Shared Horizons

US - India Aviation Cooperation Program

A Biannual Publication of the US-India Aviation Cooperation Program

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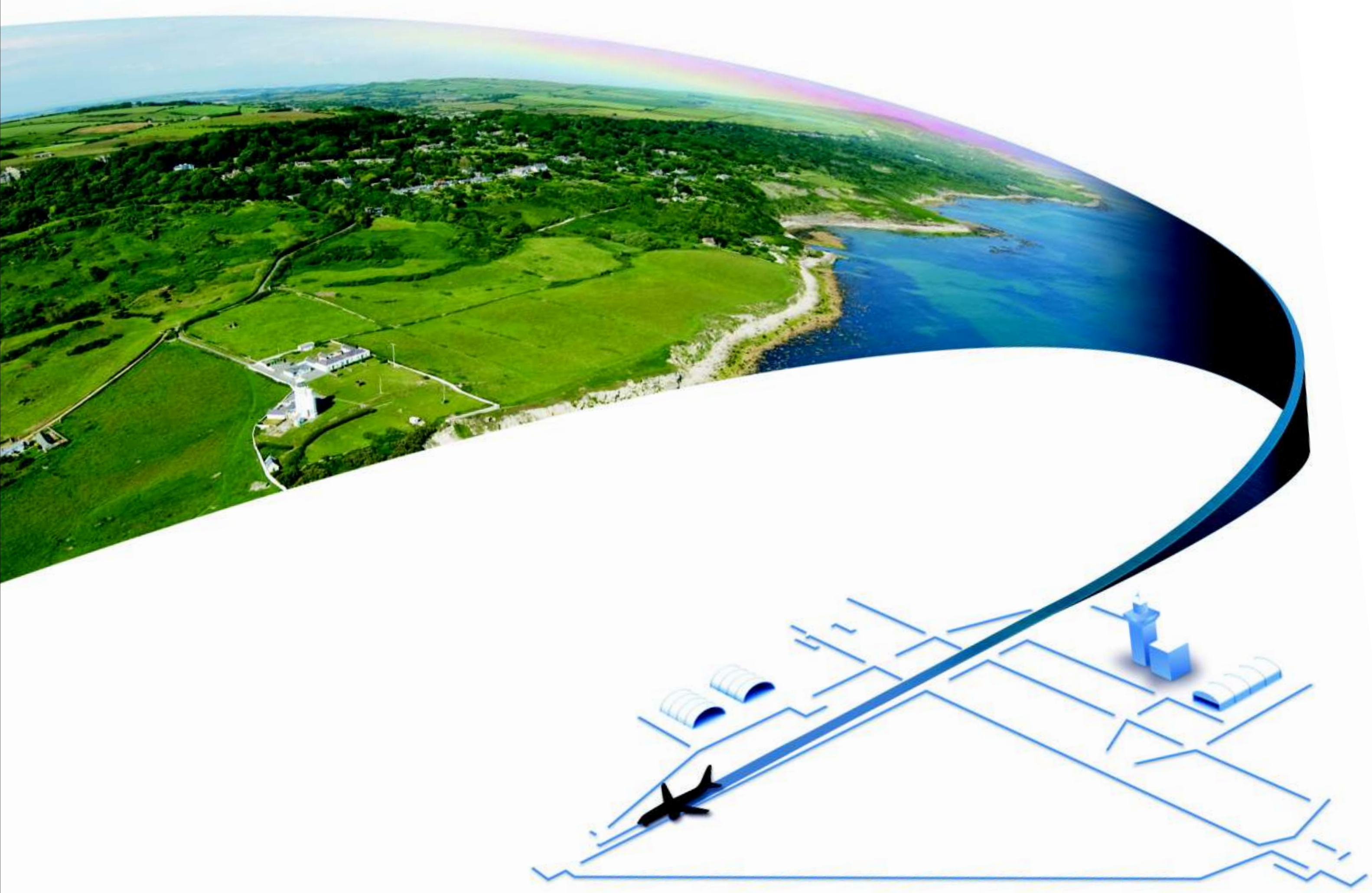

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We are pleased to deliver the first issue of "Shared Horizons". This edition covers our focus and progress in the first half-year of 2012. ACP's projects and events cover a broad area of Air Traffic Management and its regulatory aspects, airports, aerospace industry, particularly manufacturing of aircraft spares and its certification process and best practices for aviation cooperation between India and the U.S. The ACP's, mission is to further support the growth of the Indian civil aviation sector, particularly airports and aerospace through technology demonstration in the shape of projects that encourage collaboration between the U.S. and the Indian industry.

In the beginning of the year 2012, ACP completed AAI Air Traffic Control Officer Capacity Assessment. Ongoing Projects: Technical, Management, and Operational Development Training (TMODT) and Technical Training for aerospace industry have been extended up to December 2012 to complete. The GBAS pilot project at the Chennai airport contract Agreement and hardware procurement Agreement has been signed and this project will be completed in the time-frame of 10 months from the date of signing the contract. The Air Traffic Flow Management (ATFM) contract Agreement has been approved by USTDA and the hardware Agreement is under process.

ACP is a working mechanism through which the Indian aviation sector officials can work with the U.S. civil aviation representatives to highlight specific areas for technical cooperation. The ACP executive committee consists of both U.S. Government and U.S. industry (private sector) representatives, and its secretariat functions as the focal point for responding to the Indian Government areas of interest, i.e. airports and aerospace in the aviation sector by identifying appropriate training programs, technology updates and other cooperative activities as well. The ACP secretariat is responsible for managing and organizing the identified training and technical cooperative activities.

However, ACP is built on the pillars of technical support from the US Federal Aviation Administration (FAA), John A. Volpe National Transportation Systems Center, financial backing of the U.S. Trade and Development Agency (USTDA) and stakeholders, and the instrumental participation of over 30 companies from the U.S. industry. But the ACP's anchor is its customers within the Government of India and the leadership within the Ministry of Civil Aviation, Director General of Civil Aviation, and Airports Authority of India. For their partnership, we are deeply grateful.

We are encouraged by what lies ahead of us and are enthusiastic about our future as an association. The "Shared Horizons" ahead looks truly limitless.

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HISTORY

- **2005**: ACP announced by Secretary Mineta and Minister Patel
- **2006**: Groundwork Meeting
- **2007**: MoU between: US Department of Transportation, US Trade & Development Agency, and Ministry of Civil Aviation; US-India ACP Inaugural Session: ACP formed
- **2008**: Third Project launched; First & Second Projects completed
- **2009**: Forth Project completed; Fifth Project completed
- **2010**: Sixth Project completed; Seventh Project completed
- **2011**: Ninth Project & Tenth Project launched; Eighth Project completed
- **2012**: Eleventh Project launched

FOCUS AREAS

- Air Traffic Management Modernization
- Airspace and Airport Analysis, Development and Planning
- Aviation Support Industry Development
- Aviation Human Resources
- Aviation Safety
- Aviation Security

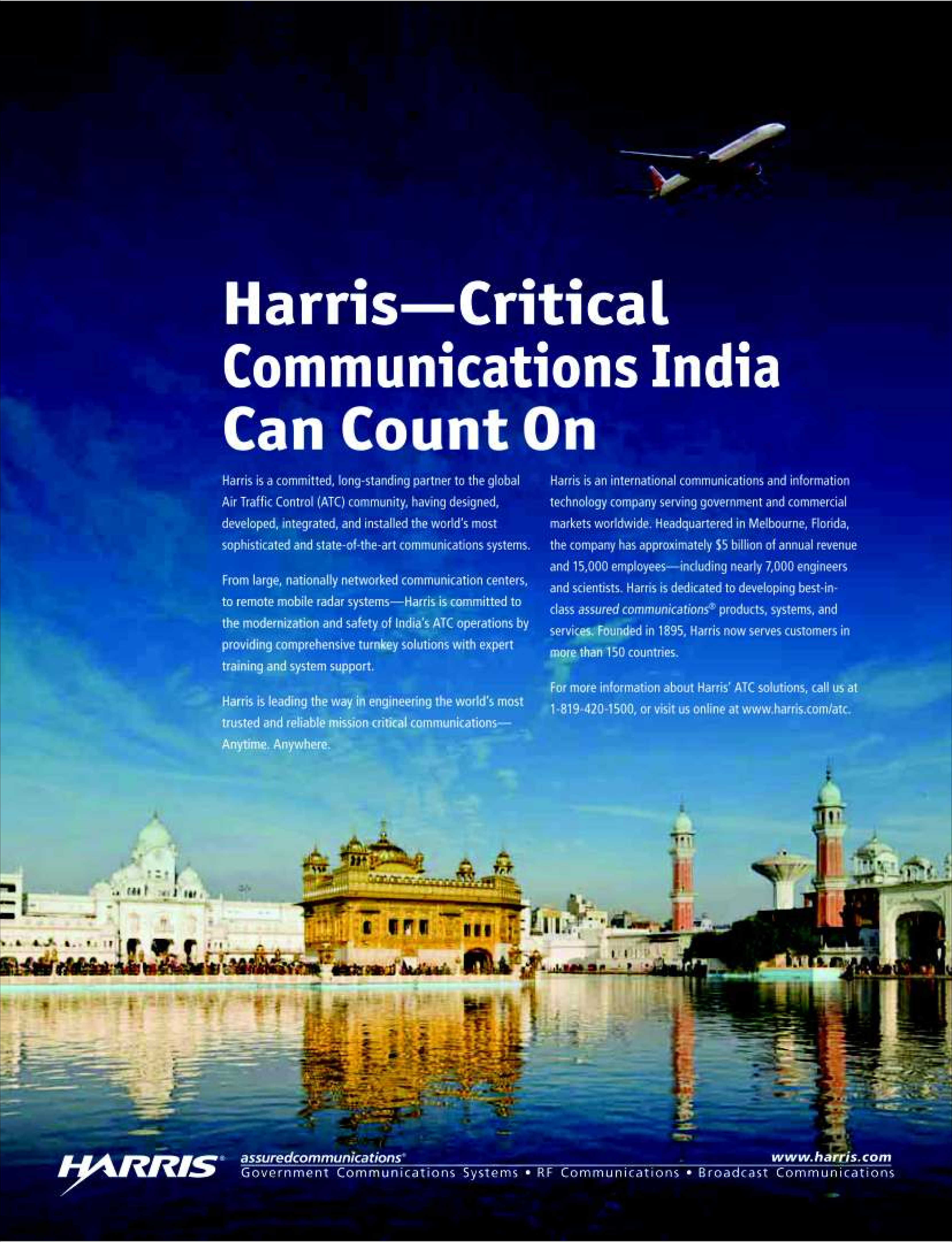
OBJECTIVES

- Promote greater engagement between the US and the Indian Government agencies and industry to enhance civil aviation in India
- Undertake projects that advance cooperation in domain, such as aviation safety, security, regulatory oversight and management
- Provide training and technical assistance to accelerate excellence in aviation operations
- Within India, increase awareness of, and facilitate access to, US expertise, technology and best practices to assist India's aviation growth

MISSION

The US-India Aviation Cooperation Program (ACP) was established in 2007 as a public-private partnership between the U.S. Federal Aviation Administration (FAA), the U.S. Trade and Development Agency (USTDA), other U.S. Government agencies and the U.S. companies.

ACP supports growth of the Indian civil aerospace sector by working directly with the Government of India (GOI) to identify and execute projects that encourage partnerships between the U.S. and Indian stakeholders, in aerospace technology and best practices.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General Avia
Opportunities

02 February, 2

Indo-American Chamber of Commerce (IACC), in the support of US-India Aviation Cooperation Program, conducted guest at the seminar. The purpose of the seminar was to review the current status of General Aviation and upcoming India in this sector and also find ways to overcome any bottlenecks in the field of General Aviation. This seminar wa discussions, several issues were highlighted by the industry professionals with recommendations to encourage the i

tion: Growth, and Challenges

012, New Delhi

d a one-day seminar on Feb 02, 2012 in the PHD House. E. K. Bharat Bhushan, Director General, DGCA, was the chief potential in India. It was also intended to identify the constraints which have slowed down the systematic growth in as attended by GA industry representatives, regulator's office and aviation professionals, etc. During the course of ndustry to increase the GA operations and its associated work in India.

"The factors that inhibit the growth of General Aviation are mainly (the) lack of infrastructure, manpower and several procedural issues relating to government controll."

E.K. Bharat Bhushan
DGCA

Points of

General Aviation: Growth,
02 February,

L- R: Radhakrishan, Reliance Infrastructure Ltd; Inderjeet Singh, URS Scott Wilson India Pvt. Ltd; Umesh Baweja, Chairman, RAHI; Andrew Kalnowke, Washington Consulting Group; and A.K. Jain, GM, AAI

L-R: Lex Den Herder, Vice President, Universal Weather & Aviation Inc.; Rohit Kapur, President, BAOA; R.P. Shahi, Ex. JDG, Adviser - MoCA; and Pawan Kumar, Dy. Director, DGCA

L-R: Atul Sharma, Partner, Legal Link; Nilanjan Sinha, GE Capital; Todd Hathway, Hawker Beeachcraft; and Somesh Arora, Legal Ally

- It is emphasized that the linkage between the civil avia
development is well recognized.
- Important issues like taxation, input costs, security, regul
liberalization were brought into discussion.
- GA facilitates emergency medical services, disaster manage
as law enforcement.
- GA is experiencing a lot of constraints. There are no exclusive
are mainly lack of infrastructure, manpower and several proc
- There is no concept of Fixed Base Operator (FBO), Helicop
ground handling is extremely restricted. There is no separa
There is a much-needed focus which the Government of India
- As far as GA potential is concerned, the demand for business
the next decade. In India, business aircraft have continuous
comfort and with a number of high net-worth individu
manufacturers will be intensifying their efforts to sell more a
- Another area of visible growth in India will be the oil and gas
new sources, there will be a need for longer-range helicopter
- The field of emergency medical services operated by helicop
fixed wing business jets, statistical studies indicate that ge
hence there is the potential. But at the same time there is an
in GA.
- From the point of view of the Safety Regulator, a large num
necessary trained manpower as well as training the personne
- One of the bad laws that affects GA is the import duty on bus
8%. By addressing the import issues, we can achieve growth c
- Ministry of Finance and Ministry of Civil Aviation coordinatio
- DGCA needs 30 days' time for clearance of a foreign registe
needs to be addressed.
- Multiple leg flight plans is again a major issue with GA operat
- Landing and parking charges should be paid through a prel
ease the procedure.
- AAI website should display the ground handling agents at all
- The Bureau of Civil Aviation Security: Again, there are issue o
day. For example, when pilot actually fills in the boarding p
pilot's pass is not ready, how can he be expected to fly?

Contention

Opportunities and Challenges
2012, New Delhi

tion sector and economic activity; and its catalytic impact on

ation of monopolies, environment as well as issues related to

ment, offshore operations, scientific research and security as well

guidelines for GA activities. The biggest hindrance to growth of GA
edural issues related to government control.

pters or GA terminals in the country. The number of agencies for
te parking for GA aircraft and helicopters operate out of airports.
a and DGCA are now putting on the GA sector.

s jets in the country is expected to go up by more than 10% a year in
sly evolved to meet the increasing market demands for speed and
als. No doubt, the business jets market will increase and jet
ircraft in the country.

s industry and in order to support exploration and development of
s and which ONGC and the Ministry of Petroleum are addressing.

pters is also emerging as a very important growth area. In terms of
nerally they are more cost-effective than commercial services and
urgent need to increase safety awareness and compliance culture

nber of issues need to be tackled both in terms of equipping with
el to undertake the responsibility which lies with the industry.

siness aircraft, which is 18%, which restricts the growth to around 7-
of 20-25% in the GA sector.

n is very much required to resolve the above issues.

ed aircraft to land in a defense airport with a civil enclave. This fact

or.

oaded card or a credit card instead of a cheque or cash, this would

their airports.

n Security passes for pilots and engineers which is happening every
ass, he does not know whether he is getting in time or not. If the

L to R: Dhiraj Chhabra, Air Works; Charan Das, JDG, DGCA; Mike Meyer, Indocopter, and Pulak Sen, Editor, MRO India

ICAO Expert panel team on General Aviation at an interactive session

Lex Den Herder, Vice President, Universal Weather & Aviation Inc. addressing the seminar

Points of

General Aviation: Growth,
02 February,

Somesh Arora, Legal Ally

Rohit Kapur, President, BAOA

Judy R. Reinke, Minister Counselor of Commercial Affairs

- There is no access for foreign pilots / engineers. Hence, they
aircraft which needs some attention as per the regulator.
- Reduce the time requirements for landing and over-fly appro
- Develop a process allowing easier ramp side access for bus
guidelines / regulations for support of the business aviation /
- It is difficult to assess issues like clearance processing and
India. DGCA needs a seven days notice for an international co
- Direct; Import of ATF recommended by the Government of
permitted / allowed.
- Custom duties on the GA aircraft, spare parts for MRO, etc. n
- As a GA financier stand in as the financial regulator, because
are multiple agencies are involved. Since the finances is amou
protected.
- RBI Issues: In India, RBI regulates remittances and their main
against the import that comes in.
- The financier who sometimes does construction finance, ha
place, but they have given an undertaking to RBI that not sen
- There is a rule on DGCA books, which requires temporary reg
how GA purchases can use that, to make sure that it has been
- GA issues like importation approval processes and the Re
process by DGCA. .
- Tax Regime: For instance, servicing an aircraft in India would
Importing spares involves custom duties of up to 18% plus
there-about.
- If an MRO is doing work for an airline industry and the airline
duties, whereas the MRO if it does import for any other priv
Currently, no exemption is provided for service tax on taxab
aviation sector. Moreover, general concessions are not curre
- Giving MRO sector the status of an industry is necessary, if t
foreign exchange. Heavy taxation is the prime reason that
being geographically located in the center of East and West.
- Custom duty and slow clearance procedure put yet another s
India. Custom clearance can take between 3 to 10 days if o
aircraft on Aircraft on Ground (AOG) and customs doesn't cle
- Blue Channel is prevalent in EU, where the travelers betwe
duties.

Contention

Opportunities and Challenges
2012, New Delhi

cann't go inside the airport to fly or do the maintenance of the GA

vals.

siness aircraft pilots and support personnel and need to develop GA.

airport formalities which limit international companies coming to mpany required to come to India, which needs rationalization.

India, is still a proposal. The industry is looking forward that it be

eeds to be relooked and liberalized.

obviously this is an area which is heavily regulated and in India there unt to 10 - 20 million dollars, we will have to make sure the assets are

concern is to make sure that remittances go out of the country are

as to make sure that not only the customer has RBI's approval in ding the money out, the financier is sending out the money.

istration, just like a ferry flight permit, but again it needs clarity that just purchased the country. That is one of the issues.

serve Bank of India (RBI) currency restrictions are under review

d entail a service tax of 12.36%. Overseas MROs do not charge this. value-added tax of 12.5% and octroi of 5.5%, totalling about 41% or

imports spares that are required, airline is not charged any custom vate operator or business aviation aircraft is charged custom duty. ble services which include maintenance and repairs provided in the ntly provided on VAT and CST laws.

he Government wants to develop it and bring the exchequer some the industry is lagging behind, despite having low cost and India

spoke in the process of MRO sector and also the aviation industry in ne is lucky and defeats the requirement of AOG. You can have an ear it.

en EU countries don't have to pay custom duties, VAT and excise

Charan Das, JDG, DGCA

R.P. Shahi, Ex-JDG


L-R: Charan Das, JDG, DGCA; Lex Den Herder, Air Cmde.; Basudev Banerjee, Textron; and Rajan Mehra, MD Universal Weather & Aviation India Pvt. Ltd

Raytheon's Auto Trac-III enables Indian Airspace Harmonization

AAI wins "Jane's 2012 ATC Award" at CANSO

Raytheon's next-generation Air Traffic Management (ATM) system, Auto Trac-III, is now operational at three Indian airports run by the Airports Authority of India (AAI) – Delhi, Mumbai and Chennai – covering three of the four Indian Flight Information Regions (FIRs). These installations are an important milestone in AAI's plans for the modernization of India's airspace in order to accommodate projected levels of growth in the region's air traffic. Recently, AAI won the prestigious "Jane's Award" for achieving the best operational efficiency through its upper airspace harmonization program for the Chennai FIR. The award was presented to AAI's Mr. V. Somasundaram, Member (ANS), at a ceremony conducted at the ATC Global Conference in Amsterdam on March 5, 2012. The event was attended by chief executive officers and top executives from the world's leading technology companies and Air Navigation Service Providers (ANSPs).

Chennai Auto Trac-III Operational System – Tower Control Area

The challenging goal of providing upper airspace harmonization in the Chennai FIR was enabled by the installation of Raytheon's next-generation ATM Automation system, Auto Trac-III. Its advanced signal and Flight Data Processing Systems (FDPSs) allowed for the seamless integration of five dynamic airspace sectors, ten radars, and the implementation of ATS Inter-facility Data Communication (AIDC). This new, highly integrated system approach provides a dramatic improvement in the operational efficiency of the Indian airspace system. The restructuring of Indian airspace in the Chennai FIR alone would result in fuel savings of 22.3 million litres per annum to the operators, on a conservative estimate, apart from substantial reduction in carbon emissions.

"Raytheon is very proud to be part of this important initiative for India and we congratulate the Airports Authority of India on this distinguished and most deserved honour," said Bill Blair, India President of Raytheon's ATM business. "AAI is truly a world leader in airspace modernization and Raytheon is committed to our continuing close partnership with them on this transformational endeavor."

The Auto Trac-III system is an advanced, cost-effective solution to the challenges facing the ATM community in the 21st century – traffic growth outpacing revenue growth and the drive to increase capacity and productivity in a cost-conscious environment. The Auto Trac-III system, with its modern open architecture design and high-performance characteristics, is fully adaptable and scalable to any ATM environment, ranging from a simple tower automation application to a fully integrated national multi-center system.


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Airport Sustainability Best Practices Strategies for World Airports

by Landrum & Brown

In the airport context, Sustainable Practices are those that frame appropriate use and recovery of resources to enable technological progress while protecting the public health, safety and welfare through balanced planning, design, construction, operation and maintenance of facilities.

Greater awareness of interrelationship of environmental and economic issues has made sustainability a common focus for most industries. While many such issues, such as energy conservation and emission reduction, are common to most, priorities and strategies vary by industry and location. Within the aviation industry, the age of an airport can also affect the balance of the focus between capital programs and operational practices. New, greenfield airports that can be developed in more remote locations may have few social impacts on neighboring vicinity plans. Overall, the benefits of highly developed air transportation facilities need to be balanced against the local impacts of airside and landside activities.

As India grapples with the issues of airside efficiency and customer service and their relationships to noise, emissions, utility consumption, it may be useful to review the findings of other airport sustainability studies.

In early 2010, the ACP-China Airport Committee team[1] completed an Airport Sustainability Best Practices Strategies report that included a review of existing sustainability standards and performance data from more than 40 airports, including 14 from the US, 12 from China and 14 other major international airports. The airports performance data displayed a number of important points, and led to some important recommendations:

Key Observations:

- There is an observable difference in the ranges of use of electricity and water use between the China airports and US/other world airports, with China's use statistics being significantly lower on a per passenger basis for the airports surveyed.
- This relates to difference in priorities:
  - China's priority is cost-efficiency of their "uses". Therefore, they follow and report the uses as a function of cost.
  - US airports have traditionally prioritized compliance requirement -- the initial impetus for environmental sensitivity was in reaction to emissions impacts. So the US began by first tracking and reporting emissions rather than utility consumption.
- This also relates to the relative age of the airports:
  - All major airport facilities in the US and Europe are older airports that were first developed before sustainability was a priority. Therefore, the efforts to become more sustainable relate to "reducing" uses and "upgrading" fixtures and equipment.
  - Majority of the airport facilities in China serving the largest numbers of passengers are new, and built using all of the latest building fixtures and materials.
- Based on the relative positions and priorities, their

purchasing strategies toward sustainability also vary:

- As China focuses primarily on use and US on emissions:
- China primarily has relied on mathematical calculations of potential impact, but rarely, if ever, has employed monitoring for existing projects and has only just begun to use calculations for potential impacts of future projects.
- US has employed monitoring of impacts for decades to develop the basis of calculations for potential impacts required for all future projects.

The team made some initial recommendations:

- Activate Eco-Aviation Partnership of airports into an annual reporting network. The team recommends a process of cooperative reporting with participating airports (an Eco-Aviation Partnership of Airports) to collect and compare key use (and ultimately emission) data on an annual basis. This could then serve the larger global aviation community and the basis of comparative ranges for appropriate use and emission levels per person, per building floor area, per operations and per land area, as would be appropriate to the use/emission factor.
- Develop a common one-page Annual Eco-Aviation "Report Card" to get the airport participants to report the key data using common methods to ensure a more apples-to-apples comparison. Currently, all airports track their own data by different methods, making information sharing more difficult. A simple common format would help reduce confusion when benchmarking and assessing data[1].
- Sustainability study recommendations present metric target ranges and thresholds for all measurable uses and emissions. Rather than "relative improvement" targets, the proposed objectives will be to identify appropriate ranges of utility use and product consumption necessary to achieve adequate to superior levels of customer service and operational efficiency. As the data gathering and reporting among airports varies, it may take two or three annual reporting cycles for the ranges to be narrowed and appropriately defined by activity level, climate and special circumstance. However, even the initial recommended target ranges should help bring some realistic context into what is achievable and appropriate.

India, like China and the US, needs to serve both large international and domestic markets. Similar to China, the rapid growth of these markets results in the need to develop more new airport facilities that make capital improvement projects for new or replacement facilities a large focus of airport development. Delhi's new Terminal 3 is such an example of outstanding new development to balance airport activity and sustainability. The rapid increases in air service demand also support the need to sustainability performance metrics to be tied to activity levels rather than specific benchmark years, as relatively newer airports with lower passenger and aircraft movements today should not logically be held to total consumption or emission levels set today for activity that may be several times greater in the future.

The US Trade Development Agency (USTDA) continues to show interest and support for cooperation with India and US priorities emphasis on environmental initiatives. As such, the Indian aviation community could benefit from the support for a similar study for Indian airports through the US-India Aviation Cooperation Program (ACP).

1The CAAC is supportive of this concept and had requested the BSCT to take the same survey sent by AAAE to the US Eco-Aviation Partner Airports to the China airports involved in the Sustainability study.




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Air Traffic Efficiencies are Available

by Steve Fulton

India is one of many countries facing the challenge of a dramatic increase in air traffic since air travel has grown in popularity over the past decade. As a result, aircraft operators, air navigation service providers and regulators are feeling increased pressure to address air traffic management inefficiencies.

Air traffic in India has tripled during the last decade and some estimates indicate that the number of passengers could more than triple in the next 10-15 years. India is already experiencing the effects of increased air traffic, including congestion, extra fuel burn, noise levels around airports and flight delays.

India has been working to alleviate the result of increased air traffic through their Future Air Navigation System (FANS) master plan to "modernize the skies" – part of which is the use of Performance-Based Navigation (PBN) technologies that will allow aircraft to fly more accurate, yet flexible, flight paths.

The benefits of PBN include shorter flight tracks (with reduced fuel burn and emissions), reduced operating costs, improving accessibility through segregated arrival and departure flight paths and greater operational efficiency.

The shorter flight tracks are achieved largely by breaking away from traditional ground-based navigational aids (as the primary means of navigation). For example, one form of PBN is Area Navigation (RNAV), which sees the flight management systems (FMSs) – as fitted to most large commercial aircraft calculating direct [straight line] navigation paths between points.

Another PBN technology is Required Navigation Performance (RNP), which is also post-fixed with a number to indicate the accuracy to which the airplane must fly. Here, the aircraft's on-board navigation system provides performance monitoring and alerting, allowing the aircraft to fly precise, three-dimensional trajectories. One of the simplest forms of RNP is RNP APCH (RNP approach), which provides instrument approaches to runways that do not currently have adequate ground-based navigation facilities. Or, they can be used to back up existing ground-based navigation procedures.

The highest performing type of PBN is RNP-AR (RNP - authorization), which requires additional aircraft functionality and pilot crew training in order to be used. RNP-AR paths are typically crafted to reduce track miles, conserve fuel, preserve the environment, and increase airspace capacity.

Note: In a trial program in Brisbane Australia aircraft flying optimized RNP-AR paths adhered to within 70 feet of their intended tracks.

Efficiency in practice

The concept of reduced track miles is being carried out around the world, including the recent work by LAN Airlines where they introduced the first seamless PBN route in Latin America on February 23. LAN flew this first continuously guided flight from takeoff to landing using PBN technology. This is part of the Green Skies of Peru project, a collaborative effort among LAN, GE Aviation, Peru's air navigation service provider CORPAC and regulator DGAC, provides aircraft flying from Cusco to Lima a highly efficient, predictable flight path throughout the entire flight.

"The Green Skies of Peru team has demonstrated that future air traffic management concepts are attainable today," said Giovanni Spitale, General Manager of GE Aviation's PBN Services. "PBN programs like this take dedication and teamwork to ensure that benefits are achievable by all stakeholders."

The project is a notable milestone in the global effort to modernize today's obsolete airspace infrastructure to match the capabilities of today's modern aircraft systems. Deploying a continuous PBN city pair flight path creates additional predictability and continuity throughout the entire flight, compared to a single PBN arrival or departure path, while solving operational challenges at the individual airports.

"Operational excellence, passenger service and environmental protection are the pillars of our sustainability strategy, as reflected in this initiative," said Mr. Jorge Vilches, CEO of LAN Peru. "At LAN Peru, we have made a great effort to properly train our pilots, to equip our A319/320 aircraft with state-of-the-art technology, to obtain DGAC certification for these types of operations, and to design and deploy these highly-specialized procedures in collaboration with GE Aviation. This is, undoubtedly, a big news for our country, and will be of great benefit to all our passengers."

Peru sees results

The PBN departure, en-route, arrival and approach procedures will save participating airlines on average 19 track miles, 6.3 minutes, 450 pounds of fuel and 1,420 pounds of CO2 emissions per flight. The new flight paths also enable increased capacity at Lima's Jorge Chavez International Airport a major hub in Latin America – while helping to reduce the carbon footprint at Cusco, the access point to the popular tourist destination Machu Picchu. LAN flies the route 11-17 times a day, depending on the season.

Since the RNP paths have been in use at Cusco, LAN has reduced cancellations from 12 to five, flight delays by 45% and un-stabilized approaches by 94%, per month on average. During the first year of RNP use at Cusco, more than 30,000 of LAN Peru's passengers avoided flight cancellations or delays, thanks to the technology. With the success of the Cusco paths, LAN selected GE Aviation in 2010 to develop an RNP program at five other airports it serves, including Lima.

Conclusion:

Performance-Based Navigation technology produces major environmental and economic improvements. Benefits are being realized from this technology in China, South and Central America, the United States, Australia, New Zealand, Canada and Europe. India is limited from a capacity perspective and new technologies such as PBN will help alleviate future congestion and give India a room to grow.

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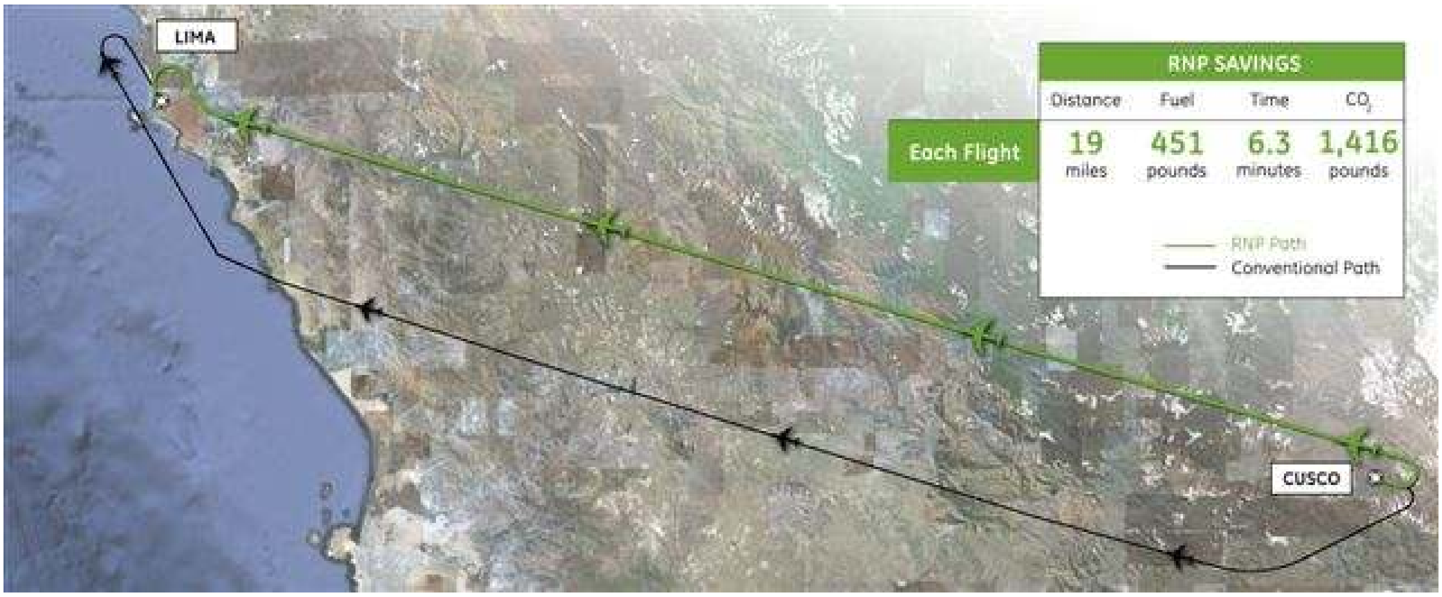

Figure: Result of Green Sky project LAN Track of Peru (Lima's Jorge Chavez International Airport)

Author's profile

Steve Fulton is a Technical Fellow at GE Aviation and was the co-founder of Naverus, Inc. in 2003, the root of GE Aviation's PBN Services. Prior to this, in his former capacity as technical pilot at Alaska Airlines, Mr. Fulton was instrumental in the development of the world's first commercial RNP AR instrument approach procedure at Juneau, Alaska.


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Advanced Air Purification for Airports: Economically Viable, Environmentally Friendly

Jeffrey L. Roseberry, President, and Bernice Valantinas, Vice-President, ProMark Associates, Inc

Air traffic in India is expected to grow to more than 70 million domestic and 40 million international passengers in the next few years. Delhi's Indira Gandhi International airport ranks first in India in passenger traffic with more than 35 million passengers in 2010-11, a 22.7% increase, while Mumbai comes second with 30.4 million passengers for the same period, an 8.2% increase.

Busy airports near densely-populated cities, with heavy vehicular traffic, high humidity and heat, and growing air passenger traffic, will experience high levels of harmful air pollutants, causing discomfort and perhaps even harm to passengers and employees.

These 21st-century air quality challenges cannot be adequately met by 19th and 20th-century air cleaning solutions and standards. Existing standards require that large amounts of outside air be brought in to ventilate the indoors. But that requires more cooling and dehumidifying and is based on the assumption that outside air is clean.

Ever-increasing energy costs create a further challenge to the problem of maintaining cleaner and healthier indoor air. Heating, Ventilating and Air-conditioning (HVAC) systems account for more than 50% of energy use in buildings. Inefficient, outdated methods of cleaning indoor air further drive up overall operating costs.

Total Spectrum® Air Purification is a 21st-century air purification technology that takes a giant step forward to meet the dual challenge of providing purified air to occupants, while helping to reduce the energy consumption of the HVAC system. Its design flows from incorporating existing methods of air cleaning and adding advanced technology to overcome the limitations of these methods. Total Spectrum®, integrated into the HVAC system, provides superior Indoor Air Quality (IAQ), safely, reliably and energy efficiently.

Air Quality Challenges for Airports

India's dramatic growth in airline travel means expanding and upgrading existing airports and building new ones. In addition, as the trend moves to create airport cities, or aeropolises, with hotels, shopping, restaurants, and serving as trade hubs, it is even more important to provide travelers, shoppers, diners, and employees with clean, odor-free air in an effective and energy-efficient way. Airport terminals are challenged by air pollutants, both particles and gases, from a variety of sources: jet and diesel fuel, vehicle exhausts around the airport, cigarette smoke, food service and cooking facilities, onsite power generation and from travelers and employees themselves.

How can these pollutants be addressed?

Ventilation Only: No Longer the Best Solution

Ventilation with outside air to create acceptable indoor air quality has traditionally been the underpinning of industry HVAC standards while cooling and heating provide occupants comfort. The currently used methods of air filtration and air cleaning partially achieve clean indoor air, but it is not enough. In ventilation theory, outside air mixes with recirculated air to continuously dilute pollutants, thus assuring there will always be pollution, just less concentrated. The rate of recommended ventilation, or the amount of outside air brought in, has varied: in 1824 at 4%, up to 30% in 1905, down to 10% by 1936, then down to 5% in the 1970s during the energy crisis in the U.S.

Today, the ventilation rate methodology is more sophisticated and allows for concentration of people, type of building and role of the facility, location, and air delivery mechanism. Most ventilation rate calculations call for 20% to 30% outside air but can be as much as 100% outside air.

Air Purification Lab Studies

In 2005, the U.S. Department of Energy funded the Lawrence Berkeley National Laboratory, in Berkeley, Calif., to conduct research on air purification methods that would also reduce energy consumption in buildings. This study found that there were disadvantages of increased ventilation. Specifically, it showed the following:

- Indoor concentrations of some outdoor pollutants increase
- Ozone from outside air is found in increased concentrations indoors
- Outdoor respirable particles increase indoors
- As the ventilation rate rises, more outdoor humidity enters the HVAC system. In turn, higher indoor humidity can lead to more dust mites and a greater risk of mold growth.

In 2007, Lawrence Berkeley did another study, using ultraviolet light and photo catalytic oxidation (UV/PCO) followed by permanganate on alumina. This combination yielded a vastly better outcome. The report stated, "In summary, the use of a multi-panel, folded scrubber filled with permanganate chemisorbant media downstream of the prototype UV/PCO air cleaner effectively counteracted the generation of formaldehyde and acetaldehyde due to incomplete oxidation of VOCs in the UV/PCO reactor.

Thus, this combined UV/PCO air cleaner and chemisorbant system appears to have sufficient VOC removal efficiency to enable a 50% reduction in ventilation rate without increasing indoor aldehyde concentration. The greatest impact on overall HVAC energy reduction, therefore, will be achieved by reducing outside air volume.

The ventilation guidelines set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE Standard 62.1, does allow for recirculating purified air to reduce the need for higher ventilation rates. When applying the IAQ procedure, the vendor must make sure that all air pollution is addressed and controlled, measured and monitored. Air must be cleaned of all contaminants of concern, including particles, gases and biologicals atoms - in other words, "purified" prior to recirculation. If this can be done, significant long-term benefits to air quality and energy preservation can be achieved. The benefits to human health and productivity can be dramatic.

Total Spectrum®'s Advanced Air Purification Capabilities

Total Spectrum® harnesses the oxidative power of ultraviolet light and photocatalytic oxidation (UV/PCO) and embeds it in a five- stage sequence of air filtration, air purification, controls, sensors and safeguards. The five-stage process eliminates viruses and bacteria in addition to VOCs, odors, oxides of sulphur (SOx), oxides of nitrogen (NOx) and particles. Any intermediates formed along with newly-created oxidation radicals are destroyed within the system. Purified air then passes downstream. The process of advanced air purification does not create hazardous waste or byproducts, is a safe process to maintain, and offers ease of operation.

The advanced Air Purification System (APS) is scalable and can be integrated into existing HVAC. Placed in front of the Air Handling Unit (AHU), it should see both outside and recirculated air. By purifying all the air each time it passes through the AHU pollutant existence is shortened to a few minutes. With pollutant levels reduced, the need for ventilation to dilute indoor air is significantly reduced.

A Five-Stage System

Stage 1: Prefiltration

Prefiltration captures particulates of 1µ (micron) to 95% efficiency. A Merv 14 filter, 95%, is used to protect the next stage from dust, particles, and reduces the buildup on any high efficiency particulate air (HEPA) downstream.

Stage 2: Dynamic Chemistry and UV/PCO

The most effective use of UV light is combining it with photocatalysis, increasing UV's germicidal power dramatically by partnering it with a catalyst. The full potential of the UV light spectrum is utilized. Viruses and bacteria are captured and destroyed in Stage 2. Powerful chemistry is generated dynamically from water molecules. These active molecules oxidize organics, such as VOCs and pathogens. Any unused chemistry travels to the activated carbon section and continues the oxidation of organics adsorbed there, such as the intermediate byproducts mentioned by Lawrence Berkeley Labs.

Stage 3: Gas Phase Filtration Media in Modules

For decades activated carbon has been used to trap and hold gaseous pollutants. Then KMnO4 (potassium permanganate on alumina) or 'purple' for short, was developed to extend the range of gases treated, especially sulfur-based, that cause corrosion of electronics.

The carbon and purple pack a one/two punch: removing both odors and VOCs. Any intermediate products of Stage 2 oxidation are captured by the carbon and converted to carbon dioxide and water. In the process, the carbon is regenerated in situ, retaining its active life, often for years.

The V-shaped media-holding modules are an advanced design for reduced air resistance, increased media bed depth, and longer contaminant contact time.

Stage 4: Controls and Sensors

Safeguards sense when UV section doors are being opened and automatically turn off UV lights to prevent accidental exposure. Sensors monitor temperature, humidity, ozone, and TVOCs in real time to provide IAQ data. Monitoring for additional target contaminants can be added. A Building Management System (BMS) interface is provided allowing integration with HVAC systems based on sensor data. Pressure gauges monitor when particulate filters need replacing. The gas phase sensors are available in wired and wireless communication options that can communicate with building management systems and the owner. It is possible to track gases of concern, use them to validate IAQ is within set limits, and to control and minimize ventilation.

Stage 5: Final Filters

Final filters serve as a stopgap for any dust from filter media that may get through from Stage 3 or 4. For critical applications, HEPA filters can be added.

Return on Investment

The investment in a properly designed air purification system will be recouped in approximately two years from realized energy savings. The savings resulting from reducing outside air volume will continue to be realized year after year.

A Clear Direction

Advanced air purification technology, integrated into new or existing HVAC systems, utilizes the capabilities and helps surmount the limitations of current air cleaning methods. An advanced APS can successfully tackle the dual challenge of eliminating harmful pollutants and reducing HVAC energy consumption. Adding an advanced air purification system to new or existing buildings is a sustainable 21st-century solution to indoor air quality and energy use challenges.

The Corporate Social Responsibility Statement of the Airports Authority of India (AAI), May 2011 "positions its social and environmental consciousness as an integral part of its business plan." This means a commitment to healthy workplaces and to quality, health and safety in all aspects of business. Further, AAI's goal for sustainable development of infrastructure is to be achieved by the use of, "innovative and sustainable solutions for environmental conservation."

Fig.1 Total Spectrum®, an advanced air purification technology, provides a triple bottom line of people, planet and profits and aligns with AAI's goal of sustainable airport infrastructure.

Common Pollutants & Sources Outside Airport Buildings

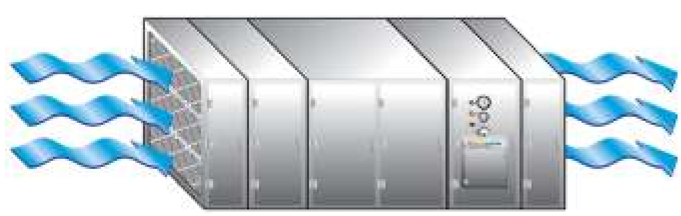

Fig.1 Total Spectrum® 5 Stage Air Purification System

and Their Effects

Case Study 1: Casino - Advanced Air Purification System

Casino Project: New construction gaming floor addition

Challenge:

CONTAMINANT	SOURCE	EFFECT
Oxides of Sulfur	Sulphur impurities in fuel, jet and diesel engines, power generation.	Odor, irritation, acidic. Damage to respiratory tract
Oxides of nitrogen	Jet and diesel engines, power generation.	Smog and haze formation, acidic. Lung irritation.
Hydrocarbons	Fuel combustion	Odor, smog, eye irritation, respiratory tract issues, headaches, dizziness
Aldehydes	Diesel fuel combustion	Odor, eye irritation, respiratory issues
Ozone	Not directly emitted, but formed from hydrocarbons and UV light	Impairment of lung function
Carbon monoxide	Jet and diesel engines	Headache, dizziness

Common Pollutants & Sources *Inside* Airport Buildings

Hydrocarbons	Painting, cleaning agents, floor covering, floor polish	
Formaldehyde	Carpets, wooden floors, furniture	
Odors	Humans, food facilities, cigarette smoke	

- 60-70% smokers
- 30,000 sq. ft. with 20 ft. ceilings
- High odor complaint volume experienced in previous facility

Solution:

- 30% fresh air, 70% recirculated air
- APS consisting of three prefilters, UV/PCO, carbon media modules, potassium permanganate on alumina media modules, final filter and controls
- Three 33,000 cfm APS units installed ahead of respective AHU
- 100% of all returning air sent to APS first

Results:

- In operation since May 2005
- Original activated carbon unchanged for 6.5 years. Replaced on 1-15-2012, still retained 50% virgin adsorptive capacity.
- UV lamps and $KMnO_4$ media only replaced twice
- Maintaining TVOCs at 200-300 nanograms/Liter, making the air on the casino floor cleaner than USBGC minimal requirements.

Fig-2 Total Spectrum APS at Mystique Casino

Fig 3: Mystique Casino in Dubuque, Iowa

(a)

(b)

Case Study 2: Airport Terminal-Advanced Air Purification System:

In 2007, an advanced solution for IAQ was sought for Indira Gandhi International (IGI) Airport Terminal 3 new construction. The proposal was based on the casino design and took into account the difference in the outdoor environment.

Challenge:

The outside air at IGI is very hot, humid, dusty, and full of both car and plane engine fumes. Ventilation alone or ventilation combined with gas phase filtration cannot eliminate odors and pollutants economically. Singular energy reduction solutions such as desiccant wheels would do little to improve IAQ. Demand controlled ventilation is the same dilution solution just more energy sensitive.

Scope of air purification system:

The unique design of Total Spectrum for T-3 includes the five stages of air purification in each AHU. Currently being installed, there are 59 AHUs sized to accommodate varying air flows at the outside air intakes of the terminal. The AHUs comprise 600,000 cfm. The second phase of the terminal will add another 4.4 million cfm. A total of 5 million cfm is specified for Terminal 3, when completed.

(C)

Fig 4 IGI Terminal 3 (a, b & c)

Economics of advanced air purification:

The Public-Private Partnership at IGI that is holding the building for 30 years has a long-term vision embracing operating savings. By including the Total Spectrum® APS, these savings were estimated at $162 M USD. The APS has an operating life expectancy of 30 to 50 years.

The initial cost of Total Spectrum APS has an estimated payback in less than two years from energy savings. The savings from reduced outside air volume will continue to pay dividends year after year.

PUSHPAK - Supersonic

On October 16, 1978, the indefatigable Tymms left Delhi in a BOAC engine with the other members of the Indian delegation, Sir Gurunath Bewoor, Secretary to the Government in the Department of Posts and Air, and two members of the Civil Aviation Directorate, Sardar G. D. Singh and S. C. Sen, the latter serving as the delegation's Secretary. At Karachi, they joined a C-54 US military air transport which flew them by way of Abadan, Cairo, Tripoli, Casablanca, the Azores and Stephenville to arrive at New York on the morning of October 19. There, they met and briefed the chairman and leader of the Indian delegation, Sir Girja Shankar Bajpai, the Agent General for India in the United States. They all flew to Montréal on October 21.

The Times of India paid editorial tribute to the great debt that civil aviation in India owed to Tymms: "His experience and knowledge of commercial flying in this country are unsurpassed and, consequently, the advice i.e. against the nationalization of India's domestic airlines, which he has given on the eve of his departure to become Britain's delegate to ICAO, carries great weight.

"In the wider sphere of world aviation, India will undoubtedly give full support to the setting up of an international 'air Government' which Sir Frederick Tymms advocates and which is even now the subject of discussion of the ICAO conference in Montreal. Common control through multilateral agreement is a prerequisite to the fullest and smoothest development of international air routes."

The Indian Air Board, an advisory set-up of senior officials of the Government of India, seems to have distinguished itself mainly by total inaction since its formation in 1920. In 1926, the Board submitted to the Government a remarkable memorandum, which also happened to be the swan song of its own dissolution as one of its recommendations. The Board's memorandum, titled "The Past History and Future Development of Civil Aviation in India," included proposals for (a) establishing landing grounds and other ground facilities; (b) the whole-time appointment of a Director of Civil Aviation; (c) a systematic survey of main trunk routes; (d) the inauguration of an air service between Calcutta and Rangoon; and (e) the grant of a subsidy to the company entrusted with its operation.

The Board's recommendations were approved by the Government and the Indian Legislative Assembly in February 1927, as recommended by Sir Sefton Brancker, Francis Shelmerdine of the Directorate of Civil Aviation in Britain, was appointed in 1927 as India's first Director of Civil Aviation.

The Government had already created, at least on paper, an entity called the Indian State Air Service (ISAS), but had failed up to then to cover its bones with the flesh of the organization and equipment. A storm was raised in the press and parliamentary debates and the Government had no alternative but to proceed with plans to give the Indian State Air Service a fleet and an administration of its own.

Four Avro X aircraft were ordered and a start was made on building up an organization. The project was,

however, promptly abandoned in 1931 on the providential recommendation of a Retrenchment Committee of the Assembly, owing to the economic blizzard which hit India along with the rest of the world – the order for Avro Xs was cancelled, retaining only one for the use of the Viceroy, and for urgent need of top Government officials.

In January 1932, Delhi Flying Club came to the rescue. With one Puss Moth loaned by the Government and one Indian pilot, it took over the mail from the mighty Imperial Airways Karachi-Delhi Service and operated it most efficiently until July 1933.

On January 23, 1946, the Central Government created the Air Transport Licensing Board (ATLB), which was charged with providing the legal operating authority to all airlines, Indian or foreign, that wished to fly over the Indian territory. The program was that all airlines in operation on July 1, 1946, namely the three surviving companies from pre-war days plus the newly-formed Deccan Airways of Hyderabad, should apply for regular licenses before August 1, 1946. These would take effect from October 1, 1946. Unfortunately, these well-conceived plans went awry when the interim Government of India, formed in September 1946, decided to do away with their essential feature which was that the number of competing airlines should be restricted to a maximum of four.

"In a mad scramble for a share in what was thought to be an unlimited prospect of airline profits twenty-one companies were registered by the time the ATLB was ready. There were more than a hundred applications for ninety-six routes. In due course, licenses were given to eleven companies for fifty-one routes. The next few years were hectic and difficult for the airlines. Inefficient operations by too many companies led to their own downfall and the industry's ultimate nationalization in 1953. The Indian independent airlines, whose efforts often cumbersome and ineffective, laid the foundation of "Indian Airlines," the nationalized domestic carrier.

Tata Airlines struggled through the war, in spite of unsuitable equipment and the demands of military services, keeping up limited communications between Bombay, its headquarters, and some of the metros and lesser important cities of India. DC-3s were introduced on March 1, 1944, and later on April 16, 1946. Tatas were allocated four war-surplus DC-3s and bought or leased eight other directly from the United States Foreign Liquidation Commissioner. In July 1946, its name was changed to "Air India" and converted to a public company. Routes were in operation to all the metropolitan cities and some secondary destinations of India and to Karachi and Colombo, in neighboring West Pakistan and Ceylon (later Sri Lanka), respectively.

Indian National Airways (INA), based at New Delhi, operated a number of war-time routes, with Government support, mainly to Madras, Bombay and Karachi. DC-2s entered service in October 1942, replacing Beech 18s at the end of the war. Six DC-3s were purchased, together with six Vickers Vikings, which were put into service in 1947. On February 7, 1946, the first Indian air service promoted by INA and distinguished by a title, the "UP Indiaman" was inaugurated between Delhi and Lucknow, followed on June 1, 1946 by the Rajputana Indiaman to Ahmedabad. Other Indiaman routes were added to Calcutta, Karachi and Peshawar.

Air Services of India (ASI), the third and last pre-war operators, was acquired in 1943 by the Scindia Steamship Navigation Company, and became known popularly as the "Scindia Line". Post-war services were resumed on May 3, 1946 on a network of routes centered on Bombay, covering the former Kathiawar territory and also extending to Lucknow, Karachi, Bangalore and Cochin. The fleet included eleven DC-3s.

"Deccan Airways", founded on September 21, 1945 by the Princely State of Hyderabad (71%) and Tata Sons (29%), was the first of the new airlines to begin operation, on routes centered on Hyderabad. About a dozen DC-3s operated services on July 1, 1946. Because of political disturbances in Hyderabad State during 1948, services were suspended from July 3 to October 14 of that year. In June 1951, Deccan also took over responsibility for the night airmail service from Himalayan Aviation. The Night Airmail Scheme was inaugurated on January 31, 1949 by "Indian Overseas Airlines", possibly the weakest airline of them all. The inevitable happened and operations were suspended in May. Deccan and INA took over temporarily from June 10 to 30, 1951.

On October 15, 1949, Himalayan Aviation, a Calcutta-based charter company founded in 1947, was licensed to operate the Night Mail until it handed over the service to

Deccan Airways on June 1, 1951. Compensation for this loss took the form of an award of a route from Calcutta to Karachi, via Allahabad and Ahmedabad. And the routes from Karachi to Kandahar and Kabul (Afghanistan) and to Zahedan (Iran).

Shortly after Deccan entered the field Airways (India), founded in September 1945, and began non-scheduled operations from Calcutta to Assam and into Burma, this airline was to become the most economically efficient amongst all the airlines operating during the pre-nationalization period. Scheduled services began on April 15, 1947 from Calcutta to Bangalore, via Vishakapatnam and Madras. Service to the new capital, Dacca (Dhaka) of East Bengal (which became East Pakistan and then Bangladesh) started on June 15, 1948 and further routes were added, to Delhi and Bombay, in 1950.

"Bharat Airways" controlled by the Birla Group, was founded on August 11, 1945. Scheduled service began on June 30, 1947, from Calcutta to Delhi, via Gaya and Lucknow, to which an alternative route, via Allahabad and Kanpur, was added in October of the same year.

"Ambica Airlines" associated with the Shri Ambica Steam Navigation Company, started local services in he Bombay-Ahmedabad region on January 27, 1947, but operations ceased on February 7, 1949, before "Indian Airlines Corporation" was created in 1953.

"Mistri Airways" inaugurated scheduled services from Bombay to Calcutta, via Nagpur in the autumn of 1946. The company changed its name to "Indian Overseas Airlines" about a year later and was concerned with the early difficulties of the Night airmail service. Operation ceased, however, by the end of 1950.

"Jupiter Airways", a Madras-based company, started to operate a Madras-Delhi route in 1948. Its slogan was "By Jupiter It's Quick" and so was its disappearance when it ran into licensing trouble less than a year later.

"Kalinga Airlines" began a daily service from Calcutta to Agartala, across East Pakistan into Assam, in May 1949, and by the beginning of 1952 frequency had built up to eight return flights a day. The fleet consisted of seven DC-3s and the company was active in 1953 when Indian Airlines was formed.

"Dalmia-Jain Airways" founded in July 1946, operated a Delhi-Srinagar service from 1947 to June 1952, when the company was liquidated.

After nationalization of the industry on August 1, 1953, the eight former independent companies became "Lines" of Indian Airlines Corporation (IAC): Air India; Air Services of India; Airways (India), Bharat Airways, Deccan Airways, Himalayan Aviation, Indian National Airways, and Kalinga Airlines.

Indian Airlines inherited seventy-four DC-3s, twelve Vikings, three DC-4s, and a host of smaller aircraft. It then began to modernize the fleet, which was to be as slow and laborious a process as the achievement of harmony between different staffs with regional loyalties.

Types of aircraft used in the Indian domestic network between October 15, 1932, when the first service was started by Tatas till the nationalization of the airline industry on August 1, 1953, were Puss Moth, Fox Moth, Percival, Gulls, Airspeed Ferry, Airspeed Courier, Waco, Dragon Rapide, Beech 17, DH-86/89, Percival Q6, DC-2 (loaned to Tatas by the Government of India and one crashed, fully written off DC-2 of RAF Transport Command rebuilt by INA), Stinson Model A, Beech 18, DC-3, Vicker-Armstrong Viking and DC-4.

In 1952, the Planning Commission recommended the merger of all scheduled airlines into a single Corporation in the Capital of which the existing companies would participate pro-rata in exchange for their holdings, while the Central Government would acquire a share large enough to exercise effective control.

In March 1953, the Indian Parliament passed the Air Corporation Act, which received the assets and business of all air transport companies operating scheduled air services in India and between India and neighboring countries, while Air India International Corporation took over Air India International Ltd.

As the air services were restored after the termination of War, the mileage of Indian air routes nearly doubled, from 4,781 on January 1, 1946 to 9,225 by July the same year. During this period of six months, the airlines in India carried 37,633 passengers.

During 1946, a total of 105,177 passengers were carried in India: Tata Airlines (re-designated Air India Ltd. in July 1946) carried 30,708 passengers. In 1947, the

passenger traffic in India more than doubled to 257, 866. The route mileage of Air India Ltd. during the second half of 1947 was 4,077 of a total of 18,020 miles covered by nine airlines in service during that period. Among these airlines were the ones that mushroomed in the immediate post-War period, founded by persons who knew little or nothing of air transport industry, paving the way to destruction of the industry in the private sector.

Air India Ltd., with its fleet of 18 Dakotas, three Beechcraft Expeditors and six Vikings, compared to the Combined fleet of 48 Dakotas, six Expeditors, six Vikings and 50 aircraft of various other types owned by its six sister airlines, carried, in the month of May 1947, 9005 passengers, 261,174 lb of freight and 72,202 lb of mail - a share of about 40 per cent of the total passenger traffic handled by the main internal carriers, and shares of 61 and 62 per cent of the total domestic freight and mail traffic, respectively. In those days, Air India Ltd. had a network covering Bombay, Delhi, Calcutta, Madras, Hyderabad, Ahmedabad, Jaipur, Bangalore, Cochin and Trivandrum within the country, Colombo in neighboring Ceylon (now Sri Lanka) and Karachi, in Pakistan, which came into being on August 14, 1947.

On March 16, 1948, Air India International's first constellation, Mugul Princess, landed at Bombay Airport at 16.10 hours: the 44-seat, 300 mph aircraft took 32 hours to cover the distance between Burbank, California and Bombay and was under the command of Captain K. R. Guzdar. The Mugul Princess was followed by other constellations.

Traveling on board the Malabar Princess was J. R. D. Tata, carrying with him personal messages of goodwill from Prime Minister Jawaharlal Nehru to the Prime Ministers of Great Britain and Egypt and the President of the Swiss Confederation.

Soon after his arrival in London, Tata flew a 500-mph Vampire jet fighter for 30 minutes at Hatfield, becoming the first Indian civilian and one of the first airline executives of the world to fly a jet aircraft. The Vampire combat aircraft was later to be produced under license by Hindustan Aircraft Ltd., Bangalore. It was the first jet to be inducted by the Indian Air Force (IAF).

In November 1949, Prime Minister Nehru, who always took keen interest in aviation, personally encouraged the airline by flying in the Malabar Princess on a Scheduled AII flight from Bombay to London, the first stage of his travel to North America: he made the trans-Atlantic flight by the US President's DC-6 aircraft, the Independence which was specially sent for him to London by President Truman.

During 1948, the first year of operation of Air India International (AII), 3,080 passengers, 89,000 lb of freight and 84,700 lb of mail were carried by the airline, achieving a load factor of over 95 per cent-no mean achievement for a hurriedly started international carrier. In October 1952, Air India International set an example in profit sharing between employers and employees by declaring a staff bonus equivalent to two weeks' salary paid to all employees of the airline in appreciation of their contribution to the profitable operation of the airline. On December 2, 1952, AII inaugurated its direct Constellation service from Delhi to London via Bombay.

This article is part of a series of articles written on the history of Indian civil aviation to commemorate the centenary year of Indian civil aviation, compiled and written by Dr. Arjun Singh, Program Director, US-India Aviation Cooperation Program.

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YOU'RE EXPECTED TO LEAD.
FOLLOW NO ONE.
An extreme world demands extreme performance. The completely redesigned Striker® helps you take control of the most volatile Aircraft Rescue and Fire Fighting threats, equipping you with all-new standards in fire suppression technology, chassis performance, visibility and overall safety.
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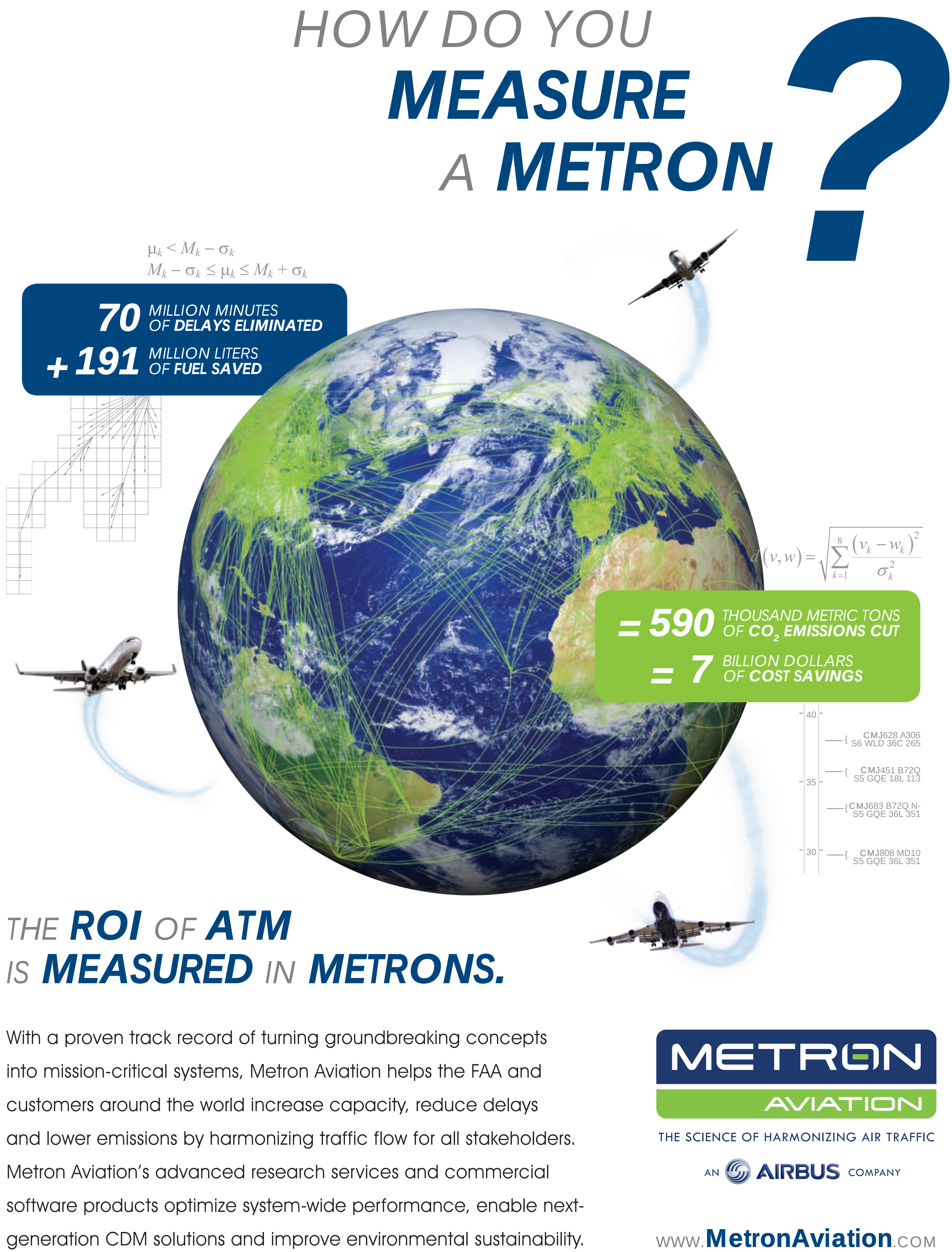
HOW DO YOU
MEASURE
A METRON?
$\mu_k < M_k - \sigma_k$
$M_k - \sigma_k \le \mu_k \le M_k + \sigma_k$
70 MILLION MINUTES OF DELAYS ELIMINATED
+ 191 MILLION LITERS OF FUEL SAVED
$d(v,w) = \sqrt{\sum_{k=1}^{8} \frac{(v_k - w_k)^2}{\sigma_k^2}}$
= 590 THOUSAND METRIC TONS OF CO_2 EMISSIONS CUT
= 7 BILLION DOLLARS OF COST SAVINGS
40
CMJ628 A306 S6 WLD 36C 265
CMJ451 B72Q S5 GQE 18L 113
35
CMJ683 B72Q N- S5 GQE 36L 351
30
CMJ808 MD10 S5 GQE 36L 351
THE ROI OF ATM IS MEASURED IN METRONS.
With a proven track record of turning groundbreaking concepts into mission-critical systems, Metron Aviation helps the FAA and customers around the world increase capacity, reduce delays and lower emissions by harmonizing traffic flow for all stakeholders. Metron Aviation's advanced research services and commercial software products optimize system-wide performance, enable next-generation CDM solutions and improve environmental sustainability.
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THE SCIENCE OF HARMONIZING AIR TRAFFIC
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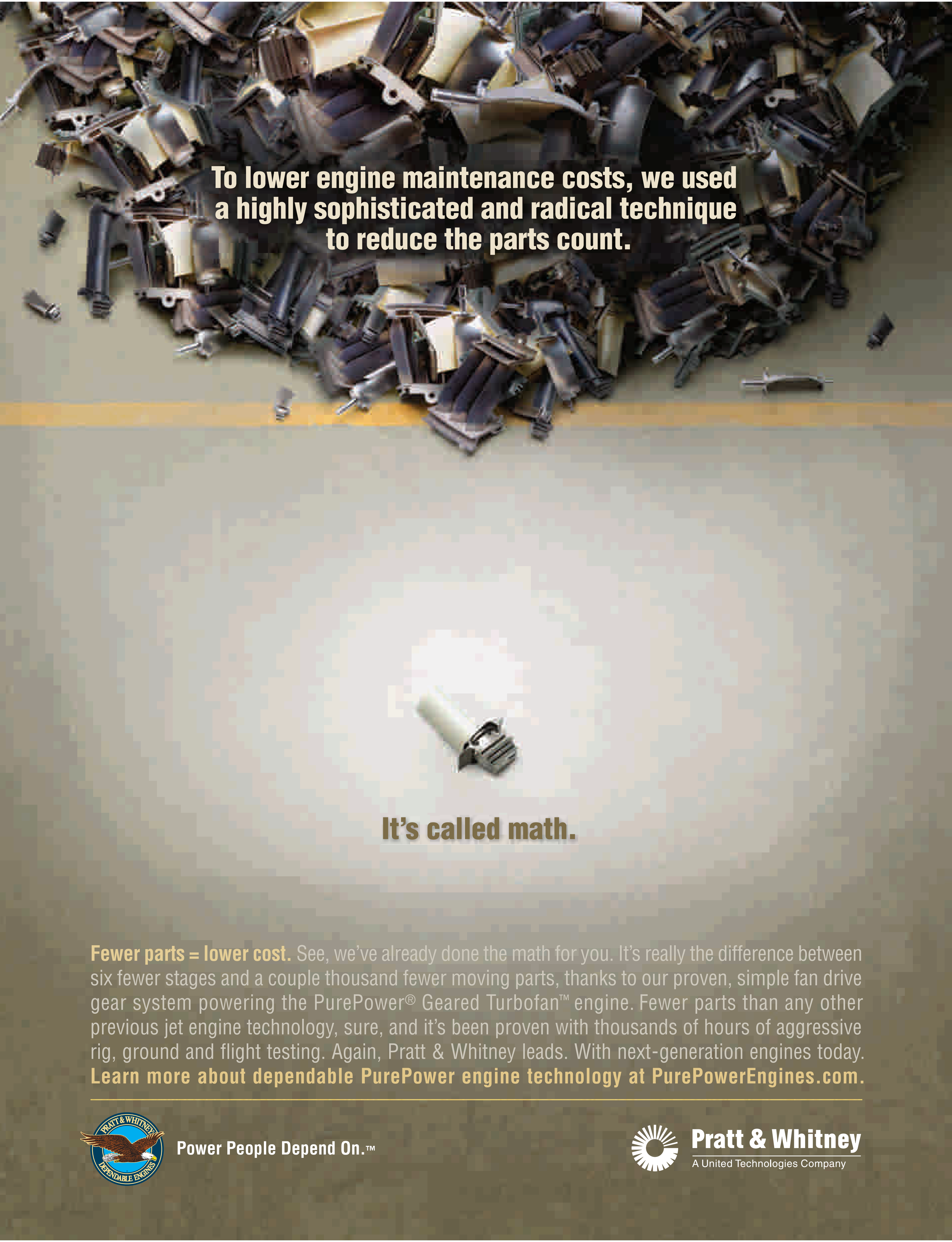
To lower engine maintenance costs, we used a highly sophisticated and radical technique to reduce the parts count.
It's called math.
Fewer parts = lower cost. See, we've already done the math for you. It's really the difference between six fewer stages and a couple thousand fewer moving parts, thanks to our proven, simple fan drive gear system powering the PurePower® Geared Turbofan™ engine. Fewer parts than any other previous jet engine technology, sure, and it's been proven with thousands of hours of aggressive rig, ground and flight testing. Again, Pratt & Whitney leads. With next-generation engines today.
Learn more about dependable PurePower engine technology at PurePowerEngines.com.
PRATT & WHITNEY DEPENDABLE ENGINES
Power People Depend On.™
Pratt & Whitney
A United Technologies Company

US-INDIA AVIATION COOPERATION PROGRAM

US Government

U.S. Trade and Development Agency

U.S. Commercial Service

Federal Aviation Administration

John A. Volpe National Transportation Systems Center

US Industry

Bell Helicopter — A Textron Company

Boeing

Cessna

Continental Airlines

CH2MHILL

FedEx Express

Goodrich

GE — imagination at work

GAMA — General Aviation Manufacturers Association

Honeywell

Hi-Tec Systems

Harris

Hawker Beechcraft

IBM

ITT Exelis

L&B

MITRE

MOOG

Metron Aviation

Oshkosh JLG

ProMark Associates, Inc.

Raytheon — Customer Success Is Our Mission

SDG — Strategic Decisions Group

Superando

TATI

UPS

Universal Weather & Aviation, Inc.

Vaughn College

WCG


Smarter business for a Smarter Planet:
What 3 million lines of code means to a piece of luggage.
It means Amsterdam Airport Schiphol will be able to accurately and efficiently move 70 million pieces of luggage per year—20 million more bags per year than they used to. The airport's automated baggage solution will allow them to increase their baggage handling capacity by 40%, so they can meet the growing demand placed on them as one of Europe's largest transport hubs. This system is built on IBM Rational® and Tivoli® software and runs on Power Systems.™ A smarter business is built on smarter software, systems and services.
Let's build a smarter planet. ibm.com/luggage/in
IBM
A data visualisation of the flow of baggage traffic at Amsterdam Airport Schiphol