

XS-1 Phase B: DARPA's new space plane looks skyward

Airforce-technology



Since the dawn of the Space Age, space vehicles have predominantly shared one major limitation - their fundamentally single-use, disposable nature, and the high mission expenses that inevitably entails.

While for a time NASA's shuttle fleet changed that, its retirement a little over four years ago, coupled with the ever-escalating costs of spaceflight and declining budgets, has put the spotlight back on developing reusable space planes. It represents an increasingly high priority for governments and commercial operators alike, with spacecraft such as the USAF's contentious X-37B, China's Shenlong counterpart and Virgin Galactic's SpaceShipOne emerging amongst the front-runners.

In July 2014, the US Defense Advanced Research Projects Agency (DARPA) joined the fray, awarding contracts to three companies to design demonstration vehicles for the XS-1 programme, which was announced in late 2013. This summer, the same three - Boeing, Northrop Grumman and Masten Space Systems - received nearly \$20m of further funding between them to move on to phase B, which could see the first orbital mission taking place within the next five years.

Not a novel concept

The space plane is not a novel concept. Practical attempts to produce a reusable space vehicle have been around since the 1950s era X-15, itself an ancestor of the space shuttle, and there have been a number of attempts in the intervening years that ultimately failed to make progress, principally because of technologies that were then somewhat immature.

Now, with those problems solved and light, cost-effective composite materials, robust thermal protection and vastly improved aerospace management technology available, DARPA believes that the XS-1 programme can succeed and make access to space straightforward, affordable and routine.

Programme requirements

DARPA set out very clear requirements for the XS-1 programme when it was first announced back in 2013.

The unmanned and fully reusable space plane is to provide "aircraft-like access" to space, being capable of Mach 10+ hypersonic flight, to launch a small payload of between 1,400kg and 2,300kg into low Earth orbit and to have a fast turnaround that enables it to fly ten times in as many days. All of this is to be deliverable at a cost of under \$5m per flight - roughly eleven times less than the current price of a launch using conventional expendable rocket systems.

The idea is that the XS-1 will fly at hypersonic speeds to a suborbital altitude, where an expendable delivery stage separates and deploys the satellite payload into low Earth orbit, while the space plane itself lands back on earth to be prepared for its next flight. According to DARPA, logistical demands will be significantly cut by the use of modular components, durable thermal protection and automated systems to manage launch, flight and recovery, enabling the XS-1 to meet the rapid turnaround target.

To turn its wish list into a space plane, DARPA chose companies that, in the words of programme manager Jess Sponable, "could prudently integrate existing and up-and-coming technologies and operations, while making XS-1 as reliable, easy-to-use and cost-effective as possible."

XS-1 contenders

All three of the competitors have released artists' concepts of their system, which give strong clues as to how each intends to bring its expertise with aerospace vehicles and autonomous flight systems to the challenge.

Partnered with Blue Origin to work on the \$4m initial contract, Boeing intend its XS-1 to use the same kind of operation and maintenance principles used in modern aircraft to get it ready for re-launch using efficient, streamlined ground infrastructure to improve the turnaround time. The artist rendition of Boeing's vision show a broadly space shuttle shaped vehicle, although DARPA's unmanned space plane will, of course, be considerably smaller.

Northrop Grumman also received \$4m for the phase 1 preliminary design contract, and teamed up with Scaled Composites and Virgin Galactic to work on a version of the space plane that uses a simple transporter erector launcher, highly autonomous flight management and lands on a conventional runway like a normal aircraft.

Masten Space Systems, awarded \$3m in phase 1, is a small specialist company based at the Mojave Air and Space Port, which has considerable experience with vertical take-off, vertical landing (VTVL) designs - notably the Xombie, Xoie, and Xaero - all of which have already met or exceeded DARPA's rapid-turnaround target. Partnering with XCOR Aerospace for the propulsion system, Masten proposed a VTVL vehicle, shown in the initial concept drawings with a conventional tail fin and wings, which represents a departure from the company's previous designs.

Déjà vu?

There is more than a slight feeling of déjà vu about the design concept artwork from all three, and comparisons with the USAF's clandestine and somewhat controversial Boeing-built X37-B seem all but inevitable.

Beginning life in 1999 as a collaborative project between NASA and Boeing's Phantom Works, in 2004 this unmanned space plane came under the auspices of DARPA and two entered service with the USAF in 2006. However, although there is a great deal of resemblance between the look of the XS-1 designs and the X37-B, they are two very significant practical differences between them.

Firstly, while the XS-1 is intended to spend very little actual flight time in space, the USAF's space plane is a true orbital vehicle built to dwell for long periods, having already flown one mission that lasted 675 days. Secondly, for all of its cutting-edge ability to manoeuvre in space and then subsequently glide back to a runway on earth, when it comes to getting up there in the first place, the X37-B is definitely old-school - blasted into orbit inside its encapsulation shell atop a conventional single-use rocket.

The XS-1, however, gets itself to where it is going. The space plane has, in effect, become the launch vehicle and although it does the same job as a conventional first-stage rocket, firing off an expendable second-stage to deliver the payload, this space plane version's first stage is reusable.

Critical urgency

It remains possible that the XS-1 may hitch a ride some of the way, at least in the demonstrator phase, even if the final vehicle does eventually take off entirely under its own power. DARPA's initial brief was very open about the potential ways the space plane could get into the air, and piggy-backing on a mothership already has a proven track record as a practical and cost-effective solution, which could make achieving the other programme goals easier, given the timeframe.

With affordably routine access to space increasingly been seen as critical to US national and economic security as global rivals become ever quicker at closing the technology gap, there is a sense of urgency to the programme.

Final designs are expected to be ready in 2016, and the first flights might take off as early as 2018. As DARPA's Jess Sponable put it at the start of the competition, "we're eager to see how their initial designs envision making spaceflight commonplace - with all the potential military, civilian and commercial benefits that capability would provide."