

# Realigning ATM Research

As U.S. and European airspace becomes more congested, air traffic management studies seen as key to transformation

DAVID HUGHES/BALTIMORE

**C**oupling air traffic management research more closely to problems that must be solved soon is now a high priority for the U.S. and Europe as they try to avoid gridlock. But the current capacity crunch is propelling the Europeans to forge ahead more quickly.

"We will hit the capacity wall soon," says Bo Redeborn, director of air traffic management (ATM) strategies for Eurocontrol. The organization has 35 member nations and aims to develop a seamless pan-European ATM system.

Last year, Europe saw traffic demand jump 5%; in some Eastern European nations, it grew 20%. This is why Eurocontrol and the European Commission have a major research initiative underway to take a leadership position in ATM innovation, he says. About 200 million euros (\$244 million) a year is being spent on research and development in Europe, which could rise to 300 million euros or more in 2007 when an ATM master plan is completed (*AW&ST* Mar. 14, p. 76).

But first, European officials plan to review all the recent ATM research to see how Eurocontrol and its partners can best exploit it. "We also want to bring research and implementation closer together. In the past, there has been too much of a free flow of research that isn't focused on added value," he says.

Redeborn and Steven Bradford, chief scientist for architecture and national airspace system development in the FAA's Air Traffic Organization, outlined their groups' research priorities at a U.S.-European ATM meeting here last month.

One system now in development—En Route Automation Replacement Modernization (ERAM)—should help the U.S. head off near-term problems by 2010, says Bradford. The \$2.1-billion project is destined to be deployed at 27 facilities to replace the aging HOST computer system. Bradford says ERAM will help the FAA break down a lot of the barriers to more efficient flight management, especially on days when the weather is less than ideal.

Another helpful development, according to Bradford, is the Traffic Man-

agement Advisor tool, which is being improved by NASA Ames Research Center and Mitre Corp. TMA will perfect the sequencing of aircraft into congested airports and airspace throughout the nation. For example, the multi-ATC-center tool should allow the FAA to avoid wasting slots that are not used now when capacity is constrained. TMA helps controllers clarify slot availability based on aircraft approaching and flying over airports.

Eurocontrol also wants to do a better job in the near term to utilize all airport slots and manage airspace dynamically to allow restricted airspace to be used by civil aircraft when it isn't needed by the military, for example.

In the U.S., the highest priority for ATM research, says Bradford, is to find ways to more effectively exploit modern avionics capability already on many flight decks—including the use of satellite navigation. One closely related goal, he adds, is to develop the ability for computers on the ground and on aircraft to manage traffic flow based on the exchange of data on "4D" trajectories (the three spatial dimensions and time).

Redeborn agrees that 4D work is crucial as pilots and controllers shift from a reliance on voice communications to downlinking flight data from automated cockpit systems. He adds that it's "embarrassing" to think how much avionics can do nowadays and how little air traffic systems exploit this capability.

Another major pursuit of the FAA and the federal Joint Planning and Development Office is to develop a more network-centric ATC system using systemwide information management, or



**Bo Redeborn,**  
director of ATM strategies  
for Eurocontrol



**Steven Bradford,**  
chief scientist for  
architecture in the FAA's  
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SWIM. In addition, the flow of information will rely on internet protocol (IP) addressing to move data in a more flexible manner and at a lower cost than is the case today.

Improving management of aeronautical data is especially critical if unnecessary ground-based nav aids are to be retired—as both Eurocontrol and the FAA want to do, notes Redeborn. He and Bradford say the "roles and responsibilities" of air traffic controllers will have to change; but accomplishing this, based on new concepts of operations being developed by ATM researchers, won't be easy.

For example, Redeborn says Eurocontrol has set a high priority on "airborne separation" research, including the process of transferring some portion of aircraft-separation duties from ground controllers to pilots, using systems on the flight deck. Bradford says it will also be essential to cut the "geo-

graphic link" between the controller workforce and the airspace they oversee. This means that, instead of sitting underneath the airspace they monitor, controllers in the U.S. should be stationed without regard to geography to provide a more flexible and agile capability.

In its Single European Sky program, Europe has a similar goal—to have nations band together to create regional airspace sections. These more functional blocks could be controlled from one consolidated ATM facility.

As a Eurocontrol Training Institute official points out, researchers will have to find a way to get controllers to buy into new concepts of operation. That's because they are "conservative" and not easily convinced that new ways of doing business are better. "They all believe

they are doing the job as best they can at the moment, and they are reluctant to change," he asserts.

Another key issue involves "safety analysis," which George Donahue insists should be done in the earliest stages of the ATC transformation process. Donahue—a George Mason University systems engineering professor who was formerly associate FAA administrator for research, engineering and acquisitions—laments the "shortage of trained professionals in the use of ATM safety methodologies," and he urges government and industry to encourage more people to go into this field.

Quantitative analysis of safety issues is now possible because there are so many flights in the U.S., and it should be conducted as part of designing a new ATC system, adds Donahue. Air traffic

was relatively sparse in the 1960s, and this encouraged engineers to take a conservative approach in their design schemes—i.e., they had to allow plenty of room for error in their safety assumptions. "Now we are getting to the

"system of systems" with highly distributed man-machine interactions. And it's interesting, Blom adds, that only financial markets are more highly distributed networks than ATM (see chart below). Over the years, the ATM community has even lost some promising research talent to Wall Street, where compensation is better.

Blom has led innovative ATM research for the European Commission on the "Hybride" project (see story below). It includes systems theorists and mathematicians, many of whom have never worked on ATM research before. The goal of the project is to study mathematical approaches to handling the types of uncertainty (such as the risk of collision) found in ATM systems. This work integrates the disciplines of computer science and control theory.

## Europe is aiming for an "ultra-green," secure, cost-effective and customer-oriented ATM system

point where the numbers have real engineering meaning," he says.

The ATM research community is a small one, notes Henk Blom of the Netherlands' National Aerospace Laboratory. But their work is interesting because ATM is one of the most "highly distributed" systems imaginable. Air traffic research encompasses the analysis of a

# Doing the Math on ATC

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Uncertainty is a way of life when it comes to managing air traffic, but new probability analysis is aimed at taming this beast.

For traffic flow managers, uncertainty about what might happen on any day in a given block of airspace is exacerbated by canceled or added flights, variable traffic flow and disruptive weather.

The European Commission has taken a novel approach to this air traffic management (ATM) problem in the Hybride project, which has brought together about 50 systems engineering theorists and mathematicians from six universities and three research institutes in Europe.

**The highly distributed nature of ATM makes it an ideal candidate for the Hybride study of how to deal with uncertainty in complex, safety-critical operations. Finance (lower right in chart) is even more highly distributed.**

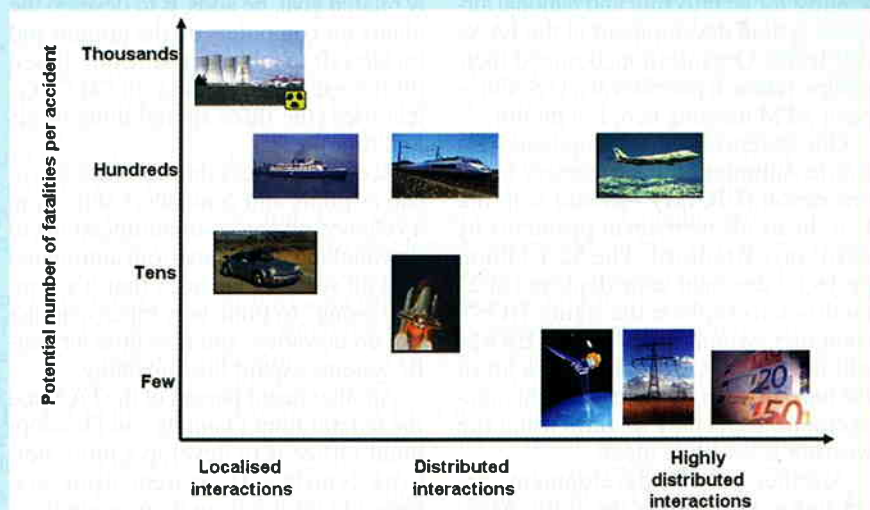
One of the difficulties in quantifying the probability of what might happen, and the risk of collision, is that an ATM system is highly distributed. It includes automated and semiautomated systems interacting with one another, along with pilots and controllers. This presents "exceptional challenges" for analyzing the risk of collision—the key safety issue for ATM, according to Henk Blom of the Netherlands' National Aerospace Laboratory.

Blom led the first phase of the Hybride project. He notes that while the ATC system the world has relied on for decades has proven to be a safe one, this has been partly because systems have been designed very conservatively. But as traffic levels rise, improved traffic management methods will be needed so that aircraft separation can be reduced and airspace can be used more efficiently with no degradation in safety.

The Hybride team has used what it terms "esoteric" approaches based on studies of "stochastic hybrid systems." Stochastic (or random) processes are

ones in which the next state of the environment is not strictly determined by the previous one. This is how the stock market and ATM systems behave.

Another objective the team tackled was to find ways to speed up "Monte Carlo" simulations by several orders of magnitude so that collision risk between aircraft could be determined quickly enough to be useful. Monte Carlo is a problem-solving technique that derives the probability of an outcome by running multiple scenarios using random variables. The aim is to determine what type of aircraft behavior creates a collision





The joint ATM conference here was the sixth of its type in recent years held with the backing of the FAA and Eurocontrol. There were nearly 70 technical papers, including first-time contributions from Australia, Japan and Brazil. A Mitre Corp. team was rated as having given the best presentation. Their topic was probabilistic congestion management (see Paper No. 8 at web address below).

Meanwhile, many challenges remain for researchers to achieve the breakthroughs needed to transform air traffic systems. This isn't surprising because, as Redeborn notes, Europe wants to create a system that's "ultra-green, ultra-secure, highly cost effective, efficient in terms of time and highly customer oriented." Clearly, the goals are lofty. Papers on airport and airspace management, human factors, environmental issues, air-ground cooperation, safety and other subjects are available at <http://atmseminar.eurocontrol.fr> ☒

risk, and avoid that behavior. Identifying potential conflicts early is key.

Hybridge consists of a variety of work packages, including modeling of uncertain systems, accident risk and conflict prediction. More than 80 technical papers produced in the first phase are available at: <http://www2.nlr.nl/public/hosted-sites/hybridge>

Ted Lewis, a Hybridge team member from BAE Systems, says it's valuable to apply a new way of thinking to air traffic management from a purely mathematical perspective. He notes there's work in progress for a second phase of the program.

Craig Wanke, the leader of a Mitre Corp. team that contributed a paper on "probabilistic congestion management" at a joint ATM conference last month, is also working on the uncertainty problem with FAA and in-house funding. He believes probabilistic methods could make contributions to improving traffic management as early as 2015. Wanke notes that several ATM specialists are looking into probabilistic decision-making in ATM for the federal Joint Planning and Development Office.

The Mitre paper outlines a simple model for forecasting flow with variable levels of traffic and changing weather. It does not include algorithms that would be needed to quantify the uncertainties involved. It would be very difficult for humans to make these calculations, Wanke explains, and the computers used in ATC centers will have to be faster to do the computations within a reasonable time. ☒

# AVIONICS

INSIDE

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**THE FAA MADE ONE SMALL STEP** toward a satellite-based navigation system on July 7 when it decommissioned 216 NDB approach procedures. But FAA spokesman Paul Takemoto notes that the actual decommissioning of NDB ground-based nav aids is farther down the road. Currently, he says, 80% of NDB services are provided by nongovernment entities such as airports, municipalities and state governments. "We're trying to reduce our 20% to a minimum." According to the Aircraft Owners and Pilots Assn., the decision on which procedures to terminate was coordinated with the general aviation community. In all, the FAA has proposed decommissioning 479 procedures, with the next set slated for elimination in September. AOPA asked that 60 of these be saved, and the FAA agreed to sustain 35 but gave no reason for canceling the remaining 25. AOPA plans to appeal the termination of at least five of the approaches because they offer lower minimums than the remaining ones at affected airports. AOPA supports the overall idea of terminating obsolete procedures—which, it says, will save the FAA \$8 million per year. This first step is part of "right-sizing" the National Airspace System, the subject of a recent Air Traffic Control Assn. seminar (*AW&ST* July 4, p. 44).

**CMC ELECTRONICS AIMS TO MORE THAN DOUBLE** its sales in five years, to more than \$400 million, according to Jean-Pierre Mortreux, the president of the Canadian company. In the past four years, CMC's revenues have grown 60% and should hit \$160 million this year. Meanwhile, staffing has increased 20%, to 1,000 employees. The growth comes at a time when CMC has won business as a systems integrator, complementing its traditional role as an avionics component and subsystem supplier. This shift in emphasis began in 1999 when CMC began providing integrated cockpit retrofits for the Boeing 747-200 and -300 for KLM, building on its role as a supplier of flight management systems. Now there are several hundred 747s flying with CMC integrated cockpits. Then Raytheon chose CMC to provide an integrated cockpit for the T-6B, a digital alternative to the avionics in the T-6A now in service with the U.S. Air Force and Navy. This cockpit 4000 configuration has become the basis for other, similar systems for Korean Aerospace Industries' KT-1 turboprop trainer and the Aermacchi M-311 jet trainer. The M-311 installation will include a CMC SparrowHawk HUD, multi-function displays, FV-4000 mission computers and other equipment. CMC is also providing flight management systems and head-up displays for a variety of helicopters. Mortreux says that while most of the projected sales growth will occur "organically," the company may make some additional acquisitions. In 2002, it completed the purchase of Flight Visions Inc. of Sugar Grove, Ill.

**GENERAL DYNAMICS CANADA HAS CHOSEN** Telephonics Corp. of Farmingdale, N.Y., to supply 31 shipsets of integrated maritime surveillance radar and Mk. XIIA identification-friend-or-foe hardware and optional spares. The contract, valued at more than \$50 million, also includes 20 years of service and support. First deliveries are set for July 2007.

**SN BRUSSELS AIRLINES PLANS TO CONDUCT** trials next year in receiving taxi clearances via data link at Brussels Airport. The airline is part of a consortium that will join with Belgocontrol for the tests. Other members include SITA, the Dutch National Aerospace Laboratory and BluSky Services (an air traffic management consultancy in Belgium). The airline intends to equip its fleet of more than 30 aircraft for the trials to demonstrate how the service can reduce congestion on voice channels and improve safety by reducing the possibility of miscommunications.