MANAGING RISK

BEST PRACTICES FOR PILOTS

DALE WILSON | GERALD BINNEMA

FOREWORD BY JOHN J. NANCE

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This book is dedicated to the memory of Bob Chapman, Ruth Chapman, Teena Daly, Jeffrey Helzer, Al Merali, Danny Penner, Graeme Seath, and Terry Townsend who, like the aviator and author who penned the following words before his life too was tragically cut short in an aircraft accident, *"…slipped the surly bonds of earth…put out [their] hands and touched the face of God."*

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Foreword

BY JOHN J. NANCE

"Every item on this checklist," I recall one of my instructors saying with great seriousness, "...was written in blood." In other words, someone had to die to get any one of them included.

He was so right, but that truth goes far beyond the authority of checklists and Standard Operating Procedures. In fact, what my IP was pointing to was the invaluable process of avoiding accidents and incidents by absorbing lessons generated by the bad experiences of others.

In a nutshell, that's what this book is about. *Managing Risk: Best Practices for Pilots* certainly weighs in as an extremely well-written and readable work, but what Dale Wilson and Gerald Binnema have produced constitutes far more: It is, in fact, a definitive and invaluable roadmap through a landscape of shattered airplanes and lives in which the telling of each and every incident offers a very real pass to avoiding the same fate.

And given the authors' long and substantial experience training new airmen, investigating accidents and teaching others about flight safety, it is thoroughly authoritative.

Have you ever watched the reaction of a group of pilots—airline, military, or otherwise—when someone casually tosses down a new NTSB report on an air accident or incident? Usually there's a polite scramble to grab it, and the reason is clear: We know that NTSB Reports ("Blue Covers" by the colloquial name) contain a wealth of information about something that went wrong, and we know the information in that publication can, if absorbed and understood, almost certainly guarantee we won't go down the same disastrous path. While NTSB Blue Covers are *species specific* to a given occurrence, the book you're holding is an easily-absorbed distillation of hundreds of accidents and incidents and

a century of evolved knowledge, all for the purpose of imparting experience-generated lessons, methods, and procedures to keep you alive.

And, by the way, knowing those lessons is not just a convenience, it's an obligation for every airman.

Whether you're a newly-minted student pilot or a grizzled veteran with tens of thousands of hours logged, the process of continuously studying and refreshing the knowledge necessary to safely operate air machines is part of the job. This book is an easy and enjoyable way to keep yourself up to speed on the categories of, and the fixes for, the many risks we face. I strongly suggest you read it, tab it, and keep it handy!

John J. Nance
Author of "Blind Trust," "Pandora's Clock," and 17 others.

Acknowledgments

The authors owe a debt of gratitude to our family, friends and colleagues who have supported us in this endeavor. We especially thank our mentors, those pilots—and non-pilots—who encouraged, supported, cajoled and critiqued us as fledgling aviators: Ivan Pettigrew, Jeanette Ritchie, David McKenzie, Joy Carscadden, Harold Faw, and John Horine. Each of you embody what it is to be a positive role model—we couldn't have done it without you.

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We especially thank John Nance—veteran Air Force pilot and airline captain, prolific author, and a person both authors have admired as one of the world's foremost experts in air safety—for providing valuable feedback and writing the *Foreword* to this work.

Most importantly, we acknowledge and thank God for always being there for us.

About the Authors

Dale Wilson, M.S., is Professor of Aviation at Central Washington University in Ellensburg, Washington, where he teaches courses in flight crew physiology and psychology, threat and error management, aviation safety management, and aviation weather. He holds a Master's degree in Aviation Safety from the University of Central Missouri and a Bachelor's degree in Psychology from Trinity Western University in British Columbia, Canada. He has held several professional pilot certifications including: Airline Transport Pilot, Certified Flight Instructor, Advanced Ground Instructor, and Instrument Ground Instructor from the Federal Aviation Administration; Master Flight and Ground Instructor from the National Association of Flight Instructors; and Airline Transport Pilot License and Class I Flight Instructor from Transport Canada. He has been a pilot for more than 30 years and has logged several thousand hours in single- and multi-engine airplanes in the United States and Canada. He has also served as an Aviation Safety Counselor and later as an FAA Safety Team representative for the Spokane Flight Standards District Office. His primary research interests include visual limitations of flight, pilot decision-making, and VFR flight into instrument meteorological conditions. He has published more than a dozen articles in scholarly journals and professional aviation magazines, and has given numerous safety-related presentations to pilots at conferences and seminars in the U.S. and Canada.

Gerald Binnema, M.A.S., is a consultant in aviation safety, based in British Columbia, Canada. He provides human factors training and assists in developing effective safety management systems for a variety of organizations, including international airports, airlines and helicopter operators. Prior to this he served as an Air Accident Investigator with the Transportation Safety Board of Canada (TSB) and as an Aviation Safety Officer with Transport Canada. Mr. Binnema also worked as a flight instructor and in Africa as a missions pilot. He holds a Master's degree in System Safety from Embry Riddle Aeronautical University and a Bachelor's degree from Trinity Western University. He has also studied human factors at Lund University in Sweden. He has been a pilot for more than 30 years and holds a Canadian Airline Transport Pilot License (ATPL); a Class 1 Flight Instructor rating; multi-engine, float, and instrument ratings; and a Glider Pilot License and Glider Instructor rating. Mr. Binnema has published several safety articles in aviation publications, including Transport Canada's *Aviation Safety Letter*, and has delivered hundreds of seminars on crew resource management, pilot decision-making, and human factors.

Introduction

This book is for every pilot who wants to avoid an aircraft accident. Whether you are a private pilot who flies a homebuilt aircraft on sunny weekends, an aspiring commercial pilot attending a collegiate aviation degree program, a first officer at your first job at an airline, or a seasoned pilot with thousands of hours under your belt, this book will help equip you with the information you need to successfully manage many of the major risks associated with flight.

The title of this book—*Managing Risk: Best Practices for Pilots*—captures its essence: it documents and describes most of the significant risks associated with flight and, more importantly, provides best-practice countermeasures that you as a pilot can use to avoid or mitigate them.

Flying involves risks. Fortunately, over the history of aviation, most of these risks have been identified—often through tragic losses—and have been managed down to remarkably low levels. Rather than deny the existence of these risks by burying one's head in the sand like the proverbial ostrich, the key is to acquire a thorough knowledge of them and the strategies necessary to identify, eliminate and/or reduce them to acceptable levels. Because "pilot error" is responsible for the majority of aircraft accidents, and because you can't treat an illness without first knowing its cause, this book is as much about discerning the *internal* human limitations of pilot performance as it is about identifying the nature of the *external* threats to safe flight.

After all, there are now very few "new" accidents. If we could apply all the lessons learned from yesterday we could prevent most future accidents, but human beings face a variety of challenges that keep us from consistently carrying out the appropriate action. We are subject to definite physiological and psychological limitations when it comes to piloting

an aircraft, so a key component of this book is explaining *why* pilots make the mistakes they do. A more complete knowledge of the external threats to flight safety, coupled with a deeper understanding of how human errors often play out in the cockpit, will help you to successfully manage both.

The book is divided into 10 chapters that cover ten major hazards gathered under four main accident categories: aircraft collisions (runway incursions, midair collisions), adverse weather (aircraft structural icing, VFR flight into IMC, low-level wind shear), physiological hazards (high-altitude flight, night flying, visual illusions, spatial disorientation), and the major threat of controlled flight into terrain.

Using statistics, aviation safety studies and actual aircraft accident examples, each chapter examines the nature of the threat itself, detailing the locations, times or phases of flight where the probability of encountering it is most pronounced. The human aspects that make pilots particularly vulnerable to that specific hazard are also carefully explained. Finally, drawing upon a wealth of expertise and experience provided by government regulatory agencies, the airlines, aviation safety organizations, and the authors' flight experience, each chapter concludes with best-practice strategies that you as a pilot can use to manage the risk.

Each chapter also includes endnote references and a list of resources—such as FAA and NASA online courses—to increase your understanding of that chapter's hazards and the strategies needed to effectively manage them. As a further strategy toward increased comprehension, key terms are indicated in **bold** font throughout the book.

To maintain interest and readability for the average pilot, this book was deliberately not written in the style of an academic textbook. However, as a professional work with a scholarly emphasis, it can be used as a textbook or supplementary text for collegiate aviation safety courses.

Finally, with more than sixty years of combined experience flying, teaching, investigating aircraft accidents, and promoting and writing about aviation safety in both the United States and Canada, the authors wrote this book with pilots from both countries in mind. Perhaps you've heard it said that "England and America are two countries separated by a common language." The same could be said about Canada and the United States. Therefore, for our U.S. readers, you will see the occasional explanation of terms or procedures used in Canada; and for our Canadian readers, you will see U.S. spelling and grammar used throughout. Though primarily written for pilots from these two countries, this book's information and insights will be helpful to pilots and educators worldwide, especially in those regions where the aviation industry is leaving its infancy and beginning to mature. This old adage is universal, applying to aviators everywhere: "*Learn from the mistakes of others. You will not live long enough to make them all yourself.*" This book is written to help you accomplish that learning.

A Note About the Accident and Incident Citations in this Book

To better illustrate the nature of the types of hazards pilots face and the errors that they typically make, the authors have cited, within parentheses in the body of the text, numerous aircraft accident reports, primarily from the National Transportation Safety Board (NTSB) and the Transportation Safety Board of Canada (TSB), and incident reports from the National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS). These reports contain a wealth of information about how and why accidents and incidents occur. Those who take the time to track them down and read them will find that most accidents don't happen by accident—they usually result from a variety of human and environmental factors that conspire together and lead to an accident. NTSB and TSB reports can be accessed at *www.NTSB.gov* and *www.bst-TSB.gc.ca*, respectively, and ASRS incident reports can be accessed at *asrs.arc.NASA.gov*. The following are examples of typical accident and incident report citations and how they are "coded."

NTSB/AAR-07/05
The 5th (05) major NTSB aircraft accident report (AAR) issued in 2007 (07).

NTSB-AAR-75-9
The 9th (9) major NTSB aircraft accident report (AAR) issued in 1975 (75). Note: in 1983 the NTSB changed the report number format from hyphens (e.g., NTSB-AAR-82-16) to slash/hyphen/slash (e.g., NTSB/AAR-83/01). Both of these formats are used for major accidents published in Blue Cover Reports, so named because of their blue and white covers.

NTSB Identification No: LAX90LA116
The Los Angeles (LAX) NTSB office filed the accident report, which occurred during the 1990 fiscal year (90). It was a limited aviation accident investigation (LA), the 116th in fiscal year 1990. If the identification number is appended with a final letter, another aircraft was involved in the accident. All NTSB accidents are assigned an accident case number such as this one; however, most major aircraft accidents, especially those involving commercial flights carrying passengers, are identified using the format in the first example above and are published as Blue Cover Reports.

TSB Report No: A04Q0089
A TSB of Canada aviation (A) accident report from the year 2004 (04) in the Quebec (Q) region, which was the 89th accident or incident (0089) in fiscal year 2004.

ASRS Report No: 763177
The report ascension number (ACN) is 763177, which is the 736,177th incident report submitted to the National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) since the program began in 1976.

The Wrong Place at the Wrong Time

1

RUNWAY INCURSIONS

It all started with a terrorist bomb. It exploded in the passenger terminal at the Las Palmas Airport in Gran Canaria, a popular tourist destination in the Canary Islands located off the northwest coast of Africa. The airport was closed, and many aircraft were diverted to the Los Rodeos Airport on the nearby island of Tenerife. It didn't take long before this small airport was overwhelmed with aircraft: The apron was crammed with passenger jets, and air traffic controllers (ATC) even had to direct aircraft to park on the only taxiway. Fortunately, within a few hours Las Palmas reopened, and crew members began their preparations for departure.

The air traffic controllers had their hands full, and to make things more difficult, low clouds and fog rolled in reducing their ability to see the runway and making it harder for the pilots to see each other's aircraft.

Flight 4805, a KLM Royal Dutch Airlines Boeing 747, filled mostly with tourists happy to be back on their way to Las Palmas, was cleared to back-taxi (*backtrack* in Canadian terminology) on the runway. A few minutes later Pan American Clipper Flight 1736, another Boeing 747 also filled with tourists glad to be moving again, was cleared to back-taxi on the same runway behind the KLM B-747. The air traffic controller intended for KLM 4805 to taxi to the end of the runway and turn around, while the Pan Am Clipper was to exit the runway and continue to its threshold via the remaining parallel taxiway. Unfortunately, the Clipper crew was having difficulty locating its exit in the dense fog. As a result, the Clipper was still on the runway when KLM 4805 had turned around and aligned for departure at the threshold of Runway 30. Due to a variety of communication problems, the KLM captain thought he had been cleared for takeoff and was certain the Pan Am aircraft was clear of the runway. Unfortunately, he was wrong on both counts. He commenced the takeoff and the

aircraft had reached takeoff speed when he first saw the Pan Am jet ahead on the runway. He desperately tried to get his aircraft airborne to clear the other B-747, while the Pan Am crew frantically tried to steer their aircraft off to the side of the runway to avoid a collision, but there simply wasn't enough room—the aircraft collided, killing everyone on the KLM 747 and most of the people aboard the Pan Am 747.[1]

All told, 583 people perished that March afternoon in 1977, making it the deadliest accident in aviation history. Amazingly, it occurred while the aircraft were still on the ground, making it also the worst **runway incursion** accident of all time. Defined several ways since then, the United States and Canada now use the runway incursion definition adopted by the **International Civil Aviation Organization** (ICAO) in 2005. Simply stated, a runway incursion is *the incorrect presence of an aircraft, vehicle, or person on a runway.*

At the time of this writing, the Flight Safety Foundation's Aviation Safety Network has identified the occurrence of more than 65 major runway incursion accidents worldwide that were responsible for the loss of more than 1,250 lives.[2] Seven of these occurred in the United States in one decade alone (the 1990s). Runway incursions don't necessarily result in tragedy; there are literally hundreds of these events each year in the United States and Canada, but fortunately most don't result in accidents. A **surface event** can be classified as a runway incursion even if there is no conflict with a departing or arriving aircraft; the runway environment is intended to be protected, and any time that protection breaks down it results in a potential threat to safety.

The most effective way to reduce the threat of a runway incursion *collision* is to reduce the number of runway incursions themselves. Unfortunately, since the mid-1990s, as airport traffic has increased and airport ground operations have become increasingly more complex, the incidence of runway incursions has increased almost exponentially. Transport Canada (TC) recorded a 145 percent increase in runway incursions in the four years between 1996 and 1999, and the Federal Aviation Administration (FAA) observed a similar trend, albeit not as steep.[3,4]

In response, both organizations implemented significant improvements to the aviation system to help reduce the number of runway incursions (we will look at some of these improvements later in this chapter). However, in spite of their efforts, the number of runway incursions continued to gradually increase in both countries. There were more than 4,200 runway incursions at towered airports in the United States (*controlled* airports in Canada) between 2004 and 2008 with an increase of 39 percent over that five-year period. (The FAA tracks runway incursions only at towered airports, and therefore the statistics do not include the many surface events involving aircraft operating at nontowered airports.)[5] Both the FAA and TC continue to work with airport operators, ground crews, air traffic controllers and pilots to prevent these potentially serious occurrences; however, runway incursions

remain a major hazard as evidenced by their presence on the National Transportation Safety Board's (NTSB's) Most Wanted List of safety improvements since it was first created in 1990 until 2013.

What's So Hard About Navigating on the Apron?

Your task is deceptively simple: Navigate from the apron to the active runway so that the "real" flight can begin. After your flight is over and the wheels are back on the ground, it's simply a matter of finding your way to the parking spot. It's this apparent simplicity that leads to a certain degree of complacency about the task. Add to this the fact that the crew might have two or three checklists to complete while navigating across wide open tarmac, often containing confusing signage, and it's easy to see how an error might be made while taxiing.

Environmental Conditions

Most runway incursions occur during the day in visual meteorological conditions (VMC), but statistics indicate that the majority of runway incursion *accidents* occur in conditions of reduced visibility, or at night, or both.[6] In fact, all six fatal runway incursion accidents involving major U.S. air carriers or regional airlines in the 1990s occurred during the hours of darkness (or at dusk) or in fog. It's simply more difficult to navigate on the airport at night or in poor visibility.[7, 8]

Crossing Active Runways

A review of runway incursion accidents and incidents provides dramatic examples of what can go wrong. One of the most common runway incursion scenarios at busy airports involves aircraft that must cross one or more active runways in order to reach their destinations. The following narrative from the captain of a de Havilland DHC-8-30, as reported in the National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS), is a typical example:

> After initiating the takeoff, our aircraft accelerated rapidly due to having a light load for that flight. During the takeoff, a C-182 crossed the runway downfield on what appeared to be Taxiway R. The C-182 was crossing the runway at a rapid rate, and by the time the first officer saw it downfield, it was crossing the center of the runway. We were at or near V_1 at this time, and seeing the aircraft clearing the runway he

> elected to continue. He rotated and we were off the ground prior to reaching Runway 5/23. I contacted tower after arriving at our destination and was told that the C-182 was instructed to "taxi and hold short" twice. On both occasions, the pilot read back the hold short instructions and still failed to hold short of our runway (ASRS Report No: 823234).

It was fortunate the Dash 8 was light enough and had the climb capability to clear the Cessna. The Cessna 182 Skylane pilot was twice cleared to "taxi and hold short" of the active runway, and as required by the FAA *Aeronautical Information Manual (AIM)*, he correctly read back his runway hold instructions both times. While taxiing, it's easy to become distracted by tasks such as programming the global positioning system (GPS), completing a checklist, or talking with passengers. You can lose awareness of your position relative to the active runway—especially at an unfamiliar airport—and become aware of the runway only as you cross it. Although hold-short lines are typically marked with yellow lines on the pavement, and red and white holding position signs are located alongside the hold-short point on the taxiway—and in some cases in-pavement lighting is also provided—pilots continue to cross onto active runways, largely due to distraction.

Lining Up and Waiting on the Active Runway

The probability of a ground collision increases when you're cleared to taxi into position on the runway. ATC will often issue such a clearance to provide better spacing between aircraft. Pilots who have been instructed to "**line up and wait**" have lined up with the runway, but all too often have not waited—instead they have initiated their takeoff roll without receiving a clearance. This is often simply a result of habit. Pilots generally enter the runway, line up with the centerline, complete the runway items on the before-takeoff checklist, advance the throttles and depart. This sequence of events becomes so automatic that they sometimes start the takeoff roll even though they haven't been cleared for takeoff.

An almost fatal illustration of this occurred at Quebec/Jean Lesage International Airport when a Cessna 172 was cleared to "taxi to position"[9] on one runway about 16 seconds after an Air Canada Airbus A320 had been cleared for takeoff on another intersecting runway. The Cessna pilot conducted a takeoff departure without a clearance. According to the Transportation Safety Board of Canada (TSB), the controller instructed the pilots of both aircraft several times to abort, but the tower transmitter had been temporarily disabled so the transmissions weren't heard by either of the pilots. The A320 was nearing its rotation speed as it approached the intersection of the two runways, and the Cessna was already in the air climbing through about 200 feet. The captain of the A320 instructed the first officer (FO), who was the pilot flying (PF), to delay rotation until after they had passed

the intersection of the two runways. A collision was avoided by only about 200 feet! (TSB Report No: A04Q0089)

Wrong-Runway Departures

Of course, the probability of a collision on the ground increases if pilots taxi to, and depart from, the wrong runway. An early 1990s NASA study of rejected takeoff (RTO) incidents found a surprising number of **wrong-runway takeoffs**—and even *taxiway* takeoffs—conducted by otherwise qualified commercial airline pilots![10] This type of error was more recently committed by the flight crew of Comair Flight 5191 in the early morning hours of August 27, 2006. It didn't result only in the risk of a collision with another aircraft, vehicle or person; it led to something worse.

The crew arrived at dispatch at 5:15 a.m. local time to prepare for a 6:00 a.m. departure from Blue Grass Airport in Lexington, Kentucky. The preflight preparations, including engine start and taxi, were relatively normal, although there were a few minor slip-ups that suggest the crew members may not have been as focused on the task as they optimally could have been. For instance, they initially boarded the wrong airplane and had to be redirected to the aircraft intended for the flight. The radio work and checklists included some minor slips and momentary confusion. According to the NTSB report, the crew also engaged in some non-operational conversations when they should have been focusing on the task of taxiing to the runway. They were cleared to taxi their Bombardier CL-600 Challenger to Runway 22 (the 7,000-foot runway) and cleared to cross Runway 26 during their taxi. The diagram shown in Figure 1-1 illustrates that in order to reach the threshold of Runway 22 from the terminal building, the crew had to taxi past the threshold of Runway 26.

Visibility that morning was about seven miles, but it was dark at the time of takeoff—sunrise wasn't until 7:00 a.m., and the moon was well below the horizon. The taxiway they needed to take (Alpha 7) was a slight left turn, as illustrated in Figure 1-1, but when they encountered the threshold for Runway 26, they turned a full 90 degrees to the left and lined up on the wrong runway. The air traffic controller didn't notice the error and cleared them for takeoff. The result was that Flight 5191 departed on a runway with insufficient takeoff distance (only 3,500 feet long) and hit an earthen berm a few hundred feet past the end of the runway. Everyone on the airplane was killed with the exception of the FO who suffered serious injuries (Report No: NTSB/AAR-07/05).

Wrong-runway takeoffs occur more frequently at airports where two or more runway thresholds are located close together, particularly if one taxiway is used to get to more than one runway, such as at Blue Grass Airport. A short taxi distance from the apron to the runway decreases taxi time and increases workload, thereby increasing the potential for

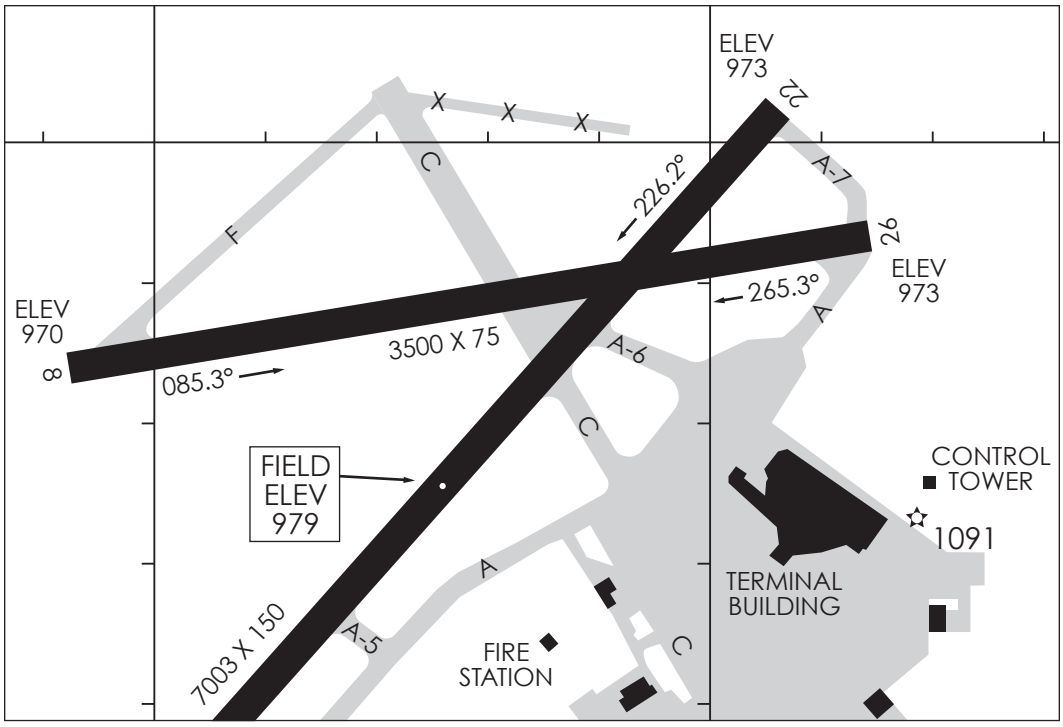

Figure 1-1. Diagram of Blue Grass Airport, Lexington, Kentucky.[11]

confusion. Also, airports with complex layouts can contribute to wrong-runway departures. If an aircraft must make several turns onto different taxiways and cross other runways while en route to the departure runway, the probability of confusion in the cockpit is increased.

Another factor that can lead to a wrong-runway departure is taxiing on a runway. If cleared to taxi via one runway in order to get to another, this increases the possibility that a pilot will depart from the runway on which the aircraft was taxiing. Even airports with a single runway can suffer from wrong-runway departures if there are several intersecting taxiways: A pilot may be cleared for an intersection takeoff and accidentally depart in the wrong direction, 180 degrees from the correct direction.[12]

Controller Error

Pilots aren't the only ones who make mistakes. Air traffic controllers are also human, and their errors, unfortunately, have put pilots and their passengers at risk. Consider the close call that occurred at Vancouver International Airport in British Columbia. Navair Flight

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"…a definitive and invaluable roadmap through a landscape of shattered airplanes and lives in which the telling of each and every incident offers a very real pass to avoiding the same fate." —John J. Nance

Flying involves risks. Fortunately, most of these risks have been identified—often through tragic losses—and the threats have been managed down to remarkably low levels. However, accidents still occur. The key to successful flight is an in-depth knowledge of these threats and the ability to effectively manage them.

Managing Risk: Best Practices for Pilots uses actual aircraft accident examples, statistics, aviation safety studies, and the authors' more than 60 years of combined experience as pilots and flight safety educators to document and describe the 10 most significant accident threat categories, shed light on the applicable human factor issues that make pilots vulnerable to them, and provide practical strategies as well as "best practice" counter-measures you can use to avoid or effectively manage them. A more complete knowledge of the external threats to flight safety, coupled with a deeper understanding of how human errors often play out in the cockpit, will help you to successfully manage both.

DALE WILSON, M.S., ATP, MCFI, CFI—With more than 30 years' experience as a pilot, flight instructor and safety educator, Professor Wilson teaches courses in threat and error management and flight crew human factors at Central Washington University in Ellensburg, Washington. He has published safety articles in professional aviation magazines and has given numerous safety presentations to pilot groups.

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