COMMERCIAL AVIATION SAFETY

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rare in such settings. Little mistakes do not cause high damage. Although USHRIs have drastically minimized errors compared to other industries, they have also been working on it for a while and are benefiting today from the disasters and efforts of yesterday. Figure 1-1 shows a captain operating the flight guidance panel to maneuver a modern airliner in the proximity of high mountains above South America. Over a century of safety improvements have made the commercial aviation industry ultrasafe, but is it safe enough?

Before going any further into commercial aviation safety, it is important to understand that there is a difference between what is considered an incident and what types of events are actually termed an accident. The term *incident* is somewhat ambiguous because there is not a general agreement of what it entails. The Federal Aviation Administration (FAA), National Transportation Safety Board (NTSB), and International Civil Aviation Organization (ICAO) all have different definitions they use to describe incidents. Simply put, an incident is something that happened during the operation of an aircraft which did or could affect the safety of operation but which did not rise to the severity of an accident. An incident could include a crewmember not being able to perform a normal flight duty because of injury or illness, an in-flight fire, or a flight control failure. In contrast, an accident is an occurrence that involves some degree of injury or damage related to the operation of an aircraft. There are different variations of the definition of an accident,

FIGURE 1-1 Flying a modern commercial airliner near the Andes Mountains of South America.

but ICAO's definition is the most widely accepted in the commercial aviation sector. There are four types of accidents identified for the commercial sector according to ICAO:

- *Major accidents*—occur when an aircraft is destroyed, there are multiple fatalities, or there is a fatality coupled with a substantially damaged aircraft
- *Serious accidents*—happen when there is either one fatality without substantial damage to an aircraft or there was at least one serious injury and an aircraft was substantially damaged
- *Injury accidents*—nonfatal accidents with at least one serious injury and without substantial damage to an aircraft
- *Damage accident*—characterized by no one getting killed or seriously injured, but an aircraft receiving substantial damage

WHAT IS RISK?

In the context of safety, risk is the combination of the severity of a dangerous condition or event and the probability or likelihood of that event occurring. For example, is it risky to walk barefoot across a field that has snakes? It is not risky at all if the field has nonvenomous or low-venom snakes, assuming you are not terrified of snakes and have a panic attack. But the same act with highly poisonous snakes in the field, such as cobras, can greatly increase the severity and therefore the risk. That explains the severity of the situation, but what about the likelihood of injury?

If there is one cobra in the field, and you only have to cross the field once, then the likelihood of injury is quite low. If there are a dozen cobras in the field and you have to cross the field once, the likelihood of injury may be deemed moderate. However, if there are a dozen cobras and you have to walk across the field to get to work every single day, then the likelihood of injury may be seen as very high. So the lowest risk is when there are no venomous snakes or low-venom snakes (low severity) and very few of us crossing the field only once (low likelihood), and the riskiest situation is having cobras (high severity) and many of us facing the cobras often (high likelihood). If you can avoid walking across such a field in the first place, you have eliminated the risk. But if you must cross the field, perhaps you can change the severity or the likelihood so that it is in your favor . . . so that you lower the risk. To mitigate the risk, you can change the severity of the threat by wearing tall boots, and you can change the likelihood of injury by crossing the field less often.

Aviation safety follows similar risk management principles. Let us take a regional airline operating in sub-Saharan Africa with service into an unpaved airfield. The airfield's eastern edge is very close to the shore of a large lake. However, there is a hazard posed by crocodiles that like to sun themselves on the runway. The larger crocodiles often hunt at night and like to sun themselves in the morning and early afternoon. The younger crocodiles are too intimidated by their larger

kin and only sun on the runway when the larger crocs have left, which is usually around 5 pm when the larger crocs go back to the water for the night's hunt.

The severity of the hazard is related to the speed at which the aircraft could impact a crocodile and the size of the crocodile. The likelihood of collision could be explained as the times when the aircraft comes close to impacting a crocodile when operating at the airfield. Imagine that you have been hired by the airline, and the vice president of operations calls a meeting to discuss safety. He asks the question, how can we improve safety at the crocodile airfield? Some of the airline employees, when faced with such a question, may answer, "That's easy, we just shouldn't fly there." But safety is not about impeding a task, it is about mitigation of risk or doing it better. After all, the population in the area near the airfield depends on the scheduled air service for medicine, supplies, and personal transportation. What would you suggest to the vice president?

If you understand the concept of severity and likelihood in risk, you may recommend any of the following, or all of the following:

- Reduce the likelihood of an encounter by contracting a local to scare the crocodiles off the runway for your time of landing and takeoff. That may require a brave employee!
- If winds allow, land and takeoff from the western part of the runway to reduce the likelihood of running into crocodiles.
- Operate into the airfield after 17:00 hours but before sunset so that you reduce the *severity* of any collision with crocodiles, since you will probably only hit the small crocs and not the large ones. It is prudent to operate only during daylight hours so that you can see any crocodiles on the runway.

As you can see in the previous example, aviation safety is nuanced and requires significant study in order to be used effectively as a way to enhance operations versus as a way to say "no" to operations. Given the size and complexity of commercial aviation, it is no wonder safety is a major topic. Looking at some statistics helps break down just how large aviation operations are and just how many opportunities there are for safety to decay. IATA reported that 3.3 billion people flew in 2014 and projected this number would increase to 3.5 billion on more than 50,000 routes in 2015. Every day, it means that over 8 million people are in the sky on more than 100,000 flights. There are more than just people moving through the sky, as pilots transported 50 million tons of cargo. Transporting people and goods resulted in a $2.4 trillion international economic footprint that supported 58 million jobs globally. When taking all those numbers into consideration, it is astonishing that in 2014 there was only one major accident for every 4.4 million flights. How is it possible to operate so safely?

The growth of the aviation industry is not forecasted to slow down, either. The ICAO Regional Aviation Group expects the Latin America and Caribbean airline industry to grow 5–9% yearly into the foreseeable future. Currently, the airline industry in this region creates $158 billion in revenue and 4.9 million jobs, with an

anticipated growth to $289 billion and 9.8 million respectively by 2032. Likewise, Airbus predicts current airline traffic is supposed to more than double by 2034 for the Asia-Pacific region. Worldwide in 2014 there were 47 aviation megacities, locations that have more than 10,000 daily flights that are between 6 and 12 hours. In 2034, this number may rise to 91 megacities.

Most importantly, it is essential to understand why we care about commercial aviation safety. First and foremost, human life is involved, often in significant numbers and also often involving not just passengers but bystanders on the ground. Ensuring people do not get hurt is a main priority. Second, when safety deteriorates, it comes with financial implications. These can come in the forms of lawsuits, insurance claims, and stock instability.

Nothing illustrates this point better than the story of the Boeing 787 Dreamliner. The aircraft contained a lithium ion battery unit in the aft electrical bay. The battery was designed to start the auxiliary power unit and provide backup lighting for the aircraft. In January 2013, there were several instances of this battery catching fire. A relatively minor problem, but when paired with a brand new aircraft type that was trying to gain purchase orders, major consequences followed. Within hours of the news about the battery, Boeing lost $2.6 billion of its company value in the stock market as jittery investors started worrying about the future sales of the aircraft. That is "billion" with a "B." Some companies and governments will incur huge financial impacts just in order to prevent safety from degrading or to prevent the appearance of not taking safety seriously. When Iceland's Eyjafjallajökull Volcano erupted in April 2010, the industry cancelled around 17,000 flights per day due to unsafe flying conditions. In turn, this resulted in $200 million losses a day. However, one aircraft loss would have been far more.

SAFETY PHILOSOPHY

Philosophy is the study of reality, existence, and the nature of knowledge. Although it does not take a philosopher with deep thoughts to define safety philosophy, there are quite a few concepts about the nature of safety that are not obvious. Unfortunately, there are industry professionals who believe, quite incorrectly, that safety is merely common sense. At its core, safety is about making life better by addressing unacceptable risks. Something seemingly so simple turns out to have many nuances. Let us debunk some common myths about safety:

- *Accidents happen to stupid people.* People may think "I'm not stupid, so I have nothing to worry about." Wrong! Accidents can happen to anyone if the right conditions are there because often external factors outside of one's control combine to work against an individual. For example, a ramp agent may say that the engine area is clear and prompt the pilot to start an engine for departure, only to realize when it is too late that a baggage cart was too close to the engine intake and was sucked into the engine, causing millions of dollars' worth of damage.

- *If it isn't broken, don't fix it.* Very often, we may think something is not broken, but there are often numerous unknown factors at work that may not be in optimal condition. For example, when asked about the condition of their aircraft prior to a flight, some pilots think they are funny by saying, "Well, I figure if it flew in, it will fly out!" Such a statement shows a pilot's ignorance to the many unknown factors that can prove the statement wrong, such as fluid leaks, ramp collisions, and ground icing; any of which could result in a fatal crash of the aircraft after takeoff.
- *If it hasn't been a problem before, then it isn't a problem.* This mindset is a slippery slope. Just because a certain factor has not been an issue before does not mean we should ignore it. There is always a first for everything. For example, modern engines are designed to minimize failures that affect the rest of the aircraft, other than the loss of power. Furthermore, one system failing should not cause another system to fail. But in November 2002 the pilots of Qantas Flight 32, flying an Airbus 380, experienced an uncontained engine failure that also severed electrical wires, hydraulic lines, and a fuel tank.
- *You have been sufficiently trained.* If employees are sufficiently trained to do everything, we would be training our whole life and never have time to move passengers around the world. Determining what situations to include in the training curriculum for airline professionals is extremely challenging since we cannot be sure of what situations may be faced. For example, in September 2010 the captain of UPS Flight 6, flying a Boeing 747-400, had an oxygen mask failure while attempting to manage an inflight fire. Both pilots perished in the ensuing crash. It is inevitable that we will face situations we are not expecting.
- *Safety is our top priority.* Safety should always be on our mind, and we should strive to operate safely at all times, but let us not kid around, the top priority of any commercial venture is profit. The stockholders and managers of an airline do not place safety as the top priority because the best way to guarantee that an airline is safe is not to fly. Well that would not make much business sense, would it? The question is not how to achieve safety, the question is how to operate and achieve profit objectives in a safe manner. Having said that, we must remember the story of the Boeing stock price plunge due to a safety event and acknowledge that there is a direct link between safety and profit.
- *Accidents are impossible to predict.* Although Chapter 14 will address research efforts underway to create short-term prediction of accidents, it is currently outside of our capability to predict specific accidents with any degree of accuracy. However, that is not to say that we cannot recognize developing accident chains by noticing the presence of undesirable factors. It is not uncommon after an accident for certain employees to comment, "Yes, it was obviously an accident waiting to happen." In the minds of such employees the factors that created the accident were obvious to them, yet nothing was done to address the factors, and an accident ensued. Often we see a threat but rationalize that it does not pertain to us, leaving the threat lingering. Some threats are obvious, while some threats are not. The same threat may create an accident in one flight, just an incident in

another, and have no adverse impact to another flight. So types of accidents and their causal factors are not impossible to predict, but specific accidents to include when and where they will occur are outside of current predictive capabilities.

- *Weather is a leading cause of accidents.* This myth creates much debate in the aviation industry. Adverse weather is often a factor in accidents. However, those who are purists about accident causation stress that weather cannot be deemed a causal factor in accidents. That is because in accident theory, as shall be covered in the next chapter, accident investigations should produce prompt, remedial recommendations written to prevent future recurrence. For example, if wind shear was a factor in an aircraft accident, we cannot write a recommendation against the wind shear because weather cannot be prevented. So instead of determining weather as a cause it is often the human role in reporting or avoiding weather that is deemed causal. For example, if an aircraft crashes on approach due to wind shear, and the crew was completely unaware of wind-shear conditions due to a malfunctioning wind-shear warning device at the airport, the cause of the accident would not be the wind shear itself but may be faulty inspection protocols for the reporting equipment.
- *There is often a single cause behind an accident.* This is a blatantly false myth. In fact, just the opposite is true. Accidents are complex events stemming from multiple causes. It is quite challenging to think of any accident that only had one cause. Anyone who says so probably has not looked into the factors that contributed to what they believe is the single cause. Historically, accidents were often conveniently written off by deeming the cause to be "pilot error" or "maintenance error" and taking minimal further action. The public was relieved to know that a single "bad apple" had created the problem, and the aviation world could return to business as usual. Clearly more is going on to cause accidents than just bad pilots. In fact, a series of negative factors combine to create accidents. Often the flight crew is only the last link in the chain of factors prior to an accident. Over the past few decades, investigators have shown that accidents usually have more than one cause, and each cause carries the same amount of importance. In fact, in 1994, the NTSB began listing probable causes in the accident report, thus the genesis of the *multi-causality* concept. Digging deeper into the causes allows investigators to determine the root cause of why things happened the way they did. One byproduct of this investigative exposé has been the decreased use of the myth of pilot error and realizing that there are flaws in the whole system.
- *Accidents are "Acts of God."* Above we mentioned that many people tend to think that accidents are impossible to foresee. For so long, we thought accidents just happen. They were mysterious occurrences that no one could control. In many parts of the world, to this day, after accidents people can be heard claiming that the event was an "act of God." Doing so brings psychological comfort because it removes ties to the truth that most accidents are preventable, if the right people are provided the right tools at the right time. Those tools may come in the form of information, technology, training, or procedures. As humans, we need to embrace the concept that we are masters of our own safety destiny by relying on scientific

tools such as forensics and logic to understand accidents, and then apply the lessons learned from prevention. Yet corners of the planet still embrace the purported inevitability of accidents, and such archaic thoughts do not just stem from the uneducated. For example, managers of Nepal's state-run airline in 2007 sacrificed two goats to Akash Bhairab, the Hindu sky God, in order to resolve a technical problem with a Boeing 757. After the ritual a senior airline official reported that "the snag in the plane has now been fixed and the aircraft has resumed its flights," without explaining what the actual problem had been.

In stark contrast to simply shrugging shoulders and leaving safety up to non-human forces, modern aviation professionals should be trained to actively search for negative factors that are coming together that could potentially create an accident. There are several challenges, however. We are constantly surrounded by such signals. Recognizing which signals should be acted upon can be challenging. Nevertheless, there are several conditions that are often notorious precursors to accidents, as listed below. There are many other such preconditions, but for now we will only address these five:

- *Distraction*. Aviation professionals can let other things affect their concentration, such as checking personal text messages during a preflight check.
- *Rushing*. Someone may take a shortcut. When we do this, we are not giving our personal best and we risk missing key information and skipping items that may not seem important now but that could prove critical in a few moments.
- *Operating outside one's training*. Accidents can occur when we find ourselves doing something outside what we are trained to do. We often know that it is something we have not been trained to do and make a conscious decision to do it anyway.
- *Desensitization*. It is easy to tune out warning signs when it is something that frequently occurs and which have not resulted in problems in the past. The problem is that the context may be different today, and therefore today may be the day that the warning applies.
- *Ignoring your instinct*. That expression may not sound very scientific, but it essentially means that something does not feel right. Professionals should not feel uncomfortable when they are doing a task. If something does not feel right, it may be our protective instinct kicking in and recognizing that an unresolved discrepancy or problem is lurking in the background, ready to ruin your whole day.

Safety Ethics

A discussion of safety philosophy would not be complete without delving into ethics. As aviation professionals, detecting precursors is an ethical obligation to making decisions. When an accident occurs, it is not uncommon to hear someone say,