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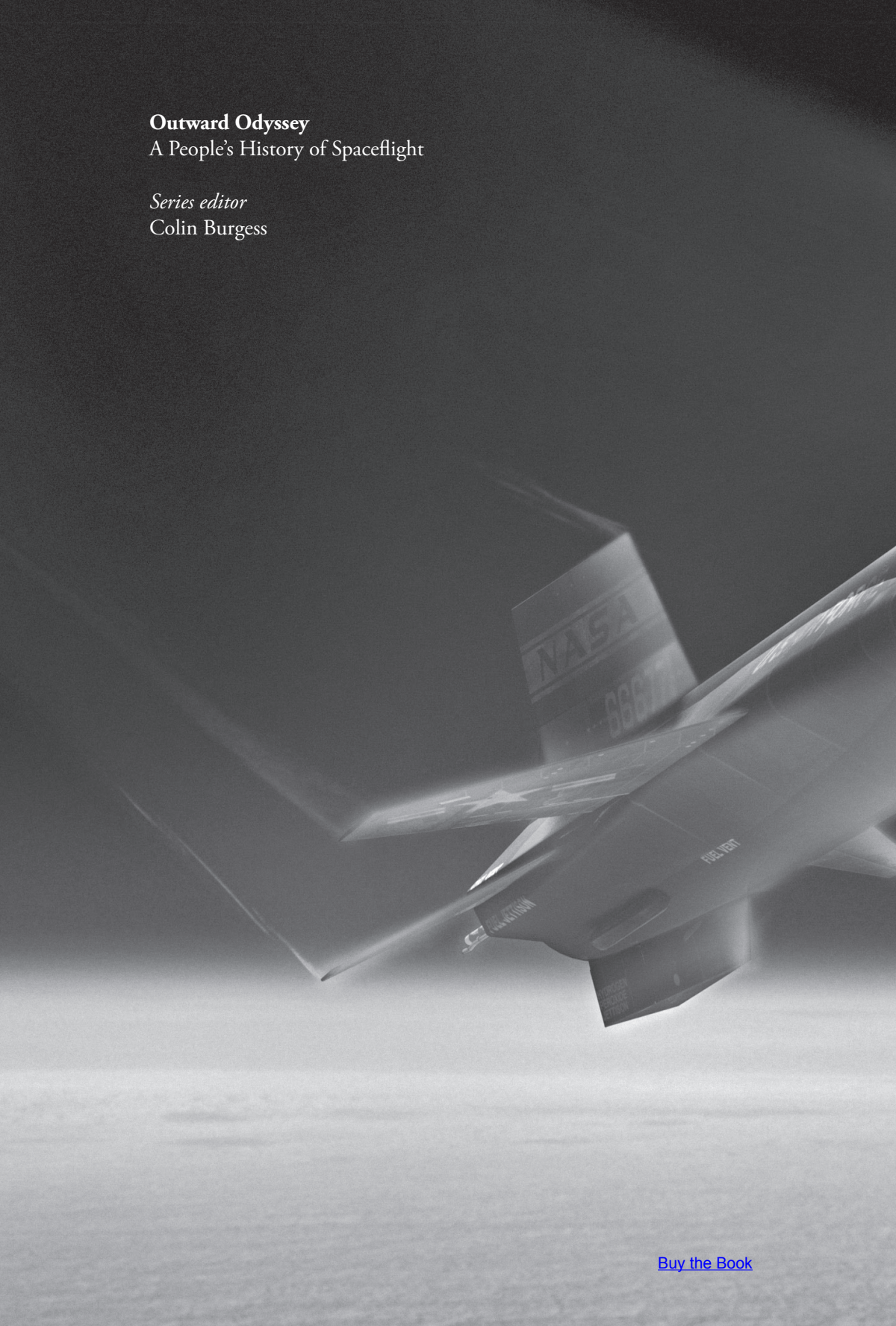
The X-15 Rocket Plane

Michelle Evans

The X-15 Rocket Plane

Outward Odyssey
A People's History of Spaceflight

Series editor
Colin Burgess



Michelle Evans

Foreword by Joe H. Engle

The X-15 Rocket Plane

Flying the First Wings into Space

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This work is dedicated to all the men and women who made the X-15 possible, in flight, on the ground, and behind the scenes, and to Milt Thompson for giving me that first interview.

And a very special dedication to Cherie, my partner in life, my wife, my muse, without whose love and support this book would have never found light. And to Fluffy and Max, who stood vigil at my computer for so many years.

[Man] is a tough creature who has traveled here by a very long road. His nature has been shaped and his virtues ingrained by many millions of years of struggle, fear, and pain, and his spirit has, from the earliest dawn of history, shown itself upon occasion capable of mounting to the sublime, far above material conditions or mortal terrors.

Winston Churchill (1874–1965)

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Foreword

As test pilots within the Flight Test community, my colleagues and I tend to associate significant advances in our world of flight in terms of hardware, specifically the airplanes. We give those airplanes names and personalities, and we speak of them respectfully (or sometimes not so respectfully) as living things. We often overlook the fact that it was people who conceived the ideas and goals, designed the often beautiful yet functional mold lines, the often critical but not visible systems, and gave these airplanes the ability to fly—with a little help from the laws of physics.

In this truly unique book, Michelle Evans has focused on those people, giving us a wonderful insight into who they were and what it was that drove them to dedicate their careers, and sometimes their very lives, to expanding our knowledge of flight. As I read the manuscript, I was familiar with many of the stories and incidents, but the accompanying details that Michelle's thorough research unearthed has made them so much more meaningful, fascinating—and fun! (I can't wait to retell them.) I've often joked that my X-15 stories get better each time I tell them. Now, at least for those told here, it'll be true.

Thankfully, the book is not limited to the pilots, who often receive the bulk of the credit and attention. We are introduced to engineers, technicians, mechanics, managers, administrative support folks, and people who, at times, were carrying out tasks far beyond (and sometimes beneath) what they were originally hired to do. But they did whatever it took to make the flight program safe and successful. The people you will read about in this book are a wonderful reminder of why this nation enjoys such a proud aviation heritage, and why we have been able to take the next steps in our continual quest for more speed and to go ever higher—even into space. They also represent why Edwards Air Force Base is universally recognized as the world's greatest flight test facility. Sure, the ideal weather and an abun-

dant array of dry lakebeds providing emergency landing areas doesn't hurt, but it's the people of Edwards and their spirit, unmatched anywhere in the world, that made it happen.

The X-15 was the greatest airplane I have ever had the privilege to fly. It was an honest, beautifully handling airplane and, most of the time, a real joy to fly. It was also the most rewarding airplane I have flown, while requiring the pilot's continuous, undivided attention throughout the entire flight profile. At subsonic, and even low supersonic speeds, the X-15 handled like a really good fighter. Because of its incredibly effective vertical stabilizer, and the fact it used differential elevons instead of ailerons mounted out on the wings for roll control, it exhibited little of the yaw-roll coupling experienced on most aircraft. The lower ventral part of this very effective directional control surface, which had to be accommodated and even removed during the high angle of attack entries on altitude flights, is discussed in this book.

The information and techniques developed in the X-15 program literally laid the groundwork for the Space Shuttle. Hardware, flight control systems, operational flight techniques, physiological data, crew operations with a full pressure suit, data monitoring of both aircraft and biological parameters, simulation, and real-time mission control were all direct beneficiaries of the X-15 program. But perhaps the most significant contribution was the airplane's demonstration of the ability to routinely manage energy of an unpowered, low lift-to-drag winged vehicle through reentry from space to a precise touchdown on a runway or lakebed.

During the design development phase of the Space Shuttle, many key engineers and managers at NASA felt it was necessary to have deployable air-breathing engines to provide go-around capability, or at least a shallower and more benign final approach to touchdown after reentering from space. Because the lift-to-drag final approach angles and the approach pattern and touchdown speeds of the X-15 and Space Shuttle were nearly identical from about Mach 5 to touchdown, those concerns were answered and put to rest. The significant resources, development time, and weight impact of air-breathing engines on the useable payload of the Space Shuttle were thus avoided.

It would be incorrect to suggest that if we did not have the information and experience of the X-15, we would never have been able to fly the Space

Shuttle. However, the X-15 was a critical step toward that goal, allowing us to get there safer, quicker, more efficiently, and with more confidence.

It will be a very long time—if ever—before we once again have a research aircraft so capable. This magnificent airplane taught us how to fly at hypersonic speeds and to routinely fly out of the atmosphere, conduct experiments, then reenter to make a precision landing.

The X-15 was a cutting edge airplane with a powerful rocket engine. This combination gave us the ability not only to go incredibly fast but to attain high enough altitudes to fly our first wings into space.

Maj. Gen. Joe H. Engle, U.S. Air Force (ret.)
X-15 pilot (sixteen missions)
Space Shuttle commander: ALT-2, ALT-4, STS-2, STS-51I

Acknowledgments

So many people helped make this book a reality. As with any work of a historical nature, it will always be true that an author cannot work in a vacuum. There are interviews, research, travel, and more interviews. Each person you meet along the way helps get you to that finish line. However, the biggest hurdle in any book is to get off the blocks. With that in mind, I acknowledge Dr. Richard Hallion, who answered my first phone call on the day I got the idea to pursue this project. His response was to come directly to Edwards Air Force Base so he could point me in the right direction. I grabbed my gear and headed up to meet with him the next day. Dr. Hallion went on to make introductions with several key people, who all eventually sat down to endure my questions.

Milt Thompson was the first in a long line of interviews. He and Jack Kolf visited with me several times. I will be forever saddened that neither of these fine gentlemen survived to see this work published.

Much later, I found a good friend in Dave Stoddard, formerly of the NASA rocket engine shop. We met after a long hiatus from my writing. He opened more doors than anyone else. For that, and so much more, thank you, Dave.

Others I must note include Sheri McKay-Lowe, daughter of X-15 pilot Jack McKay. One of eight children, Sheri spent a lot of time with me in her home, and on the telephone, sharing memories of her parents and her life with seven siblings.

Francis French was the one who first put me in touch with my editor, Colin Burgess. I am forever grateful to Francis for getting the ball rolling that night at "Killer Pizza from Mars" and to Colin for believing in me, even when he could have easily given up and gone elsewhere. Colin, you put up with a lot from me throughout the gestation process, reassuring me I was the only person who could tell this story. You are amazing.

Thommy Eriksson first contacted me many years ago, telling me of his love of the X-15 and of his special skill in creating photo-realistic computer images. The marriage of those two skills is seen throughout this book with the amazing images he conjured while skillfully manipulating pixels. My gratitude in what he created is as high as the altitudes reached by the X-15.

Special thanks go to all those people who shared their time and stories of the X-15: Brent Adams, Freida Adams, George Adams, Bill Albrecht, Johnny Armstrong, Neil Armstrong, T. D. Barnes, Florence Barnett, Larry Barnett, Roger Barniki, Paul Bikle, Phil Brandt, Dean Bryan, Stan Butchart, Vince Capasso, Scott Crossfield, Sally Crossfield Farley, Bill Dana, Meryl DeGeer, Joe Engle, Frank Fedor, Fitz Fulton, Billy Furr, Charles Gerdel, Byron Gibbs, Don Hallberg, Bob Hoey, David Knight, Pete Knight, Jack Kolf, Eldon Kordes, Terry Larson, Wade Martin, Charlie McKay, John McKay, Mac McKay, Mark McKay, Sheri McKay-Lowe, John McTigue, Phil Moore, Edward Nice, John Painter, Forrest Petersen, Bob Revert, Ralph Richardson, Daniel Riegert, Jim Robertson, Bob Rushworth, Harry Shapiro, Glynn Smith, Dave Stoddard, Harrison Storms, Bill Szuwalski, Milt Thompson, Daryl Townsend, Jim Townsend, Donald Veatch, Grace Walker-Weismann, Gene Waltman, Lonnie Dean Webb, Bob White, Ray White, Walt Williams, and Jim Wilson.

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Introduction

The X-15 was the first winged rocket ship to take astronauts into space and back again. It was designed in the mid-1950s, at a time when, to the public, rocket ships meant gleaming silver stilettos with swept-back fins, filled with astronauts in bubble-headed spacesuits, doing battle against aliens bent on the overthrow and subjugation — or annihilation — of Earth.

Although the X-15 was sleek from a distant perspective, a closer look revealed construction much heavier than might be expected. Protuberances such as bug-eyed cameras and antennae bulged from the heat-resistant hypersonic skin, while surfaces at the rear were corrugated for strength rather than aesthetics. Seeing the intricate details of the craft reminded one more of an industrial boiler rather than of the sculpted visage people were used to seeing in the science fiction of that period.

Yet the X-15 was still a beauty in its own right, not created to please an audience, but instead was the vanguard of a far-reaching research program that dealt with the real idea of being able to fly a fully reusable spacecraft out of the atmosphere and land it safely back on terra firma under a pilot's control. And even though the experimental data garnered from more than nine years of flight testing often lent itself to technical journals and scientific publications, the program also inspired people about the real excitement and promise of air and space exploration.

A generation earlier, a silver, single-engine, high-wing monoplane, with only a periscope for forward viewing, swung in over the ocean and landed at a small field. Local military men, with arms linked, tried to hold back the swarm of onlookers who attempted to rush the field. Inside the *Spirit of St. Louis*, Charles Lindbergh shut down the engine and organized his materials and thoughts, then climbed out of his airplane to the waiting jubilation of the people. This was not the evening of 21 May 1927 at the Le Bourget

airport outside Paris but instead in St. Thomas, U.S. Virgin Islands, more than eight months later.

In early 1928 Lindbergh was finishing a tour that extended throughout Latin America and the northern parts of South America, culminating with stops in the Caribbean. He was riding the crest of fame and admiration for his feat of the first solo crossing of the Atlantic. As with so many places around the world, the entire island of St. Thomas had been enthusiastic followers of Lindbergh's exploits. Although not on his original itinerary, the territorial governor of the Virgin Islands, Waldo Evans, sent a special invitation for Lindbergh to visit St. Thomas before he returned to the United States at the end of this tour. He was hoping not only to have the famous aviator in his territory but that Lindbergh's presence might help foster aviation throughout the islands and the resultant tourism that would entail. Governor Evans's request had originally been misplaced by the State Department; however, the governor was finally able to make contact while Lindbergh was in Panama. With just a few weeks until he would arrive, Lindbergh accepted the invitation, landing on St. Thomas on 31 January.

The following day was full of festivities, including horse races, tours, and official government receptions. The U.S. Navy was responsible for most of the arrangements, which included having their official photographer record the events. He was Milton Barron McKay, or simply "Cap Mac" to close friends and family. His twin sons were Jim and John, although John preferred the nickname Jack. The boys were just past their fifth birthday when Lindbergh landed.

Eighty years later, Sheri McKay-Lowe, daughter of Jack, said that after the great aviator's visit, both boys immediately fell in love with the idea of flying into the clouds. They started making small popsicle-stick airplanes. As they grew, so did their ambitions to emulate what they had seen in Lindbergh. They built proper model airplanes, and both hoped for later careers in aviation. Jim eventually became an aeronautical engineer, working for the National Aeronautics and Space Administration (NASA) at the Flight Research Center. Jack was able to enter test flying, becoming the fifth pilot of the X-15 research aircraft.

My passion for exploration began at about the same age as the McKay twins. When I was a young child in kindergarten and on into grade school, my

father worked for a company called Sangamo Electric, setting up expensive, multitrack data tape recorders at government locales such as the Naval Weapons Center at China Lake and the Flight Research Center at Edwards Air Force Base in the Mojave Desert of California. His instruments acquired telemetry from military tests of missiles and weapon systems; most of what he did he could not share with me. One morning before going to school, my father asked if I would like to tag along on one of his day trips to Edwards. I jumped at the chance, although for a five-year-old kid, it was a scary proposition to head into the desert with fighters, bombers, and everything else under the sun thundering through the clear, bright sky. I waited outside my classroom at the appointed time for my father to pick me up to begin my adventure—one that continues to this day. The trepidation of that first trip quickly turned to awe as I saw the wonders in store. It was the first of many such excursions over the next several years.

This was the era of spaceflight, when we could go everywhere and do everything. The moon was within our grasp. The rockets being launched at Cape Canaveral were wonderful, but I saw them only on television; whereas, on these trips to the other NASA at Edwards, I could see the real stuff up close. I also had a young child's delight in getting to meet the men who flew the test flights, and lots of other people on the ground who truly made it all happen.

Since my father also had work to do, he often found a friend who could walk me around on behind-the-scene tours. We'd wander through the hangars or out on the flightline to see what was on the ramp being prepared for a future flight or what may have just come back from a sortie. I vividly recall watching with fascination as the X-15 was slung under the wing of a B-52 and made ready for flight. There was so much going on: the jumble of equipment, personnel going about their jobs, everyone often doing things where I had no idea of their purpose. It was paradise for a curious kid with lots of questions and a yearning for excitement.

On one such trip, my father's designated friend decided to take me to see the X-15 simulator, known as the "Iron Bird." He knew it was currently in use and thought I might like to see its operation. It was a long contraption, with pipes and wires and sheet metal, looking like something a child such as myself might cobble together out of an Erector Set. We stood and watched for a bit, then the pilot finished his "mission" and exited the cock-

pit. Instead of walking directly away to some debriefing or to his office, he saw me there and decided to come over, say hello, and shake my hand. I have no idea who my guide was that day, but I will always remember that moment when he introduced me to the research pilot who had just exited the simulator. His name was Neil Armstrong.

When I was first getting the idea to write the book you now hold in your hands, I contacted Neil for an interview, writing a letter asking to set up the appointment. Neil called me one morning to let me know he was willing to get together. After a couple months of planning, I drove into a tiny Ohio town on a rainy Thursday afternoon in early May, looking for his office. Somehow the address was off by a digit, and I ended up blocks away from where I should have been. The place just didn't look right. I knocked on the door and for a long time no one answered. Had he forgotten our appointment? Finally, the door creaked open and a very old man was standing there. When I said I was there to see Neil, he thought for a long moment, scratched his head, then said, "Oh, you must be looking for that astronaut fella." I told him I was, and he explained the mistaken address number, directing me to the right location down the street.

Soon afterward I was knocking at the correct door, and his secretary immediately answered and invited me in out of the rain. My first glimpse of Neil in his office that afternoon—the first time I had seen him in person since that day with the X-15 simulator—was him standing in the middle of his office with a wastebasket in hand, trying to place it to catch the rain coming in through leaks in a bad roof. The can was just one of several I saw scattered about the room. Introducing myself, we shook hands, then he set the can on the floor under a drip. Looking around the room at the mess, he suggested we find a new location for the interview, so we walked across the street to a neighborhood ice cream parlor. We found a corner table near the front window and sat down to talk for a couple hours. I recall that meeting fondly and can now listen to that tape of his mild but assured voice answering my queries. In the background are the various sounds of the parlor: chairs scratching on the tile floor, the cash register ringing up, the low murmur of other patrons, the tinkling of the tiny bell as the door is opened and closed.

This is just one of my many vivid memories from all the interviews conducted for this book, part of my personal journey with regard to the X-15.

Earlier on that same research trip to speak with Neil, I had an appointment in the suburbs of Virginia to see the only navy pilot in the program, Forrest Petersen. Early Saturday morning I was looking for his street near Georgetown Pike and Dolly Madison Boulevard when I recognized the entrance to the Central Intelligence Agency on my left. Just a few blocks later I turned onto the small dead-end street where Admiral Petersen lived and pulled to a stop. When he invited me in, I immediately saw it would be an informal interview as he had apparently just awakened and was wearing a light blue robe covered in cat hair. We conducted the interview at his kitchen table, as his wife puttered around making coffee.

Each interview was special: Joe Engle in a dimly lit sitting room with a porthole at the Queen Mary cruise ship in Long Beach; Scott Crossfield on a bench in the echoing hallways of the Rayburn Senate Office Building in Washington DC; another Armstrong, this time Johnny, opening his desk drawer at Edwards, pulling out a piece of the X-15A-2 scramjet he found in the desert after Pete Knight's high-speed flight in 1967; Jack Kolf and Milt Thompson at their desks at Dryden on Christmas Day with brownies Cherie and I brought to share as we conducted the research; Robert Rushworth with his doormat reading "Aliens Welcome," when we went to see him on my birthday; Pete Knight fielding phone calls as he was deciding whether to run for political office for the first time; Walt Williams in a dark house, hooked up to his oxygen tank; seventeen technicians and engineers from the program in a back room at a restaurant, speaking together of their X-15 exploits, "to keep each other honest," they quipped; Billy Furr sharing a pizza in an out-of-the-way place up in the Sierras; John McTigue proudly displaying a leftover rear landing skid in his living room; Jim Robertson talking of working on the external tanks, then pulling out numerous display cases of creepy and exotic bugs he had collected from his trips all over the world; Jim Townsend, becoming animated with stories, just weeks before he passed away; Grace Walker and Freida Adams, at opposite ends of the country, but both with mist in their eyes as they talked of their X-15 pilot husbands now long gone.

Although I was never able to become a pilot myself, at a very young age the X-15 and that first meeting with Neil Armstrong had inspired me onto my career path in aerospace, as the *Spirit of St. Louis* and Charles Lindbergh had for the McKay twins a generation earlier.

The X-15 Rocket Plane

1. The Whole Nine Yards

There is no such thing as an accident. It was
either designed wrong, built wrong, or used wrong.
Generally, it's used wrong.

A. Scott Crossfield

Scott Crossfield started the X-15's rocket engine and moved the throttle forward to 50 percent thrust. The bright exhaust lit up the surrounding area as a long string of Mach diamonds formed and stabilized. Scott then throttled forward to 100 percent. Firmly secured to the test stand, the aircraft strained to pull away with more than 50,000 pounds of force. At a level of 140 decibels at the cockpit, the noise generated by the LR-99 rocket was crippling if unprotected. Inside the nearby control room there was a loud muffled roar, something felt through to the bones.

The purpose of the test was to check the ability of the rocket to restart. Crossfield shut down, then primed the engine for a second ignition. As he brought it back up to 50 percent, the safety system automatically stopped the sequence. Scott called over the radio, "Malfunction. Throttle off." His hand moved toward the instrument panel to make another attempt to relight the engine. He called, "Reset." The moment Scott hit the switch, the X-15 exploded.

Eleven weeks previous to the accident, on 28 March 1960, the first XLR99-RM-1 powerplant for the X-15 was delivered to Edwards Air Force Base (AFB) in the California desert. It was shipped in from the Reaction Motors plant in Denville, New Jersey. By late May the engine was mounted into aircraft no. 3, and the entire assembly was trucked down to the Propulsion System Test Stand (PSTS). It was backed into the fixture, with the exhaust nozzle of the LR-99 butted up against the rectangular yellow and silver structure

at the rear of the stand. A four-foot-diameter hole in the fixture allowed the exhaust gasses to pass through during the test. The aircraft was firmly secured in position for the first engine firing, which was successfully accomplished on 2 June at the PSTS. On Wednesday, 8 June, another run was scheduled to test the restart capabilities of the engine.

People from North American Aviation (NAA), NASA, and the military started arriving at the facility. Vehicles seemed to be parked haphazardly. Hoses, toolboxes, barrels, and ladders cluttered the area. Power carts and a fuel truck added to what looked like a chaotic scene. For those people whose job it was to make the X-15 ready, everything appeared in perfect order.

Crossfield approached the aircraft wearing business attire rather than the expected silver spacesuit. In this instance, he was not planning to fly but to remain firmly attached to the ground, so there was no need to put on the cumbersome and hot multilayered garment. He climbed up an aluminum ladder into the cockpit, while engineers and technicians continued their work.

Preparations proceeded well into the waning light of the early evening hours. Surrounding the aircraft, two banks of three light boxes atop tall poles provided bright, even illumination. Crossfield put on an oxygen mask, since he did not have his spacesuit supply to breathe. Finally, the canopy was closed and secured over Scott. Even bolted to the test stand pad, with access panels removed for instrumentation wiring and miscellaneous plumbing, the X-15 looked ready to leap into space. It was easy to imagine the speeds this rocket plane would achieve in just a few short years.

One by one, and in groups, everyone cleared the area, entering the protection of the blockhouse about fifty feet away. The rectangular command structure had steeply angled exterior walls, giving the casual impression of a truncated pyramid. Inside were racks of electronic instruments and television monitors, and even a periscope for more direct observation. Most important, the blockhouse provided protection for everyone in the event of a malfunction of the highly volatile rocket motor. It was fueled by 18,000 pounds of liquid oxygen and anhydrous ammonia. The concrete structure was a recent addition to the rocket test facility, having been installed barely a month previously. Strapped into the vehicle, Scott had no such protection.

Crossfield lit the rocket, and the first run was completed successfully.

He reset for the second, which triggered the powerful explosion. As the aft end of the aircraft disintegrated behind him, Scott, inside the fuselage, was hurtled twenty feet forward, with a force estimated at fifty gs—fifty times that of gravity. He later said of the noise and fire, "It was the biggest bang I had ever heard. It was like being in the Sun."

Sally Crossfield Farley is the second daughter, the fifth of six children, of Albert Scott Crossfield and Alice Virginia Knoph. She talked about her father, who was one of the best-known rocket pilots during the 1950s and 1960s and who was the first to fly the X-15. "My dad missed most of my life growing up. When I go back into my memory bank, I don't have as many memories as I would have liked. . . . It never felt like he lived with us until I was sixteen, and by then I resented him."

Like many in Crossfield's profession as a test pilot, he was a driven man. Scott paid the price for that single-mindedness. Sally continued, "Years passed and understanding grew, and we healed our relationship. People like him, who pursue the improbable, the once considered impossible, often have to focus so intently on the goal, that it is inevitable something gets lost in the process. It is that very intensity and sole pursuit of the goal that also saved his life on occasion. I understand that now, but regret not having him during those days. I am very proud of him, but that pride had a price."

Pride is what Scott Crossfield had in all he accomplished as a test pilot and even more so as an engineer. He firmly believed he was responsible in great measure for the success of the X-15 program because of the fact he was part of it from the very beginning. Scott was right in having that pride. At that time, he put the success of the program ahead of his personal life, ahead of his family, ahead of all else. Scott explained why he had such a focus on his job: "One thing I have never been able to get people to appreciate, I was a test pilot only in that it was an inherent part of building better airplanes. I wasn't a test pilot to be a test pilot; I was a test pilot because I'm an engineer, a designer. I think that single purpose helped the X-15 be as successful as it was. I was much more involved in the program than I was in just the flying. I designed a lot of that airplane, contributed a lot to that airplane."

There are many people who might disagree with how responsible Crossfield was in this regard. It took hundreds of people at North American Aviation to complete the design and construction of the X-15, and hundreds

more in the U.S. Air Force, NASA, and the U.S. Navy to bring the potential of the rocket plane to fruition. Without Scott Crossfield, however, there is little doubt it would have been a different aircraft.

Sally spoke of what drove her father; it was what he called "The Crossfield Way." She explained, "[My father] believed in rules but wasn't necessarily confined by them. He would see a problem, situation, or possibility, and work out a solution—often a very creative one. He could think outside the box, yet didn't always go for the difficult answer. Sometimes a very easy one is sitting right in front of you and it gets missed." But that wasn't all. Sally continued, "He didn't let anything stop him once he set his mind on something. He was always a positive thinker. He could build or repair absolutely anything. . . . If he needed a bolt, he would go down to his lathe and make it. He was such a unique individual. He wasn't by any means perfect . . . [but had] strength of character [and] personal integrity."

Crossfield's mother, Lucia Dwyer, was born in Mexico. His father, Albert Scott Crossfield Sr., originally came from Browns Valley, Minnesota. His mother and father wound a convoluted path toward each other. By Scott's account, as a child Lucia helped the family fight off Mexican bandits with a bullwhip before she and the rest of the ten children were sent north to El Paso. Lucia eventually moved west to attend college at the University of California, Berkeley. Across the Pacific, Scott's paternal grandfather, Amasa, served as chief of the Customs Department in the Philippines under the governor of the islands, William Howard Taft. Amasa's three children, including Scott's father, spent many formative years in the island territory. They returned to California, where Scott Sr. graduated high school and moved on to college at Berkeley, where he met Lucia. Scott's parents married in 1916, and on 2 October 1921, the future test pilot was born. He explained his complicated family heritage in his book, *Always Another Dawn*: "One chemical result of this union was me, Albert Scott Crossfield, Junior, one-quarter Mexican, with a good sprinkling of English, Irish, Boston Brown, and the good Lord only knows what else."

Scott's father was a chemist, who instilled a love of science. "Outwardly, my father was the coolest man I have ever known," he wrote. "He took great pains to disguise his courage." Working for the Union Oil Company in Wilmington, California, his father was, at one time, responsible for firing many people during the Great Depression of the early 1930s. He found

rampant discrimination from above, being told to fire anyone without an Anglo-Saxon name. With the Mexican heritage in their family, he couldn't abide this and left the company himself. Soon after, he formed a dairy, but the family money was gutted by price wars, and the business ultimately failed.

The family moved to a farm in the Boistfort Valley, about ten miles west of Chehalis, Washington. Scott's father turned the scientific methods he had been taught at Berkeley into a meticulous plan for a successful poultry and dairy farm. The hard work and long hours to make a go of the new family business proved beneficial to Scott. He became determined to design and build radio-controlled model airplanes, then to finish his flying lessons and finally solo in a Curtiss Robin at the Chehalis airport. Scott had melded his two loves together into what became his career in engineering and flying.

Once he graduated from Boistfort Consolidated School in June 1939, Crossfield intended to immediately leave the farm to head for the University of Washington. Before he graduated, his younger sister, Mary Anne, died of polio. Her death devastated Scott and the family, so he forestalled his plan for a year. Once into the engineering program, he still did not sail right through but instead took several turns along the way over the next eighteen months. Crossfield described his route: "I had entered the University, graduated from a civilian aviation school, officially soloed, and obtained my private pilot's license, withdrawn from the University, worked for Boeing Aircraft Company, quit to join the air force briefly, worked for Boeing again, quit again to join the navy."

Scott's first attempt at joining the air force following the attack on Pearl Harbor was short-lived due to the service not being able to find a class in which to put him. Restless to get into the fray of World War II, he joined the navy instead. That plan also went awry when he was assigned flight instructor duties, which kept him stateside. He didn't get close to actual combat until he was moved to Hawaii as part of the preparations to invade Japan, which were canceled after the atomic bombings and the Japanese surrender in August 1945.

While Crossfield was working at Boeing, he met Alice Knoph and they became engaged. Sally explained some of the qualities her father saw in Alice, "My mom [is] a beautiful blond, blue-eyed Norwegian, even to this day, though the blond's gone silver. She is strong, determined, and has the

best sense of humor of anyone I've ever known." When Scott and Alice first met, she was engaged to another man, but this never deterred him. Sally went on, "She would put up with nothing from my dad or any of us. I've never felt more loved by anyone, and I know my dad loved her more than life itself."

Following four years in the navy flying Grumman's F6F Hellcat and Chance Vought's F4U Corsair, Crossfield returned to the University of Washington, receiving his bachelor's degree in aeronautical engineering in 1949. He went directly into the master of science program, completing his thesis the following year. It was titled "A Semi-Empirical Method of Obtaining Static and Dynamic Aerodynamic Parameters of Swept-Back Wings Analyzed on the Basis of Plan Form." As Scott explained, "A thesis had to respond to the requirement to be a new and innovative contribution to the art. I devoted all my effort to coming up with a very simplified way to determine the characteristics of wings. . . . It was only twenty pages long, including all the figures and contents. . . . When I took it to the University library, the librarian hefted it and said, 'That's a thesis?' I just thought the quality was better than the quantity."

By June 1950 Scott decided to resign his commission in the naval reserve and applied for a job with the National Advisory Committee for Aeronautics (NACA) at the High Speed Flight Research Station at Edwards AFB. His timing was fortuitous: within three weeks after he left the navy, his unit was called up for duty in Korea. Upon arrival at the NACA facility, Crossfield took the slot being vacated by pilot John Griffith, who was leaving to take a job at Chance Vought. Scott said, "This was really the place to be. . . . I was awestruck. When Walt Williams showed me the airplanes they had, there was no question in my mind where I belonged."

Scott's reputation at NACA grew quickly, and he became the first pilot to rival Col. Charles E. "Chuck" Yeager for notoriety. He flew a steady stream of experimental airplanes, some with the coveted "X" designation, such as the XS-1, the tailless X-4 Bantam, and X-5, which first used variable sweep wings in flight. He entered the cockpits of many other aircraft, including the XF-92 Dart, which was used to test theories concerning delta-shaped wings and tail surfaces.

With the variety of aircraft in the inventory, many of his first flights had

anomalies: an XS-1 went into a spin, the XF-92 ran off a runway onto a dirt road before it could be brought to a stop, and an F-107 flipped around and nearly upended when the brakes caught fire during high-speed taxi. The one he is most remembered for occurred on 8 September 1954. Scott brought an F-100A Super Sabre in for a dead-stick landing, found he had no brakes, and crashed the front end through a hangar wall. Except for his ego, he was uninjured, and the airplane was eventually repaired and returned to flight status. In an NBC News interview, Crossfield explained how Yeager took this mishap as an opportunity to jab at Scott's piloting abilities, which highlighted their growing rivalry, lasting until after Scott's death in 2006. He said of Yeager, "Every time he had a chance in public, Yeager would always say, 'The sonic wall was his, the hangar wall was Crossfield's.'"

The one experimental aircraft Scott flew more in his career than any other was the sleek, white Douglas D-558, Phase 2. It was built for the U.S. Navy in their effort to compete against the U.S. Air Force for government flight research funds. Also known as the Skyrocket, the severely swept wings and tail lived up to the name's expectations.

In 1947 Charles Yeager broke the previously impenetrable sound barrier of Mach 1. Six years later, as the fifty-year anniversary of the Wright brothers' first powered airplane flight neared in late 1953, the next Mach number had yet to be pierced. The race between Yeager and Crossfield heated up to see if either could get there first.

Crossfield made a bid to accomplish the flight using the D-558-2 but was hampered primarily because the aircraft was designed for a maximum speed of only Mach 1.5. Modifications to the LR8-RM-6 rocket nozzles added nearly a half-Mach number but was just short of the requisite speed. Scott felt he knew the plane intimately enough so he could coax it through Mach 2, with the navy's support. In a NASA interview in 2003, Scott said, "Everybody on base knew we were going to make the try, but very few people thought we were going to make it. . . . Frankly, we had our own doubts that we just were asking the airplane to do more than it was ever designed to do." At the same time, Yeager and the air force prepared the X-1A for his bid, knowing this aircraft was made for those high speeds.

On the morning of 20 November 1953, Scott made his final attempt to break the record. He said of the event, "We cold-soaked that thing. Wiped off every fly speck. There wasn't any excess drag on her at all. We started

loading [the fuel], oh, six or eight hours earlier than we [usually] would, and let that liquid oxygen soak it until it was so damn cold you couldn't touch [it]. Your hand would freeze on it, anywhere. It was a good, cold morning, miserable morning. I had the flu, [and the] weather was bad." The combination of the cold-soaked aircraft, along with the frigid and dry winter air in the desert, was exactly what Scott and the engineering team calculated was needed to increase the D-558-2 performance past the threshold.

The navy had modified a B-29 Superfortress into the mothership used to carry the Skyrocket aloft for launch. The new designation was the P2B-1S and had been nicknamed "Fertile Myrtle" because of its ungainly look with the D-558-2 attached inside the bomber's belly.

Once at altitude, Crossfield dropped away and fired the four chambers of the LR-8 rocket engine. He quickly climbed and accelerated. When he reached approximately 72,000 feet, Scott dipped the nose and started a shallow 10,000-foot descent, which increased his speed to 1,291 miles an hour. This equated to Mach 2.005, a tiny fraction of a percentage past where he needed to be, but enough to nab the record. Scott said, "[I] wanted to be first, particularly if I could needle Yeager about it." He later explained, "NASA claims to be pure in their technical programs, but they don't mind making a record now and then. I started that with the Mach 2 flight."

Yeager didn't like having someone beat him to a record. Three weeks after Crossfield's flight, Yeager took the X-1A easily past Mach 2. The previous best speed on this aircraft was Mach 1.9, and Yeager pushed it by more than a half-Mach number, maxing out at Mach 2.4, nearly 275 miles an hour faster than the D-558-2 had attained. But he'd pushed too hard and lost control due to inertial coupling, the phenomenon where several aircraft axes coupled together and caused a dangerous tumble. Yeager spiraled downward at a rate of 1,000 feet a second. The thicker air at low altitudes slowed his speed to subsonic, where he was able to recover from an inverted spin at 25,000 feet. Yeager found the lakebed and landed as quickly as possible. Scott credited Yeager's skill as a pilot in saving the aircraft, and his life. "It was probably fortunate that Yeager was the pilot on that flight," he said.

Just five years after he arrived at NACA, in addition to all his other experimental flights in a weird menagerie of aircraft, Crossfield had racked up eighty-seven rocket-powered flights, ten of those in the Bell XS-1 and the

rest in the Douglas D-558-2. This was a record number of such flights for any pilot. Coupled with his fourteen still to come in the X-15, Scott has a record that will be hard for any modern day pilot to exceed.

In the late 1930s a German engineer, Eugen Sänger, who was unknown to aeronautical scientists in the United States, started thinking about the concept of extremely high velocity human flight. Long before any aircraft had gone supersonic, Sänger, along with Irene Bredt, designed a vehicle that could travel at hypersonic speeds (above Mach 5). Using the upper atmosphere to literally skip over intercontinental distances, their *Silbervogal*, or Silverbird, was envisioned by the Third Reich as a weapon that could bomb targets as far away as America. The technology at that time was not yet up to the task, and the project was canceled in 1942.

Following World War II, the work of Sänger and Bredt came to the attention of John V. Becker and Hartley A. Soulé at NACA's Aeronautical Laboratory in Langley, Virginia. Becker wrote in 1968, "Until the Sänger and Bredt paper became available to us . . . we had thought of hypersonic flight only as a domain for missiles. The concept of manned rocket aircraft flying efficiently at hypersonic speeds for very long ranges was new and highly stimulating. The remarkably detailed analyses of many aspects of their new concept . . . gave real substance to the idea. . . . These studies provided the background from which the X-15 proposal emerged."

The primary barrier against building such a hypersonic vehicle was heat, with expected skin temperatures in the range of 1,200 degrees Fahrenheit. This problem was solved with the introduction of a steel alloy called Inconel, initially manufactured in the 1940s as part of the emerging development of jet engine technologies. Creating small parts, such as turbine blades inside the engines, was much different than expanding this concept to encompass the outer skin of an entire aircraft. The largest technological leap was the ability to machine the alloy and to shape it into large pieces. Weight was also a major factor, in that the Inconel-X, which was eventually settled on for use on the X-15, weighs approximately three times more than standard aluminum. Inconel-X was seen as a key piece of technology; instead of trying to protect the aircraft from high temperatures it was turned into what was called a hot structure, where these temperatures were embraced and made part of the overall research effort.

1. Scott Crossfield checks out the cockpit on the original engineering mockup of the X-15. Courtesy of North American Aviation.

Seeing the devastating potential of missile technology through the use of the V-2 against England during the war provided an impetus toward engineering more powerful rockets in the United States. As Becker wrote, "In 1954, nearly everyone believed intuitively in the continuing rapid increase in flight speeds of aeronautical vehicles. The powerful new propulsion systems needed for aircraft flight beyond Mach 3 were identifiable in the large rocket engines being developed in the long-range missile programs. There was virtually unanimous support for hypersonic technology development. . . . The X-15 proposal was born at what appears, in retrospect, as the most propitious of all possible times for its promotion and approval."

While these discussions were happening in the early 1950s, Scott Crossfield recalled a fateful trip, saying, "Coming home with Walt Williams from a fishing trip one night, [Gerald M.] Truczynski and [Joseph R.] Vensel were asleep in the back end, and Walt and I were just talking. We heard over the radio there was a successful firing of the Viking engine at [the Rocketdyne

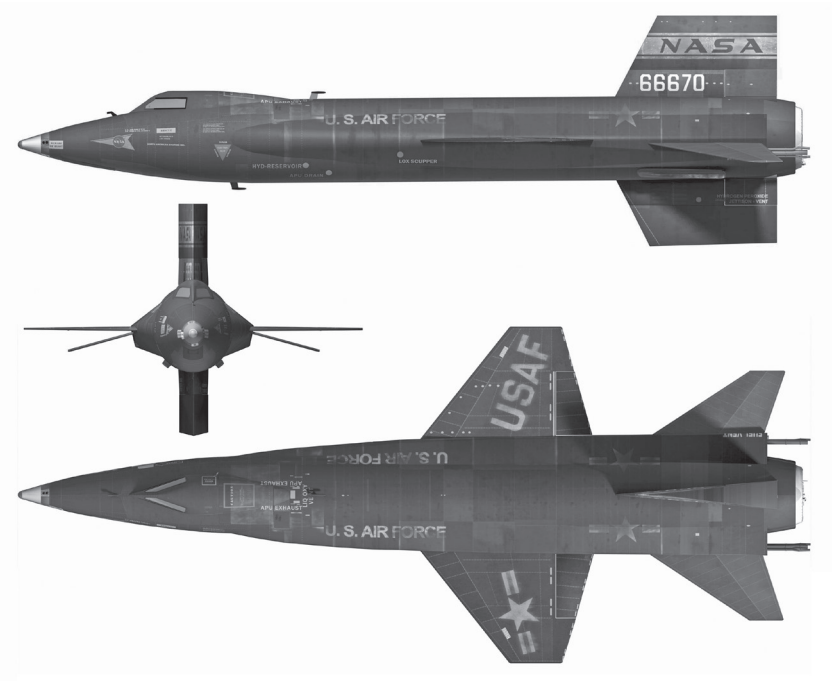
facility in] Santa Susanna, [California.]" Scott pondered the idea of mating such an engine to a manned aircraft. "I picked a piece of scrap paper from the glove compartment and came up with what was awfully close to the X-15 specification of how much energy you'd have available, how high, [and] how fast. We were estimating that an airplane . . . would go to Mach 6 or 7." The idea was sound, and the Viking engine was used in some X-15 baseline studies.

It didn't take long to get moving with the idea, since the groundwork had now been laid in metallurgy and rocketry. Scott said, "By 1954 it was very active, and the contract was let in 1955, which is pretty fast for a harebrained idea."

The X-15 was right in the middle of a map set up by NACA on the road they envisioned into space. The three sections were called simply Round One, Round Two, and Round Three. The first was supersonic flight, such as with the XS-1 and its follow-ons, the second became the X-15's assault on the hypersonic regime, and the last was to take astronauts into orbit. All three expanded on winged technology, but by the time the third round was ready with the development of the X-20 Dyna-Soar, wings were upstaged by the brute-force methods of ballistic rockets.

Since coming to NACA, Scott had seen how the research airplanes often got hijacked by military priorities and how they would often come in over budget and under performance. During the development of the X-2, he had gone so far as to consider a transfer to Bell Aircraft to overcome these challenges. Scott recalled, "I felt, if I could go to Bell and provide the single purpose they needed to put back into this program, I could get that airplane out of there and get rid of a lot of the make-work. . . . That's why I left NACA to do exactly that on the X-15. I think the results were pretty evident. It came in on-time and on-money."

Scott went on to explain the merits of the competing designs from the various prospective contractors. "The Bell airplane was, to my mind, the best proposal, but maybe not the best airplane . . . [but] there was ample evidence they had been in the rocket airplane business before. . . . The Republic airplane followed traditional Republic design as being heavy and complicated. . . . North American showed some engineering ingenuity in their approach to it. . . . They actually proposed an airplane that had much more capability than the basic specification. The Douglas airplane . . . was



2. Three-view layout of the standard X-15 rocket plane as it appeared in December 1960. © Thommy Eriksson.

a magnesium airplane and it would do exactly, and only exactly, what the design asked it to do."

Harrison Storms at North American Aviation remembered how his company won the competition. "We picked up on one feature NACA wanted. They were not too particular about how fast it went, but they wanted to make sure that it was plenty strong and stable. Those were the things we concentrated on, the stability and the strength."

By December 1955 Scott left NACA to start his new job at North American, shepherding the X-15 through construction and into the flight program.

Paul Bikle took over as head of the X-15 after Walt Williams departed to work on the Mercury program. He explained who was who when it came to the X-15. "My understanding was, when Scott went to North American, he felt he would have far more impact on getting a good airplane from within the company than from without. I think that's probably right due to his normal ego, and then, due to his close association with it for a good part of his life. . . . Harrison Storms, he was really the top gun on the X-15 from

3. X-15 no. 2 proudly displayed on 27 February 1959, the day of its rollout from the North American Aviation plant in Los Angeles. Courtesy of North American Aviation.

the contractor standpoint. Decision-wise, of course, Charlie Feltz was the chief engineer. I think he was the brains behind almost everything."

Inside the North American Aviation building, at the corner of Imperial Highway and Aviation Boulevard, near the southeast corner of Los Angeles International Airport, the X-15 took shape. NAA had been reluctant at one time to even accept the contract, but soon transitioned to the proud parent of the rocket plane. A neon sign was mounted on metal trestlework on the roof of the building, proudly proclaiming "Home of X-15" for all to see.

Across the country, at the Reaction Motors plant, work was slow on the LR-99. Many critiqued the company and the design of the world's first rocket engine able to be throttled. The entire science of building rocket engines was relatively new, and no one had ever done anything remotely like the LR-99 previously. The closest idea was the LR-11 engine (and the navy equivalent, the LR-8), which had four chambers that could be independently ignited. This did change the thrust but was far from the same as doing this within a single large chamber.

Fires and explosions plagued the engine program, and there was talk of bringing in Rocketdyne as a second contractor to build an alternative engine in case Reaction Motors failed. Crossfield understood the problems and the reality of the situation, saying, "I don't really think there was all that much difficulty. It was a new engine, it was a totally new concept, and it was hard to do. You have trouble with an airplane and you made dents in it. If you had trouble with the rocket, you blow up the whole stand."

The rocket was delayed because Reaction Motors overestimated their ability to do it from the beginning. According to Scott, "You can't speculate on what's going to cause trouble until you go and do it. Because of that, I don't think Rocketdyne could have really done the job any better. . . . They didn't know how to make a throttleable engine any more than Reaction Motors, and RMI had actually built manned rocket airplane engines longer than anybody in the world." By 1953 more than 250 manned rocket flights had used the RMI engines on the X-1 series and the D-558-2. Crossfield reiterated, "Naturally, you're going to go to the people with that track record, and that was RMI, which was bought out by Thiokol [in 1958]."

With the production version of the engine falling behind, the question then became one of what to do with the X-15. The construction of the rocket plane was proceeding on schedule at NAA, but there was little chance of the LR-99 being ready at the same time. Should the X-15 just sit as a hangar queen? With so much invested in the program, that was never considered a viable option. The idea was floated to use not one, but two, upgraded LR-11 engines, the XLR11-RM-13. Each chamber of this version of the LR-11 produced 2,000 pounds of thrust, making for 16,000 pounds total. Hardly the 57,000 pounds expected at altitude for what was called the "big engine." However, this compromise provided the opportunity to get X-15 testing underway more than a year before it would otherwise have happened.

One possibility of which Crossfield was paranoid was fire in the cockpit. He was instrumental in having it designed to be filled with inert nitrogen when sealed. The pilot obtained oxygen only from his spacesuit supply and, even then, just in the face mask area. The rest of the suit was filled with nitrogen and was segregated by a rubber bladder that fit snugly around the face, with a second around the pilot's neck. Harry Shapiro, an engineer at NAA, recalled Crossfield's unyielding nature concerning flame:

"Scott got very disturbed down there when the guys were building the airplane. There were guys smoking, and he said, 'I don't want to see anybody smoke in here.' He put 'No Smoking' signs up and had them paint white lines around the airplane."

Harry also talked of a prank that made it look like someone was ripping the finely honed cockpit apart. One of the guys in the shop played the joke when Crossfield came by, possibly to get back at him for taking away their cigarettes while on duty. "One of the mechanics was sitting in the cockpit and conspiratorially said, 'I'm going to shake up Scott a little bit.' He had this extra wire with him, and he cut it up into little pieces. Then he started throwing it out of the cockpit to fake out Scott, shouting, 'We don't need this wire! The heck with it!' Scott was livid."

After years of plans and designs, fabrication and construction, ready or not, the X-15 was finally unveiled to the public on 15 October 1958. Just two weeks earlier, NACA had been officially converted to a new civilian space agency, the National Aeronautics and Space Administration, better known as simply NASA.

The assembled crowd consisted of military officers, civilian contractors, and invited guests, along with several of the pilots who had been selected for the program. Scott Crossfield was joined by Joe Walker from NASA, Bob White and Bob Rushworth from the U.S. Air Force, and Forrest Petersen from the U.S. Navy. The highest-ranking dignitary was Vice President Richard M. Nixon. Harrison Storms explained that with these political concerns, "You had to set that date maybe six months ahead of time. As far as the airplane schedule goes, it couldn't care less who's coming and what's set up. If it ain't done, it ain't done!"

A large stage was constructed in front of the giant door to the building where the aircraft would appear. A barrier of fabric and flat panels was behind the stage to shield the view. The VIP speakers sat in an arc of two rows behind the podium. Once the ceremony began, one after another came forward to extol on the virtues and promise of the X-15. Just over a year previously, the Soviet Union shocked the world, and frightened many in the United States, with the launch of the first Sputnik satellite. The news of Sputnik had shaken people to the core when it came to America's supposed infallibility. Nixon was there to instill new confidence in beating the Russians. The following is an excerpt of what he said to the assembled crowd:

It is a tremendous and exhilarating experience to see, as I have for the first time, this vehicle destined to carry the first man into space. . . . We are here today to mark a major step in man's greatest adventure in exploration beyond our world. . . .

No one can question the accomplishment of Russian scientists in placing a vehicle in orbit. . . . The achievement could not be taken lightly. . . . Americans can proudly say today that we have moved into first place in the race to outer space. More than that, we are on the threshold of even more exciting adventures into space, of which the X-15 is but one manifestation.

But the X-15 is perhaps the most exciting because of the fact that it is designed to carry man into space for the first time. . . . [It] is an integral part of an orderly and reasoned space program. . . .

These [pilots] are men to be envied, for theirs will be the ultimate goal toward which men's dreams have stretched for centuries since the first medicine man gazed into the heavens and sought from them their secrets. It is useless for me to cite their bravery. We can only envy them for the opportunity which is theirs.

Pilots Bob White and Bob Rushworth talked about reactions at the rollout. White said Nixon's private thoughts on his first view of the X-15 were somewhat different from his public speech. "It's one of these things where you hope the microphone isn't open. When it came rolling out, Nixon made a side comment to someone up on the stage, saying, 'Gee, that's a funny looking thing isn't it?'" Considering the type of language Nixon was often known for in private, White smiled and said, "That may not be a direct quote." Bob Rushworth admitted he was initially shocked at the black color. "When I first saw the X-15 the day before it rolled out, they were still hard at work. It was just like any other airplane, aluminum-colored, silver, beautiful. Then they opened the door and rolled it out and it was black! I thought, 'What the hell was that?'" The black paint was added as a way to control what is called "emissivity," or the control of the heat rate of the structure during flight. Once the X-15 was soaked in high heat during flight, the Inconel itself changed color to a deep blue-black, negating the need for paint.

One major component required to flight test the research aircraft was a mothership that would take it aloft for launch. The X-15 was unable to take off from the ground under its own power, much the same as earlier experimental rocket planes. With its bigger size and weight, the X-15 needed a

large carrier, which originally was planned to be the Consolidated Vultee B-36 Peacemaker.

The carry point in early designs had been inside a modified and enlarged bomb bay, but questions emerged about the viability of the B-36 over the span of the program, especially since the bomber was ready to be phased out of military service. Next in line was the Boeing B-52 Stratofortress. The difficulty with this idea was the X-15 could not be carried beneath the bomber but must be mounted to a pylon on the wing. This meant the pilot would have to ride to altitude already secured inside the cockpit, unable to transfer to the mothership if a problem arose. The wing-pylon concept had first been tried as early as 1947 in the Soviet Union with their answer to the XS-1, the T-tailed Samolet 346. It was mounted under the right wing of the Tupolev Tu-4 bomber, itself a reversed-engineered copy of the American B-29.

For the X-15, launching from a higher altitude and faster speed were major considerations in selecting the B-52 over the B-36. Proving the choice a good one, the Peacemakers were retired in early 1959, four months before the first X-15 flight. Walt Williams related, "Crossfield was not very enthusiastic about changing from the B-36 to the B-52, and neither was Boeing. In fact, North American did the modification [of the bomber], not Boeing, because they really didn't want to do it. [Boeing] knew it would end up taking early test aircraft away from them—which it did."

Two B-52s were eventually selected for use with the X-15: NB-52A no. 52-0003 and NB-52B no. 52-0008. Due to the three zeros in each tail number, the aircraft were often informally called "Balls 3" and "Balls 8." Officially, no. 003 received the name "The High and Mighty One," while early in the program no. 008 used the nickname "The Challenger." Nose art was added to both aircraft reflecting those names, but only no. 003 retained its name through retirement.

Modifications were needed allowing the X-15 to be attached and carried. The most notable changes were that a pylon was added between the right side of the B-52's fuselage and the first jet engine pod on the right wing, along with a trapezoidal section that was cut out of the rear of the wing to allow clearance of the X-15's vertical tail. This cut precluded the B-52 from using its flaps for takeoff and landing, necessitating higher velocities for both actions. Because of this, a special set of high-speed landing gear was also added.

Capt. Charles C. Bock Jr. and Capt. John E. "Jack" Allavie were the primary pilots first assigned to the B-52s. A total of twenty-four men flew in the cockpit over the course of the program, most notably Maj. Fitzhugh L. Fulton Jr. He came along soon after Bock and Allavie and ended up flying a record ninety-four X-15 mothership drop missions.

Fulton earned his pilot's wings in 1943 and saw combat in the Korean War flying the Douglas B-26 Invader. One of the most notable aspects of his early career was flying the C-54 Skymaster on 225 supply missions during the critical Berlin Airlift of 1948 and 1949. He admitted he would have been happy to have flown the X-15 but knew that heavy aircraft pilots were not going to get those sorts of invitations. Fitz said of the crews of the motherships: "We always flew with two pilots, a launch panel operator [LPO], and flight engineer. We were adamant that we did not take any more. There were a few rare missions where we might have taken a photographer or an advisor along, but we really discouraged that. . . . Everybody should have an ejection seat, and there were only four in the airplane."

Three X-15s were eventually going to fly, so a system had to be devised to properly signify and record each flight. The numbering system settled on consisted of three elements. The first designated the aircraft number, the second specified the number of the flight (or used "A" for aborted missions or "C" to signify a captive flight), with the final number recording how many times that particular aircraft was carried aloft by a B-52. An example is flight 3-29-48. This meant X-15 no. 3 completed its twenty-ninth flight, after being carried forty-eight times by the mothership on attempted missions.

With the numbering system complete, the B-52s modified, the first of three X-15s completed and delivered to Edwards AFB (trucked by convoy on the back of an air force flatbed, wrapped in plain brown paper), and an interim rocket engine selected for installation (with a much bigger one yet to come), the pieces were all in place for the start of the flight test program envisioned to expand the frontiers of aerospace knowledge, while taking pilots to hypersonic speeds and spaceflight altitudes.

Crossfield nurtured a vision of becoming the sole pilot on the X-15 program. This was true even though North American assigned a backup pilot who also hoped to fly the rocket plane, Alvin S. White. Nearly three

years Scott's senior, White was never given the chance. As Scott laughingly said, "Al was laying awake nights figuring out how he could break my legs so he could get into the X-15." Storms agreed, "Well, he just never got by Crossfield, that's all. . . . I know it was one of the big disappointments of Al's life, but there were only so many flights, and once you got going, there was no reason to change. . . . The situation never arose where Al could be worked into the cockpit."

Eventually, White was given a new assignment as the chief pilot on the massive XB-70 Valkyrie bomber program, another aircraft in Storms's arsenal of futuristic designs. The opinion differed on how he got the job, with Crossfield explaining, "I gave that to Al because . . . it gave him something to do. I wasn't all that enamored with bombers." Storms said, "I gave him the B-70 because I wanted him to fly it." Considering Storms's position at NAA as Crossfield's boss, his statement carries more weight.

Arriving at Edwards AFB two days after the rollout ceremonies in October 1958, X-15 no. 1, tail no. 66670, remained earthbound. By the spring of 1959 the contractor was beginning to feel the pressure of canceled and aborted flights. A scheduled captive flight on 10 March was the first time the aircraft left the runway under the bomber's wing. During three attempts to launch in April and May, the rocket plane had been unable to drop from the B-52 and glide back for a landing, let alone fire the rocket engines for a press into the sky. The primary culprit was the twin auxiliary power units, critical for supplying electricity to the X-15 systems during flight. The APUs remained problematic throughout much of the program.

The media was clamoring for evidence that Americans were going to upstage the Soviets by firing the X-15 into space. Reports, fueled by the publicity department at North American, kept telling people the X-15 would quickly reach 100 miles altitude, even though the design specifications called for only half that. They also ignored the concept of an incremental buildup to high altitude and speed, seemingly expecting a man in space within the first few flights.

On the flightline at Edwards, the expectations were more realistic. Most everyone had been involved with rocket planes previously in some capacity and knew they could be temperamental beasts. Repeated delays as the weeks, then months, passed were causing what Harrison Storms called "cancelitis." Combating this as much as possible, Crossfield spent large amounts

of time in the X-15 cockpit after it was mated to the B-52 in order to provide inspiration to everyone working diligently to get off the ground.

When Scott was asked about his preparations for flight, he grinned and explained his two rules: "Stay sober the night before, [and] get at least four hours sleep." Then Scott got serious, saying, "The test flight has to be designed and implemented just as carefully as you design a wing spar, because you leave no known chance, not even a calculated risk. . . . You have a lot of time to think about the design and building, and when you use it, it gets more dynamic, so there's more room to make mistakes. . . . You deviate from the plan with great reluctance. But that's why you have a pilot there, too, so he can use judgment."

Before dawn on Monday, 8 June 1959, the ramp lights bathed the B-52 and X-15 in harsh contrast, creating an oasis in the dark of the desert. Personnel crawled into the bomber to check its systems, while near the pylon and X-15, others on ladders, jack stands, and portable stairs gave the once-over to the rocket plane. Ground fog appeared as liquid oxygen was pumped into the tanks, lending the scene a surreal appearance.

With the sun breaking the horizon, Crossfield arrived in the suiting van. His silver spacesuit, made for a seated position inside the X-15, forced him to walk toward the aircraft slightly hunched over. Scott climbed the stairs, and technicians helped him into the cockpit, connecting him to the internal supplies, then closing and sealing the canopy.

All the paraphernalia was pulled away, the area cleared so the bomber could start its engines. Radio communication between everyone verified readiness to taxi. By the time they reached the threshold, the mission was still a go. At 8:00 a.m. B-52 no. 003 rumbled down the runway, spewing clouds of black jet engine exhaust as it took off. Air force X-15 pilot Maj. Bob White in an F-104, along with two F-100s with Capt. James Wood and Capt. James Roberts, took off to join as chase planes.

The entourage stayed relatively close to the base, climbing counterclockwise to an altitude of 37,500 feet before preparing for the drop. The plan called for a simple glide flight by Crossfield back to Rogers Dry Lake. This was only a test to verify the low-speed handling characteristics, with no rocket fuel on board, just water ballast.

As they approached the launch point about fifteen miles from Edwards, the B-52 was heading northeast, passing over the southwestern edge of Ro-

samond Dry Lake. Crossfield ran through the last few items on his checklist. Over the radio Scott notified Q. C. Harvey, the X-15 test director and supervisor for North American Aviation, along with the B-52 crew and chase planes, that all was ready. He flipped the ready to launch toggle on his left-hand control panel, then said, "I'm ready when you are, buddy."

At this point, control of the launch of flight 1-1-5 was in the hands of B-52 pilot Charlie Bock. He quickly went through his checklist and set the appropriate switches on the launch panel to the left of the pilot's yoke. He said, "Master arming on. System arm is on. Fifteen seconds . . . ten seconds . . . Starting countdown . . . three, two, one . . . release." At 8:30:40 a.m. the X-15 was dropped from its shackles, its wings providing lift for the very first time.

The nose of the aircraft dipped slightly, and the right wing dropped in what would become a signature of sorts due to the position on the pylon and the B-52 slipstream. From the lead chase plane, Bob White called to Crossfield, "Clean break." Scott replied, "Looks pretty good here." The heavy Inconel-skinned airplane, with small wings and no power, dropped quickly.

Crossfield noted all the flight parameters and aircraft response, then quickly had to ready for the landing. He asked White in the chase plane, "Where am I sitting now?" to which Bob replied, "Right off runway 4." The seconds quickly passed as Scott rolled into a right turn, then back toward the left to line up on the lakebed. Crossfield could tell he was coming in a bit faster than anticipated. "Going to land a little long on the lake," he said.

About four minutes after release, the X-15 had dropped 20,000 feet. Scott called, "Wish I had guts enough to do a barrel roll here. Feel like I'm back in the saddle again, buddy."

The X-15 was designed with two nearly equally sized vertical tails, one above the fuselage and one below called a ventral fin. At high angles of attack during future flights out of the atmosphere, the upper tail could be blocked from the airstream, necessitating the large lower tail. Because of its size, the lower half of the ventral had to be jettisoned, to clear the main landing skids. A small parachute was supposed to drop it safely for reuse, but that often turned out to not be the case.

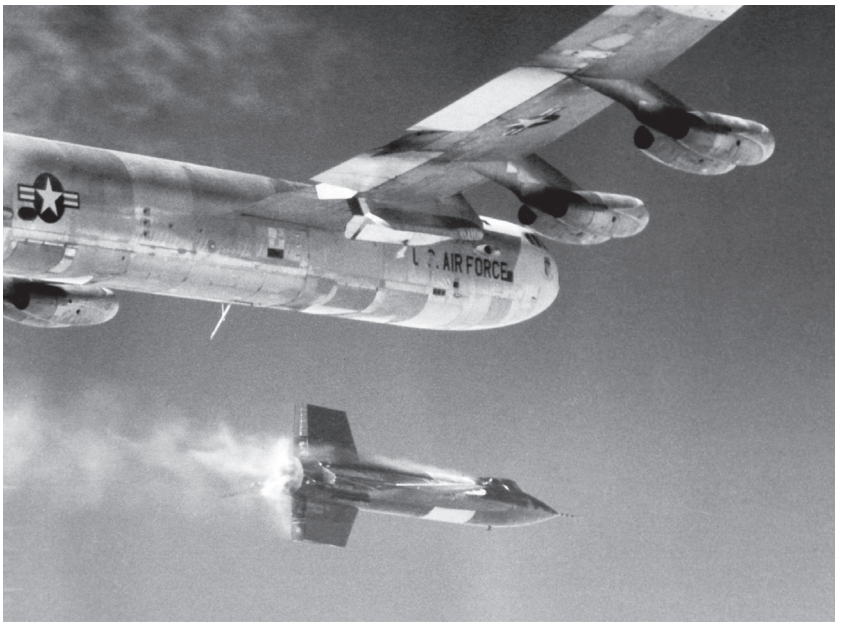
As touchdown approached, Bob White, in his F-104, stayed close to Crossfield to help him through the landing. White had to deploy his own

landing gear and drop his power to stay with the rapidly descending X-15. He reminded Scott, "Don't forget your ventral." Crossfield replied, "Okay, wait till I clear the edge of the lake here." Once clear, Scott called, "Coming off now," and the ventral popped away.

Soon after the jettison, Scott remarked, "She handles nice right along here." He spoke too soon. As the speed dropped, his inputs started feeding back into the plane's control system, developing a PIO, or pilot induced oscillation. With little time to correct the problem, it could have turned deadly. The nose started a deep pitching up and down. Crossfield's breathing intensified and was heard on the radio as his adrenalin surged to work the problem. He called, "Gear down." White stayed with him, telling Scott his altitude above the lakebed, calmly offering encouragement. "About thirty feet. . . . Just hold it steady and set it right there." As the rear of the X-15 dipped to the bottom of a cycle, Crossfield expertly put the skids onto the dirt, the nose gear slamming down a second later. After 4 minutes, 56.6 seconds, the first X-15 mission was successfully completed.

The press was out in force that day at Edwards. Scott's daughter, Sally Crossfield Farley, recalled, "I saw him on the news with a bunch of microphones in his face, but then he came home and he was the same dad. He made it a point to keep his professional life separate from his personal [one. It] was just his job." Of course, most other fathers didn't fly rocket planes for a living. "In the X-15 days, he started flying his [Beechcraft] Bonanza to and from [Edwards] because we had moved from Lancaster to Los Angeles, and it was the only way he could get any home time. The powers that be didn't like him flying his personal plane because they thought it was too dangerous. How's that for ironic?"

During the debriefings following the flight, Crossfield thought a design oversight was responsible for the wild pitching as he tried to land. Storms knew better and told as much to Scott. "Oh, that was ridiculous. I didn't have to prove it to him. I just told him. I was his boss. . . . You've got to remember that Scotty was a little excited that day. A few minutes before, he was sitting on a time bomb under a B-52, then he got dropped with no power, and now he's ready to land. His heart rate was very high, so he's not what you'd call a relaxed, normal pilot at that point." Other than an adjustment made in the pitch damper system, and Storms's talk with Crossfield, it was time to add fuel and apply rocket power.



4. Scott Crossfield drops away from the B-52 mothership. Courtesy of North American Aviation.

Crossfield was proud of his first flight achievement and later talked of a special award presented to him following the flight. "A soaring society gave me a beautiful streamlined brick trophy for the record of having the shortest time from 38,000 feet to the ground."

Six weeks later, mission 2-C-1 was taken aloft. As a scheduled captive flight to check all systems with a full fuel load, this was the first time aircraft no. 2 was under the B-52's wing in flight. It had arrived at Edwards from North American on 10 April, and the process began toward the first powered mission. Two LR-11 rocket engines were mounted, one on top of the other, in the X-15 engine bay.

It wasn't until 4 September when the first attempted launch was made but was stopped when a vent caused fluctuating pressure in the liquid oxygen tank. By 17 September the problems had been resolved. As with all flights Crossfield made for the contractor, the B-52 stayed in the local area of Edwards AFB and the safety of either Rogers or Rosamond Dry Lakes. Once in position, Scott finished his checklist and again turned over launch control to Bock in the B-52. The drop was smooth, and Crossfield quickly

flipped the toggles, turning on each of the eight chambers of the two engines. Unchained at last, the X-15 leapt forward as flight 2-1-3 commenced.

Scott felt the controls respond. They were perfect as he accelerated, outpacing his backup pilot Al White in an F-104 chase, as well as Joe Walker and Bob White following in the other chase aircraft. Keeping his speed to a maximum of Mach 2.11, or 1,393 miles an hour, Scott had to hold the X-15 back from its full potential. After burning the engines for 224 seconds, Crossfield shut off the switches, the LR-11s going silent. Beside the intermittent radio chatter, the only sounds were the whine of the auxiliary power units, servo motors, and the whistle of the supersonic air over the Inconel-X skin.

The X-15 flew as Crossfield imagined it would after that late night ride home from his fishing trip with Walt Williams, Joe Vensel, and Gerry Truczynski. He was exhilarated by the performance, letting his passion show by doing an unplanned barrel roll, as he said he wished he could have done on the first glide flight. This time, at a higher altitude, there was more latitude as the plane flipped a full 360 degrees. The maneuver caused him to drop even quicker than before, sliding past the chase planes. This same maneuver would have repercussions for air force pilot Joe Engle four years in the future, on his first flight. Crossfield had full confidence in the ability of the X-15. He worked for the contractor, not NASA nor the military, so he felt no qualms in what he did. Soon after the roll, he touched down, sending counterrotating vortices of dust up from the skids at the point of contact.

The landing gear on the X-15 was unique. A standard undercarriage with wheels at the center of gravity was weight prohibitive, so they were changed to skids made from Inconel-X. The position was moved to the rear of the aircraft, which meant that at the moment of touchdown, the nose wheel slammed down immediately. Scott explained how the gear worked: "They were gravity-fall and no actuation. Fell down, kerchunk! It was a very simple way to do it. On landing, lakebed dust would collect the heat from the skid rather than the skid itself heating up. [It was like] putting something to a grind wheel. You put your hand on the track [the skid made] and it was hot, but the skid itself was not."

Two flights were aborted in October, followed by a successful launch on mission 2-2-6 on 17 October, one month after the first rocket flight. Trying to get the third powered flight resulted in two more aborts, the last, 2-A-8,

on Halloween morning. This was the first time a flight was canceled due to bad weather after the B-52 was airborne.

Flight 2-3-9, or simply 2-3 for short, quickly changed from routine to dangerous. Moments after being released from the B-52, Crossfield ignited all chambers of the LR-11s. The four nozzles for each engine were arranged in a diamond shape, with numbers one through four assigned starting with the left chamber and moving clockwise. The number two chamber on the lower engine exploded, destroying several inches at the rear of the chamber, along with the nozzle. Immediately a fire started, putting the aircraft and pilot in jeopardy.

Chase pilot Bob White called to warn Crossfield: "Got a little blowout in back, and fire, Scott." He acknowledged, then asked for more information: "Got a fire warning. How much fire have I got?" White replied, "Doesn't look like too much. A little back by the rear of the engine."

Scott shut down the engines and started to jettison propellant. It appeared the fire was out, but the condition inside the fuselage was unknown. Crossfield remained calm as he went through his emergency checklist, making the decision to land on Rosamond Dry Lake, west of Edwards. He kept up a commentary as he approached for landing. "Felt the explosion incidentally, whatever it was. . . . I have good control. . . . Lost the roll damper on launch. . . . I still have a fire warning light. . . . Fire warning light just went out."

With the nose-down attitude, jettisoning the propellant was difficult. White called, "You're still jettisoning, but it's showing signs of giving out." Scott unnecessarily apologized for the shortened flight: "I'm sorry I'm going to miss those couple of data points coming in here." Then: "I'll be heavy this time, so I may make just a little faster descent than we're used to." He stopped the jettison to prepare for landing, then dropped the ventral. As he closed on the lakebed, the chase verified the gear release and altitude, then Scott touched down—hard.

Paul Bikle, head of the X-15 program, delineated what happened in the next moments as the skids hit the lakebed. In his report for NASA headquarters he wrote, "At initial main gear contact [talking of the rear skids], the . . . shock struts compressed about sixty percent, then extended to about twenty-three percent. This was followed by nose gear contact and bottoming of the nose gear oleo [the strut made to absorb the shock, where the

tires were attached]." The excessive landing loads exposed a weakness in the structure and the fuselage buckled just forward of the liquid oxygen tank. The aircraft literally broke its back. Bikle finished, saying, "The joint opened and sheared about seventy percent of the bolts. The fuselage contacted the ground and dragged for the remainder of the runout, which covered a total distance of about 1,500 feet."

Bob White in the chase plane called to test controller Q. C. Harvey after Scott came to a stop: "Q.C., he is in the middle of the dry lake at Rosamond." Harvey asked, "Is he okay, Bob?" White replied, "Yes, looks okay." Flying overhead, Bob could see the X-15 bent in the middle, but otherwise intact. Scott was opening the canopy, so it appeared he was fine. The aircraft was another matter, yet to be determined by the investigation that followed.

Scott later said, "There was a design oversight in the nose gear, and that's what caused it to break in two." Harrison Storms disagreed, saying, "Actually, the whole thing was caused by the engine fire. Let's put the blame where it really belongs. . . . The fuselage broke further aft—it was supposed to break right at the cockpit."

Considering the fire and fuselage break, the damage was easily repaired back at the North American plant. X-15 no. 2, tail no. 66671, was back in the air with Crossfield at the controls three months later, on 11 February 1960. Flight 2-4 also marked the highest altitude Scott attained in the program—88,116 feet. After all his push for the X-15, sacrificing his career at NACA to work directly with NAA, he never broke through 100,000 feet in an airplane designed to fly 50 miles high.

The program was maturing quickly. After one additional flight by Scott in aircraft no. 1, that vehicle was turned over to NASA and the military so they could begin their own flight tests to find the true capabilities of the X-15. Crossfield flew the four remaining LR-11 flights of the contractor program in aircraft no. 2 before moving on to test the LR-99 big engine.

Exactly one year after the first glide flight, Crossfield was surrounded momentarily by the fireball of the horrendous explosion at the test stand on 8 June 1960. The force pushed the front end of aircraft no. 3's fuselage far enough forward that it was relatively safe from the rest of the conflagration. Scott understood he was in a vehicle designed to withstand very high

temperatures, although those were supposed to be generated during high-Mach reentry from space, not from sitting on the ground.

Wearing only his civilian clothing, Scott mentioned how he got wet during the extraction from the airplane, later making a comment to a reporter, "The only casualty was the crease in my trousers." Scott immediately regretted his choice of words, thinking someone would then run the headline: "Space Ship Explodes; Pilot Wets Pants." He said in an interview in 1981 that an East Coast newspaper did run with that headline.

Thirty years later, at a NASA X-15 symposium, Harrison Storms pointed out what likely saved Crossfield's life: "I was very glad that we had a nitrogen cockpit pressurization and cooling system. Had we employed oxygen, we would no doubt have also lost one pilot, one crew member, and a cockpit." In his NAA report, Crossfield said what was on everyone's mind, "The first reaction we had was that the engine had blown up, but like many first impressions, this was wrong." With all the delays and problems during development, a natural reaction was to think the LR-99 was at fault for what happened. If that was true, the entire X-15 program was in jeopardy.

Without the LR-99 to take over from the LR-11s, pushing the X-15 to its full limits, there wasn't much point to the program. Mach 6 and 50 miles altitude were out of the question. The answer had to be found quickly. Scott said, "Just before the blow-up a cloud of vapor appeared ahead of the engine, so the search was concentrated on this area."

Very quickly, the LR-99 was cleared of any culpability. The problem instead was found in a small valve that was supposed to provide pressure relief to the ammonia tank. That relief system had been hooked up to a line that ran about a hundred feet away, venting excess ammonia vapors into a water-filled trench. This caused a back pressure in the line due to a differential temperature between the tank in the X-15 exposed to the sun and the cooler water in the trench. NASA engineer John McTigue explained, "It built up enough pressure that it was over the limits of the ammonia tank, and that tank ruptured. When it did, it blew it back against the peroxide tank [and] ruptured the peroxide tank. The peroxide and ammonia then became an explosion that made it look [at first] like the engine had blown." The entire pressurizing and relief systems were analyzed, redesigned, tested, and retested before everyone was convinced the problem was solved.

The rear of the no. 3 airframe had been destroyed by the accident. Har-

rison Storms said the decision to rebuild "didn't take very long. We needed three airplanes." John McTigue detailed how much had to be replaced. "Everything behind the wings [was new]. We salvaged some equipment out of the back end. . . . The big problem, which we lived with for the rest of that airplane's life, was that every single wire at the end of that wing going aft had to be spliced. . . . Later if you had a problem, you knew where it was [because of those splices]." Storms recalled that the rebuild amounted to approximately 60 to 75 percent of the aircraft.

In the meantime, the LR-99 program needed to move forward. Testing was then transferred to aircraft no. 2, since no. 3 was out of commission for close to a year. Four months after the test stand accident, on 13 October 1960, the attempt at a first flight with the big engine was ready. Problems with the auxiliary power units and leaking liquid oxygen aborted this flight, as well as the second attempt on 4 November. Finally, on 15 November the flight was able to proceed.

With Captain Allavie at the controls of the B-52, and Capt. Charles Kuyk in the right seat, an hour was spent as they circled and climbed high enough to be able to drop Crossfield for flight 2-10. At 9:59 a.m. the X-15 dropped from the pylon, and Scott pushed the LR-99 throttle forward. After years of development and testing, and a ground accident that could have stopped the program cold, the complete X-15 was finally taking flight.

Crossfield, in X-15 no. 2, powered directly east from the launch point, about halfway between the towns of Palmdale and Rosamond. The plan was to achieve Mach 2.75 at an altitude of 78,000 feet. Soon after passing through Mach 1, he deployed the speed brakes to help add drag and keep the velocity below his contracted maximum of Mach 3. Passing south of Rogers Dry Lake, he performed a left bank, turning north, then proceeded with a 20-degree pull-up toward his peak altitude. After running the engine for 137 seconds, he shut down the rocket. Scott was still relatively low, at approximately 60,000 feet, but was continuing to climb, peaking at 81,200 feet. He then made another left turn of 180 degrees to line up for landing.

Contrary to many reports that stated he never exceeded the contractual speed limit, Scott confided in our personal interview: "I did go over Mach 3 by the cockpit instruments. I don't know what the internal documentation was." Officially, his speed was recorded at Mach 2.97, or 1,960 miles an hour. Would anyone have quibbled giving Crossfield another official

Mach number? When I asked Scott about this, he said, "Civilian professionals aren't allowed to make records. My contract very clearly called out the limit of Mach 2 and 100,000 feet, which would break no records. But you couldn't keep it down to Mach 2, so they opened that up to Mach 3." If his flight was recorded as achieving this speed, it would have not made any difference. Lead NASA pilot, Joe Walker, had already surpassed that number three times in the X-15, while the air force's Robert White had done so once. Scott's daughter, Sally, also confirmed that her father told her he had surpassed Mach 3.

Crossfield made his decision years previously to move to North American Aviation and thus gave up any chance of seeking the true speeds and altitudes of which the X-15 was capable. He had hoped to change their minds, but it was clear that would never happen. In a news interview Scott said, "I got just about all any man could get out of a single program. . . . I got all eight yards. Didn't get to nine yards, that's all."

At this point, the only thing left for Crossfield was to meet North American's obligation to demonstrate the LR-99's restart capabilities in flight. This was the same type of test that went wrong when the ammonia tank ruptured and exploded on the test stand on 8 June. If something happened in the air, Scott would not have firefighters and other emergency personnel standing by to help him from the cockpit.

One week after the first LR-99 flight, mission 2-11 went perfectly. The engine restart task was accomplished, and specific throttle settings of 50, 70, and 100 percent were all run with no problems. To make sure the speed was kept within limits, the flight plan called for Mach 2.5. Two weeks later, on 6 December, Scott repeated the test at a slightly higher speed, Mach 2.85. At 1:29 p.m. he launched away from the B-52 one last time. He throttled up, then purposely shut it down to restart. The engine did not catch, so he calmly went through the sequence again. This time he got the requisite ignition. He then did one more successful restart. Slightly more than eight minutes after the flight began, Crossfield came to a stop on the lakebed, his time on the X-15 and the contract flights for North American Aviation completed.

Harrison Storms spoke about Crossfield's desires with regard to the X-15: "Scott was primarily looking for a way to haul the X-15 from the cradle to the grave." Storms said that once the NAA portion was finished, "[Scott]

then really wanted to leave the company and finish the program with NASA, except they didn't want him. Bikle said he could come back, but not on the X-15." Scott apparently asked his boss to put in a good word for him at NASA, but Storms decided against doing so. "We weren't going to advise them on personnel."

Several other pilots weighed in on the controversy. One of the last X-15 pilots, Pete Knight, said, "Nobody got along with Crossfield too well, because he thought the X-15 was his airplane. He didn't understand why he couldn't do the envelope expansion, and figured he was the most qualified to do that. [He felt] it was ridiculous to leave the airplane and the program to NASA and the air force. . . . There was always a professional friction between Crossfield and the government pilots." Scott said he understood he would not be able to continue to fly after the basic requirements had been met. Pete explained, "He knew that, but he was always lobbying to get it changed."

Bill Dana flew the X-15 at the same time as Knight and had this to say: "Crossfield was an extremely abrasive individual, and I don't think that Walker or White liked him. I was never very fond of Crossfield, either. . . . He [was] certainly a colorful individual. He really accomplished a lot, probably not as much as he'd have told you he did. . . . Crossfield was educated, [but] he let his education overtake his natural flying ability. . . . That got him into some trouble with the X-15."

Paul Bikle added this about Crossfield: "He got to where he thought the program couldn't go on without him. . . . I guess he visualized in his own mind something along the lines that he was going to not only be one of the pilots throughout the program, but, because of his vastly greater experience, he was the key voice in deciding what the operation was going to be. That didn't happen."

There was also the fact that NASA had a job to do, and couldn't really get started until the contractor was finished. "I didn't select pilots to start with," Bikle continued, "but I was probably as much responsible for selecting Scotty out of the program as anyone. . . . We wanted our own program and our own pilots, and we wanted to get the contractor out of there as quickly as we could. . . . While they were there, it made it look like we couldn't handle it."

Many people around Scott felt very positively toward him. B-52 pilot Fitz

Fulton shared his thoughts, saying, "My contact with Crossfield was he was always a friendly, happy pilot. Maybe if you worked for him it might be different." Sheri McKay-Lowe, daughter of X-15 pilot Jack McKay, fondly recalled, "I always liked his personality. To me, he really stood out as a remarkable person."

In the end, Crossfield stayed at North American, although his attitude also gave him difficulties in that regard. Harrison Storms said, "By that time, he had alienated himself from the other [NAA] pilots. . . . See, he was either working on the X-15 or working on the engineering, but he wasn't getting the time with other airplanes. There was a little bit of feeling [of] 'Hey, you've got your airplane, now why are you coming to look at ours.' So I took him with me over to Apollo."

The end of the contractor portion of the X-15 program meant the team that had been assembled, and had worked so well together for several years, was to be broken apart. Harry Shapiro from North American Aviation recalled, "The X-15 team split in two. One became the Apollo group and the remaining people stayed as the X-15 group. It was about a fifty-fifty break. The people who stayed on had the responsibility of three X-15 airplanes, two B-52 carriers, and two engine test stands. . . . It was a lot of work, but nobody was ever overworked."

After Crossfield had poured his heart and soul into the rocket plane for so many years, he recalled that in the end, "I transferred over to Downey, I believe, in January or February of 1961. It was a couple of months after the X-15 [flight testing] was completed. I went on to the Saturn/Apollo program and didn't pay any attention to the X-15 after that." Scott explained what transpired next: "Harrison Storms . . . was made president of the Missile Division in Downey, which was about to become defunct and close its doors. He was a very ambitious guy, and he took about twenty of us over there that everybody called the 'Storm Troopers.'"

With the Apollo lunar program getting under way, there was a push to be a part of this national effort. Scott said that Storms was a driven man. "He was going after the second-stage Saturn booster, which was the first of the whole lunar program proposals to go out. Everybody said, 'No way this stinking little division was going get it.' Well, we got it! Actually, that was probably the biggest technological challenge on the whole Apollo program — the second stage booster. Then we went after the Apollo, and every-

body said, 'No way you're going to get two major contracts back-to-back.' Well, we got the contract for the Apollo Command and Service Modules, and the Earth Escape System. So Apollo was really North American's." Scott was magnanimous enough to add, "Douglas cut a little tin for the third stage and Boeing cut some tin for the first stage."

It was a tough but rewarding time, as Scott recalled: "When you worked for a man like [Storms], the rest of the world doesn't exist. You worked twenty hours a day, seven days a week, and we put together the Apollo program. I was responsible for all the quality assurance, the reliability engineering, and systems test. . . . We set up [at the Kennedy Space Center] and from there on it deteriorated because of the difficulties with NASA. It turned to politics, so I got fired."

Crossfield left North American Aviation on New Year's Eve 1966. From there, he moved to Eastern Airlines, becoming their vice president of Technical Development. He said, "Primarily, I was responsible for everything forward of the cockpit bulkhead. . . . Eastern probably [flew] the best cockpit in the air. A lot of airlines specified Eastern cockpits." Scott also went to Boeing in Seattle to fly acceptance tests for aircraft coming off the assembly line prior to being transferred to the airline. His stay at Eastern lasted until 1972.

In 1974 and 1975 Crossfield had a short stint at Hawker-Siddley Aviation, before feeling the need to get more directly involved with the roots of aerospace technology in America by becoming a technical consultant for the Science and Technology Committee of the U.S. House of Representatives. In this capacity, "Our intent [was] to weigh what resources [were] available and hope we got the most of importance out of our research buck. All of the space program comes out of that committee," Scott said.

His specialty on Capitol Hill was, naturally, in aeronautics, and Scott was a primary mover behind the X-30 Aerospaceplane project. The idea initially appeared to take flight by catching the public's imagination with a vehicle that could go to any point on Earth in an hour or less. It was nicknamed the "Orient Express."

Crossfield explained the problem, which continues to occur: "There came out of that period of the 1960s a terrible disdain for technology and what it could do. It's what I call the 'Volkswagen Mafia.' They came up with absurd reasons to cancel everything. I call them that because, no matter what

you wanted to do, there'd be a bunch of Volkswagen drivers who would come up, and a group of broad-beam women would get out with signs and start marching around." Scott had truly thought the X-30 would make it through, but unfortunately, like so many other programs that pushed aerospace technology after the X-15, such as the American supersonic transport, the Aerospaceplane eventually fell to the budget ax. Scott was critical of the airline industry in particular: "It's a crime this country is still flying these aluminum clouds around. They have the same technology as the B-17, just better engines." In the end, a smile crossed his face as he laughingly said, "We have the worst system in the world—except for all the others."

By 1993 Crossfield decided to stop trying to change the system and retired. The NASA administrator at that time, Daniel Goldin, presented him with the Distinguished Public Service Medal for his half century of service to the aviation community and flight research. Scott was quoted as saying, "Our biggest risk for the future is to *not* risk for the future."

One question that pressed was, with his love of flight and the early possibility of going into space in the X-15, why would Scott not apply to the NASA astronaut office? He explained, "[Dr.] Randy Lovelace and General [Donald] Flickinger were on the selection board. They took me to supper one night and asked me not to put in for astronaut. I asked them, 'Why not?' and they said, 'Well, we're friends of yours. We don't want to have to turn you down.' I asked, 'Why would you have to turn me down?' and they said, 'You're too independent.'"

During our interview I asked Scott how much of his work on the X-15 he had kept over the years. "I don't have any of the personal files that I kept." He went on to explain: "A navy A-7 [Corsair II] hit an apartment house out near Alameda and went right down to the basement; burned the whole thing down. My ex-secretary from North American lived in that apartment house, and she had all my papers. I'd asked her to organize them and put them all into some kind of useful form. They were just the way we'd packed them up in boxes when we left Los Angeles. She'd gone out to dinner and this airplane burned the place down. All of those papers are gone, every note I ever took on the X-15, every bit of correspondence is gone."

The incident occurred at 8:13 p.m. on 7 February 1973. Two Corsairs were on a training flight out of Sacramento, heading to Lemoore Naval Air Station. The flight leader was Lt. John B. Pianetta, with his wingman,

Lt. Robert L. Ward. While flying over the San Francisco Bay, Ward's plane suddenly veered off and disappeared. Pianetta turned back and descended, just in time to see an explosion on the ground. The A-7E came down almost vertically, hitting the Tahoe Apartments in Alameda, killing Ward and ten others on the ground.

A flash fire occurred in the cockpit, centered on the pilot's face mask and oxygen hose. It was demonstrated that the most likely cause of the fire and subsequent accident was that Ward lit up a cigarette and was smoking, a bizarre and lethal choice in the closed confines of a fighter jet cockpit with pure oxygen being pumped in. The thirty-six-unit apartment building, including all of Crossfield's X-15 records, were consumed in the flames. The fact his secretary decided to go out for dinner that Wednesday evening saved her life.

Even after all this, Scott Crossfield was not done with aviation. Soon after the turn of the twenty-first century, plans started to form concerning the centennial of the first powered flight by the Wright brothers. A re-creation of the 1903 *Wright Flyer* was in the works, and Scott was asked to participate as director of Flight Operations. This translated into Crossfield being the trainer for the pilots who would attempt to take it into the air from the same location at Kill Devil Hills, North Carolina, exactly one hundred years later.

The Experimental Aircraft Association partnered with a group called The Wright Experience, headquartered in Warrenton, Virginia. Ken Hyde was the president, in charge of the reproduction. The press event to unveil the *Flyer* on 18 March 2003 was held in Washington DC, at Reagan National Airport. Hyde said, "It's pretty easy to build a *Wright Flyer* replica that looks like the first plane, but it's very difficult to build one that is an exact reproduction. Building this *Flyer* was the ultimate reverse engineering job, with a major catch—we had to ignore what we had learned over the past 100 years and embrace the Wright brothers' way of thinking."

While Orville and Wilbur could choose exactly the correct moment to bring their invention into the wind and start the engines, the clock ticked down on the centennial, and the weather proved uncooperative. The Wright airplane was created to fly in winds of 15 to 20 miles an hour, but on 17 December 2003 it was cold and rainy, with no wind. A friend with me at the event that day said, "I would have been drier had I jumped in a lake with

all my clothes on." President George W. Bush arrived and made his statements of history to the crowd, then departed with a ghostly pass of Air Force One through the low, black clouds.

About two hours after the appointed time, the rain subsided long enough to tow the *Flyer* into position in front of a crowd estimated at 35,000. With the engine clattering and propellers spinning into a blur, Kevin Kochersberger, the pilot trained by Crossfield for the task, throttled up the engine and slid down the rail. The *Flyer* appeared to jump from the track momentarily, but lift from the nonexistent wind never materialized. It could not be sustained in the air. Kevin fought the controls, while the *Flyer* skidded to the right, landing inelegantly in the mud. Sally Crossfield Farley said of her father's disappointment, "[My father had] the best time working on that project. He admired the Wrights tremendously. He and my mom hand wove the rope that towed the *Flyer* in the Warrenton training." Ken Hyde said of Crossfield, and the entire team, "I have nothing but pride about the people involved in this project."

Scott Crossfield's career spanned a large part of that first hundred years of human flight, so it was appropriate he was a part of this historic event. He helped design the world's fastest rocket plane, then, toward the end of his life, trained the pilots to fly the world's slowest.

When Scott was working for the Science and Technology Committee, he invited me to sit with him at the Rayburn House Office Building. We were just across Independence Avenue from the Capitol and a couple blocks east of the Smithsonian National Air and Space Museum, which houses X-15 no. 1 in its Milestones of Flight gallery. He said, "I've done what I wanted. The reason I'm working here is, aviation's been very good to me. I feel I owe it a debt."

Years later Sally said, "My special memories growing up were of our Los Angeles home, mostly. Playing in the pool with my brothers and Dad, watching them race the go carts that my dad made. . . . Family dinners with all eight of us, each one sneaking the carrots to the next plate until they all ended up on my dad's." Switching gears, Sally continued, "The X-15 had always been a member of my family, like the seventh kid. . . . [My father] always said he got more out of that program than any man could ask for, and he marched on afterwards. . . . I think he was heartbroken when he lost the X-15. He never said that, but I saw it in his eyes. Yet again the 'Cross-

field Way' wouldn't let him dwell on it or wallow in it. He moved on and looked for new challenges and opportunities."

Scott Crossfield's legacy remains. Johnny Armstrong, an X-15 flight planner who came to the program after Scott left, talked of how he was inspired while a sophomore in high school. "One of the reasons that motivated me to come to Edwards was to work on rocketships like the D-558. When [Crossfield] went to Mach 2, that really got my attention." Johnny said, "Scott started in a very different time period. He was there for all the unknowns in the development [of the X-15]. He had a totally different picture from the rest of us. By the time we walked in, it was already a piece of hardware."