Air Show Performers

Safety, Risk Management and Psychological Factors

Manolis Karachalios
Daniel Kwasi Adjekum

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Air Show Performers

Air shows are high-risk activities that must be conducted with careful thought toward the general public, spectators, and flying and nonflying participants to ensure that the activity is as safe as reasonably possible. The impromptu, ad hoc, unrehearsed, or unplanned must never be attempted. This book offers a holistic overview of the state of safety, including safety cultural variables, safety risk parameters, and human performance factors, in the international air show community.

The aim of this book is to close the knowledge gap on safety management in air shows. It imparts to the aviation sector and other high-risk and high-performance industries the experience and knowledge that airshow performers have gained regarding risk assessment, psychological aspects, and mindfulness techniques used for safe and effective performances. The book highlights how resilient safety culture can change the air show community's mentality to deliver safer and more spectacular air show events and promotes the culture of excellence that the air show community is wedded to. The reader will obtain a thorough understanding of safety issues in air shows.

Air Show Performers: Safety, Risk Management, and Psychological Factors is a critical read for professionals within the international air show community including nonflying participants. Its appeal extends to practitioners in aviation, health and safety, and events management.

"[…] For sure, this book will become a reference and a source of inspiration for future generations of Display Pilots."

Jacques Bothelin, French Aerobatic Jet Team Leader,
Honorary Board Member European Airshow Council

Manolis Karachalios was the Hellenic Air Force's F-16 Demo Team "*ZEUS*" Display Pilot for the 2010–2012 display seasons. Dr. Karachalios holds a Master of Business Administration (MBA) in Aviation Management from Coventry University, and a Doctor of Philosophy (PhD) in Aerospace Sciences from the University of North Dakota focusing on air show safety and development.

Daniel Kwasi Adjekum has over 25 years of experience in aviation as a former Ghana Air Force squadron commander, command pilot, and air display safety director. He was also an airline pilot and is currently an aviation safety consultant and professor of aviation. He is an Internationally recognized aviation safety subject-matter expert and an International Air Transport Association (IATA) certified Safety Management Systems (SMS) implementation and control expert.

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Dr. Manolis Karachalios was the Hellenic Air Force's F-16 Demo Team "*Zeus*" Display Pilot for the 2010 to 2012 display seasons. He joined the Hellenic Air Force Academy in 1996 and graduated with honors in 2000. Upon graduation he spent 2 years as an operational A-7H Corsair pilot and then he joined the 340 Squadron, flying the F-16 Block 52+. Since 2014, he has been a civilian instructor pilot and an aviation consultant, while in 2018 he took over as the flying display director (FDD) of the Athens Flying Week International Air Show (AFW). His passion for air shows keeps him involved as a Member of the Board of the European Airshow Council (EAC) and the International Air Show Safety Team (IASST), as well as a moderator of the annual Fast Jet Solo Display Pilots' Safety Workshop.

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Dr. Daniel Kwasi Adjekum has over 25 years of experience in aviation as a former Ghana Air Force squadron commander, command pilot, and air display safety director. He was also an airline pilot and is currently an aviation safety consultant and professor of aviation. He is an Internationally recognized aviation safety subject-matter expert and an International Air Transport Association (IATA) certified Safety Management Systems (SMS) implementation and control expert.

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Dr. Adjekum has published extensively in peer-reviewed academic journals and presented at academic conferences and industry workshops both in Ghana and in the US. He is regularly sought after by local, national, and international media houses to provide expert insight on aviation accident investigations and relevant aviation safety issues.

Foreword

I first heard of Dr. Manolis Karachalios when I was invited to participate in a survey he designed to contribute to a deeper understanding of the safety culture in the international air show community, and I was immediately intrigued.

I have flown airshows for more than 35 years in a variety of different airplanes, around the world, in all sorts of weather conditions. Airshows are a high-risk environment, and managing those risks is my most important job. For me, it begins months before the airshow season when considering next year's schedule, maintaining my airplane, and organizing my life around my training and practice program by staying in good health and conditioning myself to maintain a good G tolerance.

For airshow pilots, psychological factors are important too. It takes practice and discipline to learn to compartmentalize and manage unwanted distractions before we fly. We have to learn to be mindful, present and focused in an extremely dynamic environment where there are many people and many demands on our time.

Safety, risk management, and the psychology of handling stress in the airshow environment are the things I have literally been obsessed with since I first began my career. Any pilot, and especially those of us who operate in a high-risk environment, must continually analyze, assess, and, importantly, learn and improve, not only for themselves but for future generations.

Dr. K's book provides a framework for continuous improvement of safety. Not just a spectator, he is an active participant in the airshow community. Dr. K's experience as a fighter pilot flying F-16s in the Hellenic Air Force, as the Flying Director for the Athens Flying Week Airshow, and as a longtime member of the Board of Directors for the European Airshow Council makes his research and insights into how we can improve our community and its safety culture, uniquely qualified and important.

Dr. K's findings give pilots like me a fresh perspective. Listening to other voices can give us a different view of our industry. And, while it's no big surprise that his findings suggest most airshow performers embrace a resilient safety culture, how we best put that into practice and manage those risks is the key.

Best safety practices in aviation and airshow flying are a lifelong commitment to learning and improving. It's thanks to Dr. Karachalios and Dr. Adjekum, and other researchers that we have been given some wonderful tools to do that with.

Patty Wagstaff
American Aerobatic Pilot, Three-time U.S. National Aerobatic Champion, Inductee of the National Aviation Hall of Fame

Preface

Picture yourself high above a bustling crowd of thousands, spectators squinting into the sun, their faces turned upwards in awe and anticipation. You're at the helm of a high-energy air show, piloting through a choreographed dance in the sky, commanding the rapt attention of every onlooker on the ground. Amid the thrill and spectacle, behind the deafening roar of the engines and the dazzling feats of aerial acrobatics, an uncompromising principle anchors everything: safety. It's in this electrifying yet demanding environment that the book, *Air Show Performers: Safety, Risk Management, and Psychological Factors*, finds its relevance and purpose.

Driven by years of hands-on experience and meticulous research, this book unravels the intricate tapestry of safety culture in the aviation industry. It's a deep dive into the complexities and dynamics of ensuring paramount safety during air shows, a spectacle that combines extreme skill with inherent risks.

The result of an ambitious study, this work seeks to illuminate the key factors that contribute to safety culture and operational risk management within the air show community. It carefully dissects the multifaceted relationships between operational risk factors, hazardous attitudes, resilient safety culture, and industry mindfulness. The outcome is a blueprint, clear and actionable, intended for the continuous enhancement of safety in the air show realm.

As you flip through the pages, you'll find it filled with insights and revelations, all distilled from rigorous fieldwork and innovative research. The narrative underscores the urgent need to foster a culture of excellence and mindfulness in the air show industry, challenging every stakeholder – performers, organizers, and regulators – to be an agent of safety.

This book is an open invitation, a call to arms, to all those who share the noble objective of advancing safety in the aviation industry. It strives to be a comprehensive resource for those committed to this critical cause. It's a call to action, a guide, and a compass, all in one.

We'd like to conclude by expressing our heartfelt appreciation to the dedicated professionals within the air show community, whose invaluable contributions have been instrumental in bringing this enlightening work to fruition. As we embark on this transformative journey together, we wish everyone safe skies and fair winds.

Manolis Karachalios and Daniel Kwasi Adjekum

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1 The Evolution of Air Show Performers

1.1 INTRODUCTION

It is a cherished honor and pleasure to introduce our readers to the fascinating world of air show performance and its development over time. Throughout this introductory chapter, we use a *5W* approach (who, where, what, why, and when) to emphasize the safety, risk management, and psychological factors related to the evolution of air show performance. As a comprehensive resource for performers, organizers, and enthusiasts alike, this book explores the challenges and opportunities associated with air show performances while shedding light on the importance of maintaining a robust safety culture within the community. Moreover, it is vital to learn from past safety events and prevent the recurrence of tragic air show disasters, such as the Farnborough tragedy in 1952, the Ramstein catastrophe in 1988, the Sknyliv disaster in 2002, the Shoreham crash in 2015, and the recent Commemorative Air Force midair collision in Dallas, Texas, in 2022.

1.1.1 Who: Air Show Performers and the Broader Air Show Community

We begin by discussing the various categories of air show performers and the wider air show community throughout history. We delve into the evolution of performances from their inception to the present day and the diversity, inclusion, and demographic aspects of this unique group of individuals. Additionally, we introduce the roles and responsibilities of key stakeholders involved in air show events, such as air bosses, regulators, and air show associations.

1.1.2 Where: The Venues of Air Show Performances

In this section, we explore the different locations where air show performances have occurred over time, including the transition from early airfields to modern venues. This will include a discussion on the types of air show venues, the unique challenges they present, and the adaptations performers have made to ensure both their safety and the safety of spectators.

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1.1.3 What and Why: The Evolution of Safety, Risk Management, and Psychological Factors

This section further examines how safety, risk management, and psychological factors have evolved alongside air show performances. We will discuss the factors contributing to human errors among air show performers and how these factors can increase the likelihood of safety events, such as incidents and accidents. Drawing on research and case studies from the aviation industry, we will provide practical strategies and recommendations for mitigating the effects of human error in air show performances. This will include discussions on training, standard operating procedures (SOPs), and the role of a safety culture within the air show community.

1.1.4 When: The Timeline of Air Show History and the Inception of This Book

The final section of this chapter recounts the timeline of air show history, from the earliest public displays of powered flight to the modern, high-energy performances we see today. We thoroughly examine critical milestones, technological advancements, and influential performers who have shaped the course of air show history, providing context for the evolution of safety, risk management, and psychological factors in air show performances.

Additionally, we discuss the motivations and objectives for authoring this book, which originate from a desire from the authors to explore and understand the complex interplay between air show performance, safety, risk management, and psychological factors and add to the existing body of knowledge. Most of the contents in this book are data-driven findings from seminal doctoral research, and it is a heartfelt desire of the authors to share these findings and recommendations with the broader aviation community.

Focusing on the development of air shows and the related evolution of safety, risk management, and psychological aspects, this chapter provides a foundation for examining the wide world of air show performers and the larger air show community. We intend to provide a thorough introduction that will engage, educate, and inspire readers as they journey through the fascinating and demanding world of aerial displays by addressing the who, where, what, why, and when of air show history as well as the conception of this book.

By providing this well-rounded introduction to the world of air shows, we hope to inform and enthrall our readers and contribute to the body of knowledge available to academia, aviation specialists, and other professionals involved in high-performance events. Ultimately, our goal is to inspire the next generation of aviation enthusiasts to explore the thrilling and rewarding world of air shows.

1.2 WHO

The awe-inspiring feats of air show performers have captivated audiences for over a century as they soar through the skies, defying gravity and showcasing the

boundless potential of human innovation. Behind the breathtaking aerial ballets and the thunderous roars of aircraft engines lies a complex and fascinating world where safety, risk management, and psychological factors play a vital role in ensuring these enthralling spectacles' success and continued advancement.

Every time most air show performers take to the skies, they demonstrate their exceptional skills and their unwavering dedication to ensuring the safety of both themselves and their audience.

The importance of writing about the safety of air show performers cannot be overstated, as it serves as a reminder of the immense responsibility that these pilots bear and the extensive measures they undertake to protect everyone involved. By exploring the intricate world of air show safety, we shine a light on the remarkable achievements of those who work tirelessly behind the scenes to make these events possible while emphasizing the ongoing need for vigilance, innovation, and collaboration in maintaining the highest safety standards.

1.2.1 Air Show Performer Categories: A Historical Overview

Air shows have been a popular form of entertainment since the early days of aviation, capturing the imagination of both aviation enthusiasts and the general public alike. From daring aerial stunts to breathtaking formation flying, air show performers have evolved and diversified over the years, with each category offering a unique perspective on the capabilities of both pilots and aircraft. An overview of the various categories of air show performers is provided, examining their historical evolution and offering insights into their unique skills and talents. This section delves into the various categories of air show performers, providing a comprehensive understanding of their unique characteristics and historical evolution. By examining both academic and air show enthusiast perspectives, we offer you a holistic view of the world of air show performers and their diverse range of talents. The section also provides a rich historical foundation of air shows and the diverse background of air show performers over time.

As stated earlier, there have been a natural evolution and diversification in performance at air shows, providing more unique and captivating experiences for all stakeholders in this area of aviation.

In contemporary times, air show performers play an essential role in showcasing the complexity, capabilities, and diversity required in aerial demonstration of aircraft and other aviation-related products. From aerobatic pilots and wing-walking performers to jet demonstration teams and glider performers, air show performers use their skill, precision, and creativity to put on thrilling displays for audiences worldwide. In the pursuit of their craft, air show performers sometimes push their skills to the very edge of safe operational envelopes. An explicit adherence to regulations, guidelines, and standard operating procedures (SOPs) set forth by aviation safety regulators is vital to ensure their safety and that of their audience while inspiring the development of new aviation technology.

As we reflect on the inspiring evolution of air show performers internationally, let us remember the indomitable spirit of the pioneers who first took to the skies and the

countless individuals who have dedicated their lives to the pursuit of their dreams. May their stories of courage, determination, and innovation serve as a beacon of hope for future generations of air show performers, reminding us all of the boundless potentials that lie within each of us when we dare to reach for the skies and embrace the extraordinary.

1.2.1.1 Civilian Aerobatic Performers

Civilian aerobatic performers are pilots who are not affiliated with any military organization and perform a variety of aerial maneuvers to entertain the audience. This category includes solo performers and teams flying a wide range of aircraft types, from vintage biplanes to modern high-performance aircraft. Some well-known civilian aerobatic performers include Jacques Bothelin, France (see Figure 1.1); Matt Hall, Australia; Rob Holland, USA; Selwyn "Scully" Levin, South Africa; Jorge Malatini, Argentina; Yoshihide Muroya, Japan; and Patty Wagstaff, USA.

Historically, civilian aerobatic performers have their roots in the barnstormers of the 1920s and 1930s, who would travel from town to town, putting on daring displays of aerial stunts in mostly surplus World War I aircraft, such as the Curtiss JN-4D, also known as the "*Jenny*" (see Figure 1.2).

1.2.1.2 Military Demonstration Teams

Military demonstration teams are composed of highly skilled military pilots who showcase their nation's aviation prowess, highlight the latest technological capabilities of aerial platforms, and invariably use these demonstrations as promotional avenues for recruiting personnel into their respective military branches. These teams

FIGURE 1.1 Demonstration team leader Jacques Bothelin. Copyright: Jacques Bothelin.

FIGURE 1.2 Gladys Roy, with her opponent Ivan Unger, playing tennis, on a Curtiss "Jenny" JN-4D aircraft piloted by Frank Tomac, who kept the plane at 3,000 feet – circa 1925. Copyright: Bettman Collection / Getty Images.

often perform formation flying, showcasing high precision and coordination. Notable military demonstration teams include the Royal Australian Air Force's "Roulettes," the Chinese Air Force's "Ba Yi," the Chilean Air Force "Halcones," the Royal Canadian Air Force Snowbirds, the Indian Air Force's "Surya Kiran," the Polish Air Force's "Orlik," the Royal Air Force's Red Arrows, the Russian Air Force's "Russian Knights," the South African Air Force's "Silver Falcons," the United Arab Emirates Air Force's "Fursan Al Emarat," and the United States Navy Blue Angels.

The first military demonstration team can be traced back to the Patrouille d'Étampes, a French team formed in 1931. Following World War II, several other nations established their teams, leading to the growth and popularity of military demonstration teams worldwide.

Jet demonstrations feature high-performance aircraft, such as fighter jets and training aircraft, showcasing their speed, power, and agility. The Lockheed Martin F-16 (see Figure 1.3), the Boeing F-18, the Eurofighter Typhoon, and the Saab JAS-39 Gripen are among the most frequently demonstrated fast jets in the air shows, while the Dassault Alpha Jet, the BAE Hawk, the Aero Vodochody L-39 Albatros, and the Aermachhi MB-339 are some of the training jets flown by military demonstration teams.

Even though military transport aircraft might not be the stars of an air show in terms of acrobatic stunts, they still play significant roles in these events, showcasing their astounding size, capabilities, and engineering marvel. These aircraft, for example, Airbus A400M Atlas, Boeing C-17 Globemaster III, Alenia C-27J Spartan, the

FIGURE 1.3 F-16 Fighting Falcon of the Zeus Demo Team, Hellenic Air Force, Demonstrating at RIAT 2015. Copyright: Hellenic Air Force.

Lockheed Martin C-130 Hercules, and Ilyushin Il-76, typically perform tasks such as equipment, troop, and supply transportation. While these aircraft don't execute aerobatic maneuvers like fighter jets, they can execute impressive displays, including demonstrations of their takeoff, landing, and cargo-loading abilities. Additionally, they may participate in flyovers and formation flights with other military aircraft. Such an aircraft that steals the crowds' attention is the *Fat Albert* C-130 Hercules (see Figure 1.4). This aircraft is part of the U.S. Navy's Blue Angels flight demonstration

FIGURE 1.4 C-130 Fat Albert of the Blue Angels Demonstration Team, U.S. Navy, Demonstrating at Fargo Airshow 2015. Photo by the author (Daniel Kwasi Adjekum).

squadron and frequently opens for the Blue Angels by demonstrating its impressive short takeoff and landing capabilities.

1.2.1.3 Helicopter Performers

Helicopter performers captivate audiences with their astonishing stunts, demonstrating the impressive capabilities and agility of these aerial marvels. Some of the jaw-dropping maneuvers include gravity-defying loops, where the helicopter climbs vertically before flipping upside down and descending back to its original position, creating a full circle in the sky. They also perform exhilarating rolls, where the helicopter rotates sideways around an imaginary line running from its nose to its tail. These talented pilots showcase other thrilling moves, such as steep dives toward the ground, spinning maneuvers resembling a corkscrew, and sharp, high-speed turns that demonstrate the incredible control and stability of these versatile flying machines.

Helicopter performers must adhere to stringent safety guidelines to address the unique challenges and risks associated with their demonstrations. Unlike fixed-wing aircraft, helicopters operate with a higher degree of maneuverability and agility, which can lead to more complex and unpredictable flight patterns. Key hazards include the potential for rotor blade strikes, tail rotor issues, and loss of lift due to proximity to other helicopters or ground structures. Unlike fixed-wing aircraft, helicopters have limited energy reserves in the event of an engine failure, making autorotation (emergency landing technique) more critical. Pilots should be well-versed in autorotation procedures and practice them regularly to ensure a safe emergency landing. To mitigate these risks, helicopter performers must follow specific safety measures, such as maintaining minimum separation distances and carefully planning flight paths to avoid potential obstructions. These precautions help ensure the safety of both the performers and spectators during these thrilling aerial displays. Otto the Helicopter has been a legend of the North American air show industry, while the Royal Navy Black Cats is an example of a military helicopter display team (see Figure 1.5).

1.2.1.4 Warbird Performers

Warbird performers fly historic military aircraft, often restored to their original condition, to pay homage to their role in aviation history and honor the pilots who flew them in combat. These performances often include reenactments of historical aerial battles or demonstrations of specific aircraft capabilities. Some notable warbird performers include the Commemorative Air Force in the United States, the Fighter Collection at the Imperial War Museum Duxford in the UK, and the Flying Heritage and Combat Armor Museum located in Everett, Washington, USA.

The rise of warbird performers can indeed be attributed to the preservation and restoration efforts that began in the 1960s and 1970s. As collectors and enthusiasts sought to preserve and showcase historical military aircraft, they paved the way for the growth of warbird demonstration performances. These performances allow audiences to experience the power and elegance of vintage military aircraft, such

FIGURE 1.5 The Royal Navy Black Cats Display Team performing at RIAT, UK, 2016. Copyright: Tim Felce.

as bombers and fighter planes, while also educating them on the rich history and significance of these machines.

Warbird demonstration performers are required to comply with specific safety guidelines to ensure the safety of both the pilots and the spectators. These guidelines typically include thorough aircraft maintenance protocols, regular inspections, and adherence to safety standards set by aviation regulatory bodies.

Some well-known warbird demonstration performers include the B-25 Mitchell Bomber and the P-51 Mustang. The B-25 Mitchell Bomber is a twin-engine, medium bomber that was used extensively during World War II. It gained fame for its role in the Doolittle Raid on Tokyo, which was a key turning point in the Pacific War. The P-51 Mustang, on the other hand, is an iconic single-seat fighter aircraft that was used by the Allies during World War II and the Korean War. Its exceptional range and performance made it one of the most successful fighter planes of the era.

These warbird demonstrations not only entertain but also serve as a living tribute to the brave men and women who flew and maintained these aircraft during times of conflict. By keeping these historic aircraft flying, warbird performers help to preserve an important part of aviation history for future generations to appreciate and learn from.

1.2.1.5 Glider Performers

Glider performers utilize engineless aircraft to perform graceful and elegant aerial displays, relying solely on their skill and the forces of nature to stay aloft. These performances often include aerobatics and formation flying, demonstrating the art and science of soaring flight. Some well-known glider performers include Manfred Radius, Bob Carlton, and Luca Bertossio (see Figure 1.6).

FIGURE 1.6 Luca Bertossio glider air show performer during his display at Athens Flying Week International Air Show, 2021. Copyright: Athens Flying Week (Photo by George Markakis).

The origins of glider performers can be traced back to the early 20th century when gliding became a popular recreational activity in Europe. As technology advanced and gliders became more capable, pilots began to develop and showcase their aerobatic skills in these engineless aircraft.

Glider performers showcase the capabilities and agility of gliders, including stunts such as loops and rolls. Glider performers must comply with specific safety guidelines, including minimum separation distances between aircraft and communication procedures between pilots. The British Gliding Association (BGA) guides glider display flying (*British Gliding Association*, 2023). The Airborne Pyrotechnics display team is an example of a glider performer team.

1.2.1.6 Parachute Demonstration Teams

Parachute demonstration teams are composed of highly skilled skydivers who perform various aerial stunts while descending under their parachutes. These performances often include formation skydiving, free-flying, wingsuit flying, and canopy piloting. Some renowned parachute demonstration teams include the United States Army Golden Knights, the United States Navy Leap Frogs (see Figure 1.7), and the Red Bull Air Force.

Parachute demonstration teams emerged during the 1950s and 1960s as military units began to develop and showcase their expertise in airborne operations. Over

FIGURE 1.7 U.S. Navy Leapfrogs performing at Fargo Airshow, 2015. Photograph by the author (Daniel Kwasi Adjekum).

time, civilian skydiving teams also formed, creating a diverse range of parachute demonstration teams worldwide.

Skydiving performers include both solo and team displays, with performers jumping from aircraft and performing stunts in freefall. The British Skydiving guides display skydiving, including safety considerations and qualifications for display skydivers. The Red Bull Air Force is an example of a skydiving performer team.

1.2.1.7 Paragliding Performers

Paragliding performers use lightweight, nonmotorized aircraft to perform stunts and aerial displays, including high-speed runs and spirals. The safety guidelines for paragliding performances can vary depending on the country or organization overseeing the event, but some general rules and regulations often apply.

For the British Hang Gliding and Paragliding Association (*BHPA*, 2023), the specific safety guidelines include the following:

- Minimum altitude: Display pilots must maintain a minimum altitude above the ground, usually between 100 and 500 feet (30–150 meters), depending on the complexity of the stunts and the location. Exact minimum altitudes might be specified by the event organizer, local aviation authorities, or the organization overseeing the event.
- Pilot qualifications: Display pilots should have the appropriate license or certification level to perform in an event. This often means holding an advanced pilot rating from a recognized paragliding organization such as the BHPA, the United States Hang Gliding and Paragliding Association (USHPA), or other national associations. Additionally, display pilots are usually required to have a significant amount of experience, including a minimum number of logged flights and/or hours in the air.

The Red Bull X-Alps, as a paragliding race and display event, would also adhere to safety guidelines set forth by the event organizers and the appropriate paragliding organizations. It is essential for pilots participating in such events to be highly skilled, experienced, and have a deep understanding of safety protocols.

1.2.1.8 Wing-Walking Performers

Wing-walking performers perform stunts on the wings of aircraft in flight, including handstands, acrobatics, and even transferring between planes mid-flight. Wing-walking performers use specially designed harnesses and may have additional safety equipment, such as life vests and helmets. AeroSuperBatics is one example of a wing-walking performer team (see Figure 1.8).

1.2.1.9 Radio-Controlled (RC) Aircraft Performers

The history of RC aircraft performances dates back to the 1930s when hobbyists began building and flying their model aircraft. As technology advanced, so did the capabilities and performance of these aircraft, leading to the growth of the RC aircraft performing community.

RC aircraft performers operate scale model aircraft, demonstrating exceptional piloting skills and precise aircraft control. These performances can include aerobatics, formation flying, and even reenactments of historical aerial engagements. Some notable RC aircraft performers include Jase Dussia, Frank Tiano, and the RC Kavala Acro Team (see Figure 1.9).

1.2.1.10 Drone Performers

Drone performers have emerged as a relatively recent addition to the world of air shows. These performers operate unmanned aerial vehicles (UAVs) or drones

FIGURE 1.8 AeroSuperBatics Wingwalkers. Copyright: Tim Felce.

FIGURE 1.9 RC Kavala Acro Team is performing a vertical hovering of their RC Yak 54 model. Copyright: RC Kavala Acro Team.

equipped with LED lights, allowing for synchronized aerial light displays and choreographed performances.

Drone performances began to gain popularity in the early 2010s as advances in drone technology allowed for greater stability, precision, and control. In recent years, drone performances have garnered significant attention for their innovative and mesmerizing displays for swarms of drones, pushing the boundaries of what is possible in aerial performances.

1.2.1.11 Mix Performances

Mix performances have developed alongside the growth and diversification of air show performers, offering a fresh approach to aerial entertainment. These performances showcase the creativity and adaptability of air show performers as they continuously seek new ways to captivate and inspire their audiences.

Mix performances combine multiple categories of air show performances, creating a unique and engaging experience for the audience. Examples of mixed performances included the Red Bull Air Race, which combines aerobatics and timed racing through a challenging course of inflatable pylons, and the jet trucks racing against aircraft (see Figure 1.10).

1.2.1.12 Aircraft Innovations

Sustained interest and continuous improvements in air show performance have inspired cutting-edge designs and innovations in aircraft designs. An example is the

FIGURE 1.10 Jet truck racing against an aerobatic aircraft at Cleveland National Air Show, USA. Copyright: Erik Drost.

Jetman wing, developed by Swiss inventor Yves Rossy, which allows a pilot to fly at speeds of up to 250 mph using a jet-powered wing. Such innovations contribute to the development of aviation technology and add to the excitement and spectacle of air shows.

1.2.2 Air Bosses and Flying Control Committee (FCC)

Air bosses and flying display directors play a vital role in ensuring the safety and success of air shows. They are responsible for managing the complex logistics of air shows, including air traffic management, designing and coordinating aerial displays, and managing risks during the event (see Figure 1.11). Air bosses and flying display directors must have extensive knowledge and experience in aviation and air traffic management to ensure the display is performed safely (International Council of Air Shows, 2023a; UK Civil Aviation Authority, 2023a).

To qualify for these positions, candidates must meet the specific requirements of their respective countries and organizations. In the United States, candidates must meet the qualification requirements set by the Federal Aviation Administration (FAA), while candidates must then complete an air boss training course and pass a written and practical exam to receive their certification (International Council of Air Shows, 2023a). Similarly, in the United Kingdom, candidates must have extensive experience in aviation and risk management to become flying display directors. They must complete a training course that covers the regulations and procedures for air shows, pass a written exam, and demonstrate their ability to manage an air show safely and efficiently (UK Civil Aviation Authority, 2023a).

FIGURE 1.11 The author (Manolis Karachalios), serving as a flying display director, is stationed in the control tower during the Athens Flying Week Air Show at Tatoi airfield, Greece, in 2013. Photo by the author.

The International Council of Air Shows (ICAS) and the European Airshow Council (EAC) also recognize the importance of air bosses and flying display directors in air shows. ICAS provides education and training for air show professionals, including the Air Boss Academy (International Council of Air Shows, 2023b), which covers topics such as air traffic management, risk management, and emergency procedures. The EAC offers a Flying Display Director Seminar (European Airshow Council, 2023) that covers the regulations and procedures for air shows in Europe, including designing and coordinating aerial displays, managing air traffic, and ensuring the safety of all participants.

In Australia, the display coordinator is appointed by the display organizer to the Civil Aviation Safety Authority (Civil Aviation Safety Authority, 2022). The display coordinator is in charge of the actual flight program and is accountable for the overall airborne component and safety of the event. In addition to the display coordinator, a display organizer may appoint a small group of experienced individuals to serve as a display committee for larger displays. Additionally, a component of air shows in Australia is the ground control coordinator, who is accountable to the display organizer. They should have a substantial and verifiable aviation background commensurate with the planned event, which enables them to identify aviation ground-based hazards and their impact on persons and property during the event.

Another function to ensure safety in air shows is applied in the United Kingdom: the Flying Control Committee (FCC), which oversees air show safety and augments

the duties of the flying display director (FDD). The UK Civil Aviation Authority (CAA) appoints the FCC for each air show, which is responsible for ensuring that the air show is conducted safely and complies with the UK CAA's regulations and standards (UK Civil Aviation Authority, 2023a). The FDD selects the FCC, which should include pilots with experience flying the Flying Display's aircraft and might be augmented by other air show experts.

Air bosses, flying display directors, display coordinators, and the FCC play a crucial role in ensuring the safety and success of air shows, and their importance was highlighted in the study's findings. Air bosses serve as risk management intermediaries in air shows, bridging the gap between the regulators and the air show performers (see Figure 1.12). As such, they are held accountable for the safe execution of an air show. Ultimately, air bosses set the tone of the air show during the display safety briefing, and they must maintain the rhythm of the air show choreography until the end of the event.

1.2.3 Air Show Regulators

In addition to the categories of air show performers listed previously, aviation authorities provide regulations and guidelines for air show performers to ensure the safety of themselves and the audience. The French civil aviation authority, Directorate General for Civil Aviation (DGAC), provides specific regulations for air show performers in France, including rules for formations and jet demonstrations (French Civil Aviation Authority, 2023). Similarly, the UK Civil Aviation Authority (UK CAA) provides safety and administrative requirements and guidance for flying displays and special events (UK Civil Aviation Authority, 2023b). In Brazil, the National Civil Aviation Agency (ANAC) provides regulations for air shows and aerial demonstrations (Agência Nacional de Aviação Civil [ANAC], 2023). ANAC's Regulation No. 17/2015 outlines the necessary procedures and requirements for conducting these events (Agência Nacional de Aviação Civil [ANAC], 2015). Then, the South African Civil Aviation Authority (SACAA) oversees regulations for air show performers in South Africa. The South African Special Air Events (SAE) Handbook is one of the documents forming the required SAE documentation set, which specifies the requirements and restrictions applicable to air displays and special events (South African Civil Aviation Authority, 2021). Then, in the United Arab Emirates (UAE), the General Civil Aviation Authority (GCAA) is the main regulatory body responsible for overseeing the safety and security of civil aviation in the country

FIGURE 1.12 The relationship amongst air show stakeholders.

(UAE General Civil Aviation Authority, 2023). The GCAA has published requirements and standards that air show organizers, participants, and display teams must follow to ensure the safety of all involved.

Air show regulators are responsible for ensuring that air shows are conducted safely and in compliance with national and international regulations. They play a crucial role in setting standards and guidelines that organizers and performers must follow to reduce the risk of accidents and injuries. Additionally, regulators can change air show procedures to address safety concerns and new technologies or equipment.

For example, after the tragic incident at the Shoreham Airshow in the UK in 2015, air show regulators reviewed safety procedures and made significant changes (UK Air Accidents Investigation Branch, 2017). The accident was a wake-up call for the air show industry, prompting a review of safety procedures and regulations. The UK Civil Aviation Authority (CAA) implemented stricter regulations, such as requiring more detailed risk assessments from air show organizers. These changes were made to mitigate the risks of accidents and improve safety for all involved.

Another example of regulators changing air show procedures is the Federal Aviation Administration (FAA) in the United States. In response to the COVID-19 pandemic, the FAA issued guidelines for air shows that included measures to reduce the risk of virus transmission. These measures included reducing the number of spectators and requiring performers and staff to follow social distancing and hygiene protocols. The FAA's changes aimed to protect public health while allowing air shows to continue safely.

In addition to responding to specific incidents or concerns, regulators can change air show procedures to incorporate new technologies or equipment. For instance, introducing unmanned aerial vehicles (UAVs) or drones has led to new regulations and guidelines from air show regulators. The FAA has developed guidelines for the safe operation of UAVs at air shows, including restrictions on their use during certain maneuvers or in certain areas.

In conclusion, air show regulators play a critical role in ensuring the safety of air shows. Air show regulators exist in many countries around the world, and even though their roles and responsibilities may vary depending on the region, they all align in setting standards and guidelines, conducting safety assessments, and making changes to air show procedures as needed so that they can mitigate the risks of accidents and injuries. As new technologies emerge and concerns arise, regulators will continue to play an essential role in ensuring that air shows are conducted safely and in compliance with regulations.

1.2.4 Air Show Stakeholders Association/Collaboration/Bonding

In addition to the national aviation regulatory agencies, other institutions, such as the International Council of Air Shows (ICAS), the European Airshow Council (EAC), the Fédération des Spectacles Aériens (FSA), and the British Air Display Association (BADA), provide valuable support to the air show industry with their

knowledge, expertise, and industry best standards that may be more stringent than regulatory requirements. Furthermore, the Fédération Aéronautique Internationale (FAI), also known as the World Air Sports Federation, is an international organization that oversees air sports, including aerobatics, which are often featured in air shows. The FAI establishes rules and safety standards for various air sports and maintains a global network of national aviation organizations.

In recent decades, the international air show community has also made significant strides in the area of safety and risk management. The establishment of organizations such as the ICAS, the EAC, the FSA, the FAI, and the BADA has played a crucial role in promoting safety standards and best practices across the industry. These efforts have helped to ensure that air shows remain a thrilling yet secure celebration of human achievement.

1.2.5 Diversity and Inclusion in Air Shows

The air show community has come a long way in promoting diversity and inclusivity, with performers from diverse backgrounds, genders, and ethnicities taking center stage at events across the globe. This progress reflects the growing recognition of the importance of diversity in aviation and the need to inspire future generations of pilots and performers from all walks of life. As the world becomes increasingly interconnected, the air show community needs to continue fostering an environment that welcomes and celebrates diversity.

By showcasing the talents and achievements of performers from diverse backgrounds, air shows contribute to a more inclusive aviation community and inspire individuals who may have previously felt excluded or underrepresented. As we continue to break down barriers and promote inclusivity, the sky is truly the limit for what we can achieve in the world of air shows and beyond.

1.2.5.1 Historical Perspectives

There has been incremental progress in the area of diversity and inclusion within the international air show community from the early 1920s till date. Male pilots dominated the early days of air shows, but as the years progressed, more women and people of diverse backgrounds began taking to the skies. Pioneers like Bessie Coleman, the first African American woman to hold a pilot license, broke barriers and shattered stereotypes in the 1920s (Rich, 1993). Despite facing immense adversity, including racial and gender discrimination, Coleman's determination and talent inspired generations of aspiring pilots from diverse backgrounds. Another trailblazer in the world of air shows was Pancho Barnes, born as Florence Leontine Lowe. She was a pioneering aviator, stunt pilot, and founder of the first movie stunt pilots' union. Pancho Barnes set numerous aviation records, including breaking Amelia Earhart's air speed record in 1930, and her fearless attitude and skills paved the way for many female pilots that followed.

In Europe, one of the earliest female air show pilots was Marie Marvingt, a French aviator who was also an accomplished athlete, nurse, and journalist. She was

the first woman to fly combat missions as a bomber pilot during World War I and participated in numerous air shows, showcasing her skills and encouraging other women to take up flying.

Currently, Patty Wagstaff and Svetlana Kapanina are indeed remarkable contemporary female air show performers who have made significant contributions to the world of aerobatics.

Patty Wagstaff, an American aerobatic pilot, is renowned for her incredible skill and precision in the air (see Figure 1.13). Born in 1951, she began her flying career in the early 1980s and quickly gained recognition for her talent. In addition to being a three-time U.S. National Aerobatic champion, Wagstaff has also won numerous international competitions and received several prestigious awards. She was inducted into the National Aviation Hall of Fame in 2004, further solidifying her legacy in the world of aviation. Today, she continues to inspire and train the next generation of pilots through her flight school and by performing at air shows worldwide.

Svetlana Kapanina, born in 1968, is another outstanding aerobatic pilot representing Russia on the global stage. With her exceptional skills and dedication, Kapanina has secured seven World Aerobatic Champion titles in the women's category, making her one of the most successful female pilots in the history of the sport. She has also won numerous European championships and other international awards, earning the respect and admiration of her peers and fans. Kapanina continues to compete and perform in air shows, further pushing the limits of what is possible in aerobatics and inspiring future generations of pilots.

Today, organizations like Women in Aviation International (WAI), the Organization of Black Aerospace Professionals (OBAP), and the National Gay Pilots Association (NGPA) provide strong advocacy and work tirelessly to promote diversity and inclusion within the industry. By providing scholarships, mentorship

FIGURE 1.13 Patty Wagstaff, flying her Extra 300. Copyright: Patty Wagstaff.

programs, and networking opportunities, these organizations are fostering an environment where everyone, regardless of their background or identity, can succeed and thrive in aviation careers such as air show performance.

Air shows have also become platforms for showcasing the talents of diverse pilots and performers. Events such as the Sisters of the Skies outreach programs and the Warriors Over the Wasatch Air and Space Show demonstrate the power of inclusion and the importance of representation in inspiring future generations of aviators. The Sisters of the Skies outreach programs, for example, highlight the achievements and talents of women pilots, showcasing their skills and breaking down gender stereotypes. This empowers and encourages more women to pursue careers in aviation, thus increasing diversity in the field. On the other hand, the Warriors Over the Wasatch Air and Space Show focus on celebrating the contributions of disabled veterans, who may have unique experiences and skills to share. By highlighting the achievements of these veterans, the event helps to raise awareness about the capabilities of disabled individuals and fosters a more inclusive environment in the world of aviation.

Another shining example of diversity and inclusion in air shows is the WeFly! Team, an Italian aerobatic display team made up of pilots with disabilities (see Figure 1.14). Founded in 2007, the team showcases the incredible skills and resilience of disabled pilots, challenging preconceived notions about their capabilities. The WeFly! Team's performances not only demonstrate the power of determination but also serve as a powerful symbol of inclusivity in the world of aviation.

Air shows today are a melting pot of diverse performers, showcasing talent from around the globe. Pilots from different countries, cultures, and backgrounds come together to share their passion for aviation, demonstrating that the sky truly has no borders. The increased visibility of diverse pilots in air shows has helped to foster a more inclusive environment, inspiring a new generation of aviators and enthusiasts from a wide variety of demographics.

FIGURE 1.14 The WeFly! Team performing in close formation at AFW 2013, Tatoi AFB. Copyright: Athens Flying Week (Photo by WeFly!).

1.2.6 Trailblazing Female Airs Show Performers

Numerous trailblazing female air show performers have left their mark on history, but two individuals, in particular, significantly impacted their generation: Bessie Coleman (1892–1926) and Maryse Bastié (1898–1952). Their remarkable accomplishments and tenacity inspired their contemporaries and paved the way for future generations of female aviators.

Bessie Coleman and Maryse Bastié proved that women could excel in male-dominated fields given the opportunity. Their accomplishment in aviation is a true testimony of their resilience and exceptional skills. These two aviatrixes have left a lasting legacy that continues to inspire countless numbers of women and marginalized people to be relentless in the pursuit of their dreams, even if it means challenging established conventions. Their stories highlighted in the next section show that perseverance, courage, and passion are required to overcome challenges in the quest for success.

1.2.6.1 Bessie Coleman: Breaking Barriers in the Sky

Bessie Coleman (1892–1926) was a pioneering American civil aviator who broke racial and gender barriers by becoming the first African American woman and Native American woman to hold a pilot's license (see Figure 1.15). Born in an era marked by discrimination and limited opportunities for women, especially women of color, Coleman's determination to achieve her dream of flying was nothing short of inspiring.

FIGURE 1.15 American pilot Bessie Coleman and her bi- plane circa 1922. Copyright: Michael Ochs Archives / Getty Images.

1.2.6.1.1 Early Life

Born in Texas on January 26, 1892, to a Native American father and African American mother, Bessie Coleman faced the double difficulties of racial and gender discrimination in early 20th-century America. Despite these challenges, Coleman was determined to pursue her dream of flying. Interestingly, her brother John's teasing, which included comparing her to French women who could fly, played a significant role in motivating her to seek a pilot's license.

However, Coleman's journey to becoming a pilot was far from easy. Due to her gender and race, American flight schools rejected her. Undeterred, Coleman sought the help of Robert Abbott, publisher of the well-known African American newspaper, the Chicago Defender. Abbott encouraged Coleman to save money, move to France, and pursue her pilot's license there. Taking his advice to heart, Coleman worked tirelessly to save funds and learn French, eventually moving to France in November 1920.

1.2.6.1.2 Aviation Achievements

After earning her pilot's license, Bessie Coleman returned to the United States and quickly gained fame as an air show performer, known as "Queen Bess." Her aerial stunts, which included daring loop-the-loops and barrel rolls, captivated audiences across the country. Coleman's skills as a barnstormer demonstrated her exceptional abilities as an aviator and set her apart from her contemporaries.

One of Coleman's most remarkable achievements was her first public air show on September 3, 1922, at Glenn Curtiss Field in Garden City, New York. Sponsored by the Chicago Defender, this event showcased Coleman's exceptional skills and catapulted her to national celebrity status. Her performances not only entertained audiences but also served as an inspiration for other aspiring pilots, particularly women and African Americans.

1.2.6.1.3 Legacy and Impact

Although Bessie Coleman's tragic death in 1926 cut her aviation career short, her impact on aviation history was profound. As the first African American woman and Native American woman to earn a pilot's license (National Air and Space Museum, 2021) and perform daring aerial stunts, she inspired future generations of African American and Native American pilots to break barriers in the field. Coleman's life and accomplishments demonstrated that with determination and hard work, individuals from all backgrounds could achieve success in the aviation industry.

Even after Bessie's demise, her accomplishment inspired the formation of multiple Bessie Coleman Aero Clubs, the organization of the first all African American Air show in 1931, and an annual flyover of her grave by African American pilots. Additionally, her name appeared on buildings in Harlem, further solidifying her status as a role model and trailblazer in aviation. Coleman gained fame outside the black community over time. In the afterword to "Queen Bess: Daredevil Aviator," Mae Jemison, the first African-American woman in space in 1992, (Slotnik, 2019) writes that she was "embarrassed and saddened that I did not learn of her until my

spaceflight beckoned on the horizon." Jemison carried a photo of Coleman into orbit, traveling higher than Coleman had dreamt.

As a trailblazer in the aviation industry, Bessie Coleman's accomplishments continue to inspire and motivate individuals from diverse backgrounds to pursue their dreams. Her remarkable journey from humble beginnings to becoming an aviation icon serves as a testament to her resilience and tenacity. Coleman's story is a powerful reminder that with passion and determination, one can overcome seemingly insurmountable obstacles.

1.2.6.2 Maryse Bastié: A Trailblazer in the Skies

Maryse Bastié (1898–1952) was a pioneering French aviator who shattered gender barriers and set multiple records during her illustrious career (Fédération Aéronautique Internationale [FAI], 2019). Bastié's achievements were awe-inspiring, considering the societal norms and expectations of women during her time. She demonstrated exceptional skill, courage, and determination, inspiring a new generation of female pilots, such as Jacqueline Auriol and Hélène Boucher, to continue breaking barriers in aviation.

1.2.6.2.1 Early Life

Maryse Bastié was born Marie-Louise Bombec on February 27, 1898. She faced considerable hardships throughout her life, starting with her father's death when she was just 11 years old. As a result, Bastié was forced to work in a factory to support her family.

Despite her tragedies, Bastié was determined to rise above her circumstances. In 1921, she met and married her second husband, the World War I pilot Leon Bathiat. It was through him that Bastié discovered her passion for aviation.

1.2.6.2.2 Aviation Achievements

Maryse Bastié's aviation career began in 1925 when she obtained her pilot's license. This was a remarkable accomplishment, considering that few women were allowed to fly at the time. Bastié quickly gained recognition for her skills, and in 1927, she set the women's world record for the longest solo flight, covering a distance of 1,243 miles.

Bastié continued to break records throughout her career. In 1929, she set the women's world record for endurance, flying for 26 hours and 47 minutes. In 1931, she broke the women's world speed record, reaching an average speed of 126.48 miles per hour (Pujol, 2014). Her most significant achievement came in 1936 when she established a new world record for the longest nonstop flight by a woman, flying 2,976 miles from Paris to Moscow in 37 hours and 55 minutes.

Bastié received numerous awards for her accomplishments, including the Harmon Trophy in 1931 and the Légion d'honneur in 1932. In 1935, she was promoted to the rank of captain in the French Air Force.

1.2.6.2.3 Legacy and Impact

Maryse Bastié's groundbreaking achievements in aviation had a profound impact on women's involvement in the field. She served as a role model for other female

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