment requirement in 2013. European airlines' share of the required investment is expected to decline as the European fleet is equipped and as eq-

Figure 6-40

Annual Aircraft CNS Investment Share by Region



Source: NEXA Forecast 2012-2021

uipage programs accelerate in other world regions (Figure 6-40).

Key Points:

- Commercial aircraft operators will need to invest more than $19 billion to equip aircraft for CNS programs.
- Operators will also be expected to participate in the funding of ANSP ATI projects, as user fees drive these.
- Governments and respective ANSPs are exploring programs to create incentives for operators to equip with the required avionics. In the US, there are discussions that operators who equip will receive preferential treatment under a program called "Best Equipped Best Served." Operators may be more agreeable to equipping aircraft if the benefits of the investment are presented in a compelling business case (see Chapter 7).

6.4 Incorporating Investment Constraints

Mature economies face multiple serious challenges in the aftermath of the global financial crisis of 2008. While each economy and region has its own particular issues, growth remains anemic across mature economies. Government debt has risen to potentially unsustainable levels, unemployment is high, and income inequality is rising. Many mature economies need to pay down high levels of public and private debt. This period of deleveraging is likely to be prolonged, if history is a guide, and will not only act as a drag on growth, it will also widen the gap between ATI investment requirements and the realities of what governments can afford.

Aviation infrastructure projects compete for funding with other infrastructure projects including roadways, railroads, ports, and bridges. The Organization for Economic Cooperation and Development estimates that a $60 trillion investment will be needed for infrastructure by the world's leading economies over the next two decades, but only 40 percent will be funded by governments. ATI is competing for these limited funds.

6.4.1 ANSP ATI Investment — Constrained

NEXA analyzed each of the 60 selected countries for ability to finance ATI. Factors influencing a government's ability to finance infrastructure include credit rating, public debt, inflation, GDP growth, number of ATI projects announced, and level of privatization of ATI. Based on this analysis, each country was assigned an expected government funding level ranging from 100 percent for China, Australia, New Zealand, Afghanistan, the UAE, and Saudi Arabia, to a low of 60 percent for Japan, Argentina, Romania, and several other countries.

Note: NEXA's analysis set the low at 60 percent, rather than the 40 percent projected by the Organization for Economic Cooperation and Development, primarily due to the military and national security elements of ATI, since a minimal baseline of ATI will be funded by governments to ensure national security.

Additionally, ANSPs will have greater ability to use ADS-B to track aircraft in their airspace and thereby increase revenues by charging aircraft operators with specific flight details. ANSPs may also be incentivized to implement ADS-B surveillance programs either through terrestrial-based receivers or by purchasing the aircraft position data stream from providers of space-based ADS-B receivers. Thus, ADS-B programs are expected to be fully funded. Programs other than ADS-B that are directly used by commercial aircraft operators, including some ATM programs, will suffer from the shortfall.

As previously stated, an $86 billion global ANSP investment is needed to modernize air traffic management over the next decade, with government sources providing an average of only 77 percent, leaving a $19 billion gap (Figure 6-42).

More mature ANSPs in the Asia Pacific region have the highest expectation of potential funding (Figure 6-43). Japan pulls down the average due to a weak economy and exceptionally high public debt. Australia and New

Figure 6-41

Aircraft Equipage Cost by Equipage Class			
Twin Aisle	Class 1	Class 2	Class 3
$ 000	Forward Fit (2014+)	Upgradable (2002-2013)	Retrofitable (1981-2001)
ADS-B Out	$ 80	$ 90	$ 100
Ads-B In	$ 85	$ 138	$ 158
Navigation	$ 75	$ 355	$ 595
Communication	$ 95	$ 150	$ 225
Total Cost per Aircraft	$ 335	$ 733	$ 1,078

Number of Aircraft Equipped			
Twin Aisle	Class 1	Class 2	Class 3
	Forward Fit (2014+)	Upgradable (2002-2013)	Retrofitable (1981-2001)
ADS-B Out	3,771	2,366	2,133
Ads-B In	2,802	936	990
Navigation	3,771	1,639	1,640
Communication	3,771	1,868	1,454

Global Equipage Cost				
Twin Aisle	Class 1	Class 2	Class 3	Total
$ 000	Forward Fit (2014+)	Upgradable (2002-2013)	Retrofitable (1981-2001)	
ADS-B Out	$ 301,680	$ 212,922	$ 213,330	$ 727,932
Ads-B In	$ 238,170	$ 129,134	$ 156,349	$ 523,652
Navigation	$ 282,825	$ 581,827	$ 976,038	$ 1,840,690
Communication	$ 358,245	$ 280,140	$ 327,150	$ 965,535
			Twin Aisle Total	$ 4,057,810

Single Aisle >100 Seats	Class 1	Class 2	Class 3
$ 000	Forward Fit	Upgradable	Retrofitable
ADS-B Out	$ 80	$ 90	$ 100
Ads-B In	$ 85	$ 138	$ 158
Navigation	$ 75	$ 355	$ 595
Communication	$ 95	$ 150	$ 225
Total Cost per Aircraft	$ 335	$ 733	$ 1,078

Single Aisle >100 Seats	Class 1	Class 2	Class 3
	Forward Fit	Upgradable	Retrofitable
ADS-B Out	7,653	7,828	5,040
Ads-B In	2,310	2,337	1,080
Navigation	7,653	6,699	4,777
Communication	7,653	5,171	4,106

Single Aisle >100 Seats	Class 1	Class 2	Class 3	Total
$ 000	Forward Fit	Upgradable	Retrofitable	
ADS-B Out	$ 612,240	$ 704,561	$ 503,985	$ 1,820,786
Ads-B In	$ 196,359	$ 322,569	$ 170,582	$ 689,510
Navigation	$ 573,975	$ 2,378,198	$ 2,842,434	$ 5,794,607
Communication	$ 727,035	$ 775,607	$ 923,859	$ 2,426,501
			Single Aisle > 100 Seats Total	$ 10,731,403

Regional Jet < 100 Seats	Class 1	Class 2	Class 3
$ 000	Forward Fit	Upgradable	Retrofitable
ADS-B Out	$ 125	$ 90	$ 100
Ads-B In	$ 35	$ 90	$ 90
Navigation	$ 60	$ 245	$ 245
Communication	$ 95	$ 180	$ 180
Total Cost per Aircraft	$ 315	$ 605	$ 615

Regional Jet < 100 Seats	Class 1	Class 2	Class 3
	Forward Fit	Upgradable	Retrofitable
ADS-B Out	1,557	2,688	688
Ads-B In	524	662	167
Navigation	726	2,442	679
Communication	1,664	2,149	462

Regional Jet < 100 Seats	Class 1	Class 2	Class 3	Total
$ 000	Forward Fit	Upgradable	Retrofitable	
ADS-B Out	$ 194,625	$ 241,929	$ 68,775	$ 505,329
Ads-B In	$ 18,344	$ 59,571	$ 15,030	$ 92,945
Navigation	$ 43,530	$ 598,168	$ 166,355	$ 808,053
Communication	$ 158,080	$ 386,766	$ 83,178	$ 628,024
			Regional Jet < 100 Seats Total	$ 2,034,350

Turboprop	Class 1	Class 2	Class 3
$ 000	Forward Fit	Upgradable	Retrofitable
ADS-B Out	$ 175	$ 175	$ 175
Ads-B In	$ 100	$ 140	$ 145
Navigation	$ -	$ 75	$ 120
Communication	$ 95	$ 180	$ 180
Total Cost per Aircraft	$ 370	$ 570	$ 620

Turboprop	Class 1	Class 2	Class 3
	Forward Fit	Upgradable	Retrofitable
ADS-B Out	1,209	1,534	3,388
Ads-B In	371	530	1,195
Navigation	1,144	1,153	3,329
Communication	1,209	692	1,678

Turboprop	Class 1	Class 2	Class 3	Total
$ 000	Forward Fit	Upgradable	Retrofitable	
ADS-B Out	$ 211,575	$ 268,398	$ 592,944	$ 1,072,916
Ads-B In	$ 37,110	$ 74,158	$ 173,319	$ 284,587
Navigation	$ -	$ 86,468	$ 399,492	$ 485,960
Communication	$ 114,855	$ 124,488	$ 302,049	$ 541,392
			Turboprop Total	$ 2,384,854

Total Twin, Single, RJ, TP	Class 1	Class 2	Class 3	Total
$ 000	Forward Fit	Upgradable	Retrofitable	
ADS-B Out	$ 1,320,120	$ 1,427,809	$ 1,379,034	$ 4,126,963
Ads-B In	$ 489,982	$ 585,432	$ 515,279	$ 1,590,693
Navigation	$ 900,330	$ 3,644,661	$ 4,384,319	$ 8,929,310
Communication	$ 1,358,215	$ 1,567,001	$ 1,636,236	$ 4,561,452
			Total Equipage Cost	$ 19,208,417

Zealand, via commercialized ANSPs, are already drawing funding from the private sector. The remainder of the Asia Pacific region is expected to fund on average 81 percent of the required investment, with China having the largest funding requirement but also the greatest capability to fund all of its investment needs.

The Middle East region is expected to fund 80 percent of the required investment due to its overall low public debt and the strategic importance of aviation. In Oman, like its regional neighbors, the government plans to adopt a new air traffic management system to complement the massive investment it is making in its airport sector.

Europe is expected to fund on average 78 percent of the required investment, with the strong economies of Germany, France, and the UK bringing supporting investment, while the weaker economies of Ireland, Italy, and Romania struggle to maintain even current levels of investment.

Both North and South America face constraints. Canada buoys the North American average via a strong economy and strategic commitment to aviation. In contrast, Latin America comprises weaker economies and competing infrastructure needs that will likely leave aviation underfunded. In the US, government officials are expected to face continued demand to reduce public spending, resulting in an expected shortfall of 25 percent of the required investment. Recent reports by the Congressional Budget Office and the Government Accountability Office found that the funding projections for NextGen ATI are inadequate. Despite the 2012 FAA Reauthorization of the FAA, little progress has been made towards securing a full ATI modernization plan. The reauthorization bill authorizes a flat amount of $2.7 billion over the next four years; however, funding is still subject to annual Congressional appropriations and may very well face future cuts.

Figure 6-42
ATI ANSP Investment Forecast 2012-2021; $Billions

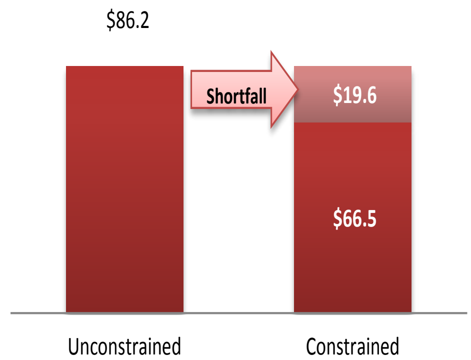
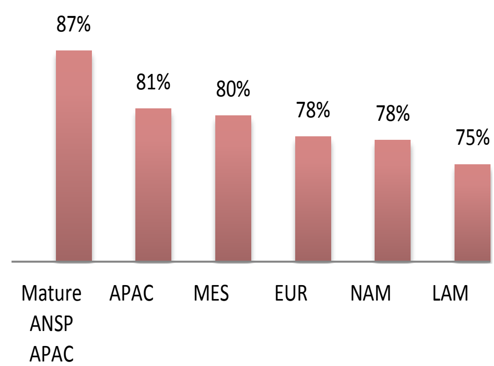


Figure 6-43
Expected Ability to Fund by World Region



Source: NEXA Forecast 2012-2021

Key Points:

- Aviation infrastructure projects often compete for government funding with other infrastructure projects including roadways, railroads, ports, and bridges.
- Factors influencing an ANSP's (or government's) ability to finance infrastructure include revenue securitization prospects, revenue quality, credit rating, public debt, inflation, GDP growth, number of ATI projects announced, and level of privatization of ATI.
- NEXA's analysis finds that on average only 75 percent of the ATI investment requirement will be met through government funding, leaving a $19 billion gap.

6.4.2 Aircraft Equipage Investment – Constrained

Commercial aircraft operators, especially passenger airlines, have been hesitant to invest in equipping aircraft with the necessary avionics for CNS without a clear commitment that it has the capability to deliver benefits that outweigh equipage costs. Simply installing the required avionics is not sufficient to achieve the benefits, which require ANSP infrastructure and procedures in place to utilize the technology.

Forward-fit aircraft will be designed with CNS equipment and will be relatively painless for airlines to acquire. The CNS equipment will be incorporated in the overall aircraft price and performance gurantees. Aircraft manufacturers will use full compliance with CNS capabilities as a selling point to airlines and will compete to provide the best and most complete package.

Thus, we expect that the forward-fit equipage will be funded. The upgradable and retrofitable aircraft will cost aircraft operators out-of-pocket to bring the aircraft to be CNS-capable and able to access the modernized ATI being undertaken by ANSPs. There is an "aircraft equipage paradox" because, as matters stand today, at least 50 percent of the aircraft fleet in controlled airspace needs to be equipped to gain the benefits of the new ATM systems.

Thus, those operators who are last to equip with new avionics to participate in CNS gain the greatest financial benefit, while those operators first to adopt the new technologies will pay a much higher price at a far greater risk. With such a clear disincentive to accelerate aircraft equipage, operators will need strong incentives. For example, long-range, twin-aisle fleets may accelerate uptake for CNS since these aircraft are used for trans-oceanic operations and can take advantage of the expected efficiencies of oceanic satellite-based ATM.

Given these operational and institutional issues, we assume that aircraft investment funding availability over the forecast period will likely vary by type of aircraft, as well as by region, depending on where benefits may exist in the near to mid term.

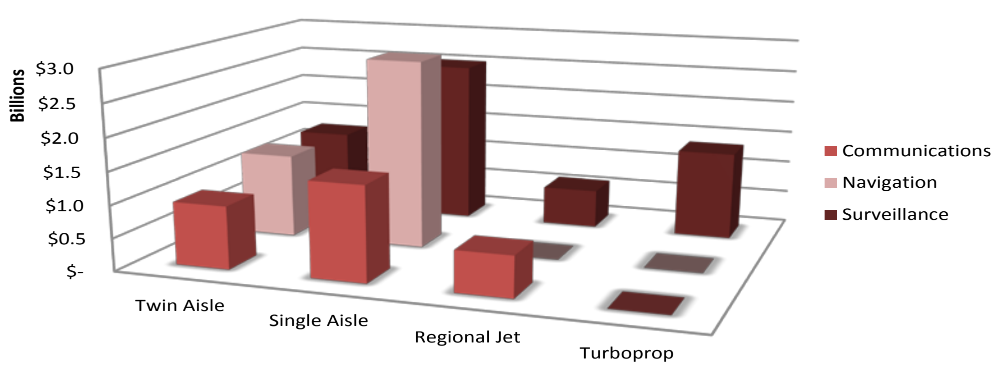
Another impetus is government imposed deadlines, such as the EU deadline of 2015 for Link 2000+ and 2017 for ADS-B Out. But mandated deadlines do not ensure that operators will be able to fund the necessay equipage. Similarly, regional aircraft will require full funding to access congested airspace in both North America and Europe and will also likely receive requisite funding approvals. Single-aisle aircraft, however, may be deemed capable with some existing capabilities, causing us to anticipate a lag in available funding for modernization in the near term.

Navigation upgrades for aircraft provide the most difficult challenge for aircraft operators. Not only are these upgrades the most costly (due to integration into flight management systems), they also require sufficient ground-based infrastructure to provide benefit.

As such, we foresee considerable benefits for navigation equipage but little appetite

Figure 6-44

NEXA Expected Aircraft Equipage Investment



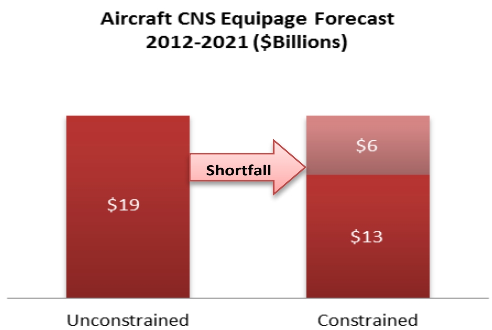
Source: NEXA Forecast 2012-2021; $US Billions or availability for funding over the forecast period. Only a portion of twin-aisle and single-aisle aircraft will offer the return on this investment.

Given mandates, quickly emerging technologies, and ANSP adoption of satellite-based surveillance, we are forecasting a fully-funded scenario for the investment in aircraft-based surveillance capabilities across all aircraft types.

Of the $19 billion investment requirement to equip the commercial fleet with CNS, our analysis anticipates that airlines will fund 67 percent, leaving a $6 billion gap (Figure 6-45)

Figure 6-45

CNS Equipage Funding Gap



Source: NEXA Forecast 2012-2021

Key Points:

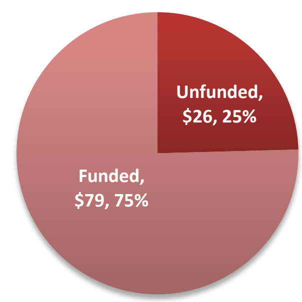
- Aircraft manufacturers will use full compliance with CNS capabilities as a selling point to airlines and will compete to provide the best and most complete packages.
- The upgradable and retrofitable aircraft will cost aircraft operators out-of-pocket to make the aircraft CNS capable and able to access the modernized ATI.
- There is a clear disincentive to accelerate aircraft equipage, since operators who are last to equip with new avionics gain the greatest financial benefit.
- In the current environment, it is possible that airlines may only be capable of two thirds of the required investment, leaving a shortfall of $6 billion.

6.5 ATI Funding Gap

According to an analysis of the financial health of both government and airlines, immediate and persistent investment constraints could produce a shortfall of $26 billion, representing 25 percent of the investment requirement over the next decade. Unfortunately, much of the gap will go unfunded, leaving ATI programs behind demand for the services and delayed and inadequately funded over the next decade. Therefore, this funding gap will require greater utilization of alternative funding sources, including the private sector.

Figure 6-46

ATI Funding Gap



Source: NEXA Forecast 2012-2021

6.5.1 Customer/User Pays Concepts

The funding gap will also help to manage the transition to user-pays and self-financing projects. To illustrate the user-pays concept, global international air passengers are forecast by ICAO to reach 1.6 billion by 2021 and domestic passengers are projected to account for 2.4 billion. At $4 incremental charges per international passenger and $1 for domestic passengers some $8 billion could be generated annually for ATI. These funds can be used to securitize private investment. This will go a long way to fund the requirements for CNS and ATM over the decade. Fiscal discipline and a business approach to ATM, with a new customer focus, will be needed to gain acceptance of the new fees.

As discussed in Section 6.2, operators will also be expected to participate directly in the funding of ANSP ATI projects. Governments are exploring programs to create incentives for operators to equip with the required avionics. In the US, there are discussions that operators who equip will receive preferential treatment under a program called "Most Capable: Best Served." Operators would be more agreeable to equipping aircraft if the benefits of the investment were presented in a compelling business case.

6.5.2 Private Sector Financing

Governments will be increasingly incentivized to pursue partial and full privatization of ATI to increase funding availability, reduce public funding requirements, and increase overall efficiency of the services provided. Other solutions include private-public partnerships.

As discussed in Section 3, many forms of private financing are emerging to address the ATI government funding shortfall. Governments are privatizing many functions and services to encourage efficiencies as well as remove funding requirements. Public-private partnerships are becoming more common as vehicles to offer government assurances to private ventures. Private equity is also getting much more involved, as infrastructure grows into a distinct asset class for many investors and institutional capital managers. For these groups, the long-term nature of ATI revenue streams are attractive as a means towards reliable diversification options for their portfolios.

Aircraft investment is slightly more complex, due to individual airline business cases that vary greatly by operator. One common impediment, however, is the delayed return on investment from major capital expenditures for avionics and other equipments, as described in the "equipage paradox".

Fortunately, private sector solutions are flexible enough to meet this challenge. Vendor financing is one of the most common ways to allow equipment buyers to extend payment of an investment over time, thus providing better rates of return. Unfortunately, most suppliers are reticent to offer this sort of support, since sellers are keenly interested in booking sales revenue as quickly as possible and avoiding the risk that comes along with customer credit analysis.

Other solutions, such as the NextGen Fund, can solve the "equipage paradox" through a combination of innovative regulatory, policy, and contractual mechanisms; supported with private sector capital, commercial financing practices, early payment deferrals, and modest government loan guarantees. The NextGen Fund is a newly established $1 billion private sector capital pool, capable of equipping up to 70 percent of the US commercial air transport fleet with basic CNS modernization capabilities. Other similar structures may be possible on a global basis, through loan guarantees are other government-backed incentives.

Key Points:

- The analysis anticipates a funding gap of $26 billion, representing some 25 percent of the total ATI investment requirement over the next decade.
- The funding gap creates opportunities for greater private involvement in ATI and can also drive the transition to user-pay and self-financing PPPs.
- PPPs have the ability to offer a combination of innovative regulatory, policy, and contractual mechanisms with which to close this funding gap.

7.0 The Airline Business Case

Without mandates, the modernization and equipage of the global commercial aircraft fleet will only become a reality when airlines individually and successfully justify the capital investment needed to equip their aircraft. Since the airlines operate in intensely competitive arenas, with strict focus on revenue generation from high cost assets (aircraft), and different capital priorities stemming from widely diverse business models, it is very unlikely that a single "one size fits all" solution can close the business case for most. Instead, by using an approach that can provide tailored solutions that address each airline's capital investment and debt-related sensitivities, the global air traffic system can move closer to closing the funding gap required to meet required airborne CNS investment levels.

For airlines to close the business case, they must address both investment risks and implementation risks. This applies to both forward-fit and retrofit aircraft; and because the capital required will be substantial on a fleet-wide basis, approval for these capital decisions will likely include the airline CEO, CFO, COO, and the board of directors.

7.1 Cost of Capital and Hurdle Rates

One key driver of closing a business case for equipage is the airline's cost of capital. Every airline's cost of capital will be different, because of wide variances in each company's sources of equity and debt corporate funding. However, each airline establishes a cost of capital largely based on the "weighted average" of their pooled capital used for discretionary capital decisions. (See Section 7.8 for more details.) Today, the airlines have few unencumbered assets to securitize lower cost debt for purchasing avionics, and strained balance sheets make borrowing costs for retrofitting avionics very high — expected to be double-digit rates from unsecured debt or new equity. Such high rates are (1) not compatible with long return-on-investment payback periods, and (2) require a significant long-term obligation on future cash flow.

More importantly, this long-term payback scenario drives their minimum required investment return (or "hurdle rate") higher, since the investment doesn't make sense unless the return is higher than the cost of capital by a significant margin. For example, an airline with a cost of capital of 12 percent will typically use a hurdle rate of 17 percent or more, so the projected return on investment must exceed 17 percent to successfully close their capital investment business case.

This is in stark contrast to forward-fit avionics, where such costs can be "bundled" with new aircraft debt and amortized with a lower, single-digit borrowing rate because the debt is secured by the aircraft being purchased.

Finally, many equipage investments are considered discretionary (i.e., not mandated), so investment decisions must compete with other airline capital needs, most of which have much shorter payback periods, and/or have a direct relationship with the competitive aspects of the passenger experience (e.g., new cabin seats, aircraft interiors, etc.).

7.2 "Cash is King" – Return of Invested Principal

Airline balance sheets are now reinforced by a historically high disproportionate amount of cash. Airlines have had to increase their liquidity cushion to protect against the many external factors that can force an airline into a liquidity crisis and potential insolvency. In the past decade, these cash crises have been triggered by acts of terrorism and other events that caused massive demand reductions or large increases in cash needs, such as credit card holdbacks and fuel price hedging.

Because cash is so precious for airlines, they now require much shorter capital expenditure (CapEx) payback periods — that is, return of invested cash — even if the long-term return on investment meets the required hurdle rates. Typically, most airline CapEx outlays today would need cash-positive returns in 18 months or less.

One way to address this issue is to defer airline cash outlays until the operating benefits can be realized. As seen in the sample typical business case analysis in Section 7.8, deferring principle and interest payments can shorten the payback period. This addendum presents a simplified airline business case analysis to make the point that it is difficult to close any aircraft CNS equipage investment case if an airline must wait years from the time of the CapEx outlay until the benefit surfaces. In the attached analysis, the benefits for an Airbus A320 retrofitted in 2013 with ADS-B, RNAV/RNP, and DataComm are assumed to produce fuel savings and other monetized block-hour reductions totaling $75,000 annually. Only Scenario 3 can satisfy the business case payback period completely because the airline essentially begins paying equipage lease payments concomitant with the benefit being realized in 2016.

Another critical cash-flow issue for airlines is the lower loan-to-value ratios in borrowing due to their weakened balance sheets. With many credit ratings at less-than-investment grade levels, most airlines can only qualify for debt financing that requires a much higher percentage of cash at risk (i.e., "down payment.") As mentioned before, this is problematic for airlines, as they want to avoid unnecessary and early cash outlay commitments and focus on current operations and revenue generation.

The aircraft leasing business is an "intermediary" model that has very successfully addressed this issue. With their higher credit ratings and loan-to-value ratios, they can offer airlines the ability to acquire aircraft with substantially lower up-front cash "down payments." A good US government example is the Export-Import Bank, which uses the aircraft lessor "intermediary model" to lease the aircraft to foreign airlines with marginal credit.

7.3 CNS/ATM Implementation Delays

In all parts of the world, airlines are concerned about the ANSPs' ability to deliver modernized ATM capabilities and related benefits on schedule. Even with deferred payments, airlines will be unlikely to make equipage commitments. ATC/ATM providers can agree to be accountable for airline costs related to delays in the schedule for delivering promised new operational improvements and benefits. This is because the accumulating financial value of the deferred principal and interest payments will be very difficult if not impossible to recover over time, as the future value of benefits in the later years must become extremely large to offset it.

While airlines would prefer to use aircraft heavy maintenance schedules to reduce the high cost of aircraft down- time needed for aircraft retrofits, they find it difficult to make these commitments without assurances that long-term implementation schedules will be met as various global air traffic stakeholders struggle to integrate legacy systems and future standards. This is because there is little flexibility to make any adjustments to heavy maintenance installation schedule commitments once they are underway. If airlines were confident in the implementation and harmonization policies and schedules, their fleet-wide plans would likely initiate retrofit as early as 2013, assuming they want to complete the retrofits for 2018 - 2020.

Other than mandates, one method for addressing business investment uncertainties is to create contractual accountability to directly address the counter-party's failure to perform. Another alternative is a performance-based environment where more capable airspace users are given additional operational flexibility.

7.4 Predominant Equipage

Because many operational benefits are not available until almost all aircraft are equipped for them, airlines are concerned that ANSPs may not be able to deliver benefits in so-called "mixed-equipage" scenarios. Nor are airlines confident that "Best-Equipped, Best-Served" will be implemented so that the equipped aircraft would receive operational priority in such scenarios. This situation creates the "last-mover advantage" problem, meaning that the airline waiting to equip enjoys the greatest financial benefit because of the shorter term of capital carrying costs (principal and interest payments).

The predominant equipage issue can be addressed by modifying the waterfall rollout of specific ATM modernization programs to pull benefits earlier for those users who commit to equip, particularly where airlines have the greatest concentration of operations or benefit potential, such as an airline hub or over the oceans.

7.5 Technical Refresh

Airlines are concerned that ATM implementation or interoperability policies will continue to change the requirements and related certification standards for avionics, forcing those who decide to equip early to spend more for incremental updates or costly upgrades to their purchased avionics. This adds even more value to the "last-mover advantage," meaning that the last airline to equip enjoys the greatest financial benefit because little or no technical refresh updates or upgrades are required before the operational benefits become available.

Since current CNS systems are essentially "information technology," airlines are understandably concerned that technical refresh will likely be necessary. The prospect of a secondary investment is yet another impediment to accelerated equipage.

7.6 Role of Government

Given government budgetary shortfalls in today's global economy, it is highly unlikely that any new stimulus will be available for the foreseeable future.

There may be an appropriate role for government support to help stimulate early equipage by applying some level of government resources to assist with financing payments on behalf of airlines or purchase a limited amount of avionics outright. In any case, the role of government support helps to create a "discount" for the first movers to equip, thus directly addressing the "last mover advantage" obstacle that hinders full equipage in today's environment.

7.7 Summary

Although all airlines differ somewhat in terms of their business models, justification hurdles, cost of capital, investment returns, and payback periods needed to close their business cases, these key issues are the common reasons why global airlines today have largely not begun to retrofit their aircraft for modernization CNS programs. Unless these issues are directly and effectively addressed, the airlines will likely continue to focus on local upgrades and/or procedural changes that allow a limited but risk-mitigated benefit from earlier equipment investments. If this doesn't change, we will never realize a next-generation air transportation system, nor will the industry reap the related benefits of economic and job growth.

7.8 Airline Cost of Capital for Discretionary Investments

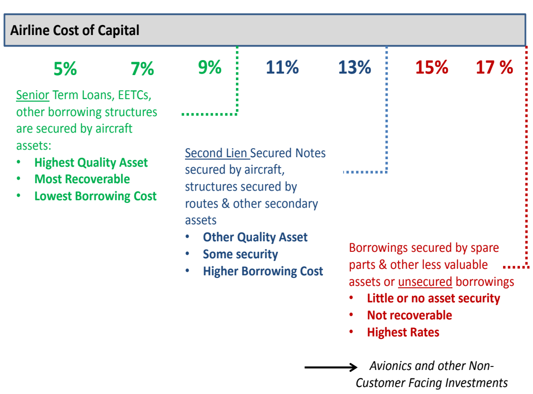
Historically, airlines could utilize excess cash flow from operations or access capital markets for discretionary capital expenditure needs. Because of the increased competitive forces and cost drivers, most airlines have had difficulty sustaining excess free cash flow from operations, particularly with the need for higher cash reserves for unexpected cost spikes (e.g., oil prices, labor) or revenue dips (e.g., acts of terrorism, global epidemics such as SARS).

Debt markets have remained an option for airlines in both good and bad times. The availability and cost of such capital (e.g. interest charged, collateralization terms, etc.) to each airline has varied dramatically. However, it is useful to think of capital market access in two parallel dimensions:

- Capital available for purchasing or refinancing aircraft, as airlines regularly refresh or update fleets.
- Capital available for discretionary uses, where the proceeds are intended for unsecured CapEx projects and general working capital purposes.

Leasing or bank loans have been common methods for new and used aircraft financing, as most airlines have not had sufficient cash or earnings to directly fund purchases. The three most common schemes for financing commercial aircraft have been secured lending, finance leasing, and operating leasing. The former two methods, secured-debt and finance lease programs, require that the borrowed funds be fully and exclusively applied to the aircraft purchase which itself becomes the collateral, often backed by government guarantees (EETCs, Export Credit Agencies).

Figure 7-1
Airline Cost of Capital



Source: NEXA Advisors

Aircraft purchase or financing costs naturally vary by (1) general airline industry conditions; (2) the borrower's credit rating; (3) quality of the collateral; and (4) credit market volatility. In operating leasing, the asset is financed by and remains on the balance sheet of a third-party whose credit rating is better than that of the airlines.

Figure 7-1 presents a range of airline capital costs and associated general use. While senior debt is the least expensive to an airline, it is accessible only for aircraft purchases, as discussed below. Generally speaking, CapEx for discretionary purchases such as ground-handling equipment, in-flight entertainment systems, and replacement or upgrading aircraft avionics, comes from working capital that is much more expensive to tap, if available at all. Thus, airline CFOs must ensure that the business case for discretionary CapEx investments provides a positive return to the airline after the cost of capital has been fully recovered. The airline CapEx hurdle rate varies by airline; however, it is generally based on and always higher than the weighted average cost of all sourced capital (WACC). WACC has been driven higher by the lack of high quality assets with which to secure lower cost debt.

SENIOR SECURED DEBT

The interest rate on secured debt depends on the "quality" of the asset on which the debt is secured. Higher asset quality drives lower interest rates (i.e. market value, recoverability, greater remarketing/disposal alternatives, etc.).

- Debt that is secured by aircraft has the lowest risk and interest rates because the lender or lessor can re-possess the aircraft if the airline defaults on its payments or other obligations. Debt secured by aircraft assets (i.e. new aircraft purchases) typically carry interest rates at about seven percent or more, fully amortized over no more than 12 years. However, this debt is not available for avionics purchases, except when purchased as part of a new (forward-fitted) aircraft being delivered by its manufacturer.

Figure 7-2

Selected EETC secondary levels

Updated as of January 23, 2012

Deal	Coupon	At issue: Amt ($mm)	At issue: Ratings	At issue: Maturity	Current: Amt ($mm)	Current: Ratings	Current: Maturity	Collateral: (Aircraft, collateral GPA)	Collateral: Age at issue	Initial: WAL	Initial: LTV	Current: WAL	Current: $ price	Current: Yield to WAL	Current: FRN sprd. (bps)
AMR 09-1A	10.375%	520.1	Baa3/A-	10.1	467.1	Baa3/BBB-	7.4	New: 16x 737-800, Used:4x 777-200ER Collateral GPA: 3.8	1.4	7.3	48.7%	5.4	109.00	8.19%	707
AMR 11-1A	5.250%	503.2	Baa3/A-	10.0	502.5	Baa3/BBB-	9.0	Used: 15x 737-800, 6x 757-200, 2x 767-300ER, 7x 777-200ER Collateral GPA: 3.5	10.8	6.6	48.3%	5.6	96.00	6.14%	389
AMR 11-1B	7.000%	152.8	B1/BB+	7.0	152.8	B1/B+	6.0		10.8	5.4	62.4%	4.4	92.50	9.20%	721
AMR 11-2A	8.625%	725.7	Baa3/A-	10.0	725.7	Baa3/BBB-	9.7	Used: 16x 737-800, 14x 757-200, 13x 777-200ER Collateral GPA: 3.4	10.1	6.7	45.3%	6.4	106.75	7.23%	566
DAL 10-1A	6.200%	450.0	Baa2/A-	8.0	404.7	Baa2/A-	6.4	Used: 10x 737-800, 9x 757-200, 3x 767-300ER New: 2x 777-200LR Collateral GPA: 3.4	7.1	5.5	54.1%	4.4	107.00	4.40%	339
DAL 10-1B	6.375%	100.4	Ba3/BB+	4.9	100.4	Ba3/BB+	3.9		7.4	4.9	70.0%	3.9	93.00	8.50%	759
DAL 10-2A	4.950%	474.1	Baa2/A-	8.5	451.9	Baa2/A-	7.3	Used: 2x 737-700, 6x 737-800, 7x 757-200, 3x 757-300, 3x 767-300ER, 1x 777-200LR, 1x A320-200, 1x A330-200, 1x A330-300 3x MD-90-30 Collateral GPA: 3.1	7.6	5.6	54.2%	4.6	103.75	4.03%	263
DAL 10-2B	6.750%	134.6	Ba3/BB	4.8	134.6	Ba3/BB	3.8		7.8	4.8	70.3%	3.8	93.50	8.78%	790
DAL 11-1A	5.300%	292.8	Baa2/A-	8.0	292.8	Baa2/A-	7.2	Used: 10x 737-800, 12x 757-200, 4x 767-300ER Collateral GPA: 3.4	11.5	5.4	52.4%	4.6	104.00	4.30%	301
DAL 11-1B	7.125%	102.0	Ba3/BB	3.2	102.0	Ba3/BB	2.7		12.1	3.2	70.6%	2.7	99.00	7.52%	690
LCC 10-1A	6.250%	262.9	Ba2/BBB	12.3	254.4	Ba2/BBB	11.3	Used : 1x A320-200, 5x A321-200, 2x A330-200 Collateral GPA: 3.4	1.4	7.9	54.0%	7.0	94.00	7.43%	484
LCC 10-1B	8.500%	77.4	B2/B+	6.3	72.7	B2/B+	5.2		1.4	4.3	69.9%	3.5	95.00	10.31%	852
LCC 10-1C	11.000%	53.3	B3/B	3.3	53.3	B3/B	2.8		1.9	2.8	85.0%	2.2	98.00	11.98%	1,122
LCC 11-1A	7.125%	293.9	Ba2/BBB	12.3	293.9	Ba2/BBB	11.8	Used: 1x A320-200, 2x A321-200, 2x A330-200 New: 4x A321-200 Collateral GPA: 3.4	1.0	8.1	53.4%	7.5	96.00	7.89%	545
LCC 11-1B	9.750%	94.3	B2/B+	7.3	94.3	B2/B+	6.8		1.0	6.0	70.5%	5.3	96.50	10.65%	896
LCC 11-1C	10.875%	83.2	B3/B	3.3	83.2	B3/B	2.7		1.0	2.5	85.6%	1.9	98.00	11.97%	1,110
UAL (CAL) 10-1A	4.750%	362.6	Baa2/A-	10.1	355.7	Baa2/A-	9.0	New: 3x 737-800, 3x 737-900ER Used: 3x 737-800, 4x 737-900, 5x 767-400ER Collateral GPA: 3.0	5.3	7.4	52.2%	6.3	103.00	4.19%	236
UAL (CAL) 10-1B	6.000%	64.5	Ba2/BBB-	8.1	61.9	Ba2/BBB-	7.0		5.3	4.7	61.5%	3.7	95.00	7.62%	529

Source: Deutsche Bank

Deutsche Bank
Corporate & Investment Bank

Source: Deutsche Bank

- Debt secured by non-aircraft assets is much more expensive, typically with costs well into double-digit interest rates and even shorter amortization periods.

This chart presents a report from Deutsche Bank for selected US airline debt (EETCs are for aircraft-secured lending) trading on the secondary markets as of January 2012. The current yields (interest rate) serve as good proxies for new senior secured lending based on collateralizing high quality aircraft — ranging from about five percent to 12 percent.

SUBORDINATED SECURED DEBT

The interest rate on subordinated secured debt is always higher than senior secured debt because the lender must wait for recovery until after any senior secured lender is repaid. These interest rates are driven even more by the creditworthiness of the borrower. Subordinated secured debt is:

- Borrowed by the equivalent of second mortgages on aircraft or other equipment that already has a senior lien or claim to the asset.
- Scarce. In the last decade, airlines have already fully borrowed against most of their previously unencumbered assets, both aircraft and non-aircraft assets such as facilities and landing slots at restricted airports.

These interest rates would be higher than the more senior debt secured on high quality aircraft assets — ranging from 11 to 13 percent due to the higher risks of recovery.

Assets less attractive than aircraft remain an option for some borrowers to utilize but are an expensive alternative to tap. Since 2001, airlines have little or no "high quality" assets remaining to borrow against, driving their borrowing costs up to unsecured interest rate levels (with some exceptions). In 2009, United Airlines borrowed $175 million at a 17 percent equivalent interest rate on a three-year debt instrument, securitized against "high recovery" spare aircraft and engine parts.

UNSECURED DEBT

Many years ago, airlines were able to access conventional credit similar to other industries, without offering fixed assets or any other forms of security, except for perhaps preference on revenue receipts. However, the cost of unsecured debt is generally higher than secured debt by at least five percent or more (depending on an airline's credit rating, balance sheet, cash reserves, etc.). Thus, unsecured debt is only used as a "last resort" by airlines to bolster their overall cash flow and reserves. Airlines have been largely shut out of the unsecured credit markets for new debt since 2005.

COST OF CAPITAL & HURDLE RATES

Airlines use an internal CapEx Hurdle Rate (CHR) for deciding whether or not to invest in non-securitized assets, such as avionics. CHR will always be higher (typically about five percent) than the airline's cost of capital, which represents the "break even" point for the business case. For these purposes, the airline's cost of capital is internally calculated and set using the weighted average of all borrowed monies from all lending sources as the basis (WACC).

While airlines consider their cost of capital as a competitive issue and strictly confidential, their WACC can be estimated by first considering the range of their historical borrowing rates for secured debt for non-aircraft CapEx – about 11 to 17 percent. Because most airlines have now depleted their availability of unencumbered, high-quality assets to securitize against, raising new capital for new avionics investments will be in the higher side of this range – roughly 15 percent.

This means that investing in NextGen avionics must generate a return greater than a CHR of about 20 percent for most legacy airlines to close their business case for equipage, and explains why airlines are seeking both earlier benefits and shorter payback periods. Since airlines cannot now and are not expected anytime soon to be able to use their own balance sheets to fund avionics upgrades, they will need to seek other sources of capital to acquire modernized CNS equipment.

Key Points:

- Airline investment decisions, especially for equipage, must pass a stringent analytical and financial business case to provide a sufficient return on investment, and airlines must carefully allocate precious capital resources.

- The business case is dependent on several factors, including timing of investment, size of investment, cost of capital, timing of benefits, and size of benefits.

- With high hurdle rates and required returns on investment, airlines are increasing looking to financial options, such as vendor financing and leasing programs, to move the equipage business case to positive outcomes.

7.9 Example of Airline Business Case Cash Flow Analysis

Present Value Business Case Analysis for NextGen Equipage

Example: Airbus A320 retrofitted 2013 with ADS-B, RNAV and DataComm

Scenario 1 - Cash Purchase

				2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Purchase Cost of NextGen Avionics Suite			350,000	(350,000)									
Installation			25,000	(25,000)									
SubTotal Cost				(375,000)	-	-	-	-	-	-	-	-	-
Aircraft Benefit (Fuel Savings, Other Monetizable)	Per Year		75,000				37,500	75,000	75,000	75,000	75,000	75,000	75,000
SubTotal Net Benefit				(375,000)	-	-	37,500	75,000	75,000	75,000	75,000	75,000	75,000
SubTotal Cumulative Benefit				(375,000)	(375,000)	(375,000)	(337,500)	(262,500)	(187,500)	(112,500)	(37,500)	37,500	112,500
			B/Even Horizon										
	Discount	B/E Year	Present Value										
FV	0%	Year 9	$112,500	($375,000)	($375,000)	($375,000)	($337,500)	($262,500)	($187,500)	($112,500)	($37,500)	$37,500	$112,500
NPV @	7%		($49,131)	($350,467)	($350,467)	($350,467)	($321,859)	($268,385)	($218,409)	($171,703)	($128,052)	($87,257)	($49,131)
NPV @	12%		($115,024)	($334,821)	($334,821)	($334,821)	($310,990)	($268,432)	($230,435)	($196,509)	($166,218)	($139,172)	($115,024)
NPV @	17%		($156,848)	($320,513)	($320,513)	($320,513)	($300,501)	($266,293)	($237,055)	($212,065)	($190,706)	($172,451)	($156,848)

Scenario 2 - Conventional Lease

Airline Business Case Cash Flow Analysis				2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Lease Cost of NextGen Avionics Suite			350,000	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)
Installation			25,000	(25,000)									
SubTotal Cost		BP/Mo	85	(60,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)
Aircraft Benefit (Fuel Savings, Other Monetizable)	Per Year		75,000				37,500	75,000	75,000	75,000	75,000	75,000	75,000
SubTotal Net Benefit				(60,700)	(35,700)	(35,700)	1,800	39,300	39,300	39,300	39,300	39,300	39,300
SubTotal Cumulative Benefit				(60,700)	(96,400)	(132,100)	(130,300)	(91,000)	(51,700)	(12,400)	26,900	66,200	105,500
			B/Even Horizon										
	Discount	B/E Year	Present Value										
FV	0%	Year 8	$105,500	($60,700)	($96,400)	($132,100)	($130,300)	($91,000)	($51,700)	($12,400)	$26,900	$66,200	$105,500
NPV @	7%		$27,230	($56,729)	($87,911)	($117,053)	($115,679)	($87,659)	($61,472)	($36,998)	($14,125)	$7,252	$27,230
NPV @	12%		($4,237)	($54,196)	($82,656)	($108,067)	($106,923)	($84,623)	($64,712)	($46,935)	($31,062)	($16,890)	($4,237)
NPV @	17%		($24,015)	($51,880)	($77,960)	($100,250)	($99,289)	($81,364)	($66,043)	($52,949)	($41,757)	($32,191)	($24,015)

Scenario 3 - NextGen Equipage Fund + Deferral

Airline Business Case Cash Flow Analysis				2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
NextGen Fund Lease Cost			350,000	-			(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)
Installation			25,000										
SubTotal Cost				-	-	-	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)	(35,700)
Aircraft Benefit (Fuel Savings, Other Monetizable)	Per Year		75,000				37,500	75,000	75,000	75,000	75,000	75,000	75,000
SubTotal Net Benefit				-	-	-	1,800	39,300	39,300	39,300	39,300	39,300	39,300
SubTotal Cumulative Benefit				-	-	-	1,800	41,100	80,400	119,700	159,000	198,300	237,600
			B/Even Horizon										
	Discount	B/E Year	Present Value										
FV	0%	Year 1	$237,600	$0	$0	$0	$1,800	$41,100	$80,400	$119,700	$159,000	$198,300	$237,600
NPV @	7%		$144,283	$0	$0	$0	$1,373	$29,394	$55,581	$80,055	$102,928	$124,304	$144,283
NPV @	12%		$103,830	$0	$0	$0	$1,144	$23,444	$43,354	$61,132	$77,004	$91,176	$103,830
NPV @	17%		$76,235	$0	$0	$0	$961	$18,886	$34,206	$47,301	$58,493	$68,059	$76,235