Anatomy of a System Failure

How seemingly small deviations conspired in an approach accident.

BY SHAWN PRUCHNICKI

The aviation system is designed with many layers of protection against accidents. Examples of this "system resilience" include established procedures and standards. When an accident does occur, we need to closely examine from a system point of view not only *what* happened but *how* and *why*.

This might require that we understand how seemingly innocuous events acted synergistically to produce the system's total failure. The goal is not to find blame when examining the relevant human behavior but rather to understand why the choices that were made by those involved seemed reasonable to them at the time. Affixing blame offers no leverage for change and hence no opportunity to strengthen system resilience.

With this in mind, let's re-examine the Oct. 24, 2004, crash of a Beechcraft King Air 200 at Martinsville (Virginia, U.S.)/Blue Ridge Airport. The aircraft departed at 1156 local time from its home base in Concord, North Carolina, for the short instrument flight rules (IFR) corporate flight to Martinsville.

During the en route portion of the flight, the flight crew reported no problems to air traffic control (ATC). Upon reaching the Martinsville area, the crew was advised that they were second in sequence for the localizer approach to Runway 30.

ATC directed them to hold as published on the approach chart at the BALES locator outer marker at 4,000 ft and advised them to expect a 28-minute delay because of the preceding aircraft.

The crew reported entering the hold at 1224 while turning outbound in the holding pattern over BALES. Seven seconds later, they were cleared for the approach and told to report inbound.

The King Air crossed BALES inbound at 4,000 ft — 1,400 ft higher than the charted crossing altitude of 2,600 ft (Figure 1). The aircraft was 2 nm (4 km) past BALES — and 3 nm (6 km) from the end of the runway, where the missed approach point (MAP) is located — when the crew began a descent from 4,000 ft. They passed through 2,600 ft as they passed the MAP.

Radar Target Lost

About 1 nm (2 km) past the MAP, the crew began a further descent to 1,400 ft — 60 ft above the minimum descent altitude (MDA). The aircraft stayed at this altitude for about a minute until it was 8 nm (15 km) past the end of the runway, where the crew began a straight-ahead climb.

The crew reported the missed approach at about 1233 and was directed by ATC to maintain 4,400 ft. Three seconds later, the ATC radar target was lost.

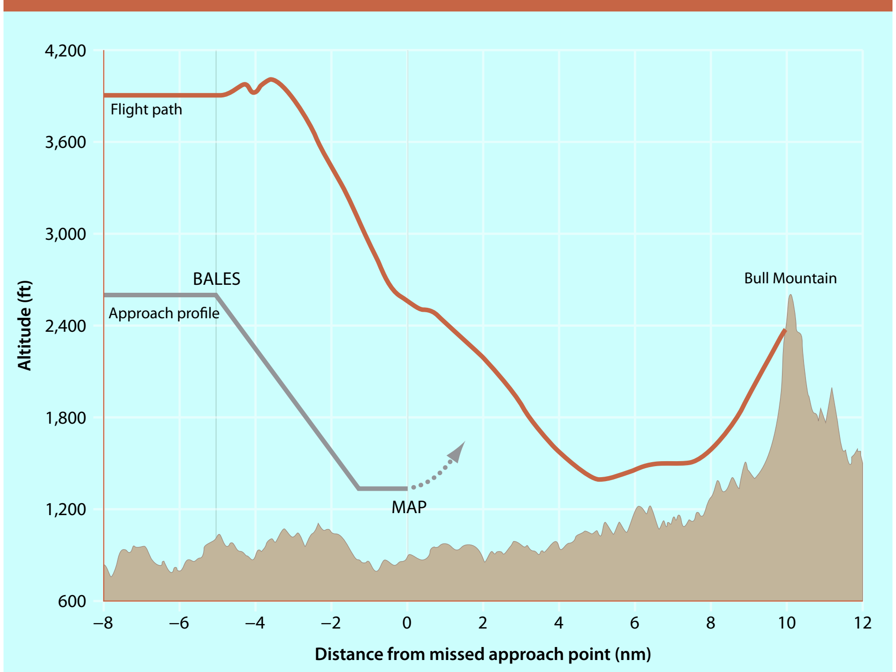
The wreckage was found the next day at 2,400 ft on Bull Mountain in Stuart, Virginia. Both pilots and the eight passengers had been killed.

Meteorological conditions recorded at the airport 15 minutes prior to the accident included calm winds, 5 mi (8 km) visibility and an overcast at 600 ft. A witness said that Bull Mountain was obscured by clouds and fog.

The U.S. National Transportation Safety Board (NTSB) concluded that the probable cause of the accident was "the flight crew's failure to properly execute the published instrument approach procedure, including the published missed approach procedure, which resulted in controlled flight into terrain."[1]

NTSB also said, "Contributing to the cause of the accident was the flight crew's failure to use all available navigational aids to confirm and monitor the airplane's position during the approach."

King Air Flight Path



Source: U.S. National Transportation Safety Board

Figure 1

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In visual conditions, Bull Mountain is a prominent feature on the extended centerline of Runway 30 at the Martinsville airport.

Closer Look

That told us what they failed to do, but the really important question is *why*. Let's take a closer look at the information provided in the NTSB final report.

The captain, 51, had been with the company more than three years. He had over 10,000 hours total time, with 210 hours in King Airs and 8,600 hours in Beech 1900s. Interviews with company personnel indicated that he was well liked, but one pilot said that she did not like to fly with him and that other pilots felt the same way. She said that he never wore his eyeglasses, although his medical certificate required them, and had a hard time reading navigation charts.

The first officer, 31, had been with the company almost three years. She had just over 2,000 hours with 121 hours in King Airs. She was described by fellow employees as easy to work with. No one expressed any concern about her flying abilities.

The pilots likely used a global positioning system (GPS) receiver as their primary navigation instrument during the approach. However, it was not certified for IFR navigation because the database was not current.

The descent profile that the crew flew was correct, except that they were 5 nm (9 km) off because they misunderstood the locations of BALES and the MAP. The aircraft did not have, and was not required to have, a cockpit voice recorder, so we can only speculate on how this happened.

To say that the pilots lost situational awareness would oversimplify the explanation and provide no true understanding of how this event unfolded. We must ask why they thought their flight path was correct and what systemic factors allowed this misperception to continue without correction.

First, let's examine the location of the GPS receiver, a Bendix/King KLN 90B. The unit was on the center pedestal between the seats, in the proximity of the pilots' elbows. To view the GPS display, each pilot would have to look 90 degrees sideways and downward. It is reasonable to assume that the location of the GPS receiver would have increased the already high workload of a nonprecision approach to minimums in instrument meteorological conditions (IMC).

Although it was stated company practice to use the GPS only as a supporting navigational device, the aircraft's flight profile strongly suggests that it was used as the primary navigational device.

Tipping Point

Past success in using a GPS that is not IFR-certified or has an out-of-date database as a primary source of information for IFR operations promotes future usage — and that is where the danger lies. In addition to the risks inherent in the outdated database, there is the possibility that other navigational aids might not be used adequately for course guidance.

Although it might seem to be a harmless transgression, a procedural deviation such as this could be the tipping point of a hazardous event that is developing without the crew's knowledge.

As part of the investigation, an NTSB official observed company pilots conduct the approach in an aircraft equipped with a KLN 90B. The demonstration flight revealed that as the accident aircraft crossed BALES and was turned to enter the holding pattern, the GPS unit would have autosequenced from the BALES waypoint to the next waypoint entered by the crew. NTSB said that waypoint likely was the airport. It is plausible that neither pilot recognized that the GPS had autosequenced to the airport waypoint.

The crew was expecting a 28-minute delay but were cleared for the approach while completing the procedure turn outbound at 4,000 ft. One can only wonder how well the approach was briefed at this point, considering the crew's mindset from the expectation of a significant delay.

Deadly Expectations

Another consideration in understanding the crew's mindset is that ATC also advised them that the pilot of the preceding aircraft had reported that he "broke out just below minimums [and had] good visibility below." This might have led the King Air crew to expect the same. Such a strong mental model of the environment can be a very powerful primer in forming expectations that affect our decision making and actions.

Was the crew really ready to begin the approach? Or did reliance on the GPS and the success of the previous aircraft in completing the approach suggest a guaranteed positive outcome? Such an expectation can be deadly in instrument conditions.

Now established inbound with a GPS that had autosequenced — without their knowledge — to the next waypoint, which was probably the airport, they began their descent to 2,600 ft as if they were still outside BALES. At this point probably nothing seemed amiss. They were approaching what they thought was BALES and were descending to the published crossing altitude.

The problem was that the aircraft had actually passed BALES before the descent to 2,600 ft was initiated. Unaware that a missed approach was in order, the crew continued until passing the next fix, which they thought was BALES. They began a descent to the MDA, 1,340 ft, and maintained a slightly higher altitude until they were well beyond the approach end of the runway.

Their persistence in staying at 1,400 ft as long as they did, apparently without navigational data for the MAP, might have been encouraged by a mindset based on the report by the pilot of the preceding aircraft of breaking out with good visibility. Perhaps they were expecting to see the airport any second. Maybe both pilots were looking outside, trying to find the runway, while in IMC and knowingly very close to the ground.

Eventually, they declared a missed approach. They climbed straight ahead instead of turning right, as prescribed by the approach chart for the missed approach procedure, and struck rising terrain at about 2,400 ft.

Treacherous Synergy

It is important to understand that none of the crew's actions in isolation was egregious enough to "cause" an accident. In fact, most of the decisions were based on what they thought was their correct location on the approach. Small variables — like having only one approach chart, the awkward location of the GPS receiver, the possibility that the captain was not wearing his eyeglasses, and the procedural deviation of using the GPS as the sole source of navigational data — created the synergy for an accident.

This is the nature of a system accident. It is not linear in causation; one event does not cause another event, and so on. A pilot can make seemingly innocuous deviations hundreds of times without event, which only serves to encourage similar decisions in the future. But, in reality, we never know how close we might already be to an accident; and these deviations further erode the built-in margin of protection until the system as a whole fails.

Sometimes, we deviate from standards to resolve conflicting goals and make the best of a bad situation. But, other times, it appears to those on the outside looking in that there is no clear answer to why a procedure was not followed. It does not mean that an answer does not exist but rather that we might be biased by the negative outcome of this event, making its absolute determination impossible.

Everyday practices and imperfections in our operations, plus the daily compromises practitioners must make in these systems — for example, having only one set of approach charts aboard the aircraft, or having important instruments in hard-to-see locations — can suddenly become very dangerous, preventing the capture of, and recovery from, an error that we may not have identified.

It is incumbent upon all of us to understand that, like the King Air crew, many pilots who have crashed probably had no idea that an accident was about to occur. They had no idea how much of their safety net had already eroded around them when they made seemingly innocuous choices based on the information in hand.

We should never intentionally give up a layer of protection and safety, because it might be the last one we have. We must follow the procedures and guidance provided for our operations, because someday we might have no idea how close we are to an accident.

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Note

1. Aircraft Accident Brief NTSB/AAB-06/01.