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Coping With Hydroplaning

Although a rare occurrence, hydroplaning requires specific piloting skills. The author explains several techniques for negotiating such a circumstance.

Experiments have shown that, when operating on runways covered by just 0.1 inch of standing water, at certain speeds and tire pressures the reactive pressure of the displaced liquid will actually lift tires from the runway surface. Under these conditions, tire "spin down" and failure to "spin up," are well-documented phenomena, and though dynamic hydroplaning happens infrequently, pilots should still be aware of it. As aircraft get heavier and faster in the future and footprints get lighter because of lower tire pressure, the problem will become increasingly serious.

The only thing currently being done to alleviate this problem is runway grooving. Although grooving is helpful, it is still possible to hydroplane during landing if a heavy rain is in progress, or if the runway grooves are full of slush. The pilot's control of the aircraft is crucial during those five, 10, even 15 seconds when the aircraft is on a slick runway with no cornering forces available.

Cornering forces are related to the static friction produced by the tires rolling on the runway. This is what keeps the plane from being blown off the side of a dry runway by a crosswind. These forces decrease as the difference between ground speed and tire tangential velocity increase, i.e., as the tire starts to skid, the available cornering forces decrease. Depending on the numbers used, at approximately a 25 percent slip ratio, cornering forces drop to zero. Some of the older antiskid systems were designed to operate around 50 percent. During heavy braking with an older system, the pilot could lose cornering ability on even a dry runway.

Try This On For Size

Consider landing an airplane on a questionable surface in the following conditions: touch down is at 150 knots on an ungrooved runway with moderate rain in progress and a 15-knot crosswind. Hydroplane speed is 112 knots. Conditions are ideal for dynamic hydroplaning, and tires do not spin up at touchdown.

Obviously, in the case of a wing low approach, a portion of the lift from the wing is used to offset the crosswind. Assuming a right crosswind, the pilot holds right aileron to bank the aircraft into the wind and uses left rudder to align the fuselage with the runway.

Then, as the aircraft touches down, the wings become level and there is no longer any component of the lift vector directed against the crosswind. The airplane instantly begins to move with the airmass — across the runway towards the downwind side. This is aggravated by the left rudder, causing the relative wind to set against the right side of the fuselage and develop horizontal lift to the left. The aircraft is now in immediate danger of departing the downwind side of the runway.

A crab all the way to touchdown would have been a better way to approach this situation. During a crab approach, a portion of the speed vector is used to balance the crosswind.

As the aircraft touches down, nothing changes until the machine begins to decelerate. Then, since V speed is decreasing, the offsetting crosswind component is reduced. The resulting track is to the left. If no other action is taken, the aircraft will begin to move downwind (left, in this case) across the runway. It moves downwind because it is slowing. Anything that causes speed reduction can be regarded as a force towards the downwind side of the runway; whether *it is reversers, dragchute or just closing the throttles.*

Consider the situation another way. At touchdown, using the crab method, everything is in equilibrium until the aircraft begins to decelerate. The aircraft slows due to an imbalance of the forces when the throttles are retarded, drag exceeds thrust. The resultant is a force vector in the direction the tail is pointing.

Dragchutes and reversers merely increase the size of that vector and the rate that the aircraft moves towards the side of the runway.

The aircraft may not be slowed by any means unless the pilot can find a force to overcome the side-setting component of the deceleration forces. At this point, on a slick surface with no cornering forces, there is literally nothing to balance the crosswind and the forces causing speed reduction.

Enter The Cavalry — Relative Wind Effect

However, relative wind is another source of available energy. With no rudder or aileron applied in the above case, the relative wind will stay right on the nose. If the pilot applies right rudder, the relative wind will move to the left and the body forces generated will tend to push (actually, lift) the aircraft to the right; upwind across the runway. This causes a large increase in parasitic drag and also allows the pilot to use some amount of symmetrical reverse. *The total speed reducing forces that the pilot may use is limited only by the amount of horizontal "lift" that he can generate with the fuselage. Dragchutes* work against the relative wind while symmetrical reverse acts in the direction that the tail is pointing; thus, the turning moment generated by a chute.

An aircraft proceeding down the runway centerline with a slowly increasing crab angle will be fine until it slows enough for the tires to break though the water film and develop cornering forces. At that instant, the momentum of the aircraft is directed down the runway. According to Newton's First Law, it will tend to keep on doing just that. However, the cornering forces that are developed act at right angles to the direction the aircraft is pointed. The tires will try to drive the aircraft in the direction that they are pointed, i.e., very rapidly off the upwind side of the runway. When the tires finally dig in, the aircraft must be returned to runway heading immediately. Up to this point, all tricycle gear aircraft behave the same. From here on, however, there is a difference between large and small aircraft.

As the tires grab hold of the runway, they develop drag. Since the center of gravity is in front of the main gear and both the CG and the main gear are not on the same line of motion, the result will be a rotation — in this case, to the left. In physics, this is called a "couple."

The amount of rotation that results varies between large and small aircraft, as the magnitude of momentum is fixed by the weight of the aircraft. The amount of drag from the gear is, in fact, the weight on the gear multiplied times the effective coefficient of friction. On aircraft with single-track main gear such as fighters and business jets, the main tires all spin up together and drag develops relatively suddenly, providing a very pronounced tendency to return to runway heading.

Transports such as the 707 and DC-10 have multi-truck main gear, and the main tires do not come up to speed at the same time. There is typically a two to four second lag for the front main tires to spinup due to the difference in the water depth in which the tires are operating. This decreases the effect of the couple to the result that many large aircraft, such as the 707, 747 and DC-10, must be forcibly returned to runway heading. This is partly due to the fact that airliners are built to be stable and to always point into the relative wind.

Now Maintain Heading Control

Up until now, the problem has been track control; it now becomes heading control. Rudder alone is sufficient to straighten out most aircraft. At the high end of rollout speeds, most tricycle gear airplanes will steer in the direction of aileron throw. In an airplane with modulating spoilers, differential deployment of the spoilers will also act like rudder applied in the direction of the furthest raised spoiler. As a result of these last two factors, a pilot must be careful about "normal" crosswind aileron deflection (into the wind). The tendency to follow the aileron in some aircraft can override the rudder and cause the aircraft to weathervane into the wind.

Any discussion about heading control would be incomplete without a few words on nose wheel steering and differential reverse. Not all aircraft have reversers, but judicious use of differential reverse is a valid procedure.

The forces available from the nose wheels are directly proportional to the weight on them. To maximize these forces, after setting the nose down, the control column should be placed gently against the instrument panel and held there until the aircraft has slowed down to taxi speed. On slippery surfaces, a pilot must keep steering angles small in order that the nose tires do not "stall" and lose their cornering forces.

Although hydroplaning is a rare occurrence, when it does happen, a pilot has very little time to figure out a proper course of action. A 15-knot crosswind means an airmass moving across the runway at roughly 25 feet per second. If a Learjet pilot is in the middle of a 150-foot-wide runway, he has about three seconds to find a solution. In a 747, he has about two seconds.

When landing in extraordinary conditions like these, there are three opportunities to depart the runway on something other than a taxiway. First, there is the downwind side; then, the upwind side. Finally, if a pilot does not get rid of his speed fast enough, there is a chance at the far end.

Forewarned is forearmed. A pilot should know approximately what the hydroplane speed is for his aircraft and whether or not the runway is grooved. Remember, if you have never encountered conditions like these and you fly professionally, it is only a matter of time. ♦

Subtle Incapacitation

When the Captain's flying skills seem to lose their sharpness, there comes a time to realize a serious problem may exist. When does another crew member take action?

by

A First Officer

I was the First Officer on a trip to Los Angeles. The Captain was a man I had known for 28 years. We had flown together many times, and I suppose we had logged more than a thousand hours together. I considered him to be the finest pilot I had ever seen and one of the finest human beings I had ever worked with. My confidence in him and his ability was unshakeable.

Our trip was cleared to proceed direct to Santa Monica VOR and to cross Bayst Intersection at 10,000 feet. Center announced that we were overtaking the airplane in front of us and requested that we make a 180-degree turn to the right for a delaying vector. Several minutes later, we were cleared to make a 180-degree turn to the right and proceed direct to Santa Monica VOR and cross Bayst at 10,000 feet. After reading back the clearance, I noted a bank angle of 60 degrees and a rate of sink of 6,000 feet per minute. I sang out, "Watch your bank angle." The Captain acknowledged, "OK, " but allowed the attitude of the airplane to remain as it was.

On at least two previous occasions, I had observed airline captains execute 60-degree-bank turns. It was unpleasant, unnecessary and contrary to rules, but not unheard of. I could not understand why he had found it necessary to make such a radical turn. I concluded that he was angry with the delay vector and that it was the intemperate act of an angry man. I had never seen this man behave like this before, but perhaps he was under personal stress I was unaware of.

The remainder of the approach was normal, and the touchdown was smooth. Passenger reaction was bad — several complained of circus flying and said so. I was embarrassed. The Captain made no comment. The remaining five legs of the trip were flown without incident.

One week later, I was flying from Los Angeles to San Francisco with the same captain at the controls. He held the airplane on course heading, even though we encountered a strong west wind, which should have been countered with at least 10 degrees of drift correction. I mentioned several times that we were off course and made many comments about the strong west wind. He acknowledged all of my comments but made no corrections. Three times Center called and gave us vectors to get back on course.

San Francisco was VFR, and we were cleared for a visual approach to Runway 28, cross Dumbarton Bridge at 4,000 feet or above. The bridge was several miles in front of us. When I noted our altitude of 3,800 feet, I said, "We are cleared to cross the bridge at 4,000," and he acknowledged, but the airplane continued to descend. When the airplane reached 3,600 feet, I said loudly that our altitude was 3,600, and we were supposed to cross the bridge at 4,000 ftee. He levelled off, and we crossed the bridge at 3,600 feet.

In the Boeing 737, we often encounter landing weight problems on short runways. Medford, Oregon, is a place where summer heat and restricted flap settings make landing a very precise operation. I had often marvelled at the way this man could put an airplane on the end of a runway so he had maximum runway for braking and stopping. I mention this because he now began a visual approach to Runway 28 below glideslope, and I assumed he was practicing his low approach.

When we passed 500 feet agl, I began to comment that we were low. I continued to talk about how low we were until we reached 200 feet, and I began to yell, "We are too low!" I noticed the rate of climb go to zero, and we held our altitude, but the airspeed began to decay. I began to sing out airspeeds, and then I yelled, "We are at reference speed!" He applied some power, but not enough; the airspeed continued to decay, and my callouts became frantic. The stick shaker began, and he instantly applied more power.

The airspeed increased, and the touchdown was smooth. I was shaken; I thought I was going crazy. The greatest pilot I had ever known was flying like a student, and he did not even seem concerned or upset about it. He was oblivious to our danger and even made several comments to the fact that I was becoming overly critical.

The Second Officer and I walked into the terminal, and he said, "What are we going to do about this?" I said, "I don't know what to do. This man has the finest record on the airline, and if we go into the office and tell them what happened, they will never believe us." He said, "Thank goodness the next leg is yours."

The next day we departed Eugene, Oregon, for San Francisco with the Captain at the controls. He maintained an airspeed of 250 kt. through 10,000 feet and then allowed the airplane to accelerate to 280 kt. for the next few minutes. We were cleared to 33,000 feet.

After leaving 20,000 feet, we were IFR in the clouds and some light chop when I noticed the airspeed begin to decay. It is not unusual to trade a little airspeed for altitude, if you feel that an expedited climb will give a smoother ride, and I assumed that was what he was doing.

The airspeed continued to decay until it reached the point where I found it necessary to comment. Because of his remarks about my being overly critical, I had reverted to the old military system of hand signals to alert him to his oversights, and I began to point to the airspeed. He turned and looked at me and said, "What are you pointing at?" I said, "My airspeed." He said, "Well, what about your airspeed?" I said, "It reads 200 knots." He said, "So what." I said, "That's much too low." He said, "Oh," and pushed forward slightly on the wheel, and the airspeed began to increase, but several minutes later, it was decaying again, and soon we could feel the air burbling under the wing, and we knew this to be the pre-stall burble.

By this time, the Second Officer and I were both looking at him, and he looked at us and, with a big smile on his face, said, "Whatever do you think that is?" We knew that he knew what it was. Any student pilot would have known. He then, laughingly put the autopilot on altitude hold, and the airplane began to accelerate, and the remainder of the trip was normal.

The Second Officer and I discussed the flight. He shared my fondness for this man, but something had to be done. We wondered if he was testing us in some way. He seemed so unconcerned and disinterested that it was obvious he was not aware of any problems.

On the ground and in the air, his speech patterns were normal, and his pleasant, good humor was unchanged.

I knew one thing for sure. I could not fly with this man again. I was a nervous wreck. The Second Officer said, "What happens if we drop the trip, and he ends up with a couple of less experienced crew members — it could be deadly."

We decided to tell our troubles to the flight office. The office requested a medical examination, and my friend of 28 years was found to have a brain tumor.

In retrospect, with the whole series of events placed together, it is easy to diagnose illness as the cause, but when these incidents come one at a time, covered with a blanket of perfectly normal behavior before and after each incident, it is very deceiving. Had I been flying with anyone else, I certainly would have been a great deal more aggressive in demanding correction. I should have taken the airplane on the low approach at 500 feet, but don't forget that this man had been my friend for 28 years — and confidence like that is very hard to shake.

ACCIDENT PREVENTION