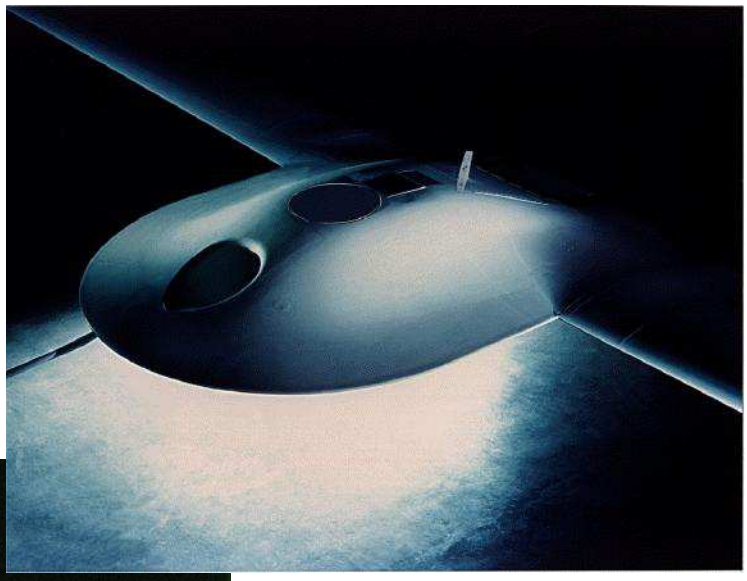
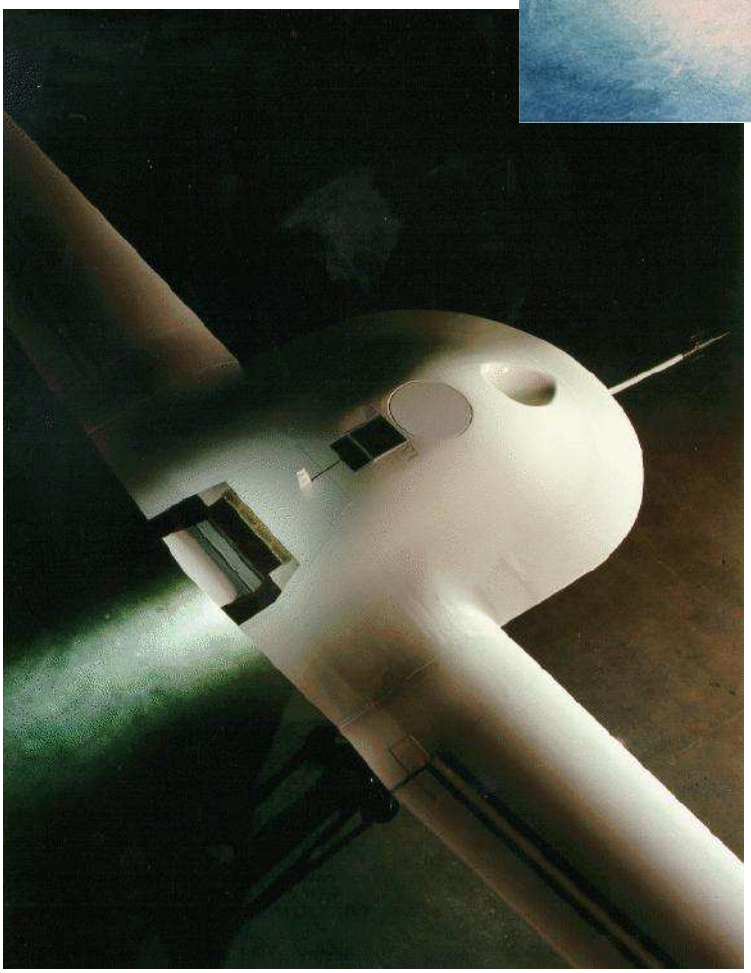
On the 'Wing... #121

DarkStar

Tier III Minus DarkStar is a joint project of Lockheed Martin Skunk Works, Boeing, and Defense Advanced Research Projects Agency (DARPA). Lockheed Martin has primary responsibility for the airframe, Boeing builds DarkStar wings and provides avionics and flight software. Testing is being done at NASA Dryden, Edwards AFB.

A stealthy unmanned aerial vehicle (UAV) designed for a number of reconnaissance roles, DarkStar is not radio controlled. Rather, it follows a pre-programmed flight path with the assistance of a differential global positioning system and a sophisticated internal flight control system.



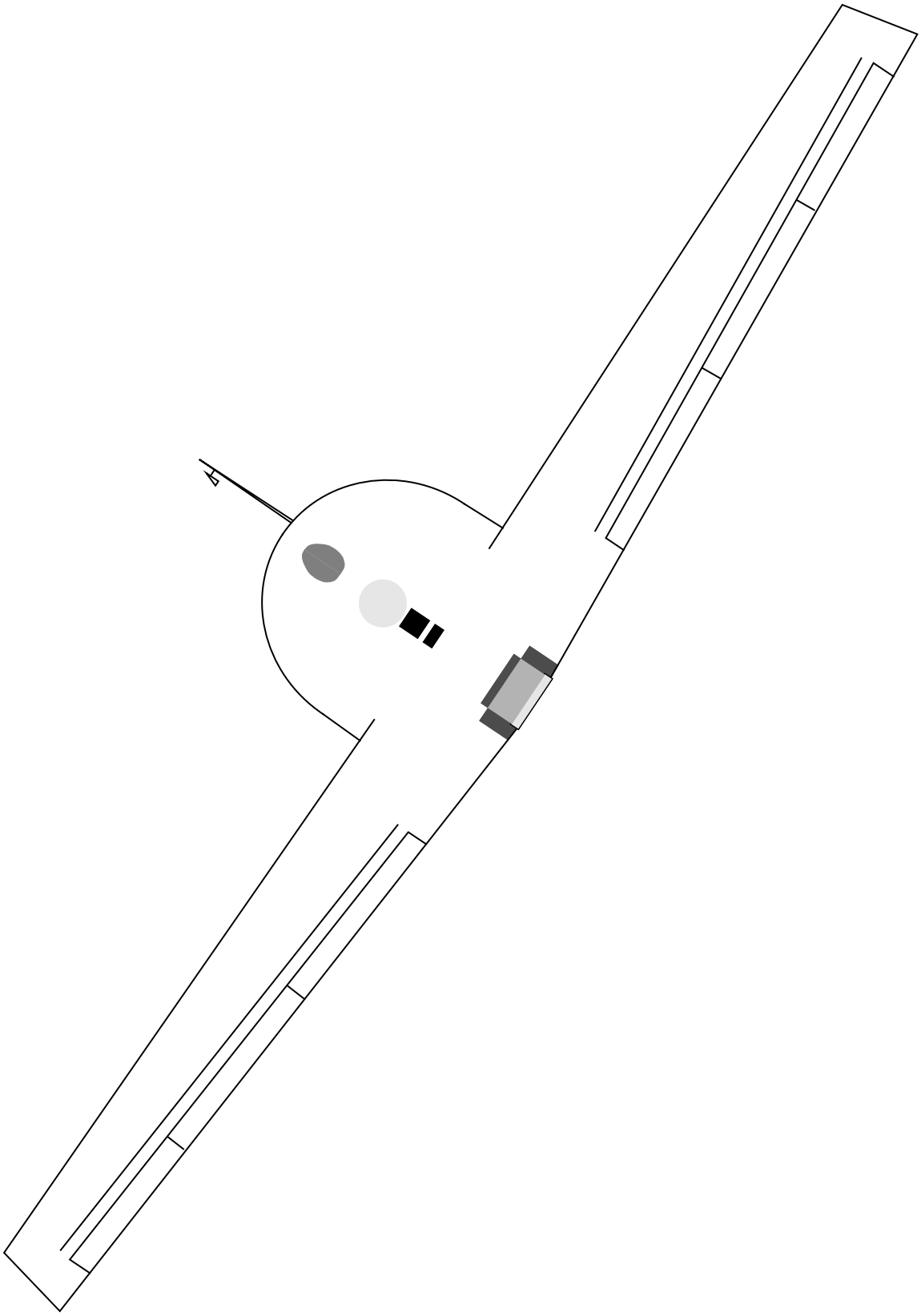


DarkStar is designed to fly 500 miles at a speed of over 250 m.p.h., remain over a predetermined target at an altitude of up to 45,000 feet for up to eight hours while transmitting information back to its base, and return Payloads may be high resolution synthetic-aperture radar (SAR) or electro-optical (EO) devices. Another long-distance UAV is also under development. Global Hawk, designed by Teledyne Ryan Aeronautical, has a different mission set and flight profile. The two systems will eventually be fully integrated.

DarkStar was rolled out on the first of June 1995 and, following ground testing, first flew on March 29th 1996. On its second flight, DarkStar began oscillating in pitch during the final stages of takeoff roll when, due to runway irregularities and/or a wind gust, the main gear left the ground prematurely. Investigation showed vehicle-ground interaction was not accurately predicted and the control system was unable to effectively damp the oscillations. Seven cycles later, DarkStar jumped into the air. The control system was also unable to rapidly transition from ground to flight mode. As the photograph shows, the aircraft went to a nearly vertical attitude, despite having both ruddervons open and all other control surfaces fully down. DarkStar stalled and fell to the ground.

While a human pilot can make small corrections to compensate for runway irregularities, or react to an in-flight emergency, a UAV must be pre-programmed to deal with anything it may encounter from the beginning to the end of its mission. Boeing engineers made more than 50 changes to the DarkStar onboard computer program, and set up a second command link to more quickly activate the abort sequence.

Boeing engineers also replaced the outer 18” of the elevons, next to the ruddervons, with separate control surfaces. These actively damp the normal structural resonance of the wing and allow the other control surfaces to be programmed for more rapid, and more aggressive, response.



Major modifications were also made to the landing gear. The elevon moment arm is very short — the distance between the elevons and the CG is just four feet. The moment arm to the main landing gear is even shorter, so the elevons cannot rotate the aircraft during takeoff roll. Initially, the landing gear was set up so that the aircraft sat at a positive angle to the ground, allowing a zero rotation takeoff, much like the B-52. The second DarkStar was reconfigured to taxi at a negative angle of attack. Takeoff is now initiated by extending the nose gear to give the aircraft a three degree positive angle of attack.

The second DarkStar was flown successfully at Edwards AFB on June 29, 1998. It remained in the air for 44 minutes and achieved a planned altitude of approximately 5,000 feet. The entire flight, start to stop, was automated.

UAVs will be used for missions where a human pilot would be placed at risk, or where limitations of the human body would be exceeded. Ideal uses would be as intelligence gathering devices, as missile defense platforms, or as pilotless attack aircraft. Besides these obvious real-time military uses, UAVs will also

find a place in civilian surveillance, such as oil pipeline observation and highway patrol, or perhaps in mail delivery systems.

UAVs must carry special payloads through challenging flight regimes while remaining stealthy. Such constraints frequently force designers to create unique and oftentimes exotic planforms. Despite their odd look, these aircraft can usually be made into stable radio controlled models. DarkStar on the slope? Hey, it could happen!

A motion picture of the first flight of DarkStar can be found on the Lockheed Martin web site. You can download the movie as either a Quicktime MOV (3.5MB at <http://www.lmco.com/video/lm1/may96/2uav.mov>) or a Windows AVI (6.5MB at <http://www.lmco.com/video/lm1/may96/uav.avi>) file.

Suggestions for future columns are always welcome. Please drop us a note at P.O. Box 975, Olalla WA 98359-0975, or <bsquared@halcyon.com>.

Resources:

Dornheim, Michael A. Many changes made to DarkStar. *Aviation Week & Space Technology*, July 6, 1998, pp. 26, 29.

Fulghum, David A. DarkStar beats problems, scores successful flight. *Aviation Week & Space Technology*, July 6, 1998. p. 25.