

Angle of Attack:

Harrison Storms and the Race to the Moon

by Mike Gray

Chapter One

In those days, the road out of Los Angeles was a tortuous two-lane blacktop winding up out of the Newhall Pass through Mint Canyon into the High Desert, and the city of Palmdale was just a gas station in a sea of Joshua trees. Stormy usually flew up the night before, but now and then he would drive up, pushing his little black Thunderbird through the twisting curves for an hour or more until the mountain range gave way to the endless sweep of the Mojave.

It was a place alien to humans, a hostile, blistering, snake infested wasteland where the sand blew over the bones of countless misadventurers, but Stormy loved it. With the San Gabriel mountains behind him, he wheeled the T-bird, hammer down through the blackness, with the white dashes of the centerline shooting beneath him like tracer bullets out of the night. He and the boys usually stayed at the bachelor officers quarters or some seedy motel in the godforsaken town of Lancaster, but they seldom slept. It was really just a place to play poker and drink bourbon and wait for the phone call.

Stormy was the oldest. Slightly built, wiry, unpredictable, smart as a whip, he was the leader of the band. With thinning hair, and rimless glasses cocked on his forehead, he had the look of an accountant--a breed he despised. And though his pals were often mad enough to kill him, they would probably have followed him barefoot across broken glass. Storms had the gift of conviction. And when he was convinced of something, he could get the rest of these guys to go along with it, often at the risk of their careers and sometimes at the risk of their lives.

Toby Freedman was a regular at these sessions. An immense, hulking line-backer of a man who could drink the others under the table, Toby loved poker, loved whiskey, loved Stormy, and was just tickled pink to be in on this whole business. Toby was the flight surgeon, the M.D., and it was his job to keep the boys in fighting trim. He did this by creating such a terrible example that some of the others actually began to lighten up on their alcohol intake.

Charlie Feltz was the Texan--atypically short for a Texan--but Charlie was blessed with an ability to relate to hardware that was positively spooky. From the time he was a kid on the Texas Panhandle, Charlie was, as he might say, "good at machinery." On the family homestead he used to drive an old truck that had lost its clutch. He'd rev the engine and sense that ephemeral instant when he could smash the gears together--and off he'd go. When he left for Texas Tech in Lubbock, they had to retire the thing because nobody else could drive it.

Occasionally, somebody in this crowd would have enough sense to get a couple of hours sleep. But most of them needed the distraction to submerge the gut-wrenching anxiety that

inspired all this back-slapping. So they would tell rotten jokes, talk about airplanes and women, play poker, and drink. Then some time around 5:00 a.m., the phone would ring and the voice at the other end would let them know the deal was on.

Outside it was always freezing cold. Storms never got used to it even though he grew up in Chicago. The chill of the desert at night was somehow worse because it was unexpected. On this particular night, the temperature had dropped into the thirties. They piled in their cars and pulled out of the gravel parking lot and headed up the Sierra Highway, all of them driving too fast, but this was one place it really didn't matter. At this hour, the road was vacant and the highway east out of Rosamond was straight as a string. Overhead, the stars and planets wheeled through absolute blackness, and the great square of Pegasus, the Flying Horse, stood high over the mountains to the south.

As they raced through the night toward the faint glow in the distance, a line of lights appeared on the horizon--a mirage--like a great city on the edge of nowhere. On they rolled, until the giant airplane hangars of a vast military base materialized out of the night, and stretching out to meet them, an endless sea--a dry lake bed--pale white, flat, boundless--reaching off in all directions as far as the eye could see.

It was still dark when Storms wheeled onto the flight line. He drove between a couple of hangars and out onto the ramp, past the hulking silhouettes of exotic fighter planes, past the moving maze of fuel tankers and emergency vehicles, lights flashing in the night. Ahead on the ramp, bathed in floodlights, was a huge bomber--an aging air force B-52--ringed by generators and tank trucks, spreading its great ninety-foot wings over a swarm of technicians. But it was not the bomber that riveted the eye. It was the cargo.

Hanging below the starboard wing was a brutal black dart that could easily have been mistaken for a missile except for the slit windows near the nose. Everything about it reeked of speed, from the mirror surface of its black steel fuselage, to the tiny wings which were not wings at all but slim steel razors. The delicate point of the nose and elegant lines of the fuselage contrasted sharply with the tail. There the vertical tail--a giant black wedge--extended right through the fuselage and out the bottom. It was a stark physical statement about the problem of stability in the high unknown. They called it the X-15. And if they could ever get the damn thing to work, it would be the first rocket ship to carry a man out of the earth's atmosphere.

The X-15 was Storms's airplane as much as it was anybody's airplane. A lot of other people could lay claim to it, of course. The theorists at the National Advisory Committee for Aeronautics--N.A.C.A.--had actually laid out the basic lines and drawn up the specifications. Some of these people thought of Storms and his ilk as "tin benders," lowly contractors who simply hammered out hardware to match the vision of the scientists. But this wasn't hardware. This was jewelry. It had taken 10 million man hours just to draw the blueprints. It was Storms who whipped everybody onward, Storms who drove them past endurance, and it was Storms who led them over the horizon into terra incognita.

Harrison A. "Stormy" Storms Jr. was 12 years old when Lindbergh flew across the Atlantic and like half the kids of his generation, he never got over it. Seduced by airplanes, stopping dead in his tracks when one flew over his house on Chicago's North Shore, he spent hours at Midway Airport just watching them sit there on the grass. His father, Harrison Sr., was a traveling salesman for a screen wire manufacturer and he was on the road most of the time. His mother compensated by submerging herself in community affairs, so Stormy spent a lot of time by himself, and like most of the Boy Scouts his age, he built model airplanes. But he built precise, intricate models that duplicated the real thing with such fidelity that he got his picture in

the Chicago Tribune, and the parks department started paying him \$5 a night to teach model building to other kids.

Stormy's father was a strict man with absolute opinions: no alcohol in the house (though he himself took an occasional nip on the road) and he dominated the family as was the custom of the time. He took care of the checkbook and gave his wife an allowance and he made the decisions. He was a self-taught man, fascinated with science and mathematics--his generation had seen the invention of the airplane, the automobile, the radio and the light bulb--and he dreamed of becoming an engineer, but without a college degree that was out of the question. So he decided the next best thing would be for his son to be an engineer. In fact, Stormy had other interests--art, medicine--but Harrison Sr. steered him into engineering, lovingly, but unremittingly.

As a freshman at Northwestern, his spotty grades gave no hint of any underlying genius. But the next year he met a cute little redhead from Rogers Park and that changed everything. Phyllis Wermuth didn't have a date for the fraternity dance so one of her sorority sisters fixed her up with a young Sigma Nu, Harrison Storms. He came to pick her up dressed as a pirate. It was an image that would stay fixed in her mind.

They ran into each other a few weeks later at Cooley's Cupboard and he asked her out. It was 1935 and the country was in bad shape and neither one of them had much spending money, so they went dutch, first to the football game and then to the movies, and by the end of the semester they were going steady. Luckily, she was a serious student and he got serious too. His grades shot to the top of the curve. But his gift for persuasion, the ability to sweep other people along on his own personal voyage, had already blossomed. Phyllis had not the slightest interest in airplanes, but he talked her into taking on the job of secretary-treasurer for the campus aeronautics club.

He graduated at the top of his class but jobs were still scarce so he stayed on for a masters degree in mechanical engineering. But for a kid with his eye on the sky there was only one place to be in the late 1930s and that was the California Institute of Technology in Pasadena. At Cal Tech the legendary Hungarian mathematician, Theodor von Karman, was in the process of defining the science of aerodynamics. The scene there was frantic, with discoveries and breakthroughs an almost daily phenomenon. Storms arrived in the spring of 1940 feeling like a kid in a candy shop.

Aiming for another masters degree, this time in aeronautical engineering, Storms paid the bills by working the night shift at the wind tunnel, a gargantuan ducted loop where they could fly an object in place while blowing air past it. The wind tunnel at Cal Tech was so powerful it could only be run at top speed in the dead of night--that was the only time there was enough spare electricity in Pasadena to turn the giant fans. Storms was young enough to handle the hours--and he was electrified by the routine daily process of discovery--but he missed Phyllis and that fall he went back to get her.

They were married on September 7, 1940, in a Catholic church on the north side of Chicago. Stormy converted to Catholicism. He said, "If the Catholics can come up with somebody as nice as you, they must be okay." The two kids pooled their cash--\$300--and Stormy's father helped them pick out a little second-hand Plymouth coupe. Their honeymoon--the last vacation they would take together for a quarter of a century--was the trip west on Route 66. As they crested the Rockies west of Albuquerque just at sunset that September evening in 1940, life and opportunity must have seemed like it was stretching off to infinity. And the following night, coming through the San Bernardino Mountains in pitch blackness, they ran

through a crashing thunderstorm and Phyllis was wide-eyed at the lightning flashing all around as Storms steered the little old Plymouth down the rugged pass at El Cajon, promising "Just a little further."

Stormy had rented a coach house near the campus and when they pulled into Pasadena it was nearly midnight, but a bunch of his pals were waiting. Phyllis was touched; she thought it was a welcoming party. It turned out the wind tunnel had just swallowed a model--the airplane they were testing had ripped loose and was sucked into the fan blades--and they needed Stormy right away. So he kissed his bride and left for the lab, leaving her standing on the driveway with the luggage. The neighbors helped her unpack. Storms didn't get home until dawn. And that set the tone for their marriage.

With Europe already at war and the U.S. on the brink, a young man in love with airplanes could not possibly have been in a better position to fulfill his dreams than Harrison Storms Jr. He was like Jack at the bottom of the Beanstalk. Von Karman's students were already doing research for every airplane company on the West Coast--Boeing, Douglas, Northrop--but the one Storms had his eye on was North American in El Segundo. North American Aviation, a scrappy young outfit with a reputation for creativity, was run by J.H. "Dutch" Kindelberger, a larger-than-life airplane builder who got his start as Donald Douglas's chief engineer. Dutch was a hard-driving bear of a man with a gruff, earthy sense of humor--mostly scatological--and he ran the kind of flexible operation that smart people loved to work for.

But one day Dutch got tired of having the boss's son, Donald Jr., underfoot--it was clear to Kindelberger that he would never be the head man in this family outfit--so when General Motors came to him in 1934 and asked him to jump ship, he was ready. G.M. executive Ernie Breech was in charge of a failing East Coast airplane company that had been pieced together from the old Berliner-Joyce Aircraft Company and the Fokker Corporation of America. Their production line, then in Baltimore, was moribund and their products were biplane antiques of another era, but they had one asset: a collection of Dutch and German master craftsmen imported by Tony Fokker.

Kindelberger said goodbye to Douglas and he took with him one of the few young men in his department with an actual engineering degree, a slender 30 year-old structural designer named Lee Atwood. With Atwood as chief engineer, Kindelberger lit a fire under the G.M. operation, and one of their first efforts was the T-6, "Texan," an all-metal low-wing monoplane that was to become the most successful training plane in history.

To the British, the North American T-6 was a godsend. With Hitler looming on the horizon, the "Harvard," as they called it, helped train the pilots who would save England in the Battle of Britain as Drake had saved England from the Armada. The British also liked the price of the T-6, and they liked the fact that the finished product always exceeded specifications.

England needed fighter planes as well. They were already buying all the Curtiss P-40s they could lay their hands on, but Curtiss couldn't make them fast enough. So they asked Dutch Kindelberger if he would build a line of P-40s under license from Curtiss. To Lee Atwood that was lunacy. He knew the Curtiss P-40 was a dated airplane. Parts of it were still covered with stitched canvas--the powerplant was for shit--and it had a radiator the size of a barn door hanging right under the prop.

Lee Atwood flew to New York City where the British Air Commission maintained a small technical staff under the direction of Sir Henry Self. In those days it was an 18 hour trip, flying in a Trans World Airlines DC-3 out of Burbank at 4:30 in the afternoon, refueling in Albuquerque at night, and again in Kansas City, and again at sunrise in Columbus, then on to

LaGuardia, touching down on Long Island at 10:30 the following morning. He met with the Commission in their little office at 50 Broad Street and told them that North American would like to build a plane "like the P-40" but they wanted to make a few "improvements in the cooling system." Without any apparent misgivings, Sir Henry agreed to give Atwood, in effect, a blank check. He signed a letter of intent ordering 320 "...airplanes... at a cost not to exceed \$40,000 each."

By the time Atwood got back to Los Angeles, the loft crew was already laying out the lines, and in less than 10 days they had a full scale mockup. That was in April, 1940, and ninety days later the first prototype of the NA-73X rolled out of the plant. It came to be known as the P-51 *Mustang*; and it was by all accounts the most remarkable flying machine to come out of the Second World War. In addition to flying circles around almost everything else in the sky, the plane's range was unbelievable. When the first P-51s appeared over Berlin, Hermann Goring told his staff that the war was lost.

Ed Hockey, the man in charge of aerodynamics at North American, was testing some of the P-51 models at the Cal Tech wind tunnel, and the student who ran the night shift caught his attention. He offered Storms \$195 a month to come to North American--\$50 less than he was getting at Cal Tech--but he snapped it up and went to work for Hockey six months before the U.S. declared war on Germany and Japan.

When the Japanese bombed Pearl Harbor on December 7, 1941, Storms was up in San Jose running tests in the N.A.C.A. wind tunnel at Moffett Field. Phyllis was pregnant, all alone in Los Angeles, there were blackouts in the city, rumors of invasion, and all he could do was talk to her on the phone. He couldn't even do much of that because they had him working round the clock. But on Christmas eve, he hopped in the little old Plymouth and drove ten hours to Pasadena so he could be with her on Christmas morning. Then he turned right around and drove back, and he couldn't even tell her what he was working on.

Phyllis found out that April, two days after Patricia was born. The hospital was buzzing with news about Gen. Jimmy Doolittle's raid on Tokyo. Somehow, a squadron of North American B-25 bombers--planes that normally needed a 2000 foot runway--had managed to take off from an aircraft carrier somewhere in the Pacific and strike the first Allied blow of the war against the Japanese mainland. Stormy came to the hospital and pointed to the newspaper headline and said, "That's what I couldn't talk about." His group had done the calculations for Doolittle's flight.

In the grand scheme of things, Storms's contribution to the P-51 Mustang was not monumental, but it managed to catch Dutch's eye. Flight tests on the P-51 had revealed a serious problem with the air intake under the wing. At certain speeds the air would just burble around it instead of going in, shaking the airplane like a jackhammer. In the company wind tunnel, Storms began frantically testing various models of the duct as fast as the moneymakers could carve them out. Working round the clock for two days straight, he discovered that by moving the mouth of the air scoop down into the airstream another inch, the air layer next to the fuselage could flow past uninterrupted and the problem disappeared.

The war years honed Storms. With insuperable villains like Hitler and Tojo just over the horizon, the United States was united as never before or since, and people waved to strangers on the street because they knew they were on the same side. In this hour of necessity, Storms was actually in a position to do something about it. Aircraft production was the key to victory, and he was right in the middle of it. He told Phyllis that as long as there were people dying in the trenches he was going to give the war effort everything he had.

This decision did not augur well for his home life, but at the plant it turned him into a tiger. The urgency of the effort, the relentless pressure, the constant demand for new ideas retooled him from a shy Boy Scout into a tough, uncompromising technical thinker with an instinct for leadership. And unlike most of his colleagues, Storms could talk. In fact, he was positively articulate. He could not only explain things in simple terms, but he could explain things in a way that made them sound exciting. So when Ed Hockey made a pitch to management about building a new triple-sonic wind tunnel, he took Storms along, and that was Lee Atwood's first clear look at him. Lee had seen him around, but "the first time he made any impact was when we were talking about the tri-sonic wind tunnel. Five Million dollars was a lot of money, but Storms was the most dynamic. He seemed to be one of the lead horses. I was convinced." Atwood also remembers that Storms had "a certain amount of the artist in him... and a certain amount of artistic temperament as well." That would prove to be both the source of his inspiration, and the engine of his downfall.

By the mid-1950s, Storms had played a major part in the design of a dozen different airplanes, and as his boss, Ed Hockey, moved up the ladder, Storms moved with him. In 1957 Storms was named chief engineer of the L.A. Division. On those rare occasions that Phyllis saw him with his eyes open, he was dead on his feet, and when he wasn't at the plant he was thinking about it. One time she dragged him to a barbecue with some friends but he passed out on the beach and they remember Phyllis gently pouring sand in his ear. But the war honed Phyllis as well. She was a stoic. For five years she had supported him like a war bride, only to discover that once the war was over he was still in the trenches. It had become a way of life. Phyllis had long since adjusted. If he came home at midnight, she served dinner at midnight.

As vice president and chief engineer of the L.A. Division, Storms almost cornered the market on Air Force fighter planes. Scrappy, cocky, confident, he was without equal as a technical pitchman, and he couldn't stand losing. The Pentagon was dazzled. He won nearly every competition that came up, but the one the old-timers still talk about is the B-70 bomber. Only three were ever built, and only one survives. But a quarter of a century later, it is still an awesome sight. With its stainless steel surface painted white to reflect the heat of Mach-3 flight, its twin rudders tower over a massive delta wing that is itself some two stories off the ground. The cobra-like fuselage, rising in a graceful curve from the apex of the wing, gives it the appearance of a prehistoric bird.

When Dutch Kindelberger started bringing the military brass around for a peek at the full-scale mockup, the generals would step into the hangar and look up at the needle nose of this great white bird three stories above them and they would say, "Je-sus Christ!" It happened every time. So they got to calling the plane "The Savior." One day Dutch turned to Storms and said, "If that's the 'Savior,' Stormy, I guess that makes you the 'Creator.'"

The design came to him as he was looking over the data from an N.A.C.A. wind tunnel test and he suddenly realized that you could probably "surf" on the crest of your own supersonic shock wave. It was like opening a door to another room--the comprehension of a simple fact seen from a slightly different angle. If you clustered the engines in a V under the leading edge of the wing, the entry shock wave would create high pressure under the wing. And if the fuselage was cantilevered forward from atop the wing, the exit shock wave would create low pressure on top of the wing--and free lift. He was right, of course, and this surfing effect saved so much power that the engines were able to drive his ninety-ton steel monster through the upper atmosphere at three times the speed of sound. It was an achievement that stupefied even his most persistent critics.

The B-70 contract was canceled by Congress in an unaccustomed fit of austerity, but Storms had already moved on to the next vista. With aircraft speeds doubling every few years, he knew the next major step would not be simply an increase in velocity, it would be a leap off the planet into space itself. Though the public was generally unaware of it, people like Storms had known for years how to get into space. The problem was how to get back. The planet's enormous gravity would pull you in at meteoric speed and the heat generated just by running into the air molecules would turn ordinary steel to butter.

By 1955 the scientists at N.A.C.A. felt the time had come to bite the bullet. There was a new nickel-steel alloy known as Inconel-X that could stand up to temperatures in excess of a thousand degrees, and some of the leading aerodynamicists felt that a rocket plane built of this material might take the heat of re-entry if it munched in at a high angle of attack--in other words, falling through the air nose-high, with the airstream meeting the wings at angles in excess of 20 degrees. In their request for proposals, N.A.C.A. called for a ship that could reach 4000 miles an hour at altitudes of up to 50 miles. Since that would be at the edge of the sensible atmosphere where there was not enough air for regular controls to push against, it would have to have clusters of little rocket motors to steer it. Ultimately, the plane would only kiss the edge of space before falling back like an anvil, but in the purest sense of the term it would be the first rocket ship from Planet Earth.

Storms wanted this project in the worst way and that put him at loggerheads with the Old Man. Dutch hated research contracts. He was a production man and he liked building airplanes by the thousands. This N.A.C.A. proposal called for three ships. That wasn't a contract, it was a hobby. And as far as going to outer space was concerned, Dutch said that was about as useful as shooting a lady out of a goddamn cannon.

After charting a course straight into the future for four decades, it seemed that Dutch Kindelberger had finally come to a horizon he couldn't see over. But he still had enough vision to let young Turks have their head. He finally told Storms to go after the goddamn thing if he had to. So Storms and his people whipped out a proposal and went up against Douglas, Bell, and Republic Aviation. Of the four companies, only Douglas and Bell had actual rocket plane experience. Bell Aircraft had built the fabled X-1 that Chuck Yeager used to break the sound barrier, and the Douglas Skyrocket had carried Scott Crossfield to Mach 2 and beyond. But Bell proposed a radical new design that ignored the N.A.C.A.'s conservative tradition, and North American's proposal was judged technically superior by a squeaking 1.4 points out of a hundred. In the fall of 1955 N.A.C.A. handed Storms the contract for the X-15.

Hanging beneath the wing of the B-52 mother ship on that cold September morning four years later, the X-15 was by then worth three times its weight in gold and it had yet to fly under its own power. Several times they had carried it aloft, climbing for an hour or more to reach the upper limits of the old bomber's performance. But the moment of truth, the moment the shackles would ram open and let the X-15 drop free and ignite its engines, still eluded them.

Ordinarily this wouldn't have caused anybody to lose any sleep. The development of a new machine was a trial and error process designed to reveal weak links. The reason one did research like this was to find out things one didn't already know, and the great thing about working up in the desert was that nobody saw your mistakes but the jackrabbits. At least that's the way it used to be. But over the last eighteen months there had been a sea change in the attitude of the American people. On Friday, October 4, 1957, the Soviets had orbited the world's first artificial satellite. Anyone who doubted its existence could walk into the back yard just after sunset and see it. Only a point of light, a mere 14th magnitude star, indistinguishable from

a million others, except that it moved, inexorably, arcing across the sky, passing over the U.S. every 96 minutes.

The idea that the Russians--a tribe that Americans had been taught to think of as peasants--could invade the sky over the U.S. with such dramatic impunity stunned the whole country. "There was deep anger and resentment that our scientists had not done better," said one Pentagon General, and around the world people began talking about the U.S. as a second-rate power. America was suddenly desperate for heroes and a quick sweep of the horizon revealed the X-15. Overnight "The Black Bullet" became "Our First Spaceship" and the sleek black machine was on the cover of everything from LIFE to Popular Mechanics. Storms was interviewed on radio and television and the newsmen on the High Desert beat made book and movie deals. At first it was a heady experience to find himself in the spotlight. In the airplane business it was the test pilots who got the glory. But public adulation has a flip side, and when the X-15 ran into routine development problems, it quickly became "The trouble-plagued X-15" and it's builders were challenged about everything from their competence to their patriotism. It was new and unwelcome scrutiny for men who were used to doing their dirty work up here in private. On this particular morning, over a hundred reporters had come up from Los Angeles and they had been out there on the lake bed for hours setting up cameras and transmitters among the dunes along the edge of the runway, and freezing their butts off. They had already come up here for a number of false alarms and the chit-chat was getting cynical.

Storms parked on the ramp near the B-52 and stepped out. The air was filled with the smell of jet fuel and a dozen other exotic chemicals as compressors and pumps whined in the pre-dawn chill. Across the ramp a slender, steel-eyed gaucho strode toward him. Storms stuck out his hand and they greeted each other, brothers in arms. While Storms had his career riding with the X-15, it was Scott Crossfield who's ass was actually on the line.

Moody, arrogant--with a chip on his shoulder befitting a man of Latino origin who had risen to the apex in a WASP world--Crossfield was Hollywood's idea of a test pilot. Fearless, with the bold Latin features of a movie star, already famous as the first man to double the speed of sound, he had a shelf full of aeronautical trophies and a trail of broken hearts to match. "Scotty" had been in on the X-15 from the outset. He was working for N.A.C.A. when the idea first came up and he recognized instantly the potential of this rocket plane. Whoever flew it into space would simply be the number one test pilot in the world, and if it was Crossfield, that would settle once and for all the running duel between him and Chuck Yeager.

Rather than take his chances in the regular line-up at Edwards, Crossfield tried an end run. He quit N.A.C.A. and went to work directly for Storms as soon as North American got the contract. Unfortunately there was a flag on the play. The other test pilots were so put out of joint by this attempt to steal the ball that they got the government to put a lid on Crossfield's performance. Any record attempts would be strictly off limits--reserved for military and N.A.C.A. pilots--and Crossfield would be allowed only to prove the plane would fly. Thus ultimate glory was snatched from his grasp after a lifetime of climbing for the pinnacle, and it did not sit well.

But Scotty was an aviator above all else, and while he probably kicked a few filing cabinets in private, he bent to his limited but dangerous assignment with dedication. To practice landing the X-15, he devised a method of flying an F-100 with its engine idling, flaps and landing gear extended, trailing a drogue parachute--literally hanging on the brink of disaster--and thus he was able to duplicate the sink rate of the X-15, which critics likened to the glide path of a tool box.

Crossfield and Storms threaded their way over the weave of cables and hoses snaking

across the concrete, and approached the X-15, its black skin glistening like gunmetal in the sunrise. For the next half hour they wandered through the tangle of engineers and mechanics, shaking hands, patting backs, calling a hundred people by name, and picking up the vibrations. High overhead in the lighted cockpit of the B-52, the ground crew was moving through a 30-page checklist.

By the time the signal was given to wind up the engines, the sun was well over the horizon and Crossfield had been sitting inside the X-15 in his silver-lame' pressure suit for over an hour. Out on the lakebed, the newsreel crews turned on their cameras as the exotic caravan began snaking its way down the flight line. The high whine of the old bomber built to an earth-shaking rumble as it taxied past, preceded by a line of F-104 chase planes. Inside the X-15, Crossfield looked out through narrow windows thick enough to stop a cannon shell, only the piercing eyes visible above the oxygen mask. Behind them came a parade of fire trucks, ambulances, tankers, vans, and jeeps. Overhead, Toby Freedman hovered in the medi-vac helicopter. And like an outrider, just beyond the wingtip of the bomber, was a little green shorty schoolbus, its roof bristling with antennas and spinning wind gauges. This was Storms's rolling command post where he and Feltz would monitor the flight.

Alongside a row of low dunes at the edge of the lakebed, the caravan of jeeps and trucks pulled up to watch the takeoff roll. Everybody got out of their vehicles as the distant bomber began to move. From the far end of the runway the giant five-story tail of the B-52 looked like a great orange sail moving majestically across an ancient sea. Slowly it gathered speed, and with black smoke screaming from the engines, the heavy jet rose toward the San Gabriel Mountains carrying the future under its wing.

It was September 17, 1959, the day that everything would finally fall into place for the X-15. High over Nevada, Crossfield would drop away from the mother ship and trigger the engines for the first time, effortlessly soaring to 50,000 feet at a speed of Mach 2 with the throttle barely cracked open. Over the next decade, a dozen test pilots would fly the X-15 to the rim of space 67 miles above the earth at speeds approaching Mach 7. It would be, by any measure, the most successful aeronautical research project in history. But as Storms stood at the edge of the lakebed that fall morning watching the seven contrails of his high armada climbing overhead, his mind was already miles on down the road.

Angle Of Attack is a staple of military aviation that seems to have been ignored by much of the civilian world. Too bad, AOA can save your life when the chips are down. Most pilots know that their wings stall at a particular angle of attack, depending on flap and other high-lift device settings. But years of simulator training has put the focus on airspeed which is only a by product of AOA. Angle of Incidence. The Angle of Attack is the angle at which relative wind meets an Aerofoil. It is the angle formed by the Chord of the aerofoil and the direction of the relative wind or the vector representing the relative motion between the aircraft and the atmosphere. The angle of attack can be simply described as the difference between where a wing is pointing and where it is going. Angle-of-attack (AOA) indicators provide a visual representation of how much lift is being generated by your wings for a given airspeed. This is incredibly useful because speed alone is not a reliable parameter to avoid a stall. That's because airplanes can stall at any speed, as long as they exceed their critical angle-of-attack. You should think of AOA indicators as instruments for stall margin awareness. In short, AOA indicators measure the current AOA of the aircraft in comparison to the aircraft's critical AOA. The Angle of attack (AOA , $\hat{\alpha}$, Greek letter alpha) is a useful concept in aviation, as it is important in determining the aerodynamic forces that act on the vehicle. Most of the airplane's critical performance characteristics are closely related to angle of attack. Article created by Jonathan Hernaut. For an aircraft, the angle of attack is defined as the angle that exists between the projection of the wind vector (or velocity vector) on the aircraft's plane of symmetry, and an arbitrary reference line