Aviation Safety:

More Than Common Sense

(Second Edition – Rev. A)

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E-Mail: danh@endeavorbooks.com
www.endeavorbooks.com

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About the Author

Dr. Nathaniel E. Villaire is a Professor of Aeronautics and holds a senior faculty position in the College of Aeronautics at The Florida Institute Of Technology (Florida Tech) in Melbourne, Florida where he teaches Aviation Safety, Aviation Physiology, National Airspace System Management and Air Traffic Control.

He holds a BS degree from The University of Georgia, a MPA from Golden Gate University and both an Ed.S and Doctorate from the College of William & Mary in Virginia. In addition, he is a senior pilot with extensive flight experience in multi-engine jet, single engine jet, and light jet commuter aircraft. He is an aviation physiologist with certifications in both hypobaric and hyperbaric chamber operations. His flight experience includes captain qualification in multi-engine intercontinental transports, instructor pilot in executive transport jets and instrument instructor in both executive and single-engine jets. He has held numerous air traffic control (ATC) positions and is a fully FAA-certified air traffic controller with IFR Tower, VFR Tower, RFC and Terminal Radar endorsements.

Dr. Villaire has taught science and aviation at the primary, secondary, junior college, college and graduate levels for many years, and has served as a guest lecturer at a major medical school, safety seminars, meetings and symposia. He has served as a team member on accident investigations, an inspector for aviation system management, a supervisor for terminal instrument procedures development, director of air traffic control training and standardization and director of air traffic control systems management. He has developed and implemented advanced aviation physiology educational systems and directed aviation physiology training in Nebraska, Virginia and Southeast Asia.

His publications include a college level textbook on ***"Applied Aviation Physiology,"*** articles on the effects of alcohol at altitude, human factors in aviation safety, aviation professionalism and professional aviation education. He has performed over 15 regional air traffic and airspace analyses for the U.S. Government, and is currently engaged in developing better screening criteria for professional aviation training. He is an active member of The Air Traffic Control Association, The Aerospace Physiology Section of The Aerospace Medical Association (Associate Fellow), The Human Factors Association of the Aerospace Medical Association, FITSA, and numerous other professional organizations.

AVIATION SAFETY: More Than Common Sense (Second Edition) is a synthesis of Dr. Villaire's diverse background, education and experience blended with the knowledge and safety management expertise of many internationally known safety experts and authors. It is an updated textbook of his original aviation safety publication and contains new safety findings, systems and methods. It attempts to attack the root causes of accidents and provides useful solutions to some of today's safety management problems. The accidents illustrated are classic events that have changed the aviation profession, safety directives and processes.

Dr. Villaire has borrowed from Aviation Law's case study methods and combined them with his unique, rhetorical question format to produce a new, provocative and thoughtful approach to the study of aviation safety. His internationally recognized publication format is very easy to follow and enhances student assimilation of information.

Introduction

News of an aviation incident or accident is flashed around the world in seconds, yet other safety disasters, such as automobile accidents, industrial accidents, drowning swimmers or household accidents cause little more than ripples in the local area in which they occur. The very visibility and spectacular nature of a serious aviation accident affects the psychological, economic and political structure of our society. Justified or not, aviation is at the forefront of the world's safety consciousness, and aviators, as aviation professionals, must have a safety awareness which engenders confidence, assures success and enhances the profession. Aviation safety must be above suspicion; it must be beyond reproach.

This textbook is intended to supplement a college level course in basic aviation safety concepts, and it is designed to compliment an instructor's experience and knowledge rather than replace it. It is not comprehensive, nor could it ever encompass all aspects of aviation safety, but it does highlight significant concepts and events which need to be examined more closely. There are numerous scholarly works on each specific area of safety which can be studied to enhance one's interests and needs. Aviation professionals should supplement their safety knowledge by consulting as many different authors as possible. A student completing a course, supplemented by this text, should have a solid understanding of just how broad and deep the subject of Aviation Safety has become. Hopefully, each student will take the knowledge and understanding gained here into the world aviation community and make the profession the safest possible.

Aviation Safety: More Than Common Sense (Second Edition) is a composite of historical observations, government documents, personal experience, manufacturers" recommendations, accident statistics, and common sense. It is a book with a historical perspective, current trends, practical advice and usable checklists and procedures. Case studies of accidents and incidents have been selected to illustrate events which affected or changed the direction of safety. **In many cases, the classic study selected actually resulted in major changes to FAA policy or operational procedures.** If placed in proper context, this work is designed to enhance the safety management instruction of future chief pilots, airport managers, consultants and CEOs in the aviation profession.

With the field of aviation progressing rapidly, and changing daily, it is inevitable that some facts and data will change. As scholars produce finer aviation products, parts of this text may become obsolete, outdated or found to be in error. I encourage students, teachers and aviation scholars who find discrepancies, have better information or have corrections to send such information and corrections to me in care of the College of Aeronautics, Florida Institute of Technology, Melbourne, Florida, 32901-6988. I will do everything possible to correct the document and maintain its integrity, but it cannot be done without your constructive assistance and advice.

IT IS IMPOSSIBLE TO ACCURATELY MEASURE
THE RESULTS OF AVIATION SAFETY.

NO ONE CAN COUNT THE FIRES THAT NEVER START,
THE ABORTED TAKEOFFS THAT DO NOT OCCUR,
THE ENGINE FAILURES AND THE FORCED LANDINGS
THAT NEVER TAKE PLACE.

AND ONE CAN NEITHER EVALUATE THE LIVES THAT ARE
NOT LOST, NOR PLUMB THE DEPTHS OF THE HUMAN
MISERY WE HAVE BEEN SPARED.

BUT THE INDIVIDUAL WITH THE FLIGHT CONTROLS,
FUELING HOSE, WRENCH, RADAR OR DISPATCH ORDER
CAN FIND LASTING SATISFACTION IN THE KNOWLEDGE
THEY HAVE WORKED WISELY AND WELL, AND THAT SAFETY
HAS BEEN THE PRIME CONSIDERATION.

(Author unknown—Modified by Dr. Nathaniel E. Villaire.)

Chapter I
Historical Roots of Safety

Early Science

Science rarely leaps forward based upon the work of a single individual or group. It almost always progresses after years of research and mountains of work have been accomplished. Aviation was, and is, no exception. Man did not suddenly fly in 1903 when the Wrights spent 12 seconds of powered flight in the skies of Kitty Hawk, N.C.; he leaped from a mountain of theories, years of research, hundreds of inventions and the work of thousands of designers, dreamers, philosophers and engineers.

Wright Brothers

As early as 540 BC, **Pythagoras** traveled the eastern Mediterranean spreading Egyptian knowledge of our planet. Plato (427?-347? BC) postulated his theory of the universe in Timaeus, and **Aristotle (384-322 BC)** carried on with four volumes exploring natural philosophy. The spinning of the earth on its axis was proposed by **Aristarchus of Samos about 300 BC** as part of his universal theory, and he even outlined the rotation of the known planets about the sun. Similarly the idea that the earth is a sphere did not begin with Christopher Columbus; **Anaximander** came to the same conclusion about **600 BC**. Even the vast distances of the globe are not new. **Eratosthenes of Greece** calculated our planet's circumference at 24,647 miles between 300 and 200 BC. How accurate was he? His measurements were within 3% of actual, modern calculations!

Pythagoras

Aristotle

Aristarchus

Anaximander

Eratosthenes

Numerous books, charts, theories and experiments built our knowledge of the stars, the earth's atmosphere, chemistry, physics, aerodynamics and propulsion through the centuries. It was a painfully slow process because communications were limited. Ponderous, hand written documents often lay unused for centuries, and it was not uncommon for several individuals to come to the same conclusion in separate parts of the world and not know others were working on the same project. The invention of **movable type** hastened the spread of information; the construction of roads and the movement of ships facilitated collaboration between scientists; the invention of the telescope, microscope, thermometer and structural materials all pushed men towards better understanding and the sky. Science progressed rapidly from about 1400 AD, and flight awaited only a better understanding of aerodynamics and the replacement of "animal power."

Movable Type

Balloons

Balloons

While man unknowingly awaited developments in aerodynamic research and the reduction in size and mass of propulsion systems, he experimented with newly identified gas laws. The early Chinese first tinkered with balloons, but it took the adventuresome **Montgolfier brothers of France** to put a smoke and hot air balloon into the air on June 5, 1783. Of course, once something is invented, men are never satisfied until they can try it themselves. Thus, **Dr. Pilatre de Royier** ascended in a hot air balloon on October 15, 1783, to the astounding height of 80 feet in Faubourg Saint Antoine, France. Within days, he was taking passengers up in the balloon (Who could resist?!!), and he gradually increased his altitudes. Naturally, travel followed. With a passenger aboard, Royier released the captive balloon, which ascended, was caught by the wind and traveled across a river. It came to rest twenty-five minutes later, and air transport had been born. Balloon activity became an international frenzy, and it was only a matter of time before aviation safety would be forced into the arena of flight. Ironically, it was this same Pilatre de Royier and a fellow flyer, Romain, who became some of the first aviation fatalities. Both men died attempting to cross the English Channel in 1785 when their balloon, a hydrogen-filled model, exploded and burned.

Montgolfier Brothers

Dr. de Royier

Charles' Law

Charles' Law, which explains the dynamics of gas expansion, was first proposed by the French scientist **Jacques Alexander Caesar Charles**, but few people know that he was the second man aloft in a balloon (who ever remembers #2?), and even fewer realize that he was the first to raise questions of safety from a medical point of view. He accurately described head pains around his face and sinuses as well as ear pains after a balloon flight to nearly 10,000 feet! Aviation physiology and aeronautical medicine were born.

The balloon continues to fascinate us, and it has made numerous contributions to aviation research and safety throughout the years. It served as an observation platform during wars and as travel machines for adventures, passengers, freight and researchers. Aircraft followed the balloons into the air, but until very recently, balloons were always far ahead. Even as late as 1957 **Kittinger** ascended to 96,000 feet in a balloon (while rocket planes were probing 90,000 feet) and Simons reached 101,000 feet in his balloon. (Kittinger later parachuted from a balloon at 76,400 ft.)

Kittinger

Gliders

Sir George **Cayley**

Louis Pierre Mouillard

John J. Montgomery

Otto Lilienthal

As balloons found their way to the forefront of aviation, and began to compose a background for safety, gliders were slowly coming of age. An Englishman, **Sir George Cayley**, built and attempted to fly a glider as early as 1804. Technology improved designs and more attempts (William Henson, 1840s) were made to bring fixed wings into the air. Finally, **Louis Pierre Mouillard** of French Algeria was successful in **1865**. He was followed by **John J. Montgomery** of the United States and **Otto Lilienthal** of Germany. Numerous problems were encountered as the aerodynamics of flight unfolded under man's assault on the air. Early pioneers of flight such as Chanute of the United States, Pilcher of England and Lilienthal faced control, landing and maneuvering problems. It is a tribute to such men that they ever discovered, and used, such ideas as elevators, ailerons and rudders.

The history of flight is littered with the wreckage and bodies of its pioneers. **Otto Lilienthal died on August 9, 1896**, after more than 2000 successful glider flights. Years later, the glider would also claim America's **John Montgomery in a crash on October 31, 1911**, some eight years after the first powered flight. The litany of death and destruction continued with experimentation. Almost everyone has seen the pictures and films of multi-winged, mushroom-winged, umbrella-winged, feathered and flapping-winged vehicles of our early explorers. Many died in proving or disproving various theories, and all of that knowledge forms the foundation of today's safety programs.

Powered Flight

Wright Brothers

Powered flight arrived with the **Wright Brothers' flying machine in 1903**. It was the culmination of literally centuries of progress in science, engineering and man's insatiable desire to press the frontiers of the unknown. Unfortunately, a few bruises, broken bones, some crippling and an occasional death quickly became the carnage of broken bodies, strewn wreckage sites and massive property damages of powered flight mishaps. High speed death and disaster were suddenly upon us, and it could be caused by a myriad of oversights, lack of understanding, complacency or just plain neglect. Man began paying a very high price for the aerodynamic, structural, physiological and atmospheric knowledge required for flight. All of the professions contributed to the rapid development of this newborn adventure, but some of them led the way with fervor. Medicine was in on flight from the beginning in the forms of **Royier**, **Jenner**, **Enler**, **Tythler** and **Fordyce**. It continues today in the form of flight surgeons, the School of Aerospace Medicine (USAF), FAA's CAMI in Oklahoma and aviation physiology. Law began to feel the impact early, and, borrowing heavily from **Maritime Law**, rose to the challenge. Individual cases were being adjudicated around the world, and as early as 1899 an international conference on the subject was held in Holland. The **First Hague Peace Conference** prohibited the throwing of grenades or other

Royier, Jenner, Enler, Tythler, Fordyce

Maritime Law

First Hague Peace Conference

armament from balloons, and the **Institute of International Air Law** discussed the implications of air law from **1902-1911**. The Institute established the concept that airspace was free to all, but nations had the right to set the rules of airspace use for purposes of national security. Air Law has progressed through numerous national and international forums to today's formal structure.

Institute of International Air Law

Soon after the birth of modern aeronautics at Kitty Hawk, powered flight began to recognize a whole series of problems. The fields of science, medicine and law were already responding to the new child's many problems, but just as a child must experience some trauma before it begins to learn, aviation had to experience some disaster before it began to respond. As history would record, the entrance of the military and its methodical procedures began to focus on flying safety and make safety an essential part of the new profession.

The **Wright Brothers** tried to sell their flying machine to England, France, Russia and Prussia prior to the U.S. Army's interest. The U.S. Army's interest stimulated the Wrights to build better versions of their original machines, and it brought others into the era of aviation too. **Glenn L. Martin** built his first Curtiss-type of airplane in 1908 and taught himself to fly! By September of that year, several ventures, including the Wrights, were demonstrating their machines to the Army, and accidents were inevitable.

Wright Brothers

Glenn Martin

The purchase of early aircraft by the U.S. Army in the early years had some unforeseen effects. One of those effects was that the U.S. Army's emphasis on records and precise job descriptions resulted in detailed records on each aircraft to include its flight time, maintenance and incident history. In addition, pilots were required to complete a log describing the exact nature, time and condition of each flight to include the aircraft's performance. These documents eventually turned into today's **Aircraft Maintenance Logs** and the **Pilot's Log Book**, and those records formed the foundation of the data necessary to start the safety management of aviation. Thus, the U.S. Army began to recognize that a pattern of problems with aircraft and pilots existed and decided to examine the situation more closely.

Aircraft Maintenance Logs

Pilot's Log Book

In 1914, the U.S. Army compiled the known data of the time, beginning with 1908, and the first accidents encountered by the Army were compiled into the first safety analysis report. It begins with the Wrights:

Early Accident Reports and Analyses

(Accidents reprinted here are extracts of War Department records of 1914.)

(Note: The accidents reproduced here include the original spelling and grammar of the day. No unnecessary correction of the text has been made.)

Accident No. 1: Mr. Orville Wright was flying the original Wright type of machine for an acceptance test at Fort Meyer, Va., with Lt. T.F. Selfridge as a passenger, on September 17, 1908, when one of the propellers broke, the machine being at that time about 75 feet from the ground. The machine sideslipped and nosedived, striking the ground with such force as to fatally injure Lt. Selfridge and break Mr. Wright's leg. Cause of the accident: Breaking of propeller and consequent loss of lift in the machine. Lt. Selfridge's death can in no way be connected with any question of type of machine or skill of pilot.

This began the Army's **Mortality in Army Aviation** reports. By February 1914, a total of eleven fatal accidents had occurred, and few pilots ever reached 100 hours of flight time before they became a mortality statistic. Reproduced below are the reports from those first accidents. Note how they increase in complexity as the accidents mount. Accident #1, above, is little more than an observation, while #11 is the report of a formal board of inquiry with witnesses and testimony. It is interesting to note that numerous military and civil facilities are named after these early pioneers who explored the unknown and frequently paid the ultimate price of curiosity and adventure.

Mortality in Army Aviation Report