GNSS APPROACHES KNOW WHAT YOU DO !

APPROACH
The pilot on VH-TNP (right) may not have been suitably familiar with GNSS approaches.

By Michael R. Grüninger and Capt. Carl C. Norgren of Great Circle Services AG (GCS)

At 0906 Eastern Standard Time on 28 July 2004, a Piper Aircraft Corporation PA-31T Cheyenne aircraft, registered VH-TNP, with one pilot and five passengers on board, departed Bankstown, NSW on a private flight to Benalla, Vic. The pilot had submitted an instrument flight rules (IFR) flight plan for the flight to Benalla and return.

After changing the route in-flight and tracking along the coast, the pilot requested a clearance direct to BLAED, one of the initial approach points for the RWY 26L GPS approach. This routing was approved by ATC. The aircraft however did not track direct to BLAED. Instead it tracked 3.5 to 4 degrees left of the cleared track. The radar controller did not question this tracking discrepancy.

The pilot descended and commenced the approach, which was in uncontrolled airspace. Shortly thereafter the aircraft struck a ridge 34 km south-east of the airfield.

During the subsequent investigation it became apparent that the pilot had initiated the approach not over BLAED, the initial approach point, but at a point approximately 34 km south-east of the airfield. How could an experienced pilot with more than 14,000 flying hours loose situational awareness and not notice such a gross navigation error?

GNSS Approaches

GNSS approaches have been established in ever greater numbers in recent years as they offer a number of advantages compared to conventional, ground based approaches. Procedure design is more flexible and new approaches can be set up quickly. They do not require expensive ground navigation installations and hence offer large cost savings. These advantages have lead to a rapid increase in the number and the types of GNSS approaches.

Flying GNSS approaches however is not as straightforward and easy at it might seem. It requires diligent planning and careful execution by the flight crews in order to maintain awareness and to properly supervise the navigation equipment and the flight guidance system during the approach.

A Delicate System

GNSS approaches have high navigational accuracy as long as the integrity of the navigation sensor is assured. For this, on-board GNSS equipment is equipped with Receiver Autonomous Integrity Monitoring (RAIM). This function monitors the navigation information received from each satellite and ensures that the required level of accuracy for each phase of flight is achieved. If RAIM detects a satellite which is sending an incorrect signal, then the Fault Detection and Exclusion (FDE) function automatically excludes this satellite from the navigation position fix. This requires a minimum number of satellites available (4 for RAIM, 6 for FDE for most GNSS systems).

All GNSS approaches must be treated with the same level of caution as non precision approaches. Many believe that a GNSS is a straightforward and reliable solution to navigation. However, error and faults are common in this highly complex system. GNSS systems are delicate and need constant monitoring.

Vigilant Monitoring

The accident report concluded that the most likely cause for the gross navigation error was that the GPS had insufficient satellites to determine its position and had therefore continued in dead reckoning mode. In this mode the GPS maintains a heading based on the last available groundspeed and track. This could account for the divergent track.

The dead-reckoning mode would have been annunciated by a "DEAD RECKONING" message on the GPS display as well as a lit MSG annunciator on the instrument panel. In addition the "RAIM NOT AVAILABLE" message would have appeared. These two messages should have made the pilot aware that his GPS was not navigating based on valid satellite signals any longer.

When the aircraft was within 2 NM of the final approach fix, the APR annunciation on the GPS should have appeared. Without this annunciation, the GNSS approach may not be commenced.

At the FAF, the receiver checks for RAIM and if not available, displays the message "RAIM UNAVAILABLE – EXECUTE MISSED APPROACH".

At this point latest, the pilot should have realized that something was wrong and that he could not continue the approach.

When flying with a GNSS as a primary means of navigation if is of utmost importance that the pilot be familiar with the meaning of the messages which the GPS receiver can generate and that he is familiar with the actions required to be taken. He must know exactly when the GPS receiver is no longer available for navigation and must then revert to alternate means of navigation.

Even if the GPS does not generate any messages, it is good airmanship and a standard operating procedure with many operators to crosscheck position information provided by the GNSS with conventional ground-based navigation aids. In the case of the approach into Benalla, the pilot could have crosschecked the position of BLAED if he had followed the standard airway routing and then joined the approach at BLAED. The waypoint BLAED is on radial 221 from Albury VOR.

Also it was noted that the navigation database of the GPS was out-of-date. Flying with an out-of-date navigation database is not only poor airmanship, but is a potential hazard to the flight – and illegal. For commercial operators an out-of-date navigation database is an MEL item which requires rectification within a specified timeframe. Without an up-to-date database an aircraft is not airworthy.

High Workload

Although many pilots expect the workload associated with safely flying a GNSS approach to be lower than performing a conventional approach, this is incorrect. Although the level of automation might be higher, the level of monitoring required to safely perform a GNSS approach is as high if not even higher than on a conventional non-precision approach. This is reflected in a survey performed by the ATSB in 2007 where pilots perceived the workload on a GNSS approach as being higher than on any other type of approach. GNSS approaches can give pilots a false sense of safety. This must be counteracted with precise monitoring of system messages and cross-checks with alternate navigation sources. In turn the study suggested that pilots considered GNSS approaches to be safer than NDB approaches, but less safe than all other type of approach.

Pilot-Controller Co-operation

Another layer of safety which could have prevented this accident would have been a query from ATC regarding the tracking discrepancy. On numerous occasions these discrepancies were realized by the ATC controllers, but the pilot was never confronted with this issue. During the enroute phase, well above MSA, the tracking discrepancies did not pose an imminent danger to the flight. Only when the flight started the approach, did this position error become a threat. At that point the pilot had switched to the local Common Traffic Advisory Frequency (CTAF) and was outside of controlled airspace.

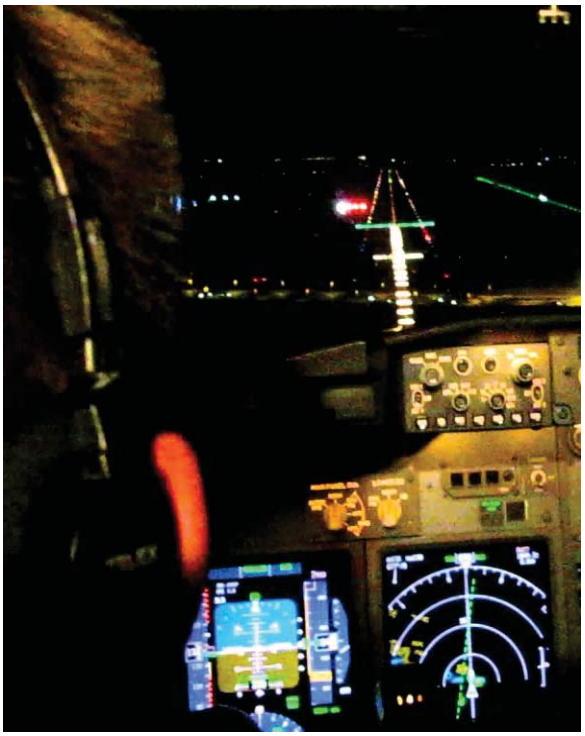
GPS = Get Procedures Straight

To ensure safe flight operations with GPS receivers including GNSS approaches clear and unambiguous procedures must be established for normal, abnormal and emergency operations.

Such procedures must be customized to the aircraft type, the installed navigation equipment and the nature of the operation.

Pilots must be trained in the handling of the navigation equipment including the handling of abnormal and emergency situations. This can be very challenging as many different types of GNSS navigation equipment have been installed in aircraft as post-modifications. Such modifications are often not available in the aircraft simulator. This means that GPS abnormal and emergency procedures cannot be simulated and trained in the flight simulator. Especially among business aircraft operators with older aircraft this is an issue. To compensate for this GNSS failures need to be trained onboard the aircraft to the extent this is possible (e.g. by deselecting GPS sensors or individual satellites in flight to generate the respective messages).

Only if pilots and operators Get their Procedures Straight can they benefit from the advantages of GNSS approaches without compromising flight safety.



PREVENTION
GNSS failures should be trained on board to the extent that this is possible.

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