Concorde 2.0: On-going Supersonic Projects

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ABSTRACT

This report serves to inform about, which role supersonic projects will play in the future of aviation.
Therefore, two recent projects, which shall bring back the former euphoria for supersonic transportation get shown.
But first of all the *Concorde*, which was the only commercial used civil supersonic aircraft gets analyzed to work out, why supersonic transportation got forgotten.
Having a look in the past to see, what problems the *Concorde* faced, makes it possible to evaluate if the projects for the future are doing better.

1 The Concorde

The *Concorde* was mainly used to make traveling between London and New York, as well as between Paris and New York faster. Powered by four turbojet engines, produced by Rolls-Royce/SNECMA the *Concorde* makes use of a delta-wing design. This design allows to fly at a high angle of attack, which makes the airplane very agile and better in terms of maneuverability than many military airplanes. [1, 2]

1.1 High technology

The aircraft is popular for its pioneering technology, which is common now, but at the time represented a world first. This includes a computer controlled air intake system, for instance. It is needed because the air would be too fast for the engines to intake, when the airplane is at supersonic speeds. To avoid major damage on the engines the *Concorde* is able to change the geometric of the air inlet to slow down the air stream. Because of putting air flaps into a certain configuration to form a nozzle, a supersonic shock wave gets produced which slows down the air. In addition, besides the *Concorde*, only a few airplanes were controlled by the fly-by-wire technology at this time, what means that the commands by the pilot go to a computer first and then to the actuators, not directly to them. [1]
This led to many advantages like saving a lot of weight and making the plane safer. [3]
If the airplane was such a milestone in aircraft engineering, it makes sense to search somewhere else for the reason why it failed.

1.2 Different problems

In many people's opinion the retirement was caused by the fatal accident in 2000, but in fact the airlines thought about stopping the use of the *Concorde* earlier. [2]
The decisive reason was that many expensive hardware updates were necessary to modernize the aircraft and the airlines decided, that this is not worth it, because of the main problems which the *Concorde* had. [1]
The *Concorde* has the two major problems of being a very noisy aircraft with a high fuel consumption. Especially in comparison to the Boeing 747, the disadvantages get clear. With the same fuel consumption the *Concorde* was only able to carry 100 passengers whereas the Boeing has 440 seats. [4, 2]
In table 1, you can see that the *Concorde* has a range of around 3500 nautical miles, while the Boeing 747 had a range of 5600 nautical miles [5, 4]
Regarding to the noise emissions, it can be said that these are quite high in comparison to other aircraft. Especially in the take-off phase, because here the *Concorde* makes use of an afterburner. [5, 1]
The *Concorde* with a maximum take-off weight (MTOW) of 185 tons is approximately 350 EPNdB loud, whereas a Boeing 747 with a MTOW of around 500 tons just emits a noise of 290 EPNdb. [5]

2 Presentation of two on-going projects

After this brief presentation of the *Concorde*, two ongoing supersonic projects, that will be develop in the near future (five to ten years), will be analysed. Knowing the reason why the *Concorde* failed to thrive is going to be useful to understand how these new projects intend to deal with the *Concorde*'s problems.

One of the first projects is called Boom (Fig. 1).

Fig. 1 Image of Boom, Overture, extracted from Boom Website [6]

Boom is a Northern American company developing the next supersonic commercial airplane, planned to fly at a top speed of Mach 2.2, faster than any possible competitor (table 1), and promising ticket prices comparable to a seat in business class. It can change the transportation the way we know it. Boom is developing their first flight prototype, a 1/3 scale 2-seat Jet engine named XB-1, with first flights taking place in 2020. Their first passenger supersonic plane, named Overture (Fig.1) is planned to arrive in the mid-20s, after enduring some thorough examination and certification, all optimized through their XB-1 test model.

The other on-going project we chose to discuss, is called Spike (Fig. 2). This plane is developed to be a business jet able to carry about twenty passengers at Mach 1.6. It is powered with two engines. Its design, as seen in figure 2, has been studied to minimize the drag.

Fig. 2 Image of Spike S-512 extracted from Spike Website [7]

2.1 Boom

2.1.1 ***Materials***

The main difference between the *Concorde* and Boom is the technology: from computation power, aerodynamics, new materials, engine improvements. Boom's SST will be mainly built from a material which *Concord* engineers could only make smaller parts: carbon fiber, the main material used in the fuselage and wings and some others structural parts. This material allows a reduced weight which is a big factor to take in consideration when developing a plane for supersonic flights. It will have Delta wings (as Spike will) due to their better characteristics at supersonic speed and a smaller size, which was one of the *Concorde*'s disadvantages for its high noise or fuel consumption.

2.1.2 ***Engines***

The prototype XB-1 will need afterburners to achieve mach 2.2. However, due to engine improvements in the last few years, Boom will not have the need to use afterburners for Overture, one of the main cause of noise pollution and a setback towards approval to fly overland and get to a country further from the sea, which was one of the *Concorde*'s problems and limited it to transatlantic flights. It will have 3x non-afterburning engines, a medium-bypass turbofan and proprietary variable geometry intake and exhaust making it more silent, and with a fuel per seat comparable to subsonic high range planes. As seen in table 1, Boom is a optimized aircraft for the amount of passengers it can hold, it has the smaller aspect ratio of the three models analysed which contributes to a reduced sonic boom. However, it is longer than Spike in order to carry more payloads.

Furthermore, Boom is developing a sustainable supersonic commercial traveling, taking in consideration the UN's existing goal of carbon-neutral growth in aviation by conducting several alternative-fuel tests, and they plan to achieve environmentally and socially sustainable travel.

2.2 Spike

2.2.1 ***Noise***

As seen earlier, one of the problem of supersonic flight was the noise, the *Concorde* was not allowed to fly at supersonic speed above land. That is why, one of the purpose of this project is to reduce the noise in order to fly overland and be able to reach more inlands destinations. Thanks to its design, Spike S-512 (Fig. 2) will be able to have a quiet supersonic noise at his cruising speed of Mach 1.6. This speed is lower than the *Concorde* in order to improve the L/D ratio of the plane. When the speed is higher than Mach 1, as the mach number increases, the $(L/D)_{max}$ decreases [8].

In order to be quieter, supersonic planes need to have an optimized aerodynamic fuselage, from the front to the back. Comparing the length of planes and

the numbers of passengers for each aircraft in Table 1, one of the conclusion is that length needs to increase in order to reduce the sonic boom. However, it won't be possible to fit as many passengers as subsonic planes can. One cannot imagine a long aircraft as it will require to redesign all airports so that the plane may fit at its gate or turn while taxing. That may be one of the reason, Boom is only able to carry 50 passengers.

2.2.2 *Size*

Moreover, due to the high speed required, lots of characteristics have to be taken into account for high-speed or high-lift aerodynamics. With the two projects developed in this paper, as seen in table 1, the size of supersonic planes (in term of passengers) decreases. As the most effective surface (flat plate) to get the best L/D ratio has the least effective payload capacity [8], that means supersonic planes will be much smaller than subsonic aircraft.

As one know the high fuel consumption of the *Concorde*, the future of the two on-going projects can be doubtful. Their L/D ratio is lower than the *Concorde* which will certainly lead to a high fuel consumption as well.

3 Tables

This table sums up the different characteristics of the different planes cited in the document. As the purpose is to present the different projects, it seems relevant to compare these data with the past supersonic plane : the *Concorde*.
Some of the following data are likely to change as the two projects are still being developed.

Table 1 Supersonic planes characteristics [5]

	Concorde	Boom	Spike 2
Nb of passengers	100	45-55	12-18
Cruise Mach	2	2.2	1.6
Length (m)	61.66	51	37
Wing area (m^2)	358	218	164
Wingspan (m)	25.6	18	17.7
Range (NM)	3500	4500	6200
Aspect Ratio	1.83	1.49	1.92
Max L/D ratio	7.14	5-6	5-6

4 Conclusion

Building a supersonic aircraft is made of concessions. Choosing to improve the supersonic rather than subsonic, the high speed aerodynamics over the high lift aerodynamics. In order to overcome the different difficulties brought by the Concorde, supersonic planes have to respect some obligations; that is why planes tend to be smaller as seen with the projects analysed.
Moreover, to reduce the fuel consumption, as seen in Boom aircraft, it is possible thanks to latest improvements in engines and these parts of the plane would certainly keep improving in the future years.
Finally, if one wants to know if supersonic flight would be feasible in the future, one can optimistically say yes, because many projects will be developed in the future and one of them would be profitable and respectful of the different standard. However, the ticket price would certainly be more expensive than a subsonic aircraft.

REFERENCES

[1] Concorde. [Used on 26.09.19].
URL `http://concordesst.com/`

[2] Engineering I. Concorde: The Real Reason Why the Supersonic Passenger Jet Failed, 2017. [used on 27.09.2019].
URL `https://interestingengineering.com/concorde-the-real-reason-why-the-supersonic-passenger-j`

[3] Cox J. Ask the Captain: What does 'fly by wire' mean?, 2014. [Used on 26.09.19].
URL `https://eu.usatoday.com/story/travel/columnist/cox/2014/03/30/fly-by-wire-cockpit-controls/7026935/`

[4] Boeing. Historical Snapshot. [Used on 27.09.2019].
URL `http://www.boeing.com/history/products/747.page`

[5] de Jolimont A O. From Concorde to new supersonic aircraft projects. Ancien Observatoire de Jolimont, 2019. [used on 27.09.2019].
URL `https://academieairespace.com/wp-content/uploads/2019/06/AAE_D46_UK_WEB.pdf`

[6] Boom. Boom supersonic, 2019.
URL `https://boomsupersonic.com/`

[7] Aerospace S. Spike s-512, 09/2019.
URL `http://www.spikeaerospace.com/`

[8] Anderson, John David, Jr. *Introduction to flight*. 8th ed. Boston: McGraw-Hill, 2016.

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