April Meeting

Topic: The X-15
Speaker: Martin Keenan
Reporter: Gord McNulty

Speaker Martin Keenan
Photo Credit - Neil McGavock

CAHS Toronto Chapter President Sheldon Benner introduced a familiar presenter in Martin Keenan, a Toronto Chapter Member since 2003, former Chapter Executive Member, and skilled aviation researcher. Martin made presentations to the Chapter in 2005 on the CF-101B Voodoo in Canadian service (*Flypast*, Vol. 39 No. 5 and Vol. 40, No. 5) and in 2007 on his aviation "birdwatching" in Florida in 2006 (*Flypast*, Vol. 42, No. 3). Martin obtained his BSc. from the University of Guelph in 1989. After working in the industrial water treatment and motion picture film processing industries, he joined Petro-Canada in 1996. Since 2000, he has been a Product Specialist for Lubricants Research and Development, dealing with aluminum complex and food grade greases. He is a member of the Society of Tribologists and Lubrication Engineers (STLE) trade society. Martin became an aviation enthusiast as result of a family trip to the first Hamilton Airshow in 1975, after encountering Voodoos, Harvards, Mustangs, Corsairs, etc. for the first time.

Martin's discussion of the X-15 expanded on the "X-planes" special presentation by Niagara Aerospace Museum members at the April, 2015 meeting (*Flypast*, Vol. 49, No. 7). Running from 1958 to 1968, the X-15 project was considered to be the second phase of American high-speed flight research intended to take aviation speeds from Mach 3 to Mach 6, and from altitudes of 125,000 feet to the edge of space and possibly beyond. The earlier X-plane presentation, on planes designed and built by Bell Aircraft in Niagara Falls, NY, covered the pioneering aircraft that took aerospace from high subsonic speeds to approximately Mach 3 from 1946 to 1956. During that period, two programs were involved: the better-known one was run by the USAF in association with the NACA (National Advisory Committee for Aeronautics), later NASA (National Aeronautics and Space Administration). It utilized the Bell X-1, then the Bell X-2, to investigate high-speed and high-altitude flight. A parallel program, by the US Navy, used the Douglas D-558-1 Skystreak and the D-558-2 Skyrocket. In 1954, various NACA research centres studied designs for the next generation of high-speed research. A proposal from the Langley centre entailed a hypersonic aircraft with a configuration and performance broadly similar to the eventual X-15.

The air force and the navy were evaluating their own hypersonic programs when discussions were held at NACA in 1954. Ultimately, in December, 1954, the air force invited 12 aircraft manufacturers to bid for a plane that would be built within 30 months, capable of speeds of 6,600 feet per second (equivalent to about Mach 6.5), and altitudes of 250,000 feet. It also requested alternative designs that would allow research instrumentation to be replaced by a second crew member. In January, 1955, the aircraft was officially designated the X-15. In May, 1955, proposals came from Bell, Douglas, North American and Republic, and were distributed to the air force, navy, and NACA.

Bell's proposed D-171, showed some similarities to the X-2. Like most of the proposals, the D-171 would be launched from a Convair B-36. It featured a stainless steel structure. Bell also investigated the possibility of ceramic external insulation, similar to what was later used on the space shuttle. But it was decided that such technology was premature. Douglas proposed the D-684, and also had a previous proposal, the D-671, which was to be the navy's hypersonic aircraft before the merger that led to the X-15. Unlike the other designs, that used ejection seats, the D-684 would have a detachable nose section for ejection, with the pilot descending in the section under a parachute. Douglas also used different construction materials, basing their proposal on a magnesium alloy with copper leading edges. It also differed from the others by being light enough to be launched from a Boeing B-50. The heaviest of the four designs was Republic's AP-76. It was distinctive in not having a conventional canopy. Instead, it had three side windows, with a periscope arrangement which would have deployed at lower speeds to provide a view for landing. The AP-76 was derived from a design that Republic envisioned for the XF-103 fighter, later cancelled. It also proposed a small fuselage stretch to accommodate a second crew member, enabling the aircraft to be flown with some research instrumentation. All of the other proposals involved removing the instruments to make room for the second crewman.

View showing the XLR-99 Rocket Engine of the X-15. Delivering 57,000lb thrust at sea level and 70,000lb thrust at peak altitude. *Photo Credit - Greg Winson*

North American Aviation's proposal was the eventual winner. Four rocket engines were considered, including the Aerojet XLR73, Bell XLR81, North American NA5400, and Reaction Motors XLR30. Challenges included making the engine reliable enough for use in a piloting an aircraft and the ability to throttle the engine, necessitating a variable thrust capability that wasn't common in rocket

engine designs then. The various proposals employed two of these engines --- the XLR30, which eventually morphed into the XLR99 --- and the XLR81. The XLR99 was powerful enough that only one engine was required, continuously variable from 13,550 pounds thrust, while the smaller XLR81 was designed for multiple use. The Bell D-171 would have used three, the Republic AP-76 would have used four. Reaction Motors' XLR99 was the winning design, but the Bell XLR81 became the engine for the Lockheed Agena upper stage.

Martin displayed video clips, including an engine ground test on June 2, 1960 illustrating the mighty powerplant. The engine was capable of burning through a ton of fuel in 11 seconds. It was mated to the X-15 and locked into a steel framework for ground firings. Famed test pilot and engineer Scott Crossfield, the first person to fly the X-15, recalled an emergency in the last engine run before the first flight. He was in the cockpit with just a white shirt and business pants when a massive fire erupted. An air force fuel truck raced to the scene with, in Crossfield's words, "water coming out from it like Niagara Falls." Crossfield remained in the X-15 rather than risk getting out. One firefighter braved the flames to open the canopy. Crossfield immediately jumped out and landed on the firefighter. Luckily, no one was seriously injured though the aircraft was left in ruins.

North American ultimately won the X-15 competition. It was felt North American had a better grasp of what was required not only for meeting performance objectives, but also providing an engineering test vehicle to study how aerodynamic heating could be met with existing technology. They hoped to achieve the desired performance with as few unknowns as possible. North American's design also allowed structural elements such as leading edges and nose sections to be easily replaced to allow alternative configurations for testing.

While the X-15 was being designed, the air force's X-2 set the pace in altitude and speed. In September, 1956, Captain Iven Kincheloe set a new world altitude record of 126,200 feet in the X-2. A few weeks later, Capt. Milburn Apt set a new speed record, becoming the first pilot to exceed Mach 3. However, immediately after reaching this speed, the aircraft went out of control. Apt fired the explosive charges and the escape capsule separated from the aircraft. It descended under a parachute but Apt died when it struck the ground. It was the second tragedy for the ill-fated X-2. On May 12, 1953, the second X-2 to be built exploded on a test flight while carried by a B-50 over Lake Ontario, about 35 miles northeast of Rochester. Bell test pilot Jean Ziegler and B-50 observer Frank Wolko were killed and the X-2 was dropped into the lake.

While the X-15 was supposed to use the XLR99 engine, the program was delayed in producing the variable thrust throttle. To save time, the first two aircraft used a pair of XRL11 engines. One of these engines had been the powerplant in Bell X-series planes. The first two aircraft would be converted later to the XLR99, while the third X-15 would have the XLR99 from the start. The B-36 was to be the carrier, with the X-15 in the bomb bay and launched in a similar manner to the X-planes. With the retirement of the B-36, the Boeing B-52 became the carrier. It could drop the X-15 at higher altitudes and higher speeds. However, because of the design of the B-52, the X-15 had to be carried on a pylon

on the wing instead of the bomb bay. This had safety implications, as the X-15 pilot had to enter the B-52 before the carrier took off. It was impossible to enter in flight, as would have been possible with the B-36. A B-52A and a B-52B carried the X-15. There was even a proposal to launch the X-15 from a North American XB-70 Valkyrie, but it never came to fruition.

The X-15 was rolled out from North American's plant at Los Angeles on Oct. 15, 1958. The space race was in high gear, as Russia had launched Sputnik on Oct. 4, 1957 and NASA was established on Oct. 1, 1958. From one of the largest programs of the former NACA, the X-15 shifted to become one of the smaller programs of NASA. The X-15 began to seem slow, given the urgency of the competition in space. Crossfield, a highly experienced X-series and Douglas Skyrocket pilot who helped design the X-15, made the first flight (a glide test) on June 8, 1959. It started out fine. However, it nearly ended in disaster as the aircraft came in and Crossfield released the rear ventral fin to make room for the landing skid. But as he approached the dry lake bed at Edwards AFB, the controls became overly sensitive. A deadly pitch instability took hold. The X-15 oscillated precariously as it dropped but Crossfield managed to get the skid on the ground at the bottom of an oscillation cycle to everyone's relief.

The fix was just a minor adjustment. Powered flights began on Sept. 17, 1959, with Crossfield flying X-15 No. 2 with XLR11 engines. While the first two powered flights went well, the third became an emergency when an explosion occurred after the engines ignited. Crossfield stayed with the plummeting aircraft and landed on the dry lake bed. It broke in two upon landing but was repaired later. Despite early problems, the program soon hit its stride. The last flight with XLR11 engines occurred on February, 1961, and by August, 1961, all three aircraft were flying with XLR99 engines. Speed and altitude records fell quickly. As the X-15 could spend portions of its flight outside the atmosphere, it needed two attitude control systems: one used conventional aerodynamic controls and the other used rocket thrusters in the nose and wingtips to control pitch, roll and yaw. The X-15 No. 3 featured the Honeywell MH 96 adaptive control system that seamlessly blended the aerodynamic and reaction controls as required, depending on the aircraft's altitude.

As for speed, the X-15 with XLR11 engines had a maximum speed slightly greater than the highest speed of the X-2. In less than a year, the X-15 progressed from Mach 3 to Mach 6, all the way to Mach 6.7 in the X-15A2 --- a speed record that remains unbroken. Similarly, maximum altitude with the XLR11 was 136,500 feet, slightly higher than the X-2. From there, altitude records rose quickly, from 169,000 feet to 354,000 feet over 2½ years. This record, set on Aug. 22, 1963, stood until 2004 when it was broken by SpaceShip One, the first manned private spaceflight. Debate ensued as to whether these altitudes constituted space flight. The current definition used by the Federation Aeronautique Internationale is a flight above 100 kilometres or 62.1 miles. By that measure, two X-15 flights made by Joe Walker on July 19, 1963, and August 27, 1963, qualify as space flights. However, at the time the USAF applied its own definition, considering flights above 50 miles or 264,000 feet, to be space flights. By this measure, 13 X-15 flights qualified as space flights. UASF pilots making such flights were awarded astronaut wings. Civilian NASA pilots were retroactively recognized as astronauts and

awarded astronaut wings in August, 2005. The high speed and maximum altitude flights of the X-15 involved distances great enough that the flight crew had to find a larger venue than Edwards AFB. Dry lakes had to be found and surveyed so that landing fields could be marked. The dry lakes had to be outfitted with emergency crews, fire trucks and helicopters for actual flights. The test range was laid out for 400 miles northeast of Edwards AFB, across California, Nevada and Utah. It included two tracking stations in Nevada for monitoring X-15 telemetry which could be relayed to the Edwards control centre.

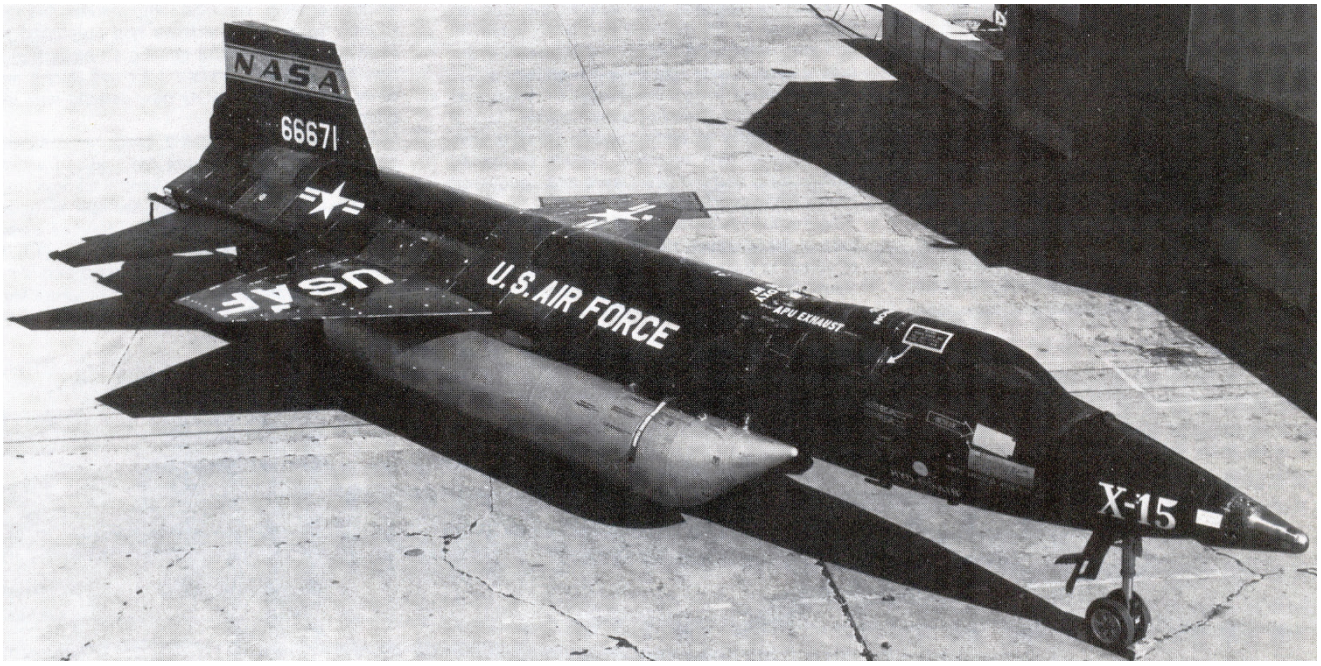
Twelve pilots flew the X-15. Scott Crossfield, prime pilot for North American, also served as a design consultant for the aircraft. He was a naval aviator during the Second World War and had worked for the NACA as a pilot on experimental aircraft between 1950 and 1955. He made the first flights of X-15s No. 1 and No. 2; the only X-15 glide flight; and the first flight with the XLR99 engine. Joe Walker, who flew P-38s during the war, joined the NACA in 1945 and flew high-speed experimental planes before becoming the first NASA pilot to fly the X-15. He flew the highest speed flight of 4,104 mph in the original X-15 and also the highest altitude flights in the program. Walker was killed in a mid-air collision between his F-104 and the XB-70 No. 2 in 1966. His family was posthumously awarded his astronaut wings in 2005. Robert White, a wartime air force pilot, became the primary USAF pilot for the X-15 after the original USAF pilot, Capt. Iven Kincheloe, was killed in an F-104 crash in 1958. White was the first pilot to exceed Mach 4, Mach 5 and Mach 6 --- all in an eight-month period. He also qualified as a USAF astronaut with a flight of 315,000 feet.

Forrest Petersen, a top naval test pilot, became the navy's X-15 pilot in 1958. He made five X-15 flights before returning for regular naval duty and retiring as a vice-admiral. John McKay, a wartime aviator who joined the NACA, made 46 rocket-powered flights before the X-15. He was seriously injured in a landing accident with X-15 No. 2 in November, 1962, when the aircraft overturned. He recovered to fly the X-15 again, but the lingering effects of injuries forced his retirement and his early death. He qualified as a USAF astronaut with a flight of 296,000 feet and was posthumously awarded astronaut wings in 2005. Robert Rushworth, USAF pilot, made 34 X-15 flights including flights to Mach 6.06 and 285,000 feet, qualifying as an air force astronaut. He was awarded the DFC for recovering his X-15 after the landing gear exploded at Mach 4. Neil Armstrong flew combat missions in Korea before joining the NACA. He made seven X-15 flights before joining the NASA astronauts and becoming the first man to walk on the moon.

X-15A2 (Aircraft No. 3- 66672) Was destroyed by a mid-air breakup Nov. 15 1967 *Photo Courtesy - NASA*

Joe Engle, of the USAF, made 16 X-15 flights, including one qualifying him as an astronaut. He made two flights as commander of the space shuttle. Milton Thompson, NACA pilot, made 14 flights in the X-15. William "Pete" Knight, of the USAF, made 16 flights including the highest speed recorded in the X-15 --- Mach 6.7 (4,520 mph) --- and qualified as an astronaut. Bill Dana, NASA test pilot, made the last of 199 X-15 flights on Oct. 15, 1968, and was retroactively awarded astronaut wings in 2005. Michael Adams, a USAF test pilot who flew 49 missions in Korea, made seven flights before being killed in the breakup of X-15 No. 3 Aircraft – 66672 on Nov. 15, 1967. The aircraft had entered a hypersonic spin while descending and then oscillated violently as aerodynamic forces increased. Forces in excess of 15G broke the airframe apart at 60,000 feet. He had exceeded the 50-mile altitude mark and was posthumously awarded astronaut wings by the USAF.

By 1962, most original flight test goals of the X-15 had been met. The aircraft had been able to fly as fast and as high as intended, and stood up to the rigours of Mach 6. So the X-15 transitioned to what was known as the X-15 Follow- On Program, using the aircraft for experiments in high speeds and altitudes that couldn't be reached by other planes. Equipment included wingtop pods, a box in the tailcone, or a small hatch behind the canopy that could be opened as needed. By 1964, an estimated 65 per cent of the data came from Follow- On. Investigations ranged from ultraviolet astronomy to structural tests for future SST aircraft to optical and photographic experiments.



The X-15 No. 2 Aircraft - 66671 was rebuilt to become one of the two X-15A2s. Note the lengthened fuselage and nose gear and the two external droppable fuel tanks. *Photo courtesy NASA*

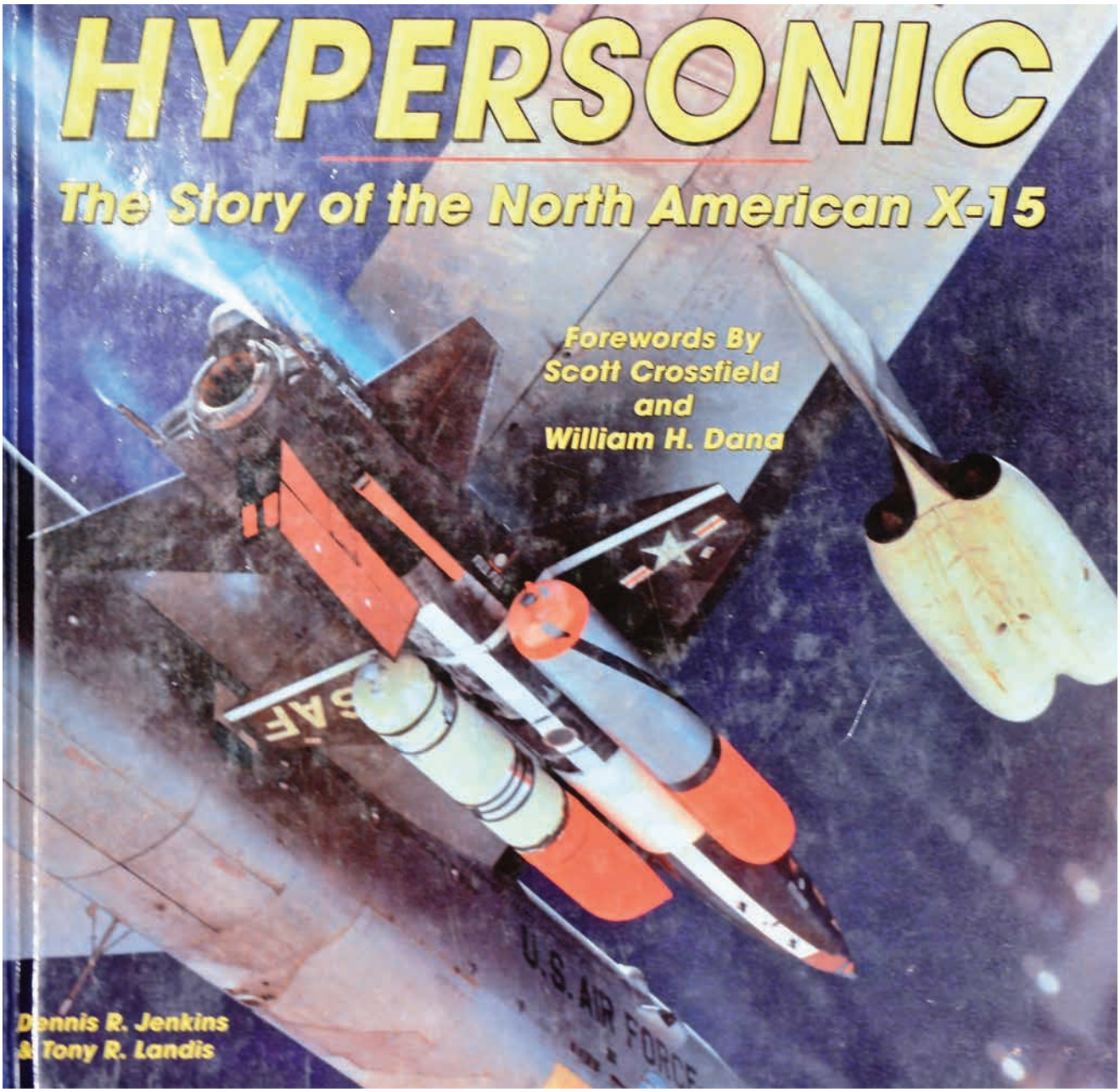
Various X-15 derivatives were considered. The X-15B was based on the idea of launching the aircraft into orbit with an expendable booster. It was cancelled, as Sputnik underlined the need to get into space faster, generating Project Mercury. The X-15A2 program started after the crash of X-15 No. 2 on Nov. 9, 1962, in an emergency landing at Mud Lake. The flaps failed to deploy in a very high-speed landing. The left main skid collapsed causing the X-15 to roll on its back, seriously injuring Jack McKay. The incident proved the value of emergency crews at the dry lakes. McKay would have died had there been any delay in getting to him. During the repairs, North American proposed modifying the X-15 to test a high-speed ramjet, mounted on the ventral fin. The modifications included a 29-inch fuselage stretch, a revised canopy, larger landing skids and two external tanks for extra fuel. The tanks were designed to be recovered by parachute after jettisoning at Mach 2.5 so they could be reused. The goal was to boost maximum speed to 8,000 feet per second, about Mach 8, higher than the original airframe was designed to withstand. The aircraft was covered with a spray-on material to protect against excessive heat. The material tended to blow back and cover the canopy windows, so one window was covered while the pilot flew the X-15 from the other window. Once the high-speed portion was over, the window cover would drop to give the pilot two windows for landing. In a climatic flight on Oct. 3, 1967, the X-15A2 launched for what was the fastest the X-15 ever flew: Mach 6.7. Afterward, the aircraft was heavily scorched, as the dummy ramjet generated shock waves that impinged upon the ventral fin, with heat melting the fin. The X-15A2 was extensively damaged. It was repaired, but didn't fly again.

It had been proposed to design a delta wing X-15, combining the improvements of the X-15A2 with a delta wing for X-15 No. 3 with the MH96 control system. The hope was that this higher performance aircraft would fly into the 1970s, but that was dashed on Nov. 15, 1967, when No. 3 was destroyed while returning from a high-altitude flight that led to the death of Michael Adams. The X-15 No. 1 made eight more flights before the program was aborted at the end of 1968. The last flight was the 199th, on Oct. 24, 1968.

The X-20 Dyna-Soar ("Dynamic Soarer") space plane was a proposed successor to the X-15. It would have been launched by a Titan III ballistic missile, and would have landed aerodynamically, somewhat like the space shuttle. It would have flown sub-orbital or orbital military missions for reconnaissance, bombing or satellite interception. Several X-15 pilots were assigned to the X-20 program, but it was cancelled in November, 1963. The shuttle was the true successor to the X-15. Fittingly, Joe Engle remained with NASA long enough to fly two space shuttle missions. He described landing the shuttle as similar to landing the X-15. Engle is the only shuttle commander to perform a fully manual landing in the shuttle.

The X-15 (Aircraft No. 1 - 66670) viewed from below at the National Air and Space Museum
Photo Credit - Greg Winson

Today, X-15 No. 1 – 66670 is at the Smithsonian National Air and Space Museum in Washington, DC. No. 2 – 66671 is at the National Museum of the USAF in Dayton, Ohio, part of a new gallery of research aircraft that will open in June. The B-52A carrier is at the Pima Air and Space Museum in Tucson, Arizona. The B-52B carrier is a gate guardian at the north entrance to Edwards AFB. Martin answered several questions in his fascinating overview of an exceptional leading-edge project that paved the way for America's space program. He recommended the book Hypersonic: The Story of the X-15, by Dennis Jenkins, for further reading. Bob Winson presented Martin with a gift in appreciation of his outstanding presentation.



Hypersonic The Story of the North American X-15

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