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ICAO JOURNAL

VOLUME 61 NUMBER 3, 2006

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ICAO Journal

The magazine of the International Civil Aviation Organization

VOL. 61, NO. 3 **MAY/JUNE 2006**

FEATURES

UPDATE

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ICAO Journal

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THE OBJECTIVES of the Journal are to provide a concise account of the activities of the International Civil Aviation Organization and to feature additional information of interest to ICAO Contracting States and the international aeronautical world.

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Published in Montreal, Canada. Second class mail registration No. 1610. ISSN 1014-8876. Date of publication of Issue 3/2006: 9 June 2006. Published six times annually in English, French and Spanish.

SUBSCRIPTIONS: $25 (by surface) and $35 (by air) per year. Single copies available for $10. Prices in U.S. funds. ***For subscription and circulation inquiries***, please contact ICAO Document Sales Unit. Telephone: +1 (514) 954-8022; Facsimile: +1 (514) 954-6769; E-mail: sales@icao.int. ***Important Note:*** Readers are advised that surface delivery may take as long as six months, depending on location. Air mail is strongly recommended. The current issue may be viewed in PDF format without delay at ICAO's website (http://icao.int/icao/en/jr/jr.cfm). Issues dated 2005 or earlier are viewable using the downloadable DjVu reader. Planned publication dates for 2006 are 15 February, 13 April, 9 June, 7 August, 8 September and 11 December.

ADVERTISING REPRESENTATIVE: Yves Allard, FCM Communications Inc., 835 Montarville St., Longueuil, Quebec, Canada J4H 2M5. Telephone: +1 (450) 677-3535; Facsimile: +1 (450) 677-4445; e-mail: fcmcommunications@ videotron.ca.

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GRAPHIC ART/DESIGN: Bang Marketing (www.bang-marketing.com). **PRINTING:** Transcontinental-O'Keefe Montreal (www.transcontinental-printing.com).

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Performance-based navigation seen as key to global harmonization

An ICAO study group has determined that an updated and globally harmonized RNP concept would be flexible enough to meet both current and future operational requirements

ERWIN LASSOOIJ
ICAO SECRETARIAT

THE ICAO concept of required navigation performance (RNP) is being revised in light of industry demands for performance-based navigation (PBN), a concept that encompasses both area navigation (RNAV) and required navigation performance (RNP).

Performance-based navigation is increasingly seen as the most practical solution for regulating the expanding domain of navigation systems. Under the traditional approach, each new technology is associated with a range of system-specific requirements for obstacle clearance, aircraft separation, operational aspects (e.g. arrival and approach procedures), aircrew operational training and training for air traffic controllers. This system-specific approach, however, imposes an unnecessary effort and expense on ICAO as well as on States, airlines and air navigation services (ANS) providers.

Performance-based navigation eliminates the need for redundant investment in developing criteria and in operational modifications and training. Rather than build an operation around a particular system, under performance-based navigation the operation is defined according to the operational goals, and the available systems are then evaluated to determine whether they are supportive. The advantage of this approach is that it enables harmonized and predictable flight paths which result in more efficient use of existing aircraft capabilities as well as improved safety, greater airspace capacity, better fuel efficiency, and the resolution of noise issues.

Original RNP concept

The original RNP concept as defined by ICAO was a supporting element of the future air navigation systems (FANS). Its purpose was to introduce more flexibility and adaptability to technological change by better exploiting the communications, navigation and surveillance (CNS) capabilities of the aircraft's on-board systems. RNP was developed to allow planners to increase airspace capacity by specifying airspace and aircraft operational requirements based on the existing capabilities of the aircraft fleet rather than relying on the normally lengthy process required for industry to comply with sensor-dependent specifications.

The ICAO RNP concept was widely acknowledged and very well received. However, the air transport industry found that the original concept was not detailed enough to be of practical use, especially in terminal airspace. To address this shortcoming, the industry developed the so-called RNP/RNAV concept, a derivative of RNP that offered more comprehensive technical support for the performance, design, development, implementation and qualification of aircraft navigation systems. An integral part of this derivative concept was the specification of requirements for on-board performance, monitoring and alerting. These measurable and demonstrable specifications support improvements in airspace design and management, among them closer route spacing and reduced separation.

As aircraft systems evolved, it became apparent that the original ICAO provisions were not sufficient to meet all of industry's demands, and consequently they were unable to prevent the development of partially divergent industry specifications. Different types of RNP and/or RNAV have been implemented in different regions (see *Figure 1*). While this approach meets requirements at a regional level, the advent of RNP variations also implied that the original concept — designed primarily to prevent "proliferation" of new technology and regional navigation requirements — was in fact contributing to this problem. The lack of harmonization raised concerns among aircraft operators, which faced an increasing burden of complying with varying regulations in different parts of the world. Potential safety risks were identified as operators and flight crews attempted

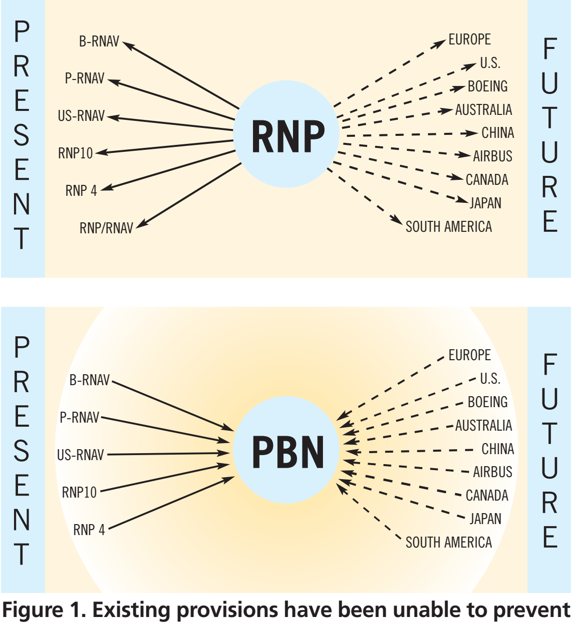

Figure 1. Existing provisions have been unable to prevent development of RNP variations to meet the needs of regions, countries and the industry. PBN convergence (bottom figure) is achieved through RNPSORSG initiatives.

to comply with all of the pertinent regulations in an environment where the rules change from region to region, and even during a single flight.

Area of application	Navigation accuracy (NM)	Navigation specification (current)	Navigation specification (new)	Requirement for performance monitoring and alerting
Oceanic/Remote	10	RNP 10	RNAV 10 (RNP 10 label)	no
	4	RNP 4	RNP 4	yes
En-route Continental	5	B-RNAV RNP 5	RNAV 5	no
En-route Continental/Terminal	2	US-RNAV type A	RNAV 2	no
	2	–	RNP 2	yes
Terminal	1	US-RNAV type B and P-RNAV	RNAV 1	no
	1	–	RNP 1	yes
Approach	0.3	RNP 0.3	RNP 0.3	yes
	0.3 – 0.1	RNP/SAAAR	RNP 0.3 – 0.1 (RNP/AR)	yes

Table of existing and new navigation specifications

ICAO responded to this undesirable situation by forming a study group to focus on all related issues and to present recommendations to the Air Navigation Commission on how best to proceed.

PBN offers solution

The Required Navigation Performance and Special Operational Requirements Study Group (RNPSORSG), which met for the first time in April 2004, recently concluded that it is indeed feasible to develop a globally harmonized concept that meets current operational requirements while remaining flexible enough for future requirements. The group, consisting of participants from several ICAO member States that are front-runners in RNAV and RNP implementation as well as aircraft manufacturers, airlines and pilot associations, has also recognized the value of industry developments in the area of on-board performance monitoring and alerting requirements. Such technology is even critical in some cases, such as in the final approach phase, where exacting obstacle clearance requirements can only be met with on-board performance monitoring and alerting.

At the same time, the study group understood that these capabilities do not necessarily satisfy the operational requirements in all types of airspace or in every application within a given airspace, and would not always be cost beneficial. This is why the group decided that the best approach to system implementation is to apply a concept focused on performance-based navigation and efforts to harmonize elements of the industry concept and ICAO's existing RNP concept. This solution includes all segments of flight including en-route terminal area operations and the final approach phase, where RNP will be used as a basis for obstacle clearance.

The revised RNP concept will likely harmonize the currently available RNAV- and RNP-designated PBN applications, particularly in the terminal area, where a divergence in implementations has been noticed.

The revised concept clearly distinguishes between those operations that require on-board performance monitoring and alerting, and those that do not. The study group agreed that navigation specifications for operations that do not require on-board performance monitoring and alerting should be designated RNAV-X, while those operations requiring such capabilities would be known as RNP-X. The "X" in the designation identifies the lateral navigation accuracy in nautical miles (NM) that is required during at least 95 percent of the flight time.

The specifications associated with each designation meet current operational requirements while allowing global harmonization, leading to greater efficiency and lower costs for aircraft operators as well as safety enhancements. Furthermore, they are fully compatible with existing implementations. Aircraft meeting the RNAV-1 navigation specification developed by the study group, for example, can fly in both precision RNAV (P-RNAV) and U.S. RNAV type-B airspace.

As depicted in the accompanying table, thus far the group has identified nine different navigation specifications for which there is a current operational need. They are listed together with the applicable type of operation. Some of the specifications were already in existence, whereas others have been developed by RNPSORSG. For existing specifications, a conversion from the current designation to the designation based on the new scheme is provided in the table.

In order to avoid future proliferation of regional navigation specifications, the group also established a process for developing a global navigation specification that addresses — in a harmonized fashion — any emerging regional requirements that cannot be met by the specifications listed in the table. The RNAV-10 (known as RNP-10), RNAV-5, RNP-4, RNAV-2 and RNAV-1 navigation specifications are either existing specifications or modifications of regional implementations.

New RNP-1 and -2 specifications, currently under review by the RNPSORSG, are designed for applications in airspace that does not necessarily require radar monitoring and enhanced functionalities such as radius to fix (RF) turns or time of arrival control. These new specifications will enable en-route and terminal operations outside the coverage of ground navi-

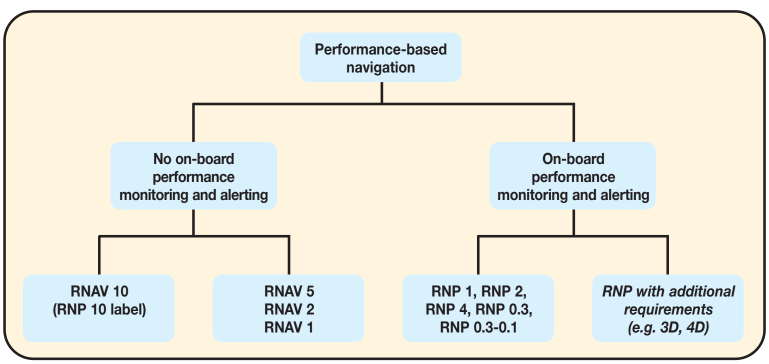

Figure 2. Performance-based navigation concept; italicized type denotes examples of future navigation specifications.

gational aids through the use of the global navigation satellite system (GNSS).

A new RNP 0.3 approach specification would provide a single, harmonized standard that accommodates basic GNSS equipment as well as RNP-certified aircraft, and satellite-based augmentation system (SBAS) navigation equipment. This will eliminate the need for sensor-specific multiple approaches designed for different aircraft configurations but very similar performance characteristics.

ICAO is also addressing performance-based navigation in the approach phase by developing the relevant procedures. The approach procedures are designated as "RNP 0.3-0.1," reflecting the fact that the accuracy requirement is "scaleable" from 0.3 NM down to 0.1 NM depending on the procedure requirement. These procedures require specific aircraft and aircrew authorization similar to that required for instrument landing system (ILS) Category II and III operations. As might be expected, the requirement for authorization is mainly because of the reduced obstacle clearance margins in comparison with conventional RNP 0.3 approaches. The goal is to establish criteria equivalent to those used in the U.S. standard developed for RNP approach procedures with special aircraft and aircrew authorization required (RNP-SAAAR). Their introduction will ensure complete global harmonization for this particular type of operation in terms of flight procedure design and aircraft and operational criteria. The reward for establishing such standardization is the significant safety and efficiency benefits that arise. (For more on RNP/RNAV approach procedures, see "Implementation of performance-based navigation making notable progress," page 9.)

The PBN concept that allows for RNAV-X and RNP-X operations will also need to be flexible enough to accommodate potential requirements such as 4-D navigation. An overview of the PBN concept, showing how this all fits together, is illustrated in *Figure 2*.

Airbus S.A.S.

The international civil aviation community is at a turning point in terms of airspace design and air traffic management, with new emphasis now being placed on aircraft navigation performance.

ICAO documentation

New guidance material under development by RNPSORSG will be published as an ICAO manual. States, aircraft operators and ANS providers will find instructions in this document on how to implement RNP/RNAV operations, as well as a compendium of navigation specifications, including the applicable approval and aircraft qualification requirements. Related terminology used in ICAO standards and recommended practices (SARPs) will also be aligned to the new designation scheme.

The PBN manual is expected to become available in draft form at the ICAO website by September 2006, while the updates of SARPs will become applicable in November 2008. This package of material will provide States with a common international framework for implementation of performance-based navigation, thus ensuring regulatory harmonization with a minimum impact on aircraft equipage and safety oversight.

The above described documentation is only the initial step towards successful worldwide implementation. Effective implementation of performance-based navigation will require that ICAO provide consistent policy and guidance across the many disciplines touched by this programme.

The RNPSORSG has nearly achieved its goals, but a few issues still need to be resolved, as summarized below.

Performance monitoring and alerting requirements. The RNPSORSG is considering the TSO-C129 receiver as a sensor that would be suitable for RNP-1 and -2 operations that require performance monitoring and alerting. It remains to be determined, however, whether the receiver's level of performance monitoring and alerting is adequate.

RNP and RNAV designation. One aspect of the RNP and RNAV designation that is not fully resolved yet is the potential need for different operations that require the same accuracy, but have dissimilar functional requirements. This could be done either by adding a suffix to the designation (e.g. RNP-1A) or by including notices on charts specifying the additional functional requirements.

Approach performance. At present, PBN is focused on linear performance criteria which supports rectangular obstacle clearance areas. Discussions continue on whether and how angular performance criteria to support trapezoidal obstacle clearance areas such as those associated with ground-based or space-based augmentation systems should be included in the concept of performance-based navigation. Another matter to be resolved is the requirement for RF legs and vertical navigation (VNAV) for RNP 0.3 approaches.

After the work of the study group has

continued on page 31

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Implementation of performance-based navigation making notable progress

The advent of RNAV and RNP procedures in the United States has already demonstrated capacity improvements and other important enhancements

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FEDERAL AVIATION ADMINISTRATION

DR. HASSAN SHAHIDI
MITRE CORPORATION
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IMPLEMENTATION of performance-based navigation in the United States, specifically in the form of area navigation (RNAV) and required navigation performance (RNP) procedures, has reaped operational and economic rewards for the aviation community. Working closely with industry, the U.S. Federal Aviation Administration (FAA) has been able to increase capacity at major airports where RNAV departures and approaches have been commissioned; other notable benefits include improved safety and important cost savings for the airlines.

Performance-based navigation is growing in importance around the world, and the United States is among several participants in an ICAO study group formed in 2004 to focus on its worldwide implementation and harmonization (see related article on page 5). As part of this global harmonization process, the FAA is amending its RNAV guidance material to establish conformity with the forthcoming edition of the ICAO *Manual on Performance-Based Navigation* (Document 9613), which will replace the ICAO *Manual on Required Navigation Performance*.

The U.S. initiative to establish performance-based navigation can be traced to an implementation strategy originally published by the FAA in 2003. Entitled *Roadmap for Performance Based Navigation: Evolution for RNAV and RNP Capabilities 2003-2020*, the document is now being updated with the expectation that the revised strategy will be released this summer.

The *Roadmap* defines the operational goals for performance-based navigation, and identifies the associated steps and milestones. It highlights key policy and technical issues to be addressed, and underscores the critical decisions that will have to be made.

The FAA blueprint for RNAV and RNP implementation identifies distinct planning periods. The near-term extends from the present until 2010. The mid-term period encompasses 2011-15, and the far term concerns developments in the 2016-25 period. The *Roadmap* also defines operational goals and concepts by phase of flight, namely the approach, terminal arrival and departure, and en-route phases.

From its inception, the implementation of performance-based navigation procedures in the U.S. has been a collaborative effort between the FAA and the civil aviation community. Collaboration is important because the development of aircraft navigation performance standards, procedure design criteria, operator requirements, and pilot and controller procedures cannot be achieved effectively without close coordination amongst all of the stakeholders.

Over the past several years, the U.S. has implemented over 150 RNAV standard instrument arrival routes — known in the United States as standard terminal arrival routes (STARs) — and standard instrument departures (SIDs), and more are under development. These STARs and SIDs are equivalent to RNAV-1 type procedures, which are currently under development at ICAO. In addition, the U.S. has implemented a number of key en-route RNAV procedures which are designated as "Q Routes". Recently, it began implementing RNP approach procedures.

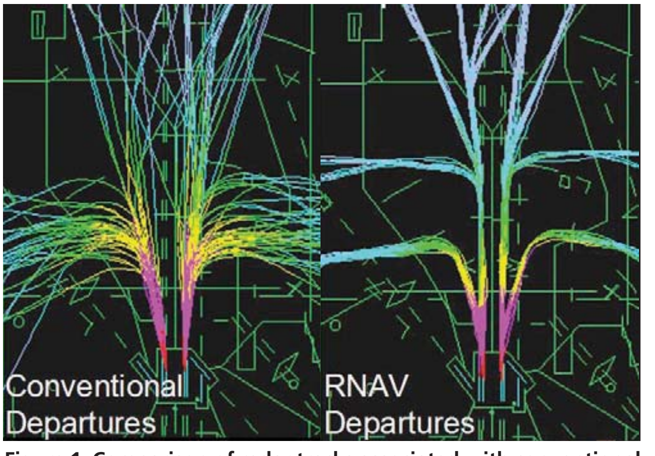


Figure 1. Comparison of radar tracks associated with conventional and RNAV SID operations at Dallas-Ft. Worth. RNAV operations were implemented at KDFW in September 2005.

RNAV terminal procedures and approaches in the United States have already paid dividends. A few examples of beneficial applications are described below, along with their key implementation and harmonization considerations.

RNAV procedures

Prior to the implementation of RNAV SIDs at Dallas-Ft. Worth International Airport (KDFW) last year, departing aircraft were typically vectored in the terminal airspace to join conventional departure procedures starting at navigational fixes at the airspace boundary. As departure operations are generally conducted on two inner parallel runways that are spaced approximately one nautical mile (NM) apart, KDFW operations routinely rely on a waiver to FAA regulations, authorizing independent successive and simultaneous departure operations on these runways.

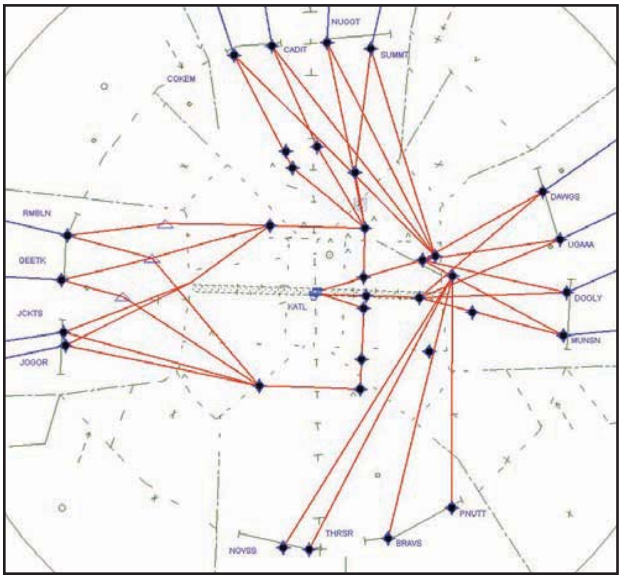


Figure 2. Route structure of RNAV SID procedures at Atlanta. The new procedures commenced on 13 April 2006.

In effect for many years, the FAA waiver has allowed operational independence of departures when certain conditions are met. Among these are a requirement to initiate course divergence no later than 5 NM from the departure ends of the runways. Given the geometry of the runway system and additional noise abatement constraints, the number of available initial headings that could be assigned to departing aircraft was limited to one heading for each departure runway. Thus, no divergence could be established between successive departures from alternating runways, and departing aircraft generally operated in-trail during their initial climbs up to distances of at least 5 NM from the airport.

Improved navigational performance associated with RNAV SID operations capitalize on the capability of flight management systems to support terminal RNAV procedures. New RNAV departure procedures at KDFW offered two initially diverging route segments from each runway. These complied with the established noise footprint of the airport and enabled "fanned" departures — that is, successive departures that make alternating use of diverging routes. As expected, this operational change has improved the efficiency of aircraft separation, as well as increasing departure capacity and reducing departure delays.

The development of the procedures, successfully implemented in September 2005, was facilitated by working closely with the airlines operating at Dallas-Ft. Worth. The procedure design required expanding KDFW's existing FAA waiver to allow independent parallel operations conducted on the two departure runways within a distance of 10 NM from the departure ends of the runways. Risk assessments were carried out to ensure that the proposed operations met the required target level of safety. American Airlines provided guidance to the procedure designers, thus ensuring that the required flight performance fell within aircraft operational limitations under various operating conditions. At present, over 800 RNAV departures are conducted daily at KDFW.

Figure 1 presents a comparison of radar tracks associated with conventional and RNAV SID departures at Dallas-Ft. Worth, with runways of a northerly orientation in use. The tracks are colour-coded to provide altitude information, with red denoting low altitude. The figure also illustrates the initial course divergence offered by two RNAV SID routes close to the departure ends of each runway.

The introduction of RNAV procedures allowing fanned departures at KDFW has resulted in greater air traffic control (ATC) efficiency. Extensive pre- and post-implementation evaluations were carried out by the Mitre Corporation to understand the associated operational changes and to validate the user benefits.

With the current number of RNAV-capable departures, fanned operations yield an estimated capacity gain of 11 departures per hour. These results indicate a potential for further capacity improvements of up to nine more hourly departures, for a total increase of 20, assuming an environment in which all departing aircraft are equipped for RNAV operations.

A key user benefit resulting from the improved departure capacity is the reduced cost associated with delays. The decrease in delays for KDFW departures was expected to provide operators with a financial saving of $10 million annually (all currency figures in U.S. dollars) based on 2005 traffic figures. The potential cost saving from fewer departure delays is estimated at $30 million annually, assuming that traffic were to increase by 13 percent over the current level.

The implementation plan for RNAV departure procedures at KDFW in 2005 called for continually monitoring route conformance. During the initial introduction, the plan also called for greater spacing between departures. With the exception of a fraction of successive departures involving mixed RNAV- and non-RNAV capable aircraft, additional separation was incrementally discontinued within the first month after implementation. Detailed post-implementation evaluations confirmed that user benefits were largely realized within the first two months of the introduction of RNAV departure procedures for Dallas-Ft. Worth.

Similarly, RNAV SIDs have been implemented at Atlanta's Hartsfield-Jackson International Airport (KATL), with Delta Air Lines acting as lead carrier. KATL, the world's busiest airport in terms of aircraft movements in 2005, has been operating both RNAV SID and STAR procedures since April-May 2005. While about 85 percent of the departing and arriving flights currently use RNAV procedures, further improvements to the procedure designs were introduced to maximize their operational benefits.

Figure 2 presents the route structure of Atlanta's RNAV SID procedures, published for implementation in April 2006. This revised route design features additional departure fixes, increasing the number of available en-route transitions, and one instrument departure using radar vectors to join RNAV routes soon after departure.

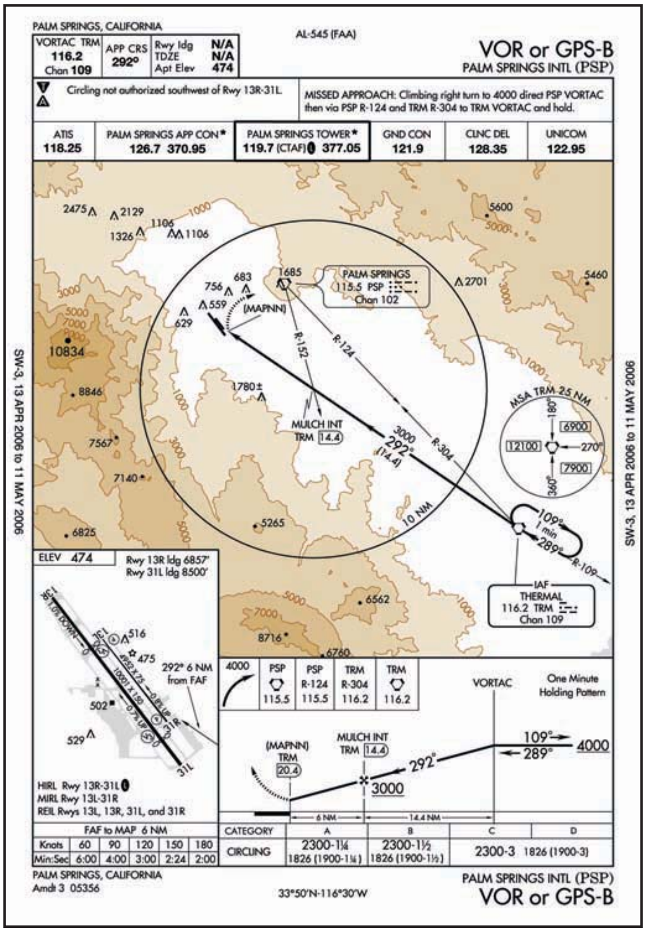
The RNAV procedure design presented in *Figure 2* is expected to further increase the operational benefits from RNAV SID operations at Atlanta. With departures to the east, the enhanced efficiency associated with fanned operations was estimated to allow 10 additional takeoffs per hour. Based on the current traffic level, Mitre studies have shown that this gain in departure capacity translates into an annual cost benefit to airlines of about $11 million.

RNP procedures

To pave the way for implementation of RNP approach procedures in the United States, the FAA worked through the primary U.S. forum for stakeholder participation in performance-based navigation strategy and implementation planning, a body known as the Performance-based Operations Aviation Rulemaking Committee (PARC). This committee works to define and develop key standards and criteria for RNAV and RNP implementations. With PARC's involvement, the FAA initially published special procedure design criteria and associated aircraft and operator approval guidance in the form of an FAA notice. This document served as the basis for the permanent, public procedure design criteria which was recently published as FAA Order 8260.52.[1] At the same time, FAA also published an advisory circular which contains the requisite aircraft, operator and airworthiness requirements for public RNP instrument approaches.

Key features of the criteria for RNP approach procedures with special aircraft and aircrew authorizations required (RNP-SAAAR)[2] include narrow linear segments along the entire approach including the final approach path; guided, narrow turns on missed-approach segments, radius-to-fix segments; and the use of a vertical error budget for the vertical profile. The RNP-SAAAR procedure provides precision-like lateral and vertical guidance.

The special RNP approach procedure implementation at Palm Springs International Airport (KPSP) is an example of an RNP-SAAAR implementation leveraging the key features of RNP criteria. Palm Springs is an airport surrounded by high terrain that prevents the use of conventional straight-in instrument approach procedures. The only instrument approach



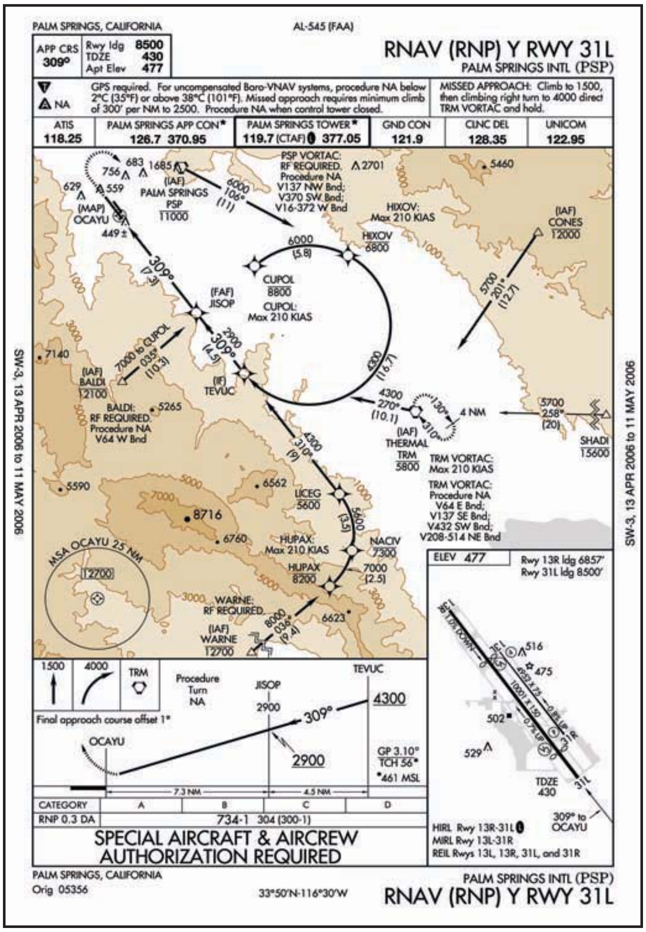


Chart at left (Figure 3) illustrates the conventional instrument approach at Palm Springs International. Figure 4, right, depicts the RNAV Runway 31L public procedure for the same runway.

at KPSP is a circling approach, utilizing a very high frequency omnidirectional radio range (VOR) or the global positioning system (GPS), to the four runway ends with approach minima of three statute miles (SM) visibility and minimum descent altitude (MDA) of 1,826 feet; the VOR/GPS circling approach chart is illustrated in *Figure 3*. Previously, when Palm Springs International lacked an approach with low minima, operators using the airport experienced numerous weather-related diversions and flight cancellations.

The KPSP special RNP procedure development process involved pertinent groups within the FAA and Alaska Airlines, which served as lead operator for the project. It was divided into two stages: the procedure design, and the approval process for the operator and the aircraft involved. Using newly developed RNP-SAAAR criteria, two special RNAV (RNP) approaches were constructed to Runways 31L and 13R.

These special RNP approaches are both designated RNP 0.3; the minima for Runway 31L are 1 SM and decision height of 296 feet, rising to 1¼ SM visibility and decision height of 374 feet for Runway 13R. Even lower minima are achievable when the RNP value is reduced.

Each approach contains a continuous lateral and vertical path from the final approach fix to touchdown. These new RNP-SAAAR approaches have resulted in a reduced number of weather-related delays and cancellations for those operators approved by the FAA to fly the special RNP approaches at KPSP. During the first few months of procedure use, Alaska Airlines reported 21 flights completed as planned because of the availability of the special RNP-SAAAR procedures. Known in the airline vernacular as "saved" flights, the 21 operations would have been cancelled or diverted without this RNP-SAAAR capability.

The FAA has recently published public RNP-SAAAR procedures at Palm Springs that were designed using FAA Order 8260.52 criteria. The public procedures follow a wider ground track to accommodate the broader range of aircraft performance characteristics for more potential users, but still provide approach minima similar to the Alaska special procedures at RNP 0.3. *(see Figure 4)*.

Data continues to be collected as part of the post-implementation analysis to further document benefits to operators.

Another example of RNP-SAAAR implementation is the Runway 19 approach at Ronald Reagan National Airport (KDCA) in Washington, D.C. The lowest conventional minima for the Potomac River approach to Runway 19, based on localizer-type directional aid and distance measuring equipment (DME), comprises 6,000 feet runway visual range (RVR) and a decision height of 706 feet. Visibility requirements for aircraft with higher approach speeds increase up to 2 miles for the "straight-in" approach. From the decision height to the runway end the procedure requires an unguided turn.

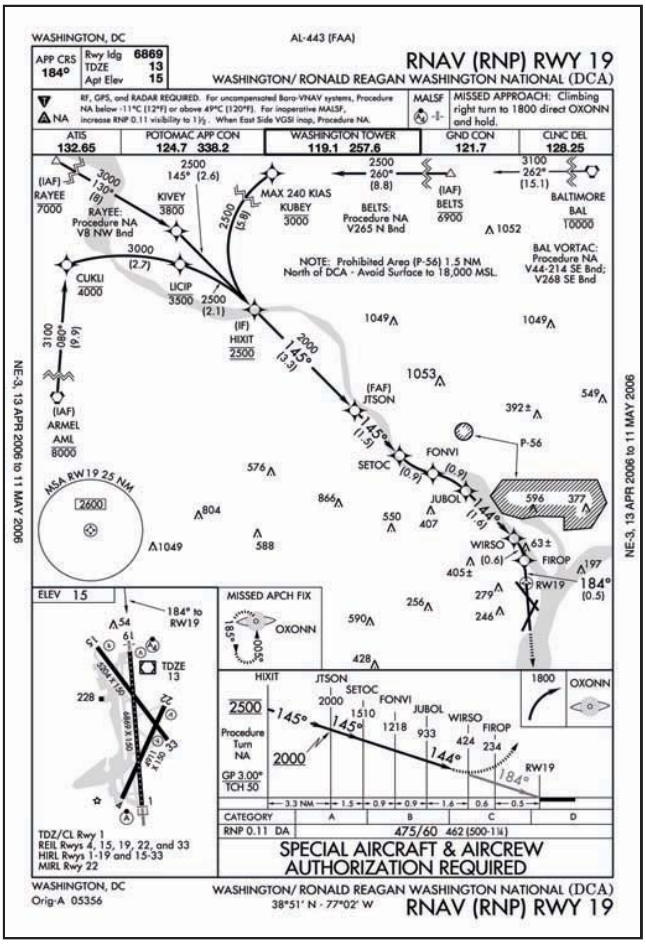


Figure 5. Runway 19 RNP-SAAAR approach chart for KDCA. The procedure enhances safety with a guided, stabilized three-dimensional path that avoids prohibited airspace and significantly improves runway availability during poor visibility.

In September 2005, the FAA published the first public RNP-SAAAR approach at KDCA. The procedure, charted as the RNAV (RNP) Runway 19 approach (*Figure 5*), enhances safety with a guided, stabilized three-dimensional path that avoids prohibited airspace and significantly improves the availability of Runway 19 during low visibility conditions.

The RNAV (RNP) Runway 19 approach is designated as RNP 0.11. The minima are 6,000 feet RVR with a decision height of 462 feet. There is a continuous lateral and vertical guided path from the final approach fix to touchdown. The guided path follows the Potomac River, a more environmentally friendly approach that avoids flight over

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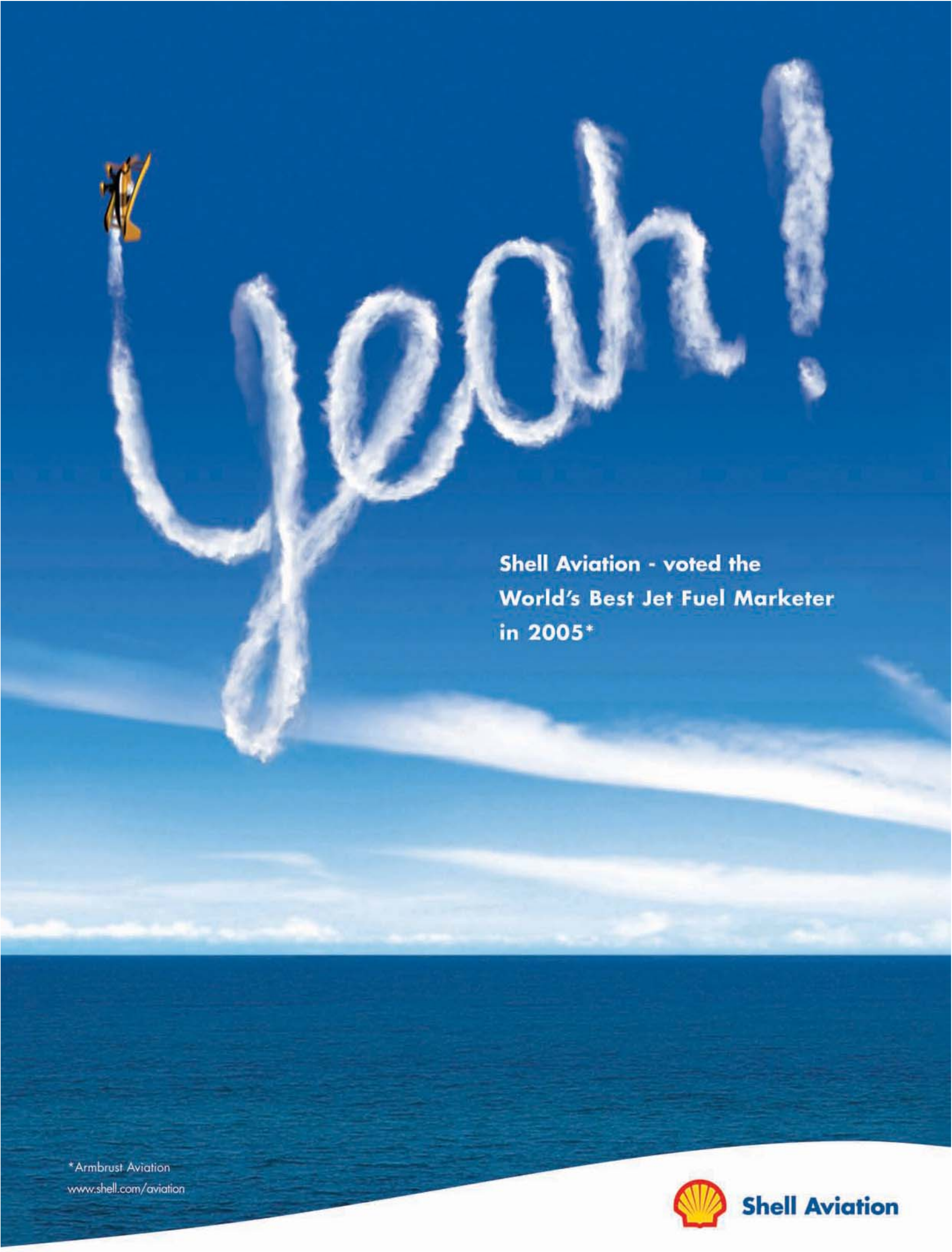
1. The full title of FAA Order 8260.52 is *United States Standard for Required Navigation Performance (RNP) Approach Procedures with Special Aircraft and Aircrew Authorization Required (SAAAR)*.
2. This is equivalent to the ICAO RNP Authorization Required (RNP-AR) approach procedures that are currently under development.

Jeff Williams is Manager of the FAA Air Traffic Organization's RNAV and RNP Group, and is the U.S. member on the ICAO RNP and Special Operational Requirements Study Group. John McGraw is Manager of the FAA's Flight Standards Service's Flight Technologies and Procedures Division, and is responsible for the implementation of new technologies into a performance-based U.S. national airspace system. Dr. Hassan Shahidi is the Mitre Programme Manager for RNAV and RNP.

Information and guidance material on the FAA's Performance-Based Navigation Programme can be found at the FAA website (http://www.faa.gov/ats/atp/rnp/rnav.htm).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Guidelines promote common process for preventing interference with CNS signals

A European planning body has developed a standardized method of determining whether buildings and other objects or structures in the vicinity of airports are likely to interfere with the signals used for communications, navigation and surveillance

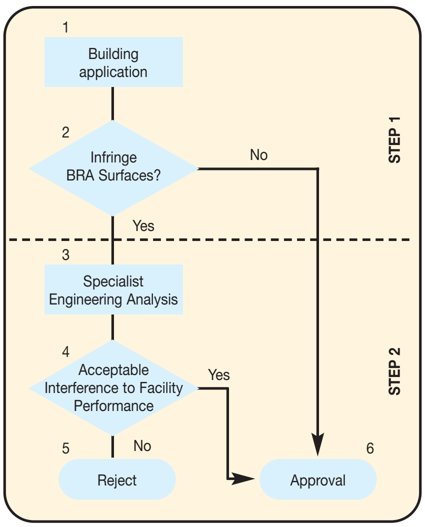
JULES HERMENS
CAA NETHERLANDS

THERE was a time when airport development was entirely a local endeavour performed by nearby engineering and construction companies, all well versed in the limitations and restrictions of daily operations at a particular airport. But today — in Europe at least — large international consortia compete for airport construction contracts. Some of these companies have already won airport contracts in more than one country and have been surprised to find widely varying limitations and restrictions with respect to safeguarding standard radio navigation facilities.

The contractors' concern about these national variations, together with comments from air navigation services (ANS) providers noting that construction activities well outside of the airport perimeter were affecting signals of instrument landing systems in particular, has been addressed through dissemination of guidance material that promotes use of a standardized process and common criteria.

Developed by the ICAO European Air Navigation Planning Group (EANPG), the guidance material concerns how to determine whether the physical presence of a building or any other structure in the vicinity of an airport may have an adverse effect on the availability or quality of a communications, navigation or surveillance (CNS) signal. The following types of facilities are addressed by the guidelines: distance measuring equipment (DME); very high frequency omnidirectional radio range (VOR) including conventional and Doppler VOR; direction finder; non-directional radio beacon (NDB); ground-based augmentation system (GBAS); instrument landing system (ILS) including localizer, glide path and markers; satellite-based augmentation system (SBAS) ground monitoring station; microwave landing system (MLS) including azimuth and elevation stations; VHF air-ground communication; primary radar; and secondary surveillance radar (SSR). Some auxiliary facilities, like satellite up/down links, VHF and ultra high frequency (UHF) ground-ground communication facilities, microwave links and HF facilities are not covered by the ICAO provisions.

Signal interference, in the context discussed here, involves reflected signals. Signals radiated by a transmitting antenna such as an ILS localizer are generally subject to reflection from any fixed or moving objects, among them buildings and vehicles, found within the coverage area. This effect is particularly pronounced when the reflecting objects are large and located at a relatively close distance. At the aircraft receiver antenna, the reflected signal is received with additional delay over the direct signal because the geometric path followed by the reflected signal is longer. Thus, the total signal received by the aircraft is constituted by the superposition of the desired signal (direct component) and delayed versions of the desired signal (reflected components). This interference to the desired signal caused by the reflected components is known as "multipath interference." The rules developed by EANPG deal with the degradation of the signal-in-space caused by this type of interference.



Two-step guidance review process for building projects near airports

The EANPG guidance material was developed with the notion of structures in mind. The information, however, applies equally well to other objects, whether moving or stationary, temporary or permanent, which may cause interference to radio signals from CNS facilities. These include machines, construction equipment used for the erection of buildings, excavated soil or even vegetation.

In the context of this guidance material, a building restricted area (BRA) is defined as a surface where infringing buildings have the potential to cause unacceptable interference to the signals transmitted by CNS facilities. All CNS facilities have a defined BRA, and this is not limited to actual site boundaries, but extends to significant distances from the facility. In establishing the correct shape of the BRA surface, it is necessary to consult the appropriate engineering authority in each State.

The objective of the new guidance material is to provide a readily accessible, practical standard procedure by which authorities

Jim Jorgenson

Construction activities well outside an airport's perimeter can adversely affect navigation signals.

may assess building applications. The general procedure has two steps (see accompanying figure) for the approval of buildings that may adversely affect CNS facilities. The intention is that Step 1 will be a quick evaluation and Step 2, if required, will involve an in-depth analysis.

Step 1 applies a general input screening method to all applications. This screening step is intended for use by appropriate authorities such as airport planners, local officials and government regulators, which usually conduct the initial review of building applications. It is intended to ascertain whether approval can be given directly or whether the application should be passed to the appropriate engineering authorities where experienced air traffic safety electronic personnel handle the case. If Step 2 is required, the safety engineers will carry out a detailed analysis based on theory, experience and existing conditions. This will cover all aspects of the CNS facility to be protected and the possible effects of the proposed building on the signal-in-space provided by the facility.

If the generic screening method determines that the BRA surfaces are not infringed, the process is then terminated and the application is recorded as approved. The guidelines recommend, however, that large excavation works and certain buildings and structures such as windmills, skyscrapers, TV towers or other tall objects be assessed at all times, even when they are located outside the restricted area. Step 2 is applied when an infringement of the BRA has been identified; at this point, the application is handed over to the responsible engineering authorities for further analysis.

The results of the analysis by safety engineers should determine if the interference effects are acceptable or not. Where conflicting results arise from the analysis or studies, it is recommended that a conservative approach be taken and that consideration be given to requiring an alteration of the proposal.

The building applicant is notified of the acceptance or rejection of the application by the appropriate authority. Rejection does not preclude a subsequent modification and re-submission of the application, and a modified proposal is subjected to the applicable review processes identified in the figure. An approval of the building application is given only after interference effects on the facility's performance, as well as impact on other operational aspects such as obstacle limitation surfaces, are deemed acceptable.

In order to protect CNS signals, each type of facility may have a specific shape for its BRA surface. In cases where more than one facility exists (as typically occurs at an airport), the individual BRA surfaces may overlap, and they are then described as being "clustered." The extremities of these shapes forming the cluster then define the one shape and will form the basis for the overall airport BRA map. The facility that requires the most restrictive BRA takes precedence in Step 1 and usually triggers a Step 2 review.

In parallel with ICAO's development of harmonized criteria for safeguarding radio navigation facilities in the European and North Atlantic regions, as well as the two-step process for assessing the need for building restrictions, Civil Aviation Authority (CAA) Netherlands has developed a method for delegating the first step of the assessment of new developments around Amsterdam Schiphol International Airport to concerned bodies

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Contributing to this article were Heinz Wipf, of Skyguide AG, of Switzerland, and John Dyson of the U.K. National Air Traffic Services (NATS).

Cost of modernizing older aircraft justified by improved airspace access

While most earlier models of civil transport aircraft have years of life remaining in their engines and airframes, without avionics upgrades their operation in various areas is increasingly limited by new ATC requirements

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CMC ELECTRONICS
(CANADA)

THE widespread introduction of new aircraft into civil airline fleets over the past several years has brought increased capacity and efficiency, new routes and air traffic procedures, and a wide variety of associated benefits to operators and the public at large. For some air carriers, however, this unprecedented expansion has also brought with it an unexpected area of concern: the increasing cost of operating two similar, but different generation, aircraft.

In many cases today, the operator is flying earlier aircraft types — many of which are now considered "classics" — while at the same time utilizing newer models that feature advanced avionics and other systems. Usually the older aircraft still have many thousands of cycles remaining in the useful lives of their airframes and engines, but differences between their electronic and avionics systems and the systems found on newer aircraft in the fleet can incur significant financial penalties.

These penalties are primarily of an operational nature, but they also arise in the areas of maintenance, spares inventory and, in some cases, aircraft availability. Consequently, many aircraft operators are looking closely at the cost benefits of avionics upgrades to their earlier fleets.

The operational impacts are many. New air traffic control (ATC) procedures and equipment requirements for performance-based navigation — both area navigation (RNAV) and required navigation performance (RNP) — as well as automatic dependent surveillance (ADS), controller/pilot data link communications (CPDLC), airborne collision avoidance equipment and other systems and technologies are becoming necessary to gain full access to many parts of the world's airspace.

Jim Jorgenson

KLM in 1999 attained important operational benefits for its fleet of B747 Classics by upgrading their avionics to provide a functionality equivalent to the systems found on its more modern B747-400s.

Associated benefits. The new avionics systems already make it possible for the latest generation aircraft to fly on more efficient, fuel saving and safer routings, and allow pilots to take full advantage of new technology. Besides these direct operational advantages, they offer a number of associated benefits to the operators of older aircraft by decreasing costs and increasing operational flexibility and efficiency at the same time.

Uppermost among these benefits is avoidance of the growing restrictions to full airspace access for less well equipped aircraft. Coupled with that, the mix of old and new flight deck technologies in a number of airline fleets often creates the need for parallel pilot training and conversion programmes that involve high overhead expenses. Moreover, operational flexibility can be lost when different pilot qualifications are required to fly earlier and later versions of the same basic aircraft.

Maintenance of earlier generation equipment can also add unexpected costs related to their slowly decreasing reliability through obsolescence. The result is increased testing and repair work, often coupled with growing shortages in repair parts.

A typical example of this additional cost is found in flight deck instruments, where earlier maintenanceintensive electromechanical pointers and dials have been replaced in newer aircraft by electronic "glass cockpit" displays. A modern flight deck normally carries six or more of these units, and although each can display different information to the crew, all will be electronically and physically identical, sharing the same part number. This provides a versatility that allows significant inventory reduction. What's more, while an in-flight failure of a critical electromechanical instrument could cause a flight cancellation or diversion, failure of an electronic display simply means that the crew has to transfer its information onto one of the other screens.

FMS at the heart of an upgrade. The common denominator in all of today's avionics upgrade programmes is the installation of an advanced flight management system (FMS). The FMS can be regarded as the heart of the avionics suite in aircraft undergoing upgrades. When coupled with a global navigation satellite system (GNSS) receiver, an advanced FMS brings unprecedented navigation accuracy and integrity to all the other new technology systems involved in the upgrade. Put another way, upgrading other avionics units without upgrading the aircraft's FMS and satellite navigation equipment would significantly reduce the economic benefit of any other new systems.

Before-and-after views illustrate a comprehensive cockpit upgrade completed recently for a Lockheed L-100 civil transport operated by the Government of Dubai.

This is particularly the case in complying with the performance-based RNAV and RNP requirements now being widely implemented along the world's busiest air routes, where RNP/satellite performance standards can demand navigation accuracies of as little as one tenth of a mile either side of track, coupled with the ability to independently monitor track adherence and alert the crew to any deviation, all to an availability of 99.999 percent. Today's advanced technology equipment, among them the CMA-9000 FMS and CMA-5024 satellite navigation receiver supplied by CMC Electronics, can achieve this level of performance.

Built-in flexibility for the future is also important. The U.S. Federal Aviation Administration (FAA) announced in early 2006 that the global positioning system (GPS), when augmented by the FAA's wide area augmentation system (WAAS), would be approved for approaches with a decision height of 200 feet. This capability is equivalent to that available with Category I precision approaches supported by today's instrument landing system (ILS). An upgraded satellite navigation capability must, therefore, include WAAS capability for U.S. operations. But it must also have built-in growth potential to accommodate coming technologies such as Europe's Galileo satellite system and regional satellite-based augmentation systems (SBAS) planned in other parts of the world, among them the European geostationary navigation overlay service (EGNOS).

B747 project

A good example of how an avionics upgrade can extend the life of an important fleet investment is the KLM Boeing 747 upgrade programme completed in 1999 by CMC Electronics (CMC), then known as Canadian Marconi Company. The airline's Boeing 747-200/300 fleet was brought up to an operationally equivalent standard to its newer -400 aircraft. Described by an FAA certification official at the time as the most complex civil upgrade and integration project under-

STAYING AHEAD OF THE FUTURE

THE KLM B747 upgrade project of 1999 clearly proved the benefit of replicating the airline's Boeing 747 avionics installation at the supplier's integration laboratory. By using actual avionics units and controls, including both the new systems and those retained from the original installation, engineers were able to test every operational function of the new configuration throughout all flight phases, including single and multiple failure modes, and precisely measure its performance against data applicable to the actual aircraft. This approach minimized the aircraft installation down time and, perhaps more importantly, significantly reduced the amount of costly test flying in each line aircraft.

The laboratory installation was built as an "open architecture" design which, by substitution of different avionics units, allowed engineers to replicate the configurations of a variety of other aircraft, large and small, following the KLM project. While this approach was successful, the need to physically introduce a variety of different avionics units — or similar units at different modification levels — occasionally posed difficult logistics problems.

A dynamic test bed provides avionics systems integrators with important flexibility while eliminating the costly and time-consuming need to use actual hardware in building a replica of an aircraft's avionics suite.

Consequently, and taking advantage of advances in computing power and simulation technology since launching its KLM test facility, CMC developed its next-generation FMS dynamic test bed (DTB) in conjunction with scientists at Montreal's Concordia University.

Now, the exact characteristics of all avionics systems currently in commercial service — and at all desired modification states — are stored in "virtual" electronic form in the DTB's computer database, from which the engineers can select units to "install" for a given upgrade project. This not only provides extraordinary flexibility to the integration team, but also eliminates the costly and time-consuming need to use actual hardware to build a replica of the candidate aircraft's avionics suite.

The DTB is designed to support all critical areas of an upgrade programme, including:

- fixed-wing and helicopter applications;
- full flight regimes, including lateral and vertical navigation;
- future navigation and ATC requirements;
- failure mode simulations;
- human factors issues; and
- certification.

Among the unique features of the DTB is a cockpit-like compartment where customer pilots and avionics specialists can "fly" and observe the operational characteristics of the upgrade configuration, and discuss them with members of the integration team. This is an important step in understanding any changes in procedures brought about by the upgrade, particularly with regard to the newer, more efficient techniques which it will offer. Important human factors issues can also be reviewed. The DTB's "pseudo

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taken to date, the programme involved the installation of three integrated flight management/satellite navigation systems, three laser inertial navigation sensors and seven electronic flight instrument displays, plus satellite communications, performance management, aircraft condition monitoring and associated units.

In recent years similar upgrade projects have been completed for over 100 classic Boeing 747s, plus a number of McDonnell Douglas DC-10s operated by several international air carriers. Less comprehensive upgrades have been performed on McDonnell Douglas MD-80s, Boeing 727s and 737s, and other earlier generation narrow-body aircraft. In parallel, a very large number of upgrades have been completed for a wide range of corporate and military aircraft, with particular emphasis on applications in trainers and transports such as the Lockheed C-130. Some of these installations include head-up displays and infrared enhanced vision systems.

A recent example of an upgrade incorporating several of the latest technologies can be seen in the Lockheed L-100 civil transport operated by the Government of Dubai's Air Wing. Here, besides new electronic instrument displays, advanced flight management/satellite navigation systems, inertial navigation sensors and an upgraded weather radar, the installation included a Mode-S transponder, an airborne collision avoidance system (ACAS), a terrain warning system, flight data and cockpit voice recorders, a digital air data system compliant with reduced vertical separation minimum (RVSM) operations and dual electronic flight bag displays, none of which are normally found in this class of aircraft.

Flexibility the key

While aircraft leave the production line in fairly uniform configurations, their

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Don Paolucci is the Director of Avionics for CMC Electronics of Montreal, Canada. Readers may obtain more information about the aircraft modernization programme described in this article on the worldwide web (www.cmcelectronics.ca) or by contacting the author (don.paolucci@cmcelectronics.ca).

Interactive analytical tool allows users to evaluate CNS/ATM business cases

A new ICAO software programme showcases the economic basis for implementing the technologies required to establish a global ATM system

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UPALI WICKRAMA
GLOBAL AVIATION CONSULTING (UNITED STATES)

WITHOUT worldwide cooperation, a saturated air traffic management (ATM) system will not be able to cope with forecast traffic growth, which is expected to more than double within the next 20 years. The implementation of advanced communications, navigation and surveillance (CNS) technologies in support of a more efficient global ATM system is expected to alleviate this traffic congestion while concurrently improving safety, reliability, and efficiency across all airspace domains.

Planning for the implementation of these systems has nevertheless been a complex undertaking. The new technologies must be based on a well developed plan that takes into account the specific requirements and objectives of air traffic management. A lack of awareness of the economics of transition to the new operational concept has so far hindered the pace of its implementation.

Both service providers and airspace users have several alternatives available to them when deciding how to achieve these ATM objectives, and their decisions are highly interdependent. In particular, decisions on what conventional equipment to keep operating and what new technology to implement, as well as when to proceed with the transition, have significant economic implications for air navigation services (ANS) providers as well as for airspace users.

Decisions concerning ANS equipment inevitably affect decisions by aircraft operators about avionics. What further complicates matters is the fact that aircraft fly through airspace controlled by different ANS providers. If there is no commonality among the solutions chosen by service providers, it is difficult and probably more expensive for operators to equip their aircraft adequately. In planning the transition to new technologies, therefore, a coordinated process needs to be established between the various service providers and airspace users. One of the ways ICAO is addressing this requirement for coordination is through its revised Global Air Navigation Plan and a set of interactive planning tools (see "Global Plan stresses initiatives that lead to direct performance enhancements," Issue 2/2006, page 13). An important aspect of the planning process is to conduct cost-benefit analyses of the various scenarios, as described below.

Planning for the implementation of advanced CNS systems includes several steps beginning with the definition of homogeneous ATM areas and the development of forecasts for the major traffic flows and traffic densities. With this information at hand, further steps involve setting the ATM objectives, determining the operational requirements, identifying the various technical solutions, and performing a financial analysis. Finally, planners must decide on a set of performance objectives, such as an optimum air route structure, supported by Global Plan initiatives and project management techniques.

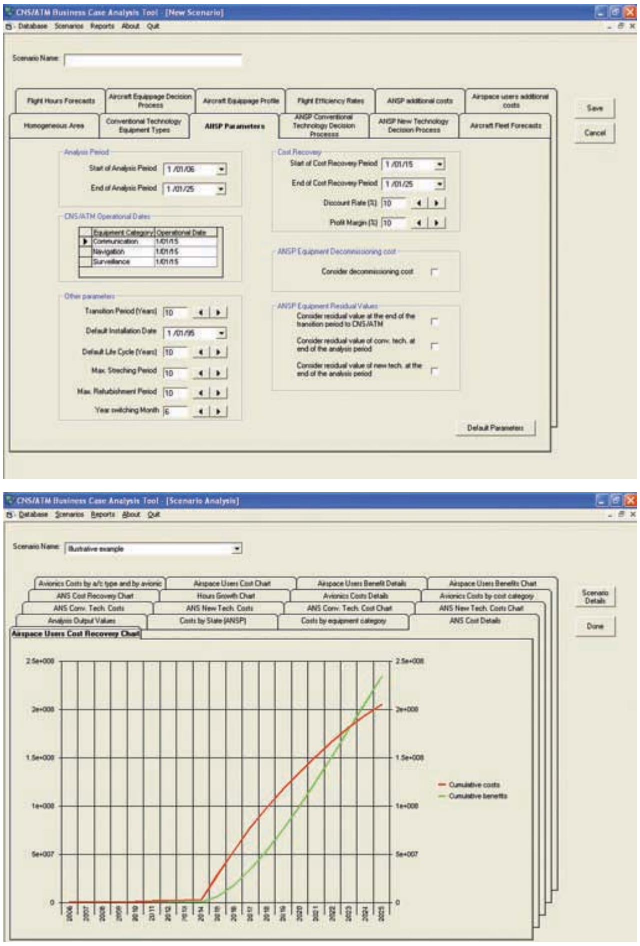
Given the rapid pace of technological change, the planning process needs to be flexible and dynamic. Planning, however, must be operationally and not technologically driven. Since the primary influences on investment decisions are financial in nature, it is critical for States to develop a sound business case. A concerted effort is required to achieve consensus among major stakeholders and the financial community on the cost-effective implementation of new systems.

There must also be a disciplined process

Jim Jorgenson

Global cooperation is paramount if the problem of air traffic congestion is to be successfully addressed in the coming years.

for the development of business cases that are available to all stakeholders, in particular for those with the primary influence — namely the service providers and airspace users. The business case should be able to demonstrate and justify the investment requirements as well as the manner in which the provider would be able to recover its investment through the provision of air navigation services. Similarly, airspace users — primarily the airlines — would benefit from operating more efficient and preferred flight profiles, thus reducing operating costs. The business case should also analyse the influence of each factor and option in order to provide guidance as to which uncertainties need to be minimized. Once the business case has been accepted by stakeholders, an integrated development plan can be established and financial requirements secured.



Example screen shots illustrate how DFACS can be used to analyse various aspects of a CNS/ATM business case.

Responding to the need for an integrated planning approach, ICAO recently completed development of software that facilitates financial analysis of CNS/ATM business cases which will support the Global Plan and its initiatives. The model, known as the CNS/ATM database and financial analysis computer system (DFACS), is an interactive tool that enables ANS providers and airspace users to build, evaluate and compare alternative scenarios for the cost-effective implementation of new systems. The interactive model has three main components: a database, scenario creation and the production of reports.

The DFACS database component helps software users to manage the reference data required for the creation and evaluation of different implementation scenarios. The reference data is classified according to three segments, each of which corresponds to a particular menu item. The segments concern geographical data, ANS-related data, and airspace users' data.

The geographical segment organizes data according to the physical location of air navigation facilities. For example, all locations published in ICAO Document 7910, *Location Indicators*, can be loaded into the database along with their corresponding States. The users can also define a region by selecting a number of appropriate States; similarly, the user may select a homogeneous ATM area based on similar characteristics of traffic density, air navigation systems, infrastructure requirements or other specified requirements. This provides the necessary tools to manage the geographical data based on any combination of requirements.

The segment for ANS-related data allows the software user to define equipment categories and/or functions (e.g. communications, navigation or surveillance), cost categories unrelated to equipment (e.g. labour and material), as well as the lists of conventional and new technology equipment types and their associated costs, including those related to equipment purchase, installation, average annual maintenance, and inspection. The list of the conventional facilities currently in operation can also be defined by physical location through this option.

The airspace users' data segment is for maintaining the data related to avionics equipment costs and also the average operating costs associated with different aircraft types.

Once the database component for each of these segments has been completed, DFACS may be used to build, analyse and compare various implementation scenarios. This feature involves the definition and selection of a homogeneous ATM area which may comprise a region, a State, or combination of States and regions.

From the perspective of the service provider, the scenarios involve decisions about the continued operation of conventional equipment or its replacement with new technology. With respect to airspace users, the scenario creation includes air traffic and fleet forecasts by aircraft type, decisions concerning the introduction and timing of avionics equipage, and estimates of the average reduction in flight time resulting from the use of new technologies. Other costs for ANS providers, such as controller and technician expenses and overhead, as well as similar costs for airspace users, are included in the scenario creation.

Aircraft operators may use the software

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Birds and aircraft are competing for space in crowded skies

Statistics show that birds and other wildlife are a growing problem for aircraft operators, with civil aircraft in the United States alone involved in some 7,000 wildlife strikes during 2005

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BIRDS and other wildlife are an increasing problem for the aviation industry. There are a number of reasons for this worsening trend, which is illustrated by statistics on wildlife strikes that have been collected over a period of years.

One reason for the growing number of strikes can be traced to highly successful programmes funded by governmental organizations during the past 30 years, among them initiatives to regulate pesticide use, expand wildlife refuge systems and restore wetlands. Coupled with land-use changes, these conservation efforts have resulted in dramatic increases in the populations of many wildlife species in North America, Europe and elsewhere.

Among the 36 largest bird species in North America, 24 have shown significant population growth in the past three decades; at the same time, only three of these large species have shown a decline. The non-migratory population of Canada geese resident in the United States — a bird that weighs from three to five kilograms — more than tripled from 1 million to 3.5 million between 1990 and 2005. The double-crested cormorant population on the Great Lakes of the United States and Canada have increased from some 100 nesting pairs in 1972 to over 130,000 pairs by 2005 (see figure, page 22). Double-crested cormorants typically weigh about two kilograms, and have a body density that is 30 percent more dense than gulls and geese.

While the number of large birds has been on the rise, it is noteworthy that most aircraft components, including engines, are not tested or certified for collisions with birds weighing more than 1.8 kilograms. There have been a number of strikes causing significant damage, including uncontained engine failures and cockpit penetrations, with birds weighing much less than 1.8 kilograms.

Wildlife strikes, the vast majority of which involve birds, cost airlines about $500 million per year in the U.S. alone. Above: An uncontained engine failure and fire occurred after a cormorant was ingested into this MD-80's port engine in September 2004. Left: Engine damage resulting from collision with two Canada geese in September 2003; one fan blade separated from the disk and penetrated the fuselage.

Many birds have adapted to urban environments and find that airports, which offer expansive areas of grass and pavement, are attractive habitats for feeding and resting. Other wildlife, such as deer and wild dogs, are attracted to airport environments for similar reasons.

Yet another factor in the growing number of strikes is the quieter engines found on modern aircraft, which are less apparent to birds than the older, noisier powerplants.

Some 7,100 wildlife collisions with civil aircraft were reported in the United States during 2005, compared to 1,719 strikes in 1990. Some experts have estimated that wildlife strikes, of which 98 percent involve birds, cost the U.S. civil aviation industry about $500 million per year between 1990 and 2004 (all financial figures in U.S. currency). One researcher has estimated that bird strikes cost commercial air carriers worldwide over $1.2 billion annually during 1999-2000.

At least 195 people have died and 168 aircraft have been destroyed as a consequence of bird and other wildlife strikes with civil and military aircraft since 1988, according to unpublished data collected by a number of scientists, including the author. Researchers have also established that at least 17 civil aircraft have been destroyed by deer strikes in the United States since 1983.

Mitigating the risk

There are a number of measures that airport authorities can take to minimize the hazards posed by wildlife. One important step is to ensure that they comply with the ICAO standards regarding bird hazards to aviation. These call for authorities to:

• assess the extent of the hazard posed by birds on and in the vicinity of airports;
• take necessary action to decrease the number of birds; and
• eliminate or prevent the establishment of any site in the vicinity of the airport which would be an attraction to birds and thereby present a danger to aviation.

These provisions, originally developed as recommended practices in 1990, were upgraded to mandatory standards in 2003 as a consequence of the increasing threat to aviation worldwide caused by birds. The new requirements contained in Annex 14 to the *Convention on International Civil Aviation* (also known as the Chicago Convention)[1] represent a significant challenge for many airports throughout the world.

Based on the findings of the assessment of bird hazards, airports should develop and implement a wildlife hazard management plan. Wildlife hazard management plans typically call for the airport to remove habitat and food attractive to wildlife. They also involve the use of various techniques, ranging from netting, pyrotechnics, lasers and even patrols with trained falcons or dogs, to exclude, disperse or remove hazardous wildlife. Wildlife hazard management plans normally require the establishment of an airport wildlife hazard working group to monitor and coordinate wildlife control activities at the airport.

Because the management of hazardous birds and other wildlife is a complex endeavour involving numerous species protected by national or local laws, professional biologists trained in managing wildlife damage are needed to conduct assessments and to develop and oversee *wildlife hazard management plans for airports*. The U.S. Federal Aviation Administration (FAA) and Department of Agriculture have published a 348-page manual, Wildlife Hazard Management at Airports, that provides detailed guidance and background material. The document is available on the web (http://wildlife-mitigation.tc.faa.gov).

Although the management of wildlife hazardous to civil aviation is primarily an airport's responsibility, there are actions that can be taken by air carriers and pilots to assist in reducing the number of damaging wildlife strikes. For example, if concentrations of birds are on a runway, pilots should not attempt take-off until the birds have been dispersed by airport operations personnel. It is important therefore to report wildlife hazards observed at the airport to the air traffic control (ATC) tower or airport operations.

U.S. Department of Agriculture

Professionally trained personnel are needed to conduct assessments and to develop and oversee wildlife hazard management plans for airports.

It should never be assumed that birds will see an approaching aircraft and disperse. Operators cannot rely on on-board radar, lights, noise or spinner markings to alert birds to approaching aircraft.

Pilots should also avoid airspeeds of more than 250 knots below 10,000 feet above ground level (AGL), especially at times of the year when birds are migrating. Aircraft speed is more critical than bird size (body mass) in causing collision damage.

Air carriers must ensure that all food waste in ramp areas is covered and inaccessible to birds and, likewise, they must prohibit the feeding of birds by their employees.

Even when there is no obvious damage, flight crews should report all wildlife strikes. The correct identification of the species struck is critical. Local biologists can often identify the species by examining feather remains. (In the United States, feather remains sent to the Smithsonian Institution will be identified free-of-charge.)

Air carriers need to provide pilots, mechanics and maintenance personnel with education and guidance concerning the actions and techniques cited above. Finally, airlines should obtain local representation on the wildlife hazard task force at airports where strike problems have been experienced.

Frequently asked questions

Any educational effort undertaken by air carriers should address the questions frequently asked by operating personnel. The most frequently asked questions in the author's experience are highlighted below, as well as brief answers based on U.S. bird strike data and derived primarily from the report, *Wildlife strikes to Civil Aircraft in the United States*, 1990-2004, which was published in 2005.[2]

Q: *At what height above ground level do most strikes occur? Do bird strikes ever occur at heights greater than 500 feet AGL?*

A: The world height record for a bird strike is 37,000 feet. In the United States, bird strikes have been reported up to 32,000 feet, but most collisions (57 percent) causing substantial damage occur below 100 feet. Thus, wildlife control on the airport is critical to reducing strikes. An additional 9 percent of strikes with substantial damage occur between 100 and 500 feet, while 29 percent occur above 500 feet and below 3,500 feet. Only 5 percent of strikes involving serious damage occur above this height.

Because a significant number of strikes involving substantial damage occur between 500 and 3,500 feet (over 445 were reported for civil aircraft in U.S. airspace during the 1990-2004 period), pilots should climb as expeditiously as possible in areas and during seasons of high bird activity in order to minimize exposure time. They should also avoid high-speed flight below 10,000 feet, since speed is an important factor in the type of damage caused by a strike. This is because the damaging force of a bird strike is generated by mass times velocity squared.

Do more strikes occur during take-off or landing? More strikes occur during landing; in fact, about 40 percent more bird strikes and 66 percent more deer strikes are reported during the landing phase of flight (i.e. the approach and landing roll) compared to the take-off run and climb.

Shouldn't birds sitting or standing on the runway notice an approaching aircraft and move out of harm's way? Pilots should not assume, as noted above, that birds will detect the aircraft in time to avoid a strike. Studies have indicated that about 80 percent of birds will attempt to avoid approaching aircraft, but their avoidance reaction may be too late or inappropriate.

One explanation is that birds often face into the wind when standing and usually take-off and land into the wind, which means that they often will face away from an approaching aircraft at airports. Furthermore, birds are apparently less able to detect modern aircraft with quieter engines, which are now far more prevalent at most airports than older and noisier aircraft.

Do birds normally dive or climb when taking evasive action in response to an approaching aircraft? An analysis of pilot observations of bird reactions to approaching aircraft indicated that when the aircraft was higher than 500 feet AGL, 87 percent of birds that showed a defined reaction attempted to dive, while just 8 percent of these birds attempted to climb. In contrast, below 500 feet AGL only 25 percent of the birds encountered attempted to dive and 32 percent tried to climb. These data suggest that avoidance manoeuvres by birds are governed to some extent by the height of the encounter. Birds above 500 feet AGL will usually dive when they detect an approaching threat and, if an avoidance manoeuvre is possible, the pilot in these circumstances should try to fly above the birds encountered. However, it is important to bear in mind that birds flying close to the ground across a runway exhibit unpredictable manoeuvres when trying to avoid an aircraft.

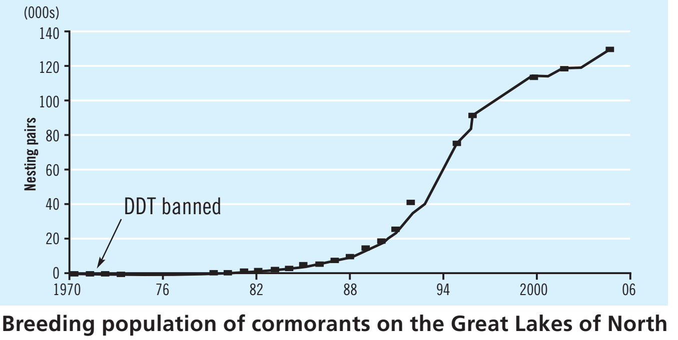
Are bird strikes only a problem during daylight? Many bird species, including geese and ducks, migrate at night. Waterfowl will also actively feed at night. If left undisturbed, gulls and other species will sometimes rest on runways overnight. While it is true that about 2.6 times more total strikes to civil aircraft occur during daylight than at night, the probability of a strike in terms of the number of aircraft movements is actually greater at night. This is especially true for strikes above 500 feet AGL. Only 16 percent of all strikes above 500 feet occur during daylight, compared to 61 percent of strikes at night.

What about the season of the year? Are some months worse than others for bird strikes? In North America, the period of July-November, and especially the month of August, is the worst period for damaging bird strikes below 500 feet AGL. In the northern hemisphere, bird populations are at their highest levels during late summer and contain many young birds that are not skilled flyers. Above 500 feet, the periods of September-November and April-May are the most dangerous seasons in North America because these are the peak times for migration.

Are strikes more likely under certain weather conditions? More strikes occur on rainy days compared to dry days, based on statistical analyses of strike data. This increase in strikes might be related to the greater abundance of invertebrate food (such as earthworms) at the soil surface during wet weather and the tendency of birds such as gulls to wait out storms by standing on pavement.

R.A. Dolbeer

Standing water is a strong attractant to waterfowl, gulls, and wading birds such as egrets and herons. Airport managers should strive to eliminate all standing water.



Breeding population of cormorants on the Great Lakes of North America, 1970-2005

Are bird strikes more likely to occur to wing-mounted engines or fuselage-mounted engines? Wing-mounted engines were five times more likely to be struck by a bird than engines mounted on the fuselage, a conclusion based on an analysis of engine strikes per 10,000 movements by commercial air carriers in the United States during 1990-99.

Does the deployment of on-board radar disperse birds from the path of an approaching aircraft? It is true that many species of birds are more sensitive than humans to certain stimuli. Some bird species, for example, use the earth's magnetic field as a navigational cue during migration, and some birds have shown an aversion to microwave radiation. Birds also can detect light waves in the ultraviolet range beyond what humans see. There is no scientific evidence, however, that birds detect radar deployed on aircraft. Furthermore, even if birds did detect such microwave radiation, there is no evidence that such detection would be sensed as a threat and cause birds to avoid the aircraft.

What about visual devices, such as pulsating landing lights or painted engine spinners, to alert birds of approaching aircraft? Studies have shown that birds often respond to light beams by performing abrupt avoidance manoeuvres. There is anecdotal evidence and limited experimental data suggesting that pulsating landing lights might reduce bird strikes. Regarding visual markings, one commercial air carrier detected a slightly reduced rate of engine strikes for aircraft with white-painted spinners compared to those with unmarked spinners in a two-year study that was published in 1988. It does not appear, however, that any follow-up study has been conducted. Additional research is needed to determine if there are strategies that could be optimized — examples include the use of electromagnetic signals, landing light pulse and wave-length frequency, and the reflective characteristics of aircraft paint — to make aircraft more visible to birds.

Do ultrasonic devices keep birds out of hangars and off the airfield? Ultrasonic devices are not effective against birds in hangars or on the airfield. Several experiments have documented that birds do not hear in the ultrasonic range any better than humans. In fact, most birds are less able to hear higher frequency sounds than humans.

Gerry Ercolani

It should never be assumed that birds will see an approaching aircraft and disperse.

Why should a pilot report a bird strike? Will reported strikes result in negative publicity for the company? National wildlife strike databases are essential to provide a scientific foundation for methods to reduce the costs and safety hazards of strikes. Scientists and airport managers cannot solve a problem they do not understand, and airports are less likely to take actions to reduce strikes if these events are not documented. Documentation of the problem also is an important means of educating the public about the need to manage wildlife at airports. In the United States, publicly released statistical analyses and summaries of data from the national wildlife strike database do not identify the airport, air carrier or engine manufacturer.

How does someone report a strike and ensure that the bird species is properly identified? Each country needs to establish a reporting procedure based on the ICAO Bird Strike Information System (IBIS). Reports compiled at the national level should be forwarded to ICAO.

In the United States, bird strikes can be reported electronically to the FAA using Form 5200-7, available at http://wildlife-mitigation.tc.faa.gov. Several air carriers have established links so that strike reports filed internally are automatically reported to the FAA. The form also can be printed, filled out manually and mailed postage-free. Wildlife biologists working at airports can often identify the species struck if sufficient remains are available.

Conclusions

As highlighted above, ICAO has responded to the growing hazard of bird strikes by introducing more stringent provisions for mitigating wildlife hazards at airports. Recommended practices have been upgraded to standards, and airports worldwide need to ensure that they are in compliance with these ICAO requirements as well as national regulations.

Integrated management programmes such as those carried out by biologists from the U.S. Department of Agriculture and other organizations at many airports in the United States provide examples of successful efforts to minimize wildlife hazards to aviation.

Finally, there is a need to better educate pilots and air carrier personnel regarding the reporting of wildlife strikes and the actions that can be taken to reduce the probability of strikes. Moreover, research is needed to obtain a better understanding of behavioural reactions of birds to approaching aircraft, and methods of enhancing the awareness of birds to these aircraft. Indeed, future research results may make it necessary to modify some of the findings and conclusions presented in this article. □

1. The technical annexes to the Chicago Convention, numbering 18 in all, contain provisions for the safe, secure, orderly and efficient development of international civil aviation.
2. The 53-page report, prepared by E.C. Cleary, R.A. Dolbeer and S.E. Wright, was published in 2005 by the U.S. Department of Transportation, FAA as Serial Report No. 11, DOT/FAA/AS/00-6 (AAS-310). The document is viewable at http://wildlife-mitigation.tc. faa.gov/.

The bird strike database used for the analysis described in this article was supported by the FAA's William Hughes Technical Center in Atlantic City, New Jersey under an existing agreement with the U.S. Department of Agriculture.

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This article was accompanied by a lengthy list of references that has not been reproduced here. For more information concerning wildlife hazard management or reference material, readers may contact the author via e-mail (richard.a.dolbeer@usda.gov).

Opinions expressed in this paper do not necessarily reflect current FAA policy or the views of any commercial air carrier. The author acknowledges the contribution of Capt. Paul Eschenfelder of Avion Corp. to the development of this article, as well as the support of FAA employees S. Agrawal, E.C. Cleary and M. Hovan.

Global cooperation is key to progress, Council President stresses

As his long tenure as Council President draws to a close, Dr. Assad Kotaite has been stressing the importance of global cooperation in addressing the various challenges faced by the international civil aviation community. At recent conferences and meetings — regardless of the focus — the Council President called for the aviation community to work as one.

"Throughout my 53-year career, I have zealously promoted global cooperation among States and all members of the world aviation community as the most effective way of addressing the challenges associated with change, be they technical, economic, social or political," Dr. Kotaite reminded his audience at the "Wings of Change" Conference organized jointly by Chile and the International Air Transport Association (IATA) in Santiago in late March.

"In this early part of the 21st century," Dr. Kotaite said, "the wings of change are taking us into sometimes uncharted skies. Safety and security, liberalization of the industry, sustained growth in passenger and cargo traffic and the environment require unprecedented levels of cooperation to further reinforce the integrity of the global air transport system and its ability to benefit mankind."

A gala dinner organized by the Latin American aviation community and IATA was held in Santiago on 29 March in Council President Dr. Assad Kotaite's honour. Pictured during the occasion are (l-r): Marcos Meirelles, former Representative of Chile on the Council of ICAO; Roberto Kobeh González, Representative of Mexico on the Council of ICAO and Council President-elect; Gonzalo Miranda Aguirre, Representative of Chile on the Council of ICAO; Vivianne Blanlot, Minister of National Defence of Chile; Dr. Kotaite; and Osvaldo Sarabia, Commander and Chief of the Chilean Air Force.

At an IATA meeting on aviation and the environment in Geneva in late April, the accent was again on cooperative solutions. Pointing out that technological advances resulting in improved fuel efficiency have so far been offset by growth in traffic, Dr. Kotaite told participants of the Second Aviation and Environment Summit that "we must pursue our work on technological and operational improvements that will bring continuous incremental reductions in noise and emissions." Policies and practices that reflect the realities of a constantly changing environment are essential, he added. "Above all, we must reaffirm our commitment to global cooperation and global consensus, under the leadership of ICAO and through its Committee on Aviation Environmental Protection. Our many successes in this and other fields have always been the result of timely, concerted and globally harmonized action through ICAO."

In Salzburg, Austria, he told delegates to the European Aviation Summit in early May that liberalization of the air transport sector, one of the profound and powerful forces shaking the world, "should not be sweet for some and bitter for others."

The fruits of liberalization should be distributed fairly and equally among all parties, as intended by the Chicago Convention. The alternative, he cautioned, could be negotiations that might favour a region or a block, rather than a system which provides a level playing field. "This would be counterproductive and only result in undermining the global regulatory framework."

The Council President also underscored the importance of regional cooperation. Speaking at the 8th Session of the General Assembly of the Arab Civil Aviation Commission (ACAC) in Morocco in mid-May, he applauded the emergence of the Arab Air Transport Liberalization Agreement, describing this as a major advance in regional liberalization.

During his recent speaking engagements, Dr. Kotaite cited important ICAO conferences that had constituted milestones for global cooperation. The 5th Worldwide Air Transport Conference held in Montreal in 2003, he pointed out, had produced a global framework for liberalization. The final declaration of the conference provided States with a clear direction and practical guidance for liberalizing their air transport industries at their own pace, and in accordance with globally endorsed principles and practices. Similarly, a conference of directors general of civil aviation (DGCAs) held at ICAO headquarters in March 2006 developed a global strategy for aviation safety in the 21st century. Underpinning this strategy is greater transparency and sharing of information among States and key stakeholders, including the public (see "Global safety conference heralds new era of openness," Issue 2/2006, pp 5-7).

During his recent travels, the Council President met with government and industry leaders to discuss a range of aviation issues. On his visit to Santiago from 27 to 30 March, he met

Dr. Kotaite addressed the 8th Session of the General Assembly of the Arab Civil Aviation Commission held in Marrakech on 15-16 May. DGCAs from all 16 ACAC member States were in attendance.

with the Minister of Defence, the Vice-Minister of Foreign Affairs, the Minister of Transport, and the Director General of Civil Aeronautics. Their discussions covered the conclusions and recommendations of the recent ICAO DGCA Conference, the status of safety and security audits of Chile, environmental issues, the ratification of certain international air law instruments, and technical cooperation activities. The meetings were also attended by the current and former representatives of Chile on the Council of ICAO, and the ICAO Council President-elect. Dr. Kotaite also met with the President of LAN Airlines (formerly known as Lan Chile).

Farewell address to ANC

ICAO Council President Dr. Assad Kotaite addressed the Air Navigation Commission for the last time on 18 April 2006. First elected as President of the Council in 1975, Dr. Kotaite will retire from ICAO on 31 July.

In his remarks to the Commission, Dr. Kotaite emphasized that safety and security were the cornerstones of the organization. Even though there is no mention of aviation security in the Chicago Convention of 1944, the charter of ICAO, security has become the “flip side” of safety, he indicated, and no flight could be safe without effective security.

Dr. Kotaite reflected on the importance of the recently concluded Directors General of Civil Aviation (DGCA) Conference that had successfully agreed on a global strategy for aviation safety (see Issue 2/2006, pp 5-7). He remarked that the conference declaration recognized that the Chicago Convention and its annexes provide the essential framework required to meet the safety needs of a global aviation system, and called upon ICAO to study the development of a new annex to the Convention dedicated to safety processes. Following Council’s consideration of the outcome of the DGCA meeting, he added, the ANC could expect to be tasked with developing specific proposals for action.

The Council President recalled that during his long career, the Commission, the Secretariat and the Air Navigation Bureau in particular had managed to provide the fundamental basis for a safe and secure air transport system despite facing many challenges. Dr. Kotaite expressed his sincere appreciation to the ANC for its “constant support over the years.”

The 4th Annual Wings of Change Conference which the Council President addressed was held in conjunction with the International Air and Space Fair (FIDAE 2006), in which 40 countries and 300 exhibitors participated. On 29 March a gala dinner was held in Dr. Kotaite’s honour. Organized by the Latin American aviation community and IATA, the event celebrated the Council President’s lifetime contribution to the development of international civil aviation (see photo, page 25). Dr. Kotaite will retire as President of the Council on 31 July 2006.

In Geneva from 24 to 26 April, the Council President attended and addressed the Second Aviation and Environment Summit organized jointly by the Airports Council International (ACI), the Air Transport Action Group (ATAG), the Civil Air Navigation Services Organization (CANSO), IATA and the International Coordinating Council of Aerospace Industries Associations (ICCAIA). The meeting, attended by more than 300 aviation leaders from 40 countries, was held to renew the environmental strategy adopted at the first summit a year ago and to strengthen collective action to reduce noise and emissions from air transport.

While in Geneva the Council President met with the Director General of the World Trade Organization (WTO) to discuss working arrangements between ICAO and WTO as well as a possible agreement between the organizations to ensure effective coordination in matters concerning the aviation sector.

On a visit to Beirut, Lebanon from 27 April to 2 May, the Council President discussed aviation matters with the Prime Minister of Lebanon, the Minister of Foreign Affairs, the Minister of Public Works and Transport, the Director General of Civil Aviation, and the President of Middle East Airlines. Discussions focused primarily on technical cooperation activities, the acquisition of a flight simulator for the civil aviation training centre in Beirut, the creation of a Middle East regional monitoring agency at Bahrain, and development of a regional safety initiative known as the Cooperative Development of Operational Safety and Continuing Airworthiness Programme (COSCAP). COSCAP projects are based on cooperative arrangements between States in a particular region, in this case those of the Eastern Mediterranean.

The European Aviation Summit that was addressed by Dr. Kotaite attracted 170 participants from European States and international and regional organizations. The main theme was the removal of barriers to competition in the European aviation industry and the signing of aviation agreements with countries of the Western Balkans, Iceland and Norway. While in Salzburg from 3 to 5 May, Dr. Kotaite during the summit discussed issues related to the environment, the Single Sky initiative, and the safety and security of civil aviation with the Vice Chancellor and Minister for Transport, Innovation, and Technology, and the Vice President of the European Commission and European Commissioner for Transport.

In Marrakech on 15-16 May to participate in the ACAC General Assembly, Dr. Kotaite had discussions with several DGCAs of Arab administrations. DGCAs from all 16 ACAC member States attended the session, as well as observers from international and regional organizations. Discussions focused primarily on activities of the Commission and its work programme for the 2007-08 period, the liberalization of air transport, open sky agreements, aviation safety and security, legal matters, financial and administrative affairs, and coordination among Arab States in aviation matters. Special emphasis was made on working and coordinating with ICAO in all fields related to civil aviation. □

Secretary General addresses staff concerning business plan

ICAO Secretary General Dr. Taïeb Chérif addressed ICAO staff on 10 May about some of the strategic initiatives that have been undertaken by the organization in recent months to address ongoing budgetary constraints, including implementation of a business plan as the cornerstone of the organization's activities.

The business plan, he explained, is essentially "a new way of doing business." (See "New ICAO business plan is part of a broad strategy initiative," Issue 6/2005, page 5.)

Among the advantages of the plan, Dr. Chérif added, is its focus on results and the introduction of new working methods that increase efficiency and effectiveness with limited resources. "Overall," he summed up, the plan "fosters a greater sense of responsibility throughout the organization and demonstrates value to member States for their [financial] contributions."

The Secretary General noted that ICAO had already benefited from the initial implementation of the business plan. The more widespread use of information technology, for example, had considerably streamlined ICAO's working processes and procedures. "This has resulted in significant savings in terms of time, money and resources," he said.

The improvements are part of an organization-wide exercise to translate the concept of a business plan into practical applications, he further explained. The transition includes a systematic and realistic assessment of ICAO's resources and corresponding priorities. Change will be essential to ensure ICAO's success in the future, Dr. Chérif reminded staff. "ICAO is far from immune to the pressures that are forcing governments, industries and the United Nations itself to adapt and reform," he stressed. "We urgently need new processes, new procedures and new structures if we are to remain relevant in the 21st century."

The Secretary General informed staff that a high-level committee had begun examining the structure of the Secretariat to identify ways to substantially improve the efficiency and effectiveness of the organization. The committee is expected to table its findings to senior management by late summer.

"As you can see, we are gradually and systematically changing the way we do business to better meet the enormous pressures of today's society …. We are providing leadership to the global aviation community and we are forging ahead with a proactive and assertive strategy. In all of this, we must act with conviction and consistency, in a spirit of total cooperation. We must recognize that changing and adapting are necessary to remain relevant and valued by the world community," he told the staff who had gathered in ICAO's Assembly Hall. □

Amended annexes soon to become effective

Contracting States have been asked to notify ICAO of the status of several annexes to the *Convention on International Civil Aviation* (also known as the Chicago Convention) that have been amended recently. Member States have been requested to inform the organization prior to 23 October 2006 of their compliance with the amended annexes, or alternatively to notify ICAO by the same date of any differences that will exist between their national regulations or practices and the provisions of the revised annexes. Where States disapprove of all or part of the amendments, the notification of disapproval is required prior to 17 July 2006, the date on which the amended annexes are to become effective.

The amendments adopted by the ICAO Council in March 2006 concern Annex 1, *Personnel Licensing*; Annex 2, *Rules of the Air*; Annex 6, *Operation of Aircraft* (Parts I and III); Annex 10, *Aeronautical Telecommunications*; Annex 11, *Air Traffic Services*; Annex 13, *Aircraft Accident and Incident Investigation*; and Volume I of Annex 14, *Aerodrome Design and Operations*. □

Disclosure authorized

Three more Contracting States have signed consent forms permitting ICAO to disclose safety information on its website beginning in March 2008. The three additional States, as of 24 May 2006, are Belgium, Mauritius and Uruguay. To date, a total of 69 member States and two territories have agreed to the disclosure of either their full safety oversight audit report or an executive summary of the audit report.

The decision to release the results of ICAO safety oversight audits to the public was made by the world's directors general of civil aviation (DGCAs) at a conference held at ICAO headquarters on 20-22 March (see Issue 2/2006, pp 5-7). The meeting resulted in a comprehensive set of conclusions and recommendations that give shape to an action-oriented global aviation strategy, with greater transparency as its cornerstone. □

Panel to consolidate guidance material on performance management

The ICAO Air Navigation Services Economics Panel (ANSEP) is in the midst of preparing material on the performance of the air navigation system in the economic and management fields. The information, to be presented to a worldwide symposium planned for March 2007, will also be published as a supplement to the *Manual on Air Navigation Services Economics* (Document 9161). Document 9161 will be available at the ICAO public website.

During a meeting at ICAO headquarters in late March, the panel decided, after examining various draft material dealing with the performance management process from the viewpoint of ANS providers, to develop a single document on the subject. The guidance material will cover such aspects as key cost drivers, selecting goals and setting targets, measurement and methodology, benchmarking, governance and ownership, incentives, consultation with users, performance reports and information disclosure, and performance management. In developing the new document, ANSEP will work closely with the Air Traffic Management Requirements and Performance Panel (ATMRPP), which is currently elaborating an ATM performance manual that is based on the global air traffic management operational concept described in ICAO Document 9854.

ANSEP is also supporting ATMRPP with the development of methods to assess the economic implications of operational performance or, to express it more simply, to assign monetary values to flight delays, flight efficiencies, and so forth.

Another issue examined by the panel was the possibility of establishing a global method for recovering the cost of operating regional monitoring agencies. The ICAO Secretariat presented a global approach to recovering the cost of the agencies, whose task is to monitor reduced vertical separation minima (RVSM) operations. The method proposed was a step-by-step procedure for the implementation of cost recovery arrangements at the regional level. The panel indicated a preference for the multinational air navigation facility model developed by ICAO and also agreed on the incremental approach to cost-recovery arrangements.

When discussing the allocation of costs related to the global navigation satellite system (GNSS), serious concerns were expressed by some participants, who pointed to the risk that civil aviation might be charged for more than its fair and equitable share of GNSS costs. It was agreed that an ongoing study on the subject should be completed during 2006, and that the final report should include any recent and new material on GNSS developments. Participants agreed that accurate cost allocation could not be made without an inventory of current GNSS applications. When completed, the ANSEP study is intended to be used by civil aviation stakeholders in their future negotiations with GNSS operators and users.

The issue of user consultations, as well as the settlement of disputes over debt recovery of ANS charges, was addressed by forming a small working group that will study the need for additional guidance material.

The meeting of 27-31 March 2006, the sixth to be held by ANSEP since its formation in 1994, was attended by 42 participants. □

SHARING OF SAFETY DATA

ICAO and the International Air Transport Association (IATA) have agreed to share information gathered from ICAO's safety oversight audits and IATA's audits of operational safety at its member airlines. The agreement will allow regulators and airlines to better manage safety risks and prevent accidents. Shown shaking hands after signing the memorandum of cooperation are ICAO Council President Dr. Assad Kotaite and IATA Director General Giovanni Bisignani (left). Looking on are ICAO Secretary General Dr. Taïeb Chérif and Günther Matschnigg, IATA Senior Vice President, Safety Operations and Infrastructure (at left).

Symposium to focus on MRTDs, biometrics and security

ICAO will convene a symposium on ICAO-standard machine readable travel documents (MRTDs), biometrics and security at its headquarters in Montreal from 6 to 8 September 2006. An exhibition will complement the symposium and highlight products and services related to MRTDs, biometric identification and border inspection systems. The event is of particular interest to officials of passport issuing agencies and authorities responsible for immigration, customs, border control and security, but also concerns airline and airport officials involved in overseeing passenger service systems, handling of travel documents, facilitation and aviation security. Government officials may attend free of charge.

The symposium will include a presentation on the key features, benefits and advantages to States of introducing MRTD systems, and applying identity management and enhanced identity confirmation, as well as the significant benefits offered to the traveller by ICAO-standard electronic machine readable passports. It will also feature a workshop focused on technical issues related to upgrading to ePassports, and the functions and usage of the prospective Public Key Directory, an ICAO-coordinated service to facilitate authentication of ePassports.

More information on the symposium, as well as online registration, is available at the ICAO website (www.icao.int). □

Bangkok to host training symposium

The 10th Global Trainair Training Symposium and Conference will take place from 30 October to 3 November 2006 at Bangkok, Thailand. The five-day event will be held concurrently with a training equipment exhibition that will feature the latest in training technologies, and will be hosted by the Civil Aviation Training Centre (CATC) of Thailand.

During its last two days the meeting will focus on items related to the organization, operation and priorities of the ICAO Trainair Programme. Trainair's goals are to improve the safety and protection of air operations and the efficiency of air transport through the establishment and maintenance of high standards of training for aviation personnel on a global basis.

The symposium and conference will explore ways that global cooperation in civil aviation can help meet the demand for skilled human resources in the future. It will consist of several panel sessions on different training topics. While the event is oriented towards directors of civil aviation training centres and managers for training policy and human resource development at civil aviation authorities, the topics will also be of considerable interest to air navigation services providers, government safety inspectorates, airline operators and maintenance organizations.

States and organizations have been urged to register participants by 31 July 2006. Further information is available from the Trainair Central Unit in the ICAO Technical Cooperation Bureau (tel. +1 514-954-6384 or +1 514-954-8219, ext. 7028; fax +1 514-954-6077).

Large-scale technical cooperation projects under way

New large-scale technical cooperation projects are being implemented by ICAO in Botswana, Guatemala and Panama, and other ongoing projects have been allocated additional funding. Several new large-scale projects are also under way at the regional level.

Valued at more than $1.19 million (all financial figures in U.S. dollars), the new project in Botswana provides the government with assistance in establishing a civil aviation authority. The 18-month project, funded entirely by the Government of Botswana, will focus mainly on the interim and start-up phases of the implementation plan.

A one-year project in Guatemala to modernize the Mundo Maya International Airport commenced in 2006 with more than $2.43 million in funding. Funded entirely by the Government of Guatemala, the project entails the construction of the north-west and south-east wings of the airport, restrooms, entry hall, restaurants, security area, office and shopping area, parking and various airport remodelling requirements. A separate one-year project also funded by the government concerns the development of the civil works required to modernize several Guatemalan airports, and is valued at over $3.37 million.

In Panama, a six-month project to modernize and equip the Howard Airport in Panama City is valued at over $954,000. The project is funded by the Agencia del Área Económica Especial Panamá.

Among major regional projects is an undertaking for the member States of a regional economic entity known as CEMAC. The project, a cooperative agreement between the civil aviation administrations of CEMAC member States, aims to enhance the safety of air transport operations in Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon and Sao Tome and Principe. It is valued at more than $4.47 million, and is funded by CEMAC. In the Latin American and Caribbean region, a project to provide civil aviation institutions with training and advice on improving efficiency and aviation security is funded entirely by the Government of Spain at a cost of $658,000. In addition, a five-year project to enhance the safety and efficiency of air transport in the Gulf States commenced in 2006 with funding of $3.7 million provided by Bahrain, Kuwait, Qatar, the United Arab Emirates and Yemen.

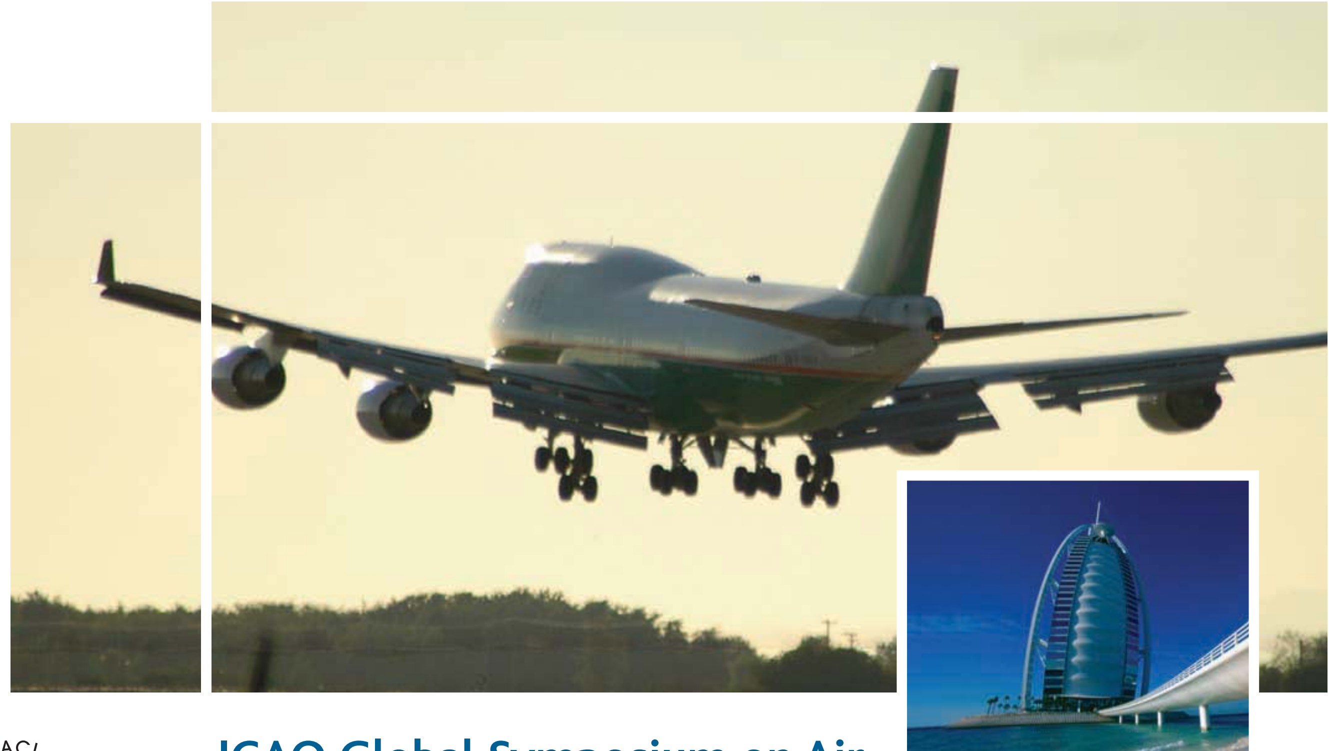
Major ongoing technical cooperation projects that have been allocated new funding include an additional $11.38 million for an initiative to upgrade the Tocumen International Airport in Panama City; and new funding of $2.14 million related to preparations for the safe and smooth transfer of operations from Bangkok, Thailand's existing international airport to the new Suvarnabhumi International Airport.

ICAO and ACI join forces on airport training

ICAO has signed an agreement with Airports Council International (ACI) to jointly develop and deliver a training programme encompassing a broad range of airport management courses (see photo, inside back cover).

ICAO Secretary General Dr. Taïeb Chérif said the multi-year agreement to provide airport training was an effective way for the two organizations to promote compliance with ICAO standards and recommended practices.

The joint programme will cover a variety of subjects in the



field of airport operations, airport financial management, safety management systems, airport certification and security. During summer 2006, ACI will survey airport managers concerning their basic training needs; the survey results will guide ICAO and ACI in developing the competency-based courses.

"We seek to develop with ICAO a programme of professional accreditation for airport managers — a concept strongly supported by our members," explained Robert J. Aaronson, ACI Director General. "Today's airport manager faces a complex array of issues from finance to environment to heightened security concerns. This has created a need for specialized professional training over the course of a career in airport management."

ICAO Journal Issue 4/2006 will feature an in-depth look at the new joint training programme. □

Dynamic test bed

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flight deck" is innovative in that it has two pilot positions, with the left-hand seat equipped with an aeroplane pilot's wheel, and the right-hand seat appropriately fitted with a helicopter's collective and cyclic controls.

Yet even with its advanced technology, the key to the DTB's effectiveness lies in its operation by knowledgeable staff. It is important that avionics, software and systems specialists understand the technical, operational and financial imperatives of today's aircraft operators.

While the development of the initial systems integration laboratory and its advanced capability DTB successor has represented a substantial capital investment, the initiative was nonetheless worthwhile. The ability to create a complex installation with myriad critical interfaces, and to then test it against all possible eventualities, generates a very high level of confidence that costly "down-the-line" operational problems will not arise when the upgraded aircraft returns to regular service. □

Performance-based navigation

continued from page 7

been finalized, it will be necessary to update all related ICAO technical provisions in a coordinated manner. This is why ICAO is in the process of establishing a long-term multi-disciplinary programme to coordinate the development and maintenance of ICAO provisions for route spacing, procedure design, chart making, aeronautical databases, flight planning, radio navigational aids, and so on. The long-term programme shall also assist with implementation of the PBN concept in various regions and States.

Programme targets. The programme goals still need to be worked out in detail, but the high-level programme objectives are known. In the short term, the objectives are to establish a PBN manual as a basis for implementing performance-based navigation as well as to adapt ICAO provisions (with respect to the terminology). Another important short-term objective is to create awareness of the harmonization initiative and win acceptance from the aviation community.

Medium-term objectives include development of ICAO provisions to support performance-based navigation, the implementation of GNSS approach procedures with vertical guidance (APV) approach procedures to every runway used for international operations, and RNAV implementation (where this is operationally required in terminal and en-route airspace). Over the long term, the objectives are to assess future operational needs and adapt implementation guidance to ensure global harmonization of future PBN operations.

While the initial concept of RNP as envisaged by the FANS Committee many years ago has served the aviation community well, leading to implementation of RNP 10 and RNP 4 in remote and oceanic airspace, aircraft navigation capabilities and ATM automation and concepts have advanced rapidly over the years. In terms of airspace design and air traffic management, the international civil aviation community is now at a turning point that places new emphasis on aircraft navigation performance. Major advances in safety, airspace accessibility, efficiency and capacity are expected from this effort to implement performance-based navigation. By helping planners and regulatory authorities to take advantage of these advances, ICAO — with the aid of an internationally recruited study group and the establishment of the PBN programme — is addressing a formidable challenge. □

Avionics upgrade

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avionics systems usually change over the years as operators perform modifications, adding or removing capabilities to best meet their particular needs. Consequently, a responsive upgrade programme cannot simply be a "one size fits all" approach to make the aircraft a perfect replica of newer models of the same basic type. While the project must be designed to bring the efficiency benefits of new technology, it must also reflect the economic realities of balancing the operator's expected return on investment against the aircraft's projected future service life, its residual value when sold, and similar considerations.

In KLM's Boeing 747 Classic upgrades, for example, the requirement was to provide equivalent functionality to the systems in the B747-400 fleet while avoiding what would have been a very costly total replication of the newer aircraft's configuration. For instance, the seven new electronic instrument displays installed on the flight decks of the older aircraft performed very similar functions to those found in the production -400s, but were much less expensive.

This flexibility allows the system designer to take a "best in class" approach in selecting the optimum equipment mix for the task, rather than arbitrarily specifying a range of units from a given manufacturer. The design philosophy should aim at achieving the required functionality and performance while staying within acceptable cost guidelines, thereby providing operators with the desired advanced capabilities while achieving significant cost savings.

A fully responsive upgrade programme must therefore be preceded by a detailed understanding of both the operational and budget criteria in order to provide the most economic solution to the operator's needs.

The KLM programme described above recognized the overriding importance of pre-planning every aspect of a major upgrade project to make certain of the exact integration of each new system element with the previously installed equipment. With KLM, this approach ensured that unexpected — and usually costly —problems would not arise as the work got under way, or after the aircraft was returned to operational service, where they could result in flight delays or cancellations or, in a worst case, require the aircraft to be taken out of service again.

Complete electronic and operational integration of newly installed equipment with the earlier systems retained in the aircraft is therefore essential. Not only must they operate flawlessly together, but adding new capabilities must not degrade the performance of retained systems such as the aircraft's previous autoland capability.

To achieve this level of integration for the KLM project, CMC established an advanced and dedicated systems integration laboratory following the initial determination of the airline's upgrade requirements. The laboratory was felt by specialists to be the only completely satisfactory way to ensure that all elements of the avionics installation, both new units and those continuing in service, would operate faultlessly together. Accordingly, the first step was to replicate KLM's Boeing 747-200/300 avionics installation at the Montreal facility.

Since that time, major advances in avionics, computing power and simulation technology have led CMC to move beyond the systems integration laboratory and to develop, in conjunction with scientists at Montreal's Concordia University, a next-generation FMS dynamic test bed (see sidebar, page 18).

Although the air carrier industry has largely recovered from recent traffic turndowns and the events of 2001, rigid cost control, equipment rationalization and operational efficiency will continue to be key priorities. Upgrade programmes have clearly brought new utilization opportunities to older members of the air carrier fleet. □

ATFM SEMINAR

A regional seminar on air traffic flow management (ATFM) was held in Tegucigalpa, Honduras from 27 to 31 March 2006. Hosted by the Central American Corporation for Air Navigation Services (COCESNA), the event attracted 47 participants from Belize, Costa Rica, Cuba, El Salvador, Haiti, Honduras, Guatemala, Mexico, Nicaragua, Trinidad and Tobago, and the United States.

CNS/ATM business case

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to compare the costs of installing various avionics upgrades with the financial savings that result from achieving more efficient flight operations.

The scenario analysis provides a series of output results in aggregate terms and in the form of tables and graphs explaining the financial implications of the selections and decisions made under different scenarios. These results can be saved as a report using MS Excel. The software has the capability of generating tables that illustrate the annual costs by component or when grouped by equipment type, location, State and/or the type of cost. Similarly, graphical displays of the expenditure and revenue streams, illustrating any cost recovery for both ANS providers and airspace users, are also available.

A sound business case would involve the development of a set of scenarios based on reasonable assumptions related to the specific CNS/ATM project at hand. These scenarios would then be analysed and compared. The scenario comparison allows for the selection of various scenarios from a list, and the production of a comparison table.

Strengths of the model. The model provides users with flexibility in the scenario-building process by allowing them to define a set of parameters. These include the analysis horizon, the dates on which each component of the new systems becomes operational, the extent of the transition period, the average equipment life cycle, cost of capital and the period of cost recovery.

Through the scenario option, users could determine the manner in which conventional facilities may be withdrawn and replaced by new technology. It may be possible to vary the timing of the transition period and defer the implementation of new technology. The users can also create a range of alternative scenarios, including a plan based on entirely new technology or any mix of conventional and advanced technologies to evaluate the cost effectiveness of each scenario.

The model provides the user with the traditional profitability measures by including detailed cash flow profiles that illustrate the financial viability of the selected option or scenario. It will allow users to examine the time profile for the expenditures resulting from a given implementation scenario and compare this with the time profile for revenue. With this information, users can ascertain the breakeven point, where the cumulative revenue equals the cumulative expense, and can calculate whether additional financing would be required for the implementation period concerned.

The model is developed with the premise that ANS providers would recover their costs through the collection of user charges. Any additional user charges incurred by the airspace user would be sufficiently offset by increased efficiency through the reductions in fuel consumption and flight crew hours.

The average annual amount of user charges to be collected by the ANS provider during the cost-recovery period is among the output results of the model. In general, revenues from user charges are directly related to traffic levels, but the average value provides a basis for service providers to establish user charges in consultation with airspace users.

The output for each scenario will also provide the annual costs by State, location and equipment in use. These costs can be grouped according to their nature, such as the costs related to purchase, installation, maintenance, operation, communications, and so on.

Since the implementation of CNS/ATM systems may lead to changes in the way that air navigation services are provided, the model has the capacity to perform sensitivity analyses to highlight these options, with the intent of minimizing the financial risks.

Additional information acquired from other sources may be added to the database and modified as required. The model is also extendable, allowing integration with other models such as an independently developed traffic forecasting module. The software and database are separate in the sense that, once the software is installed, the database file can be copied separately.

The model addresses the concerns of both the ANS providers and airspace users, while providing similar output results for both partners.

Current limitations. Generic costs are used for all ANS equipment. While the capability of assigning specific costs to particular locations or equipment does not currently exist, changes to these generic costs can be made by users, taking into account factors involved in the equipment and/or the location.

Currently, a separate module does not exist to estimate the flight efficiency benefits achieved by airspace users. This is an input to the model rather than a built-in analysis. These rates have to be estimated by the users for each of the scenarios concerned. Nevertheless, the model allows such an enhancement to be included in the future.

It is important to bear in mind that all costs and efficiency benefits are only predictions. For example, it is possible that a demand forecast will not materialize as planned or that a forecast may exceed expectations.

In the case of a multinational facility or service, the model is capable of including the segments attributed to each State separately, but cannot include the shared segments in the scenarios, although such an extension is possible.

In conclusion, a logical process for the development of

AGREEMENT WITH EASA

ICAO has agreed to cooperate with the European Aviation Safety Agency on safety oversight audit and related matters. A memorandum of cooperation was signed by the two organizations on 21 March 2006 by ICAO Secretary General Dr. Taïeb Chérif (right) and EASA Executive Director Patrick Goudou. Looking on are William Voss, Director of the ICAO Air Navigation Bureau and Henry Gourdji, Acting Chief of the Safety Oversight Audit Section in the Air Navigation Bureau (at left).

CNS/ATM business cases has been established in the form of an interactive software tool. The methodology developed is capable of examining the business case from the major stakeholders' points of view, recognizing that there are significant differences in infrastructure and traffic levels in different regions of the world. Importantly, transition to the new systems will be a gradual process, and will occur at different rates across each region.

ICAO has recently released the software for evaluating CNS/ATM business cases. Member States may obtain this CD-ROM tool free of charge, together with a user's manual, by contacting the Economic Analyses and Databases Section of the ICAO Air Transport Bureau (sta@icao.int). The DFACS software is also available to all others for a fee. □

RNAV and RNP procedures

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built-up areas. Alaska Airlines, the first U.S. carrier approved for public RNP-SAAAR approaches, has already recorded "saved" flights at Reagan National as a result of utilizing the RNP approach.

Summary. The United States is committed to working with ICAO on harmonization issues related to the implementation of performance-based navigation procedures, both RNAV and RNP, worldwide. For example, U.S. RNAV guidance is being amended to be compliant with the new edition of ICAO Document 9613, currently under development by the ICAO RNP and Special Operational Requirements Study Group (RNPSORSG).

Moreover, the U.S. is participating in ICAO activities to establish guidance for RNP procedure design criteria, operational approval and aircraft evaluation guidance through the Obstacle Clearance Panel (OCP) and other appropriate bodies. It is also working regionally through a trinational group known as the North American Aviation Trilateral (NAAT) to promote a harmonized way forward for RNAV and RNP implementation across Canada, Mexico and the United States.

Within the United States, implementation of RNAV and RNP procedures has provided benefits to aircraft operators and the FAA air traffic services provider. RNAV procedures have enhanced situational awareness for pilots while also reducing the workload for both pilots and controllers. They have maintained a high level of predictability regarding flight tracks and have allowed aircraft on RNAV departures to maintain better climb profiles.

Voice communications between pilots and controllers has been reduced where these procedures are in effect, and notably, the number of read-back errors has also been reduced. This potentially improves safety while at the same time removing one cause of extra time and distance flown. With RNAV, moreover, airspace planners can design efficient arrival and departure routes where flight tracks are optimized for efficient airport operations.

Over the next several years, approximately 200 more RNAV and RNP procedures will be implemented in the United States. Significant progress in implementation of RNAV and RNP operations has been made, but there is much more to be done, and as the performance-based navigation programme matures, the United States will continue to pursue worldwide harmonization of procedures design criteria through ICAO. □

Criteria for building restrictions

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such as local governments, project developers and communities. This method involves providing all interested parties with free CD-ROM containing software that defines all surfaces relevant to the specific situation around the airport.

These authorities must ensure that no obstacles, whether static, temporary or moving, result in an infringement. The surfaces defined comprise not only those required for protecting CNS equipment, but also the surfaces defined in ICAO Annex 14, *Aerodromes*, which ensure safe flight above and away from obstacles.

The software indicates, for any chosen location on the ground, the obstacle height restriction. If the height of the object at the chosen position is lower than the restriction, no further action with respect to acquiring permission from CAA Netherlands is necessary. If the planned height is greater than that permitted, the construction plan has to be submitted to the CAA to be further assessed by means of a detailed study. For this purpose, CAA Netherlands uses a more detailed version of the software which indicates, in addition to the height restriction, the particular surface which is violated. Depending on the facility associated with the surface, the request for permission is passed to the responsible department. In the case of CNS facilities, this would be the Netherlands ANS provider, which has the expertise to deal with the matter. In the Netherlands, this system has now been expanded from Amsterdam Schiphol to cover the entire country.

The initiative in Europe to ensure that common criteria are used in determining building restrictions near airports may generate interest in taking similar action in other regions where national variations exist. The ICAO project team formed by the EANPG All Weather Operations Group is confident that its initial work could yield significant benefits for ICAO member States outside the European region as well. □

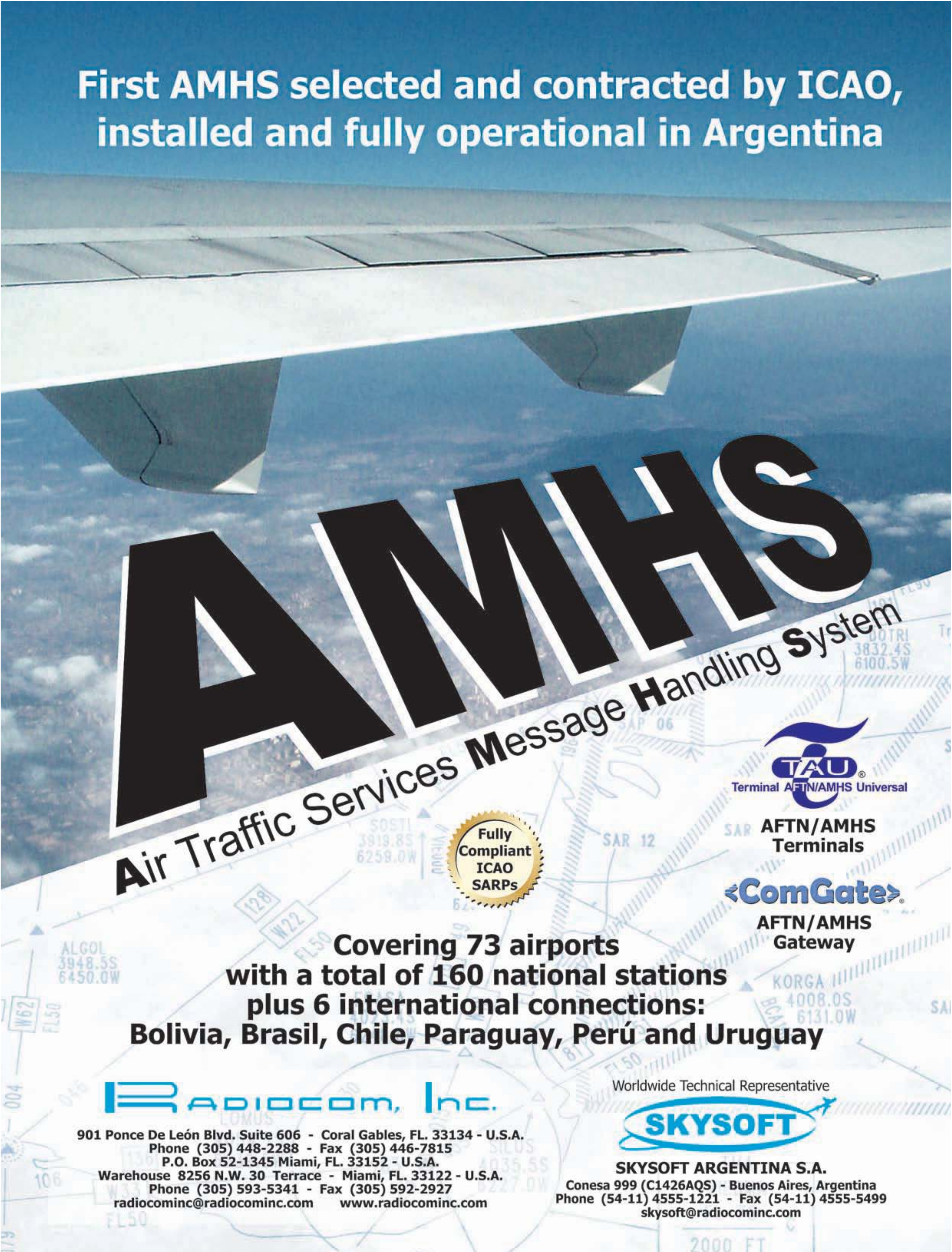
IN THE SPOTLIGHT...

JOINT TRAINING
ICAO has signed an agreement with Airports Council International (ACI) to jointly develop and deliver a training programme encompassing a broad range of airport management courses (for more details, see page 29). Pictured at ICAO headquarters following the signing ceremony are (seated, l-r): Anne McGinley, Director of ACI's Montreal Bureau; Robert J. Aaronson, ACI Director General; ICAO Secretary General Dr. Taïeb Chérif; Silvério Espínola, Principal Legal Officer, ICAO. Standing (l-r): Mohamed Elamiri, Director of the ICAO Air Transport Bureau; William Voss, Director of the ICAO Air Navigation Bureau; ICAO Council President Dr. Assad Kotaite; Denys Wibaux, Director of the ICAO Legal Bureau; and Xavier Oh, Manager, Environment and ICAO Liaison, ACI.

HAVANA MEETING
The Central Caribbean Working Group met in Havana, Cuba from 20 to 24 February 2006 to discuss the development of air navigation systems in the Central Caribbean based on the *Regional Air Navigation Plan* and conclusions of the Caribbean/South American Regional Planning and Implementation Group (GREPECAS). The sixth meeting of the working group, hosted by the Instituto de Aeronáutica Civil of Cuba, attracted 43 participants from the Cayman Islands, Cuba, the Dominican Republic, Haiti, Jamaica, the United Kingdom, the United States, Venezuela, ARINC and the International Federation of Air Traffic Controllers' Associations (IFATCA).

AIR CARGO SEMINAR
A seminar on airport development and management of air cargo activity was conducted by ICAO in Cartagena, Colombia from 27 February to 3 March 2006. The event was co-sponsored by Aeropuertos Españoles y Navegación Aérea (AENA), of Spain, and the Spanish Agency of International Cooperation (AECI). Sixty-one participants from 14 States of the Caribbean, Central American and South American regions attended presentations by experts from Colombia, Cuba, the Dominican Republic, Spain and ICAO's Technical Cooperation Bureau.

DAKAR WORKSHOP
A regional workshop on forecasting and economic planning for States in the western and central African region was convened at the ICAO regional office in Dakar from 27 February to 3 March 2006. Thirty-four participants from 13 States and four international organizations attended. The workshop provided a forum on forecasting techniques and CNS/ATM implementation economics as well as guidance on CNS/ATM business cases. There were also discussions on airport and airline planning, future prospects for the region and other aviation planning issues.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