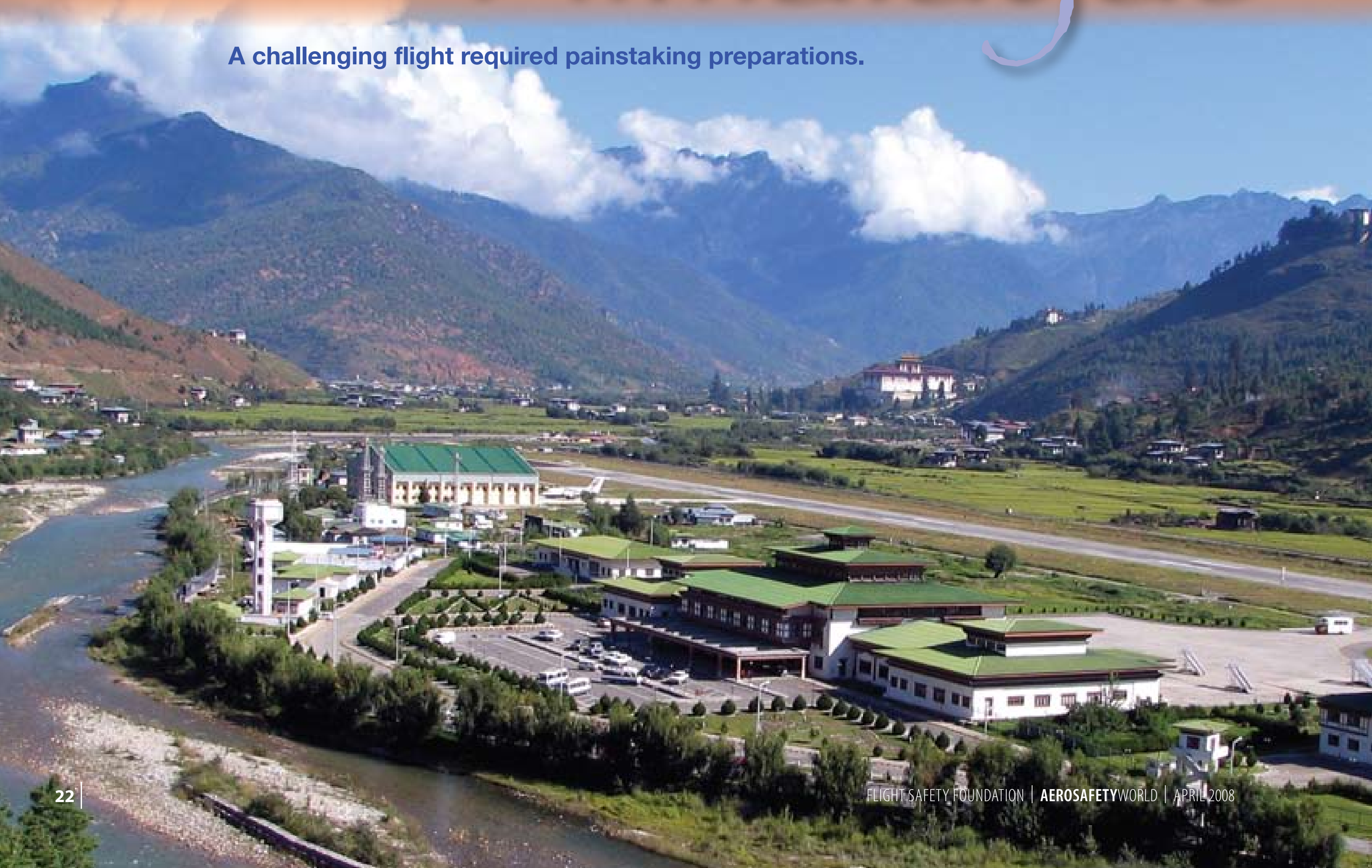
VFR in the Himalayas

BY PATRICK CHILES

A challenging flight required painstaking preparations.

Early in 2007, our company was approached about conducting an around-the-world flight that promised to be a real logistics challenge. The itinerary and time frame were daunting, but one location in particular gave us pause. Our customer needed to fly into Paro, in the Kingdom of Bhutan.

To say we were unfamiliar with the place would be an understatement — most of us had never heard of it. We knew Tibet, had even worked trips to Nepal, but never to the small, isolated country nestled between them. Our initial look at the airport was not encouraging. At an elevation of 7,300 ft, the airport is tucked ino a deep valley, flanked by 18,000-ft mountains. The only instrument approach was a very-high-minimums "cloud-break" procedure that did not even serve our approach category. One portion of the chart was filled with the type of terrain contours that immediately give one pause, but an equally large portion of the chart was blank and marked "Relief Data Incomplete." As far as we were concerned, it may as well have read "Here Be Dragons." Internet searches yielded photos of the airport environment that did not offer much encouragement.



At an elevation of 7,300 ft, the airport is tucked into a deep valley, flanked by 18,000-ft mountains.

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As our research progressed, we were fortunate to find an article in a 2003 issue of Boeing's *Aero* magazine describing technical demonstrations at Paro of a BBJ, the same type aircraft that we operate. The demos actually were flown in an aircraft that had originally been destined for our company. So, with photographic evidence of a BBJ in NetJets livery taking off from that very airport, with a majestic Himalayan valley in the background, how could we say no?

Not Been There, Done That

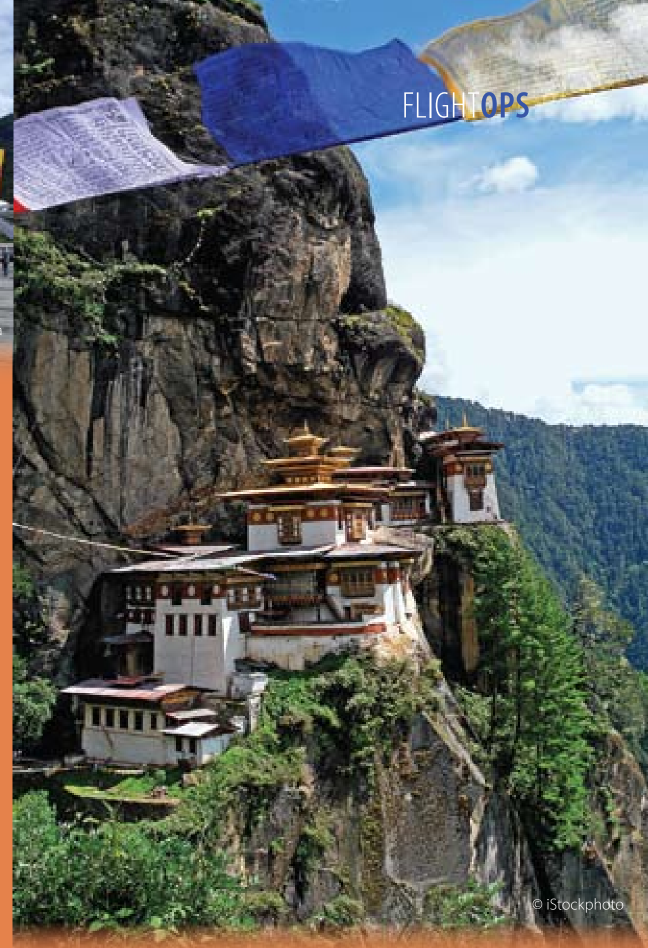
Of course, things are never that simple. A picture is no guarantee of success. The demo flights were conducted under the general operating and flight rules of U.S. Federal Aviation Regulations Part 91 — though their obstacle analysis went far beyond anything strictly required for Part 91. The procedures were validated by Boeing engineers and flown by their test pilots. Our company, on the other hand, would have to run this operation as a Part 135 charter, requiring rigorous procedure development and pilot training.

We first looked for the "low-hanging fruit" and investigated potential required navigation performance (RNP) procedures, such as those recently developed by China for Linzhi, one of Tibet's most inaccessible airports. As a matter of fact, the final approach to one of the runways in Paro looked remarkably similar to Linzhi. However, no such procedures existed — Paro is a daytime-only, visual flight rules (VFR) airport. There certainly would not be enough time to create and certify a new RNP approach — the trip was two months away.

So, our planning had to be based on the simple fact that the flight would have to arrive and depart in visual conditions.

VFR operations meant that we would have to carefully analyze our approach and departure paths, and set appropriate minimums. We obtained detailed topographic maps created by the former Soviet Union and terrain data from the U.S. National Aeronautics and Space Administration space shuttle radar topography mission (SRTM). The SRTM data proved to be an excellent source, with resolution down to 90 m (295 ft).

Initial attempts to develop an engine-out departure path focused on attempting a steady climb out of the valley with a minimum of turns. Our goal was to limit turns to a maximum of 15 degrees of bank. This led to a creative solution that clearly would not work, because it ultimately would have required a blind 180-degree turn around a 12,000-ft ridge, with no way to know what type of weather was coming up the valley on the other side of the ridge.



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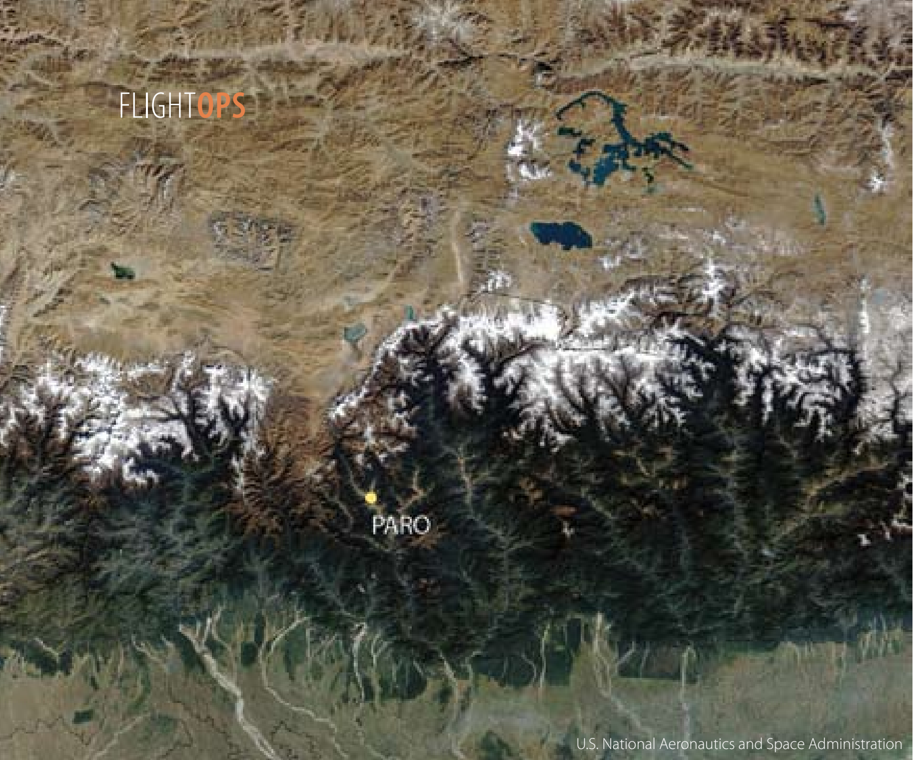

U.S. National Aeronautics and Space Administration

In a locale of Shangri-La proportions, Paro lies deep within the Himalayas.

This led us to have another look at the existing procedures. These departure paths were based on turns inside the valley walls at 25- and 30-degree banks, which we had hoped to avoid. But given the terrain and our engine-out climb capability, there was no alternative but to plan for turns inside the valley. We determined right away that it would be wise to use a greater allowance for lateral terrain separation than the regulatory 300 ft/90 m (*ASW*, 7/07, p. 26). The procedures we had seen had used a 500-ft/150-m margin, and that seemed a fine place to start.

As it turned out, there wasn't much room for breaking new ground in procedure design.

Terrain Dictates Flight Path

Planning for the flight out of Paro gave us our expected takeoff weight, which we used to make an early determination of V-speeds. This defined our climb capability and turn performance, so procedure development became an iterative process: fit the curves defined by weight and speed within the valley at the appropriate heights, with a 500-ft margin. The valley walls would define the path our flight crew would have to follow in the event of an engine failure before V_1 and a decision to continue the takeoff. Although we endeavored to not copy those who had gone before us, in the end the procedures were almost identical. The terrain is what it is — there was little margin for individual preference.

Previous experience in designing area navigation (RNAV) procedures at Eagle Regional Airport, high in the Colorado Rocky Mountains, prompted us to hire an outside vendor to assist in terrain evaluation and procedure design. ASRC Research and Technology Solutions' assistance and insight proved invaluable in validating our procedures. They were able to acquire the old Red Army topographic charts and applied three-dimensional stereo-imaging of overhead photos to confirm the charted contours and evaluate both man-made obstacles and naturally occurring obstacles, such as trees.

We made it a point early in our relationship to avoid leading the vendor to any one preferred conclusion. ASRC's analysis came to the same independent conclusion about the takeoff paths from Paro's single 7,332-ft (2,235-m) runway. This was also good for our comfort level; now we had three different analyses — Boeing's, ASRC's and our own — that arrived at nearly identical solutions.

Eyes in the Sky

While our chief pilot, Rick Weeks, and I worked on procedure design with ASRC, our director of safety and standards, Mark Atterbury, established contact with Bhutan's state airline, Druk Air. Their chief pilot, Dhondup Gyaltshen, was invaluable to our success. To obtain a landing permit at Paro, any private aircraft operator must train its pilots in a flight simulator that has a visual model of Paro or have one of Druk Air's pilots in the observer's seat during actual operations at the airport.

We elected to do both. Atterbury, who would serve as pilot-in-command during the trip, received training in a BAe 146 flight simulator at the BAE Systems, now Oxford Aviation Academy, facility in Manchester, England. The facility has one of only two visual simulator models of Paro; the other model is at the Airbus facility in Beijing.

Atterbury also flew to Paro as a cockpit observer in a Druk Air A319. While on the ground in Bhutan, he drove up the valleys from each end of the runway to identify landmarks he had seen from the air.

Flying the simulator, observing from the cockpit and arranging to have an experienced

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You probably associate the name Bruce Dickinson more with rock band Iron Maiden than with flight safety. In reality Bruce is just as happy piloting an aircraft as he is belting out heavy metal numbers and frequently takes the controls when flying from gig to gig on their latest world tour.

The Boeing 757 used for the world tour was converted by, and is leased from, Astraeus who use Flight Data Services (FDS) to monitor and manage their flight data.

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safety pilot in the jump seat gave everyone a high level of confidence that we could accomplish this trip safely and on our customer's demanding schedule. The simulator training alone would have been adequate for practicing the engine-out turns, but the safety pilot was crucial for getting there in the first place, because descending into the wrong valley reportedly was easy to do and could have disastrous consequences.

The visit to Paro provided a surprising revelation, which pointed out the limits of our comparatively academic exercise with the turn procedures. Despite the care we had taken to evaluate topography, our conclusions about the safest direction for takeoff were literally turned 180 degrees. Our analysis had led us to believe that departing on Runway 15 would be preferable, but the opposite was true, according to Atterbury's flight to Paro and look-around from ground level.

As he put it, "Runway 33 was the obvious choice since you could see the entire maneuvering area from the airfield, and it provided enough clearance to continue climbing while circling in the valley, if need be. Runway 15 could have you flying into weather not visible from the ground and then rely on the terrain mapping to stay out of the 'cumulogranite' buildups."

Back to the Drawing Board

A departure from Runway 33 would require immediate turns as soon as the aircraft reached the regulatory minimum of 50 ft above ground level (AGL). The most challenging turn would require a 30-degree bank to reverse course within the valley, back toward the airport, for a 228-degree heading change. We determined that keeping a maximum V_2 of 140 kt true would produce a turn radius adequate to maintain 500 ft of lateral separation and keep the deck angles within a reasonable value — this would allow the crew to visually avoid the terrain. This speed limit included a 10-kt margin for improved climb performance and stall protection in the steeper bank, recalling that the V_2 values in the aircraft flight manual provide stall protection for turns with 15 degrees of bank. Besides needing a higher speed for stall margin, the improved climb benefit was needed to ensure that the aircraft would clear a ridge at the end of the turn.

Once the required true airspeed for a given weight and flap setting is established, turn radius becomes a function of bank angle, regardless of the aircraft — a specific model's aerodynamics are relevant only to the loss of climb gradient within the turn.

This led to an interesting conclusion that fell outside the well-known takeoff performance limitations: field length, tire speed, brake energy, climb and obstacles. While obstacles and climb gradient were certainly driving forces, the takeoff effectively would be limited by turn radius and airspeed. Due to the turn clearance, it was critical to keep V_2 as close as possible to the established speed limit without exceeding it. That, in turn, drove the weight down to a hard limit to ensure the 140-kt "magic number."

This would allow us only about an hour's worth of trip fuel, not counting reserves. One factor that worked in our favor was that the Boeing demo flights had been performed at a thrust rating of 26,000 lb (11,794 kg) to emulate a standard-issue 737-700. The BBJs are rated to 27,300 lb (12,383 kg) thrust, which improved our weight off the runway over that of the demonstrator.

Limited Alternates

Other mitigating factors worked to narrow our window of opportunity. The weight-limited range would, of course, reduce our choices of destinations and alternates. There are few airports within range that could be used for either. If the weather went below minimums at these airports, the flight would be stuck in Paro until the weather improved. In addition, very high minimums had to be set for the visual arrival and departure. Finally, this trip would be operated just prior to Bhutan's monsoon season. Temperatures would be getting warmer, and winds in the valley are such that it is common practice to cease operations after 1000 local time even though the airport technically is open until sunset.

Because of this, we found it useful to gather all the historic climatology data that were available, and we contracted special forecasting services through our international handler, Jeppesen. We also used this information to evaluate the effects of unanticipated winds aloft on turn radius and climb distance.

Armed with this information, the simulator training and the site visit, the flight crew was able to safely make this challenging trip happen on schedule. Several other individuals and entities helped our success, particularly the authorities and airline employees at Paro. Only within the last few years has Bhutan been opened to expanded tourism. It is by all accounts a beautiful locale of "Shangri-La" proportions. We have since had more requests for trips, as have other BBJ operators I have met, and our European division has flown there twice this year.

Paro is certainly an excellent candidate for RNP procedure development. Until that happens, our experiences are presented here to the aviation safety community in the hopes of encouraging thorough training and rigorous analysis. ●

Patrick Chiles is technical operations manager for the NetJets Large Aircraft (BBJ) program and a member of the FSF Corporate Advisory Committee.