Opening new doors by mining aviation data linked to operating trends, a new FAA-industry program delves into safety vulnerabilities.

Preventive Fusion

BY WAYNE ROSENKRANS

Twenty U.S. airlines routinely analyze parameters of airplane operation captured by their flight operational quality assurance (FOQA) programs. Sixty-one have processes to rectify safety deficiencies identified by narrative reports submitted by pilots through aviation safety action programs (ASAPs).[1] These airlines for years have had measurable safety improvements, but none has had — until 2008 — a robust way to compare its safety performance indicators with industry benchmarks or with broader trends identified through the new Aviation Safety Information Analysis and Sharing (ASIAS) program, a collaborative effort
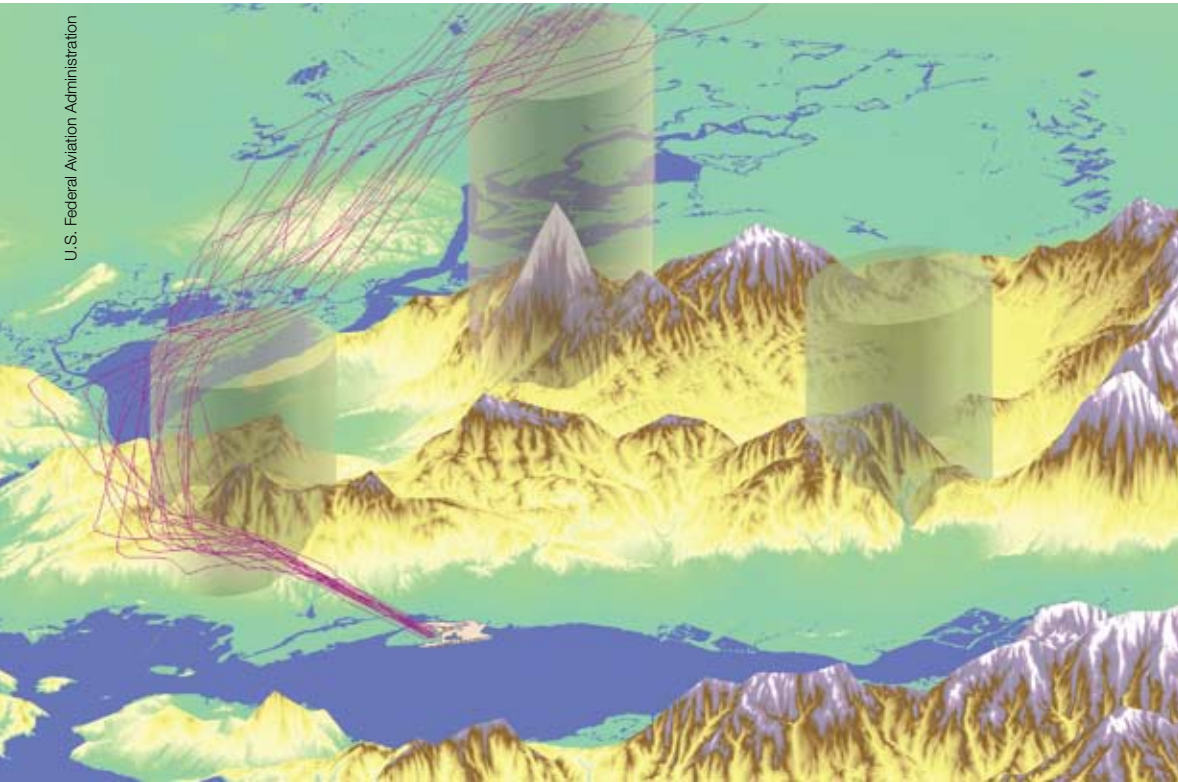
of the U.S. Federal Aviation Administration (FAA) and private-sector partners.

The FAA and airlines now have the capability to cross-query de-identified aggregate data distributed across private network servers and corresponding data on government servers. ASIAS analysts then make sense from results of this fusion of numerical data and narrative-text records. This nascent capability is expected to enhance the safety intelligence that airlines have gained individually with FOQA and ASAP, both voluntary safety programs (*ASW,* 2/08, p. 34-39).

FOQA data typically are shared with the FAA during quarterly briefings of

personnel from the agency's certificate management offices or flight standards district offices, covering trend analysis and corrective action plans without physical exchange of data, and during twice-a-year FAA meetings known as FOQA/ASAP Infoshare. ASAP reports from pilots, with some exceptions, typically are handled monthly by event review committees that include an FAA inspector, then are archived in a secure airline database and at the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS).

Each participating air carrier has primary responsibility for identifying

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The FAA and industry partners generate computer graphics, like this simulation, to combine radar tracks of flight arrivals, terrain maps and minimum vectoring altitude sectors.

threats and errors, taking corrective action and monitoring program effectiveness. Less well known, however, are details of how the FAA benefits from FOQA, ASAP and the other voluntary programs.

By the end of 2006, the FAA, NASA, government contractors and data-analysis companies had made headway with several proof-of-concept demonstrations, all to enable safety analysis by the FAA and industry at the national level. A high-level architecture for timely awareness of problems had been a key missing element, according to Jay Pardee, director, FAA Office of Aviation Safety Analytical Services, and Michael Basehore, Ph.D., FAA ASIAS program manager. Some prior efforts — such as Voluntary Aviation Safety Information-Sharing (VASIS) and the U.S. Commercial Aviation Safety Team (CAST), which both laid the groundwork for launching ASIAS in October 2007 — had grappled with the challenges of managing extremely large volumes of data, they said.

Multiple Breakthroughs

Among factors that make ASIAS possible are recent advances in the suitability of text-mining

tools in commercial off-the-shelf software and the long-sought capability to link weather conditions and/or air traffic control (ATC) environment to aggregated flights without compromising airline or pilot anonymity. The FAA assigned the Center for Advanced Aviation System Development at the MITRE Corp., its federally funded research and development center, to develop the high-level architecture and to synthesize new databases from a secure networked repository of remote databases.

"The primary responsibility for safety is still at the air carrier level, but the FAA has a responsibility to advance a coalition for information sharing beyond the capability of any single carrier, tapping into the industry's vast operational and technical expertise," Pardee said. "The accident at Lexington [Kentucky, U.S.; a Comair Bombardier CRJ100ER in August 2006] exhibited and emphasized the very low frequency of some threats … and the inability to detect them. This was the first fatal accident on a wrong-runway departure in 20 years [*ASW,* 11/07, p. 38–43]. When we went back to incident data during our subsequent wrong-runway departure case study — knowing what we were looking for — the significant disappointment to us was that there were 116 prior events, yet we did not see the Lexington accident coming. We identified 22 contributing factors and nine airport geometries that contributed to wrong-runway departures. Probably no single carrier's database would have revealed more than one event, if any. It was such a rare case."

The FAA considered this case study a breakthrough in narrative text mining. "We

were able to look at 5.4 million records — most in the ASRS, the U.S. National Transportation Safety Board Accident Database and the FAA Accident/Incident Data System — in 10 days," Pardee said. "That would not have been possible six to eight months earlier."

The urgency of analysis at the national level also has been driven by the forecasted near-tripling of the number of U.S. airline flight operations by 2025. "From a safety perspective, that means that we need to reduce the accident rate by an equivalent order of magnitude," Pardee said. "We are no longer looking only at repetitive/recurrent threats like controlled flight into terrain, loss of control or approach and landing accidents (*ASW*, 7/06, p. 26–39). Cross-querying databases did not exist at the refined level we have needed; we need to do it now automatically 24 hours a day, seven days a week."

Part of the task of ASIAS is developing safety vulnerability–discovery applications of text–mining tools and tools that manually or automatically can find trends, atypical events, exceedances and aberrations. "We want to transfer technologies and key data sources into the FAA's national distributed data archive," Pardee said. "We want to cast our net around as many databases as possible — including service difficulty reports and international sources such as the European Coordination Centre for Accident and Incident Reporting Systems — leveraging them to get the earliest indication of something to which we can draw the attention of the subject matter experts working for ASIAS."

Automated tools being developed at MITRE and elsewhere eventually will enable ASIAS to monitor databases. "We need to know the important emerging safety threats as they are occurring, or as early as we could possibly detect them," Pardee said. "Automated tools will flag any of the criteria that we direct them to flag. We expect to have the ability to cross-query for the presence of problems we think we already have mitigated through 70 CAST safety enhancements to make sure that, in fact, they have been declining in frequency, and they have not been exacerbated by changes to the National

Airspace System or increases in the number of operations."

Trends to monitor include the number of stabilized approaches at various points in the approach; circumstances of minimum fuel/emergency fuel declarations; and systemic factors involved in runway incursions, he said.
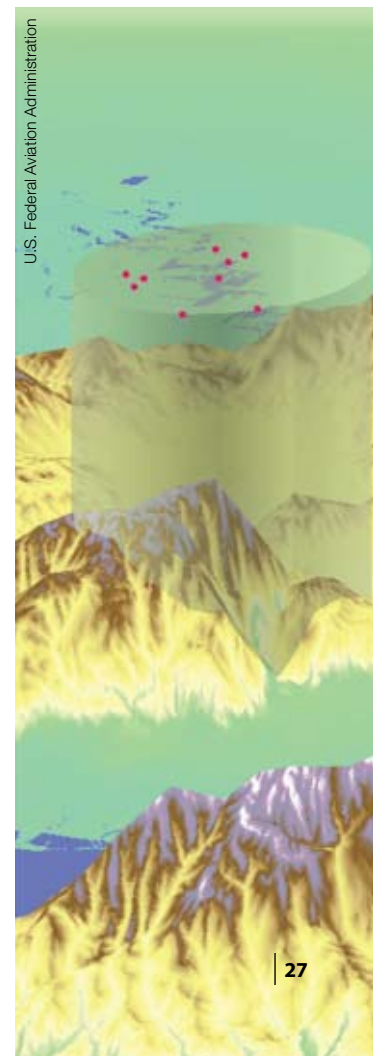
Directed by the government-industry ASIAS Executive Board, the ASIAS program focuses on known-risk monitoring, vulnerability discovery and directed studies.[2] The board determines priorities and where to send investigation results and analyses for follow-up action. As of April 2008, ASIAS had access to de-identified FOQA and ASAP data from seven airlines that operate under U.S. Federal Aviation Regulations Part 121; MITRE's national airspace data related to flight operations, weather, radar and air traffic; and the FAA's data on safety and air traffic trends. "Aircraft manufacturers are likely to be added in May 2008 and maintenance and repair organizations probably will follow within a few months," Pardee said. "ASIAS is in its stand-up phase and to a certain extent beginning to deliver safety products. The primary role of NASA has shifted to development work on vulnerability-discovery tools for ASIAS."

TAWS Alert Example

The ASIAS Executive Board can order a directed study, either on its own initiative or when an issue comes to its attention. In December 2007, the ASIAS Issue Analysis Team, the board's analytical arm, got the green light for its first directed study. Building upon the VASIS process and nearing completion as of April 2008, the study has been examining unexplained terrain awareness and warning system (TAWS) alerts at several mountainous-terrain airports in the United States. Any pattern of TAWS alerts is a red flag to the FAA because of the risk that pilots could become complacent about immediately conducting the escape maneuver. "That is a negative reinforcement of a safety warning system," Pardee said.

FOQA data had provided the first awareness of clusters of TAWS alerts, which are designed to prevent collisions with obstacles or terrain. Alerts can be triggered when, as ATC provides tactical

Simulated FOQA data, overlaid as magenta points, show where TAWS alerts occurred near a minimum vectoring altitude used by ATC above a mountain ridge.

radar vectoring, the aircraft has an excessive rate of closure with — or reaches a predetermined distance from — a hazard identified in the TAWS terrain database. Assignment by ATC of the minimum vectoring altitude (MVA) for an ATC sector, a predetermined altitude based only on a required 1,000 ft or 2,000 ft of obstruction clearance, complicates scenarios when the MVA is lower than the minimum sector altitude that the crew sees on paper charts or electronic charts.

"From FOQA data, we have known the event locations," Pardee said. "We have known the height above the ground from NASA space shuttle terrain database mapping and U.S. Geological Survey data. We have known the arrival procedures for the various ATC sectors at the airport … from FAA Standard Terminal Automation Replacement System radar data for

Fusion of FOQA data with air traffic data enables ASIAS analysts to investigate trends in airplane flap speed exceedances and late gear extensions.

arrivals, including the MVA portion of it. We have known which MVA areas were involved. Using FOQA data and FAA National Offload Program data — ATC radar traces — we have been able to correlate the locations where TAWS alerts have been triggered, and by overlaying the approach paths on one particular MVA area of interest, we saw what the typical flight arrival procedures were for a day selected at random."

Instrument meteorological conditions also have been suspected as a factor in how descents below MVA occurred. "Given the charted arrival and ATC vectoring procedures for arrivals from the east at one airport of interest due to weather, and actual weather at the time, we could see from radar traces airplanes penetrating one MVA on at least six arrivals for a particular date," Pardee said. "We have known from FOQA events at those latitude/longitude coordinates how to filter by this arrival flight pattern all the flight arrival data for any MVA penetrations. This showed that these, in fact, were the arrival tracks that actually produced TAWS alerts."

The reasons are still being sorted out, but ASIAS analysts so far have revealed several things. "For example, ATC instructed crews to make some very sharp turns to the airport and in arrival procedures, ATC set up some flights with difficult maneuvers required to round out the descent and not penetrate the MVA," he said. "ATC also gave some of the flights studied a high descent rate."

ASIAS also has been used to address concerns about the accuracy of specific terrain databases. "We see potential areas for improvement, such as to upgrade the algorithms in the TAWS box [equipment], to reconfigure the MVAs used by ATC for compatibility with the arrival flow from an ATC perspective," Pardee said. "Certain flight profiles lend themselves to TAWS alerts, and aggressive flight profiles during vectoring may make it more difficult for flight crews to avoid penetrating an MVA.

"We also think it makes a difference which version of TAWS software is installed, although none have MVAs embedded in terrain data. Later versions of TAWS software are more attuned to rising terrain and high descent rates. There also

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needs to be fine-tuning of MVAs and fine-tuning of arrival flight tracks. We need to make sure that all of these system pieces interact properly."

Investigation Without an Accident

Because of its fusion of databases and extensive use of subject matter experts, ASIAS research likely will begin to resemble the accident investigation process — *without* the accident, Basehore said. "We pull in the folks who are familiar with the avionics design, the mechanical design of the aircraft and its capabilities, as well as what ATC and pilots were doing at the time," he said.

During the first fiscal year of ASIAS, the FAA is keeping its scope of investigation narrow and trying to set realistic expectations internally and externally, emphasizing what can be done without major new expenditures by the government or air carriers, Basehore said. "That was an eye-opener to the industry," he said. "We want to demonstrate what we can do with tools that already exist and databases that are already out there." Pardee added, "We have taken on four critical problems, two directed studies, three airline benchmarks and four CAST safety enhancement indicators. We will document how they are done so they can be automated."

Striving for Harmony

To accomplish the ASIAS program's mission, the FAA has had to address not only the technical issues but building relationships of trust, implementing governance and policies that maintain the legal protection of data for safety purposes, convincing airlines and others of the value of participation and dispersing some of the investigative responsibilities among many non-FAA specialists.

From inside the FAA, ASIAS also leverages the expertise of the Air Traffic Organization and its resources, such as terminal radar control radar-track arrivals data, National Offload Program en route data, airport geometry data, Airport Surface Detection Equipment Model X data from more than a dozen airports and ATC national flow data.

"Some of these databases are sensitive and protected — FOQA, ASAP and the FAA's

radar-track data, for example," Pardee said. "An agreement in place with all the contributors cites the basic principle that the information is solely used for the purposes of safety, to drive safety decisions — not punitive actions."

Safeguards against misuse of data provided by airlines and other non-government suppliers include physically keeping source data at the suppliers, using "middleware" for one-way encrypted transmission of de-identified aggregate data only; and externally archiving all ASIAS-generated data at MITRE. For FOQA/ASAP airlines — and programs at counterparts such as the new ASAP for FAA air traffic controllers — a memorandum of understanding between MITRE and each data supplier details how data are de-identified, aggregated and digitally bundled for transmission to MITRE/ASIAS, including the conditions for its use by ASIAS.

Pardee and Basehore frequently meet with people who bring to the table a history of concerns about any voluntary program for information sharing with the FAA. Pardee said, "We have to say to them, 'This is a new deal, a golden opportunity. We can reconstitute all of the prior information-sharing programs — taking you to a place that you cannot go by yourself.' The suppliers of proprietary, sensitive data have knowledge of how their data is accessed and used. Various members of the ASIAS community are granted authority to generate queries based on the kind and nature of the data they submit. We make them part of the analysis teams because they have knowledge and expertise — and not just so that they can see that proper governance procedures are being followed." ●

For an enhanced version of this story, go to <www.flightsafety.org/asw/may08/asias.html>.

Notes

1. ASAPs also have been implemented for flight attendants, dispatchers and maintenance technicians.

2. The co-chairs of the board are the co-chairs of CAST: Don Gunther, senior director, safety and regulatory compliance, Continental Airlines; and Margaret Gilligan, deputy associate administrator, Aviation Safety, FAA.

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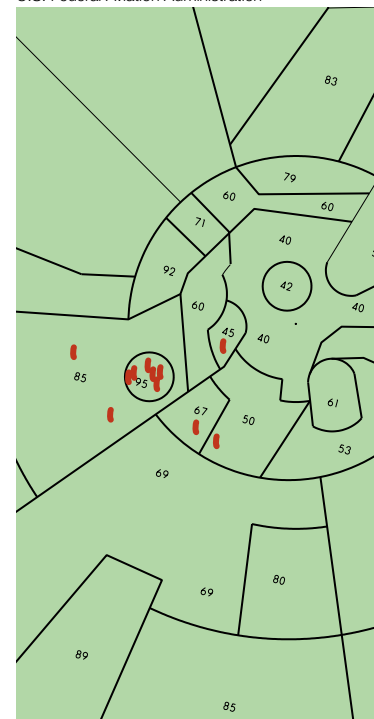
Simulated FOQA data, overlaid in red on an illustration of an ATC radar display, show that a sector with a minimum vectoring altitude of 9,500 ft, marked as "95," had the most TAWS alerts on the day studied.