This page intentionally left blank.

Heavy Lifting?

Australian pilots say that when flying small and medium-size airplanes, an RNAV (GNSS) approach means a heavy workload.

BY LINDA WERFELMAN

Many pilots perceive their workloads as heavier and their losses of situational awareness as more frequent when they use area navigation global navigation satellite system — RNAV (GNSS) — approach procedures than when they use most other instrument approach procedures, a report by the Australian Transport Safety Bureau (ATSB) says (see "RNAV (GNSS) Approaches"; Figure 1, page 48).[1]

The report, based on questionnaire responses from nearly 750 Australian pilots, said that, overall, the pilots believed that among instrument approaches, only nondirectional beacon (NDB) approaches involved similarly heavy workloads and reduced situational awareness levels.

One group of pilots, however, had a different opinion. Pilots of "Category C"[2] aircraft with faster threshold-crossing speeds and increased automation — predominantly high-capacity jet airliners, defined in Australian regulations as those certified as having maximum seating capacity of more than 38 seats or maximum payload of more than 4,200 kg (9,259 lb) — typically said that RNAV (GNSS) approaches were more difficult than only daytime visual approaches and instrument landing system (ILS) approaches. These pilots also reported fewer problems with situational awareness on RNAV (GNSS) approaches, saying that they had lost situational awareness less frequently while using RNAV (GNSS) approaches than while using most other approaches. ILS approaches and daytime visual approaches were associated with fewer situational awareness problems, they said.

The report cited several likely explanations for the divergent opinions:

> *Firstly, the Category C pilots mostly conducted RNAV (GNSS) approaches using autopilots and have more sophisticated*

Mark Wagner/aviation-images.com

autopilot systems and vertical navigation (VNAV) capabilities not available to the slower and less-complex aircraft. Secondly, … pilots [of high-capacity airliners] mostly conducted RNAV (GNSS) approaches inside controlled airspace, while Category A and B[2] aircraft [slower and less-complex aircraft] mostly operated RNAV (GNSS) approaches outside controlled airspace, where the latter increased workload levels during an approach. More detailed approach briefings and company approach procedures in high capacity airlines probably also contribute to the differences.

"Workload" was defined by the report as the number of mental and physical tasks that a pilot must perform, the complexity of the tasks and the time available for their completion. Researchers have found that increases in pilot workload typically result in decreased pilot performance, especially in cognitive matters.

The report said that although RNAV (GNSS) approaches — originally known as global satellite system nonprecision approaches — have become common in Australia since their introduction in 1998, they have been the subject of relatively little research, especially outside the realm of high-capacity airlines.

The ATSB, however, has investigated two fatal accidents that occurred in recent years while pilots were conducting RNAV (GNSS) approaches. In the first accident, which the ATSB categorized as a controlled flight into terrain accident, the pilot and all five passengers in a Piper PA-31 Cheyenne were killed when the airplane crashed during an RNAV (GNSS) approach to Benalla Aerodrome in Victoria on July 28, 2004. The final accident report said that the pilot "commenced the approach at

RNAV (GNSS) Approaches

An area navigation global navigation satellite system — RNAV (GNSS) — approach is a nonprecision instrument approach procedure that provides pilots with lateral guidance to a runway. This type of approach procedure was designed in the late 1990s.

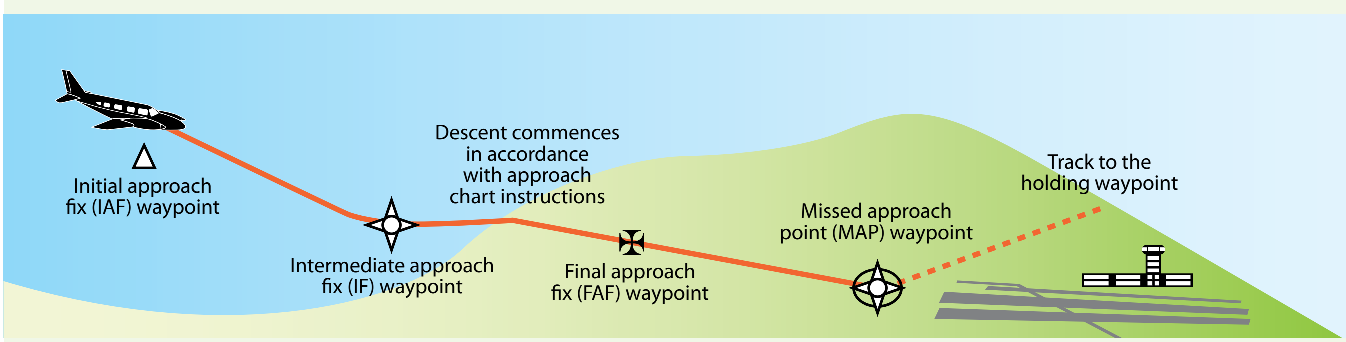
An RNAV (GNSS) uses "waypoints" — locations with specific latitude and longitude positions that are programmed into a global positioning system (GPS) receiver or flight management system (FMS).

In Australia, most RNAV (GNSS) approaches include five waypoints, each with a five-letter name. Within an approach, the first four letters of the waypoint names are the same, representing the three-letter airport identifier, followed by the direction from which the aircraft travels during the final approach. The fifth letter identifies which waypoint the aircraft is approaching, and the final four waypoints contain standard fifth letters — "I" for intermediate fix, "F" for final approach fix, "M" for missed approach point, and "H" for holding point when a missed approach is conducted.

To conduct an RNAV (GNSS) approach, pilots must select a preprogrammed approach in the GPS receiver or FMS and select one of several initial approach fixes (IAFs). The GPS or FMS then provides navigation guidance to the IAF, and a course deviation indicator on the GPS unit or on the instrument panel displays navigation error.

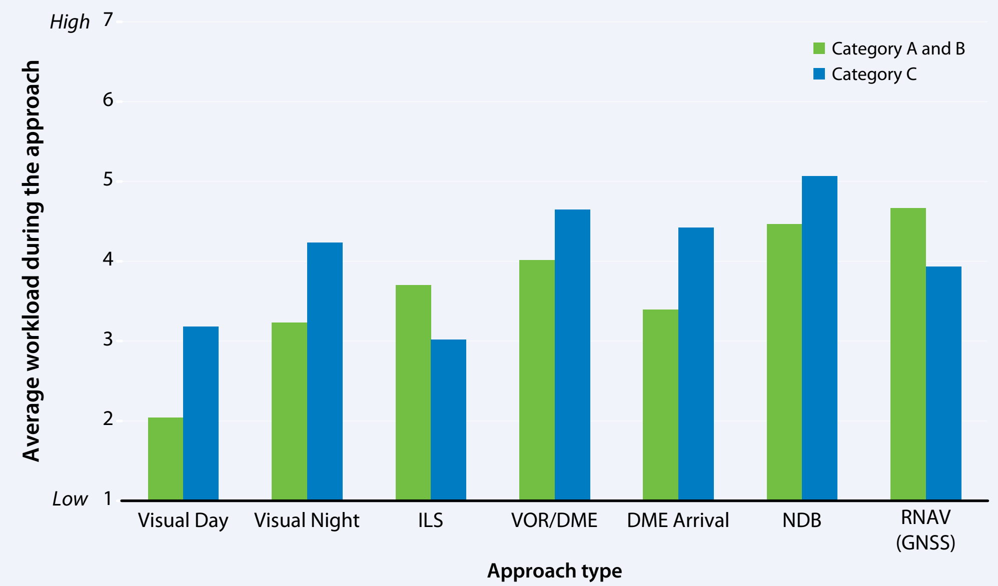
A 1996 decision by the Australian government and the aviation industry calls for RNAV (GNSS) approaches to be designed with waypoint distances of 5 nm (9 km) whenever possible. Standards established by the International Civil Aviation Organization call for descent paths of no more than 3.5 degrees for larger aircraft and 3.77 degrees for smaller aircraft.

— LW



Source: Australian Transport Safety Bureau

Pilot Characterization of Workload During Various Approach Procedures



DME = distance-measuring equipment NDB = nondirectional beacon ILS = instrument landing system
RNAV (GNSS) = area navigation (global navigation satellite system) VOR = VHF omnidirectional radio

"Category A" pilots are those who fly predominantly single-engine and small twin-engine airplanes. "Category B" pilots fly larger twin-engine propeller airplanes. "Category C" pilots fly larger, faster, more automated airplanes, predominantly jet airliners.

Source: Australian Transport Safety Bureau

Figure 1

an incorrect location" and was "not aware that the aircraft had diverged from the intended track."[3]

In the second accident, two pilots and 13 passengers were killed when a Fairchild Industries SA227-DC Metro 23 crashed during an RNAV (GNSS) approach to Lockhart River on May 7, 2005. The investigation was continuing, and an interim accident report said that items under review included "the design and chart presentation of RNAV (GNSS) approaches."[4]

The research from which the ATSB's RNAV (GNSS) report was developed was intended to enhance understanding of "the experiences and perceptions of RNAV (GNSS) approaches in Australia" from the pilots who use them. For this report, the responses of the pilots — each of whom had an RNAV (GNSS) endorsement — were analyzed.

Overall, the pilots said that they considered an RNAV (GNSS) approach as "safer than an NDB approach, [and] equivalent to a visual approach at night."

Overall, the pilots said that they considered an RNAV (GNSS) approach as "safer than an NDB approach, equivalent to a visual approach at night, but perceived it as less safe than all other approaches included in the survey," the report said. "However, … pilots [of the high-capacity airliners] differed, and assessed the RNAV (GNSS) approach [as] safer than most approaches, with the exception of the ILS and visual (day) approaches. [These] pilots indicated that automation, and vertical navigation functions in particular, increased safety."

The pilots expressed concerns about several aspects of the design of RNAV (GNSS) approaches, especially the absence of a reference for distance to the missed approach point on the global positioning system (GPS) or flight management system (FMS) display throughout the approach. In addition, they considered the limited distance references on approach charts to be inadequate, the report said.

"This response was common from respondents in all types of aircraft categories and was listed as affecting all areas of this survey," the report said. "It was one of the most common issues influencing mental workload, approach chart interpretability and perceived safety; influenced physical workload and time pressure assessments; and [was] the most common aspect of the approach that trainees took the longest to learn. The inclusion of distance to the missed approach point throughout the approach on the cockpit display and approach chart was also the most common improvement suggested by respondents."

The report said that 21.5 percent of RNAV (GNSS) approaches in Australia had "short and irregular segment distances, and/or multiple minimum segment altitude steps" — characteristics that were identified by the pilots as a major concern.

These characteristics were cited as "the most common reason pilots experience time pressures and were one of the most commonly mentioned contributors to mental workload, physical workload, lack of approach chart interpretability and perceived lack of safety."

Pilots from all categories said that RNAV (GNSS) approach charts were more difficult to interpret than charts for other approaches, the report said. The number of approaches conducted per year had no effect on the reported ease of chart interpretation. Among the reasons for the difficulty was the depiction of waypoint names with five capital letters and "only the final letter differing to identify each segment of the approach," the report said. This not only resulted in clutter on charts and on GPS and FMS displays but also increased the chances that a pilot would misinterpret a waypoint.

The pilots also said that the time and effort required to prepare for an RNAV (GNSS) approach exceeded the time and effort required for all other types of approaches.

Of all external conditions that might complicate the conduct of an RNAV (GNSS) approach, the most common was late notice of an air traffic control clearance to conduct the approach, the report said.

In evaluating their training in RNAV (GNSS) approaches, 86 percent of respondents said that their endorsement training had been adequate; the most frequent complaint cited by the other 14 percent was insufficient approach practice. Flight instructors said that the most frequent problem affecting their trainees was difficulty maintaining situational awareness, which the report said was "often related to becoming confused about which segment they were in and how far away they were from the runway threshold."

Forty-nine pilots — one in 15 — reported involvement in an event associated with an RNAV (GNSS) approach. The most frequent event, reported by 15 pilots, was a premature descent caused by misinterpretation of the aircraft's position. In addition, three pilots said that they had misinterpreted the aircraft's position but discovered the error before descending, four pilots said that they had descended below the constant-angle approach path and/or minimum segment steps, and five pilots reported other losses of situational awareness.

The pilots also cited attributes of RNAV (GNSS) approaches that they believed increased safety; the most frequently cited — by 30 percent of the pilots — was the runway alignment of RNAV (GNSS) approaches.

As a result of the study, the ATSB issued several recommendations intended to enhance the safety of RNAV (GNSS) approaches. Recommendations were issued to Airservices Australia calling for:

- "A study to determine whether the presentation of information, including distance information, on RNAV (GNSS) approach charts is presented in the most effective way;
- "A review of the 21.5 percent of approaches with segment lengths different from the 5 nm [9 km] optimum and/or multiple steps to determine whether some further improvements could be achieved;
- "A review of waypoint-naming conventions for the purpose of improving readability and contributing to situational awareness; and,
- "A review of training for air traffic control officers for the purpose of ensuring clearances for RNAV (GNSS) approaches are granted in a timely manner." A similar recommendation to the Civil Aviation Safety Authority of Australia (CASA) called for a review of pilot training to help ensure timely issuance of RNAV (GNSS) clearances.

ATSB also recommended that CASA conduct further research "to better understand factors affecting pilot workload and situational awareness during the RNAV (GNSS) approach."●

Notes

1. Godley, Stuart T. *Perceived Pilot Workload and Safety of RNAV (GNSS) Approaches*. Report no. 20050342. Australian Transport Safety Bureau (ATSB). December 2006.
2. The survey categorized four groups of respondents:
   - 145 Category A respondents flew airplanes with target threshold speeds of up to 90 kt, such as the Beechcraft 36 and 76, Pilatus PC-12, Cessna 182 and 210 and Piper PA-30;
   - 271 Category B respondents flew airplanes with target threshold speeds of 91 to 120 kt, such as the Fairchild SA227 Metro, de Havilland Dash 8, various King Air models and the Saab 340;
   - 231 Category C respondents flew airplanes with target threshold speeds of 121 to 140 kt, such as the Boeing 737 and other high-capacity jet airliners; and,
   - 42 Category H respondents flew helicopters. The relatively small number of responses "did not allow for reliable statistical analysis" within this category, the report said.
   - 58 respondents did not specify an aircraft type.
3. ATSB. Aviation Safety Investigation Report — Final. No. 200402797.
4. ATSB. Aviation Safety Investigation Report — Interim Factual. No. 200501977.