

THE BELL X-1

The first plane ever that flew faster than the speed of sound



The X-1 was the first airplane built purely for research purposes and it has changed the aviation history dramatically. In the past, people were pessimistic about the possibility to fly faster than the speed of sound. They thought that no airplane with the power plants available in that time could ever overcome the large drag that occurs at speeds near Mach 1. However, on Oct. 14th 1947, Captain Charles Yeager proved the opposite with the Bell XS-1, later changed in Bell X-1. Eventually the X-1 would reach a speed of Mach 1.45. After the determination of limitations some improvements were made, which even further extended the flight envelope of the aircraft.

TEXT Elise Bavelaar and Lisanne van Veen, members of the 17th Aviation Department

X-PLANE PROGRAMME

New and unknown technologies are always unpredictable until they are fully built and tested. This became clear by the 1940s as engineers started using experimental aircraft for research purposes. These planes were designated as X-planes, where the X indicates 'experimental'. The X-plane programme, subsidized by the US government, is still the research tool for flight regimes that could not be approached by wind tunnel tests or simulations.

Until now, many planes were built to explore new flight regimes and untried technologies, but not only to fly faster or higher. One of the testing subjects was for example boundary-layer-airflow control theories at transonic speeds. Smaller, propeller-driven reconnaissance vehicles are also part of the programme. Manufacturing is all done by American companies. The production is limited, because the aircraft are solely built for research. One exception is the X-35, which is now well-known as the Joint Strike Fighter. This aircraft was initially designated as X-plane and won the JSF-competition from the X-32. In the near future, it will be in full-scale production.

Although the programme variety grew, all designs had one thing in common, being highly valuable research tools for the advancement of aerodynamics.

X-1 DESIGN PROCESS

The X-1 was designed and built by Bell Aircraft Company. The project began in 1944 and its goal was to investigate the possibilities of supersonic flight. Nowadays, some technologies, first employed in the X-1, are used as standard equipment on transonic military aircraft. Most important design parameters for success were the development of powerful engines and heat resistant materials.

But a good fuselage, wing and tail design have definitely helped to fly through the sound barrier and reach supersonic flight as well.

FUSELAGE

The shape of the fuselage was unusual compared to the existing aircraft at that time. It was modelled on a .50-caliber bullet to reduce drag but the aerodynamic experts were also searching for a shape that did not tumble at high speeds. This was the only known shape that met these requirements.

One additional advantage was the internal volume of this shape, which can be used for the engine, fuel and data collection equipment.

WING

Flying at higher speeds requires a different wing shape design. The local velocity on a wing is higher than the undisturbed velocity of the airplane. When locally this velocity reaches a value of Mach one (supersonic flight), shockwaves occur. This increases the drag enormously, which is not beneficial for flight performance and fuel consumption. The flight speed at which this phenomenon occurs depends on the airfoil type of the wing. Using thinner wings extends this point and allows the aircraft to fly at higher speeds without the large drag increase. Therefore, the wings of the X-1 were extremely thin, which was very uncommon for that time period. Normally, the wing thickness was around fifteen percent of even higher. For the X-1, a wing thickness of ten percent was used for more routine flights. For the flights intended to fly supersonic, the wing thickness was reduced to eight percent.

Table 1. Specifications of the Bell X-1

Property	Value
Wing span	8.5m
Length	9.4m
Height	3.3m
Wing area	12m ²
Maximum take-off weight	5,557kg
Engine thrust	26.7kN



Figure 1. Schiphol

Nowadays, the use of thin airfoils on high-speed aircraft is almost a standard design practice. High-speed aircraft are also characterized by the use of swept wings. The concept of the swept wing already existed in the 1930s in Germany. By sweeping the wing the critical Mach number of the wing is increased and an airplane can fly faster, having less drag than a straight wing. The concept of swept wings is used for most high-speed airplanes since the middle 1940s. However, the Bell X-1 did not have a swept wing, simply because knowledge of swept wings was not available in the United States yet. If the swept wing concept would have been applied to the Bell X-1 it would have flown even faster.

TAIL

A new tail design was used; the horizontal stabilizer was not fixed to the fuselage but an adjustable tail was mounted at the back. This improves the controllability of the airplane, which is especially needed during the transonic part of the flight. The thickness of the horizontal tail was even thinner than the main wing; only a six percent thick wing was utilized. The thickness of the tail is always thinner than the main wing, to avoid stall conditions acting on both components at the same time. Due to the success of this type of stabilizer, all modern military aircraft are designed with all moving horizontal stabilizer.

ENGINE

A rocket propulsion system was used as engine. It was a liquid-propellant system and consisted of four different chambers. The thrust was generated by burning ethyl alcohol diluted with water and liquid oxygen. Each chamber generated a certain amount of thrust. The thrust could be increased by firing more chambers and could reach a

maximum value of 26,700 Newton.

LAUNCH AND FLIGHT PHASE OF THE X-1

Something very special about Bell X-1 is that it does not take off like a normal airplane. Due to its limited endurance, the Bell X-1 had to be carried in the belly of the B-29 Bomber. At an altitude of 20,000 feet it was dropped free, after which the rocket engine was fired. After the launch, the aircraft climbed to its test altitude, where the tests were performed. Due to the short range and limited fuel capacity, all fuel was used during the test phase. When the X-1 was running out of fuel, it glided down for a dead-stick landing on the flight test centre Muroc Dry Lake.

The first flights were only gliding flights to test the stability of the aircraft or to give new pilots the possibility to get used to the airplane. After almost one year, the first powered flight was made. Afterwards, the investigations could begin. First, only at subsonic speed to check the feasibility of the aircraft and to be sure that everything worked well. This was all part of the Bell contractor programme. The Air Force took over and the real testing part could start. It started again with familiarization of the aircraft by the pilot, in this case Chuck Yeager. Within a few months the first supersonic flight took place.

IMPROVEMENTS IN THE PROGRAMME

Due to the limitations of the X-1, the Air Force decided to extend the programme and Bell started with the fabrication of three new models of the X-1. These were designated X-1A, X-1B and X-1D. These aircrafts had an increased fuel capacity and an engine improvement. Trying to fly higher and faster was the idea behind it. The goals were reached; the speed went up to Mach

2.4 and the X-1A continued flying until an altitude record of 90,000 feet was achieved.

Unfortunately, accidents also occurred. The engines of some aircraft caused trouble and some of them exploded. After reaching the altitude record, the X-1A data collection equipment was extended. The first flight after these modifications, the X-1A exploded during its first climb after launch. Due to the new instruments on board and chemical analysis of the fuel, the engineers figured out what happened. A substance used in the engine reacted with the fuel, which caused the explosions. After this problem was solved for the other planes (X-1B and X-1E), no further explosions occurred during the rest of the programme.

After the records set by the X-1A, the X-1B was used by the Air Force to familiarize the pilots with supersonic flight. The last of the X-1 series was the X-1E. Originally, this was an X-1 plane, which was modified and renamed. The wings were redesigned to revolutionary thin wings, which had a thickness of only four percent. Speeds of Mach 2.24 were achieved and the new goal was to reach Mach three. Some additional modifications to the ventral fins and the engine system were applied. Only one flight was performed with the new aircraft before fuel tank cracks were discovered. This was the end of the X-1 programme.

CONCLUSIONS

The Bell X-1 was one of the biggest breakthroughs in aeronautics field. The aircraft made planes like the F-16 and the Joint Strike Fighter possible. Now the question is: when will engineers come up with new designs, which will cause a similar breakthrough as the Bell X-1? ✈

References

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AVIATION DEPARTMENT

The Aviation Department of the Society of Aerospace Engineering Students 'Leonardo da Vinci' fulfills the needs of aviation enthusiasts by organising activities, like lectures and excursion in the Netherlands and abroad.

