Offsetting for Survival: The Strategic Lateral Offset

When your navigation equipment is too accurate, you may need to add some SLOP to it.

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Implicit in human achievement from the moment our ancestors climbed down from the trees in the stand upright in the tall grass of the savannah has been the Law of Unintended Consequences. It works like this: Leave the arboreal sanctuary for the foraging temptations of the plains, and you increase your vulnerability to predation, perhaps winding up as some larger creature's lunch — and possibly leading to extinction of your species. Ten million years of evolution later, develop a satellite-based navigation system of unprecedented accuracy, and you increase the potential for a midair collision in the event of loss of vertical separation between aircraft operating at different flight levels on the same route or track. Thus, the Law of Unintended Consequences prevails.

The latter conundrum — a navigation system so accurate it could lead aircraft into physical contact under adverse circumstances — was confronted by the International Civil Aviation Organization (ICAO) in March 1997 when Reduced Vertical Separation Minimums (RVSM), in the program's first application to reduce vertical separation from 2,000 ft. to 1,000 ft., went into effect on the North Atlantic Track System (NATS). The satellite triangulation navigation aid, of course, is the Global Positioning System (GPS), lofted into low-earth orbit in the early 1990s, the use of which is now so ubiquitous that the system has evolved into a utility accessed by billions of people every day through multiple applications.

In terms of air navigation, GPS, through its constantly orbiting constellation of satellites, can provide positioning expressed in latitude and longitude so precisely that aircraft using it can track down the centerline of a route for thousands of miles with a drift error of a couple of meters.

In the pre-GPS era, when long-range navigation over oceanic or remote landmass areas was based primarily on inertial guidance and reference systems (INS/IRS), a wider tolerance of accuracy was the norm and drift was cumulative.

"My international flying started in the late 1970s when we were using INS," Paul Stinebring, retired director of international operations for a major U.S. corporation, told B&CA. "In the oceanic environment there was no updating. When you saw aircraft going by, they were hardly ever on the centerline — and neither were you."

Added Robert Swain, a retired United Airlines Boeing 777 captain who now consults for FAA contractor CSSI Inc., "In the old pre-GPS days, if I was within four miles of my course, that was considered accurate."

Thus, there was an almost unintentional built-in error tolerance that manifested itself in a course offset that greatly reduced the possibility of a midair collision. (The existing 2,000-ft. vertical separation in effect at the time also helped to mitigate wake turbulence and vertical contact in the event of clear-air turbulence [CAT]).

Navigating Very Precisely to the Wrong Place

But with the introduction of GPS navigation in the 1990s, that tolerance went away. "With today's accuracy, the aircraft are flying so precisely both altitude- and navigation-wise that it's virtually impossible to miss each other," Swain continued. In the late 1990s, mathematicians calculated that in the North Atlantic region and especially on the organized track system, "if everybody had GPS, the risk would increase 115% at that time. The target level of safety in the North Atlantic is 5 x 10^-4." When planners saw that they weren't meeting that target, there was even consideration of removing RVSM and reverting to 2,000-ft. vertical separation.

According to another CSSI consultant, retired FAA airspace management expert Roy Grimes, GPS's accuracy level "means when humans screw up, the airplanes can be navigated very precisely to the wrong place. The theory is that, for example, a pilot enters the wrong waypoint on a track into the aircraft's flight management system, so now the airplane is going to go where it's not cleared to go and is not protected or separated from other aircraft."

With GPS accurate within meters, Grimes continued, "If two airplanes are at the same spot and one shouldn't be there, then there is an increased chance..."
Offset Procedure

for a collision. That’s pilot error, but it can also be true of a controller error, where the controller sends two airplanes to the same place. An altitude error or a track error, it’s the same situation, two going to the wrong place and not separated.

In addition to the wake turbulence problem endemic to RVSM is the GPS-generated hazard of vertical overlap with all aircraft flying precisely on the centerline of a route or track. As Dave Stohr, president of Air Training International, explains, “Aircraft with 1,000-ft. separation converging or overtaking, above or below on the same routine or track, results in lateral overlap, so if you run into clear air turbulence with aircraft directly above or below, you could cause an overlap or, worse, a midair.”

All this came to the attention of ICAO, various civil aviation authorities, and the North Atlantic Systems Planning Group and its cohort agency, the North Atlantic Implementation Management Group, which define and oversee the NATS, in the late 1990s. It was obvious that the combination of GPS and RVSM — conceived to enhance efficiency and capacity in the world’s airspace — had inadvertently conspired to create a potentially hazardous situation.

Capt. Swain articulated it with an example: “If you were flying to London, you would enter the oceanic airspace at Gander, and all the traffic would be flowing in the same direction you were. Now, assume you’re cleared to climb to a higher flight level and, misunderstanding the controller, you climb to the wrong level. You will pop in between two airplanes that are at least 80 nm apart, and all will be at the same speed so you won’t overtaking another aircraft. In this scenario, there is one chance in 80 of a collision. But if the traffic flow is in the opposite direction, you would encounter 43 airplanes with a 1,000-mph closure rate and with each airplane within 30 ft. of your track. So the risk went out of sight.”

Thus, a need existed for a mechanism to redistribute traffic on heavily congested route systems like the NATS. Some type of lateral offset might be the answer, and a precedent actually existed.

“The progenitor program came into effect to mitigate wake turbulence in the mostly unidirectional North Atlantic organized track system after RVSM was implemented,” Madison Walton, aviation safety inspector for operations at FAA headquarters in Washington, told B&CA.

“There was a need for a methodology so that the aircraft causing the wake or the one receiving it could offset and get out of the way of the turbulence or mitigate it,” Walton, also a retired United widebody captain, continued. In the original offset program, a flight crew could fly a parallel course on either side of the route or track centerline at pilots’ discretion to get upwind of an overtaking aircraft to avoid wake turbulence. But “as time went on,” Walton explained, “we also needed an additional possibility to address vertical overlap — or the unfortunate possibility of two aircraft trying to occupy the same airspace — and that was when [planners] realized that in other areas than the North Atlantic, you would not have unidirectional traffic, and there was a need for a single offset [i.e., on only one side of track].”

American SLOP

Is there a chance that the Standard Lateral Offset Procedure, or some variation on it, will be authorized for use in non-oceanic U.S. airspace? The answer is a qualified, “Yes.”

While the FAA is not actively studying a domestic SLOP, B&CA has learned that at the ICAO level, an alternative dubbed the Advanced Strategic Offset Concept is being studied for the express purpose of implementation in domestic airspace among signatory countries (if they individually choose to do so). Reportedly, the offset would be more restrictive to accommodate closer domestic route separation.

The primary difference between domestic, or landmass, airspace and oceanic airspace is that the former is generally monitored by positive radar coverage and, in most developed countries, Mode C transponders advising ATC of aircraft altitude and position approximately every 12 sec. Thus, there is an existing mitigation of loss of aircraft separation with positive radar control. Automatic Dependent Surveillance-Broadcast (ADS-B) technology, destined to come on line in the U.S. and Europe in the next five years, will also be a factor in that it will transmit flight information every second. The addition of a lateral offset procedure will serve as a further enhancement to safety of flight in en route operations, especially as predicted traffic growth comes to fruition.

According to sources, a revision of Section 16 of ICAO Document 4444, Pans-ATM, accommodating the Advanced Strategic Offset Concept (or a renamed iteration) is scheduled for release in November 2014.
An Afternoon’s Work and the Need to Add ‘Randomness’

Enter the Strategic Lateral Offset Procedure, a risk-mitigating initiative with, arguably, the most unique acronym in aviation: SLOP. The procedure was developed by Swain and FAA airspace manager Dave Maloy during a break in an airspace design conference in 1998. “We knew the risk analyses the mathematicians had done and worked out SLOP based on their data,” Swain recounted. Due to its concerns about RVSM and GPS always putting an aircraft within 30 ft. laterally of the centerline of track, ICAO had considered a right-hand offset of 1 nm, but Swain and Maloy maintained this would not meet the math models for safety.

“After we conceived the new model, we had to sell it to the North Atlantic governing agencies,” Swain said, adding that the North Atlantic Systems Planning Group subsequently turned the plan over to ICAO. But while the procedure went into effect as a trial on the NATS early in the new century, ICAO would ultimately ponder SLOP for six years before approving it for worldwide oceanic and remote landmass implementation and adding it to its Standards and Recommended Practices (SARPs) in Document 4444, PANS-ATM, in 2004. Once implemented in the North Atlantic, the progenitor offset program was abolished.

What Swain and Maloy conceived was a procedure — performed at the pilot’s option — in which the aircraft, once established in oceanic airspace, would be moved either 1 nm or 2 nm to the right of course. As Grimes described it, “The idea is that you always offset to the right, and what they tried to do was to introduce some randomness in it, so they gave three positions: centerline, 1 nm right and 2 nm right and always to the right of centerline.”

The FAA’s Walton elaborated: “Before GPS, you were constantly correcting [in oceanic airspace], and so the traffic was laterally dispersed. Today, everyone is exactly on the centerline all the way across, so SLOP adds randomness to where the airplanes are — you have a probability of one [0.1] of encountering another airplane on the same route without SLOP.”

By casting the procedure as “strategic,” Walton claimed, “there is a randomness. You want to move off the centerline or spread the traffic out so, if there was a significant vertical or longitudinal deviation, the airplanes would pass without colliding. It came about by allowing the pilot to do it on a strategic basis whenever he or she decides and always to the right of the direction of flight.

“There is a Separation Standards Analysis Team at the FAA Technical Center,” Walton continued, “and its collision risk modeling shows that if we can get an even distribution of airplanes in the airspace for a single-direction situation and get half of the airplanes all the time using SLOP, we will cut the risk by 60% in relation to vertical overlap. In a bidirectional system, it decreases the risk by 60%.”

But here’s another interesting feature of using SLOP: Once established on the offset, aircraft can move around within the limits of the procedure (centerline to 2 nm right). “You are not expected to fly a single offset throughout the flight,” trainee Dave Stohr pointed out. “You can change the offset through the flight to avoid other aircraft — you can move as many times as you wish within the defined corridor. The overlap will exist with aircraft crossing over one another.

SLOP References

**Here are prominent references addressing the necessity for the Strategic Lateral Offset Procedure and how and where it can be flown:**

- International Civil Aviation Organization, Document 4444, Air Traffic Management (PANS-ATM), Chapter 16 (“Miscellaneous Procedures”), Paragraph 5. This is the source document for the justification, implementation, definition, and execution of the Strategic Lateral Offset Procedure in oceanic and “remote continental” airspace. The section is short and to the point, including:
  - That SLOP does not affect lateral separation minima and applies to both bidirectional and unidirectional routes.
  - Where SLOP is authorized, procedures to be used by flight crews will be promulgated in the aeronautical information publications (AIPs) of countries providing oceanic or remote landmass air navigation services.
  - The decision to apply SLOP is the responsibility of flight crews who are not required to inform ATC that they are using it.


- Federal Aviation Administration, Advisory Circular 91-70A, Oceanic and International Operations, August 2010, Chapter 3, Paragraph 9, page 39. Among guidance material in this AC are the following points:
  1. Identification of all oceanic airspace where FAA provides air traffic control services in which SLOP can be performed.
  2. Emphasizes that the procedure can only be flown via “automatic offset programming,” i.e., by the aircraft’s flight management system. If an aircraft’s FMS is unable to perform the offsetting function, the aircraft must...
Many Gulfstream pilots feel immune to the SLOP issue, saying they always fly above the tracks and they usually fly random routing. As you can see from the drawing, there is one problem with that argument. If you are on the track, chances are you are flying the same direction as your nearest neighbor and while the sky is considerably more crowded, the chance of a collision is reduced. The guy behind you might make an altitude error but he is behind you and likely to stay behind you.

You might be on the random track because you are flying an unusual city pair or for some other reason. But what if there is somebody flying the same city pair in the opposite direction? Now what if that guy makes an altitude error? Wouldn’t an extra mile of separation be nice?—“Eddie Sez”

on the centerline; that’s what they are trying to get away from with SLOP.

“Tactical” in the sense that it meant that if you were in proximity to another airplane and being overtaken, you could offset either left or right as your option. With today’s SLOP, the procedure dictates only a right offset.”

The fact that the procedure is not assigned by ATC was a caveat insisted upon by Swain when he and Maloy devised SLOP. “When we started doing this, one of the things I was adamant about was it would be the captain’s option,” Swain said. “The ATC people thought it would increase their workload and refused to have controller involvement. So we built the procedure such that it would be voluntary, and the controller would have nothing to do with implementing it. ICAO rules say you must fly the centerline and SLOP had to be worked out as an amendment to the SARPs.”

Nor is SLOP a “contingency” procedure, Stohr emphasized. “I attended the meetings of the North Atlantic Implementation Management Group around 1998 [where Swain and Maloy did their afternoon’s work conceiving SLOP]. “I pointed out that pilots would use it as a contingency instead of a procedure. The second thing they [ICAO] did that reinforced pilots looking at it that way is that they published it in Section 15 of Document 4444, the contingency section; later they moved it to Section 16, the miscellaneous section. Thus, after that, it could no longer be considered a contingency procedure. It continues to be at pilots’ discretion.”
Today, SLOP is authorized in just about all oceanic airspace, although Stinebring pointed out that the procedure is emphasized more in the North Atlantic region “because of the concentration of the traffic.”

According to Walton, “The FAA in all the oceanic airspace in which it provides air navigation services encourages the use of SLOP: the Gulf of Mexico, the West Atlantic Route System (WATRS), and all of New York, Oakland and Anchorage oceanic, which covers a lot of territory. The FAA Monthly NOTAM Book contains it, as well as appropriate publications for the various regions. It is a good procedure and it reduces risk.” (See sidebar for SLOP references.) In the commercial aviation sector, the International Federation of Air Line Pilots Associations (IFALPA) has encouraged its member pilots to use SLOP in oceanic and domestic remote airspace.

“It isn’t used in a radar environment for obvious reasons,” Stinebring said. “However, if you fly through a radar environment like Iceland, you will be authorized to continue the offset if you desire. All business aviation flight departments conducting international flying are including it in their SOPs. If you look at different air traffic facilities, especially in the North Atlantic, there is some inconsistency in their literature, but the thrust of it is that they all want you to do it. In China, even in a radar environment, they are assigning it — sometimes left, sometimes right.”

Stinebring recommended that operators heading abroad check the Aviation Information Publications (AIPs) of the countries in whose airspace they will be transiting to determine if SLOP-type offsetting is permitted or assigned.

How many aircraft are using SLOP? “As you can understand, since SLOP is a pilot procedure not requiring an ATC clearance,” Walton answered, “ATC has no way of knowing how many airplanes from which pilots use HF radio to make position reports are executing SLOP.”

However, aircraft equipped with the Future Air Navigation System (FANS) suite of Automatic Dependent Surveillance (ADS) and Controller Pilot Data Link Communications (CPDLC) avionics provide a record of course offsets via their automated position reporting in oceanic airspace. The technology is being adopted in increasing numbers: One air navigation service provider in the North Atlantic region claimed that 67.3% of 2012 flights it worked relied on data link for position reporting. Data from that ANSP for the period October-December 2012 yielded an estimate of 62.5% of the flights performing SLOP offsetting.

“Thus,” Walton said, “it is reasonable to estimate that 42% of the flights in the North Atlantic region fly 1 nm or 2 nm right of centerline of track (0.6739 x 0.625 = 0.4211).”

Get SLOPy: It’s a ‘No-Brainer’

Flying the Standard Lateral Offset Procedure is straightforward. “In my own experience, making some 400 transatlantic crossings,” Stinebring said, “once it went into effect, we used it all the time, and I personally flew it maybe 50 times. It’s a no-brainer. Once you select the offset function on the FMS, nothing looks different — the waypoint reporting is all the same, there’s no fuel penalty; it doesn’t cost you anything.

“For most operators,” he continued, “it becomes an SOP — as soon as you cross the oceanic entry point, you select it for the remainder of the crossing to the exit point, when you select it unless you have a clearance from ATC to continue it over domestic airspace and the radar environment. If you are not back on track, ATC may think you’re off course, and in a radar environment, particularly in congested airspace, it is important not to be off course in airspace with a 5 nm separation.”

Brad Baas, a Dassault Falcon 900 and 7X captain and former chairman of the NBAA’s International Operators Committee, reports, “Some pilots are hesitant to do [SLOP], as it induces the potential for an error on the other end if you don’t return to centerline as you exit oceanic airspace. You can’t offset until you reach the oceanic entry point. You don’t need ATC approval to do it, provided you follow the guidance on it.” This includes the requirement that the operator’s flight management system (FMS) must have the ability to program an offset (i.e., contain the relevant software).

“It’s pretty much a non-event,” Baas continued. “Another thing I’ve heard is that you typically want to do it if you’re following a larger airplane, and there is a chance for wake turbulence. It’s even recommended in a random route in North Atlantic airspace in case someone is off altitude. China has introduced it for domestic operations; once you are off your SID, they will assign it. Most training vendors teach it as a standard operation for oceanic airspace and remote landing areas.”

Emphasizing the logic of employing the offset procedure, Capt. Swain offered a chilling observation: “Had they been applying SLOP in Brazil, the 2006 collision between a Gol Airlines Boeing 737 and a Legacy business jet over the Amazon Basin would not have happened. Radar is great, but it isn’t perfect.”