The Flight to Orbit

There are numerous ways to get there—from rocket launch to space maneuver vehicles—and the Air Force is keeping its options open.

By John A. Tirpak, Senior Editor

THE Air Force would like to go back and forth to Earth orbit as easily as it goes back and forth to 30,000 feet—routinely, reliably, and relatively cheaply. Such a capability goes hand in hand with being a true "aerospace" force but is one which has long eluded a hardware solution. Concepts such as the X-20 Dyna-Soar of the 1960s and the X-30 National Aerospace Plane of the 1980s and early 1990s reached beyond the technological grasp of their times. The space shuttle, while a formidable technical feat, has never lived up to the twice-monthly launch schedule or cost originally envisioned for it.

All this may soon change. As the demand for both commercial and military satellites multiplies almost exponentially, more than two dozen private and government projects are under way to try to meet the corresponding need for inexpensive launch services. One concept calls for winged vehicles to be towed to altitude, then released for a rocket-powered flight to orbit. Another anticipates a midflight air refueling before the final ascent. Still another envisions employing giant rotors that both help reach orbit and slow descent. Many involve international partnerships, particularly with Russian outfits, but all emphasize reuse of all or most of the system, with an eye toward becoming a space-age version of today's overnight package companies.

Even if only a fraction of the new concepts work out, access to space will broaden and the cost of getting there will drop significantly. One industry official made the analogy between today's rush to build cheap launchers to the barnstorming days of aviation, which paved the way for an explosion of new machines and new applications.

Around the Corner

As then–US Space Command chief Gen. Howell M. Estes III said to defense writers just before his retirement in August, "This is going to come along a lot quicker than we think it is. ... We tend to think this stuff is way out there in the future, but it's right around the corner."

The Air Force and NASA have divided the task of providing the US government with a means of reliable, low-cost transportation to Earth orbit. The Air Force, with the largest immediate need, is heading up the effort to revamp the Expendable Launch Vehicles now used to loft military and other government satellites. Called the Evolved ELV, this program is focused on derivatives of existing rockets. Competitors have been invited to redesign or value-engineer their proven boosters with new materials and technologies to provide reliable launch services at a far lower price than today's benchmark of around $10,000 a pound to Low Earth Orbit. The reasoning is that an "evolved"—rather than an all-new—vehicle will yield cost savings while reducing technical risk.

The goal is to reduce launch costs by at least 25 percent; industry leaders are shooting for a cut of 50 percent or more. The Air Force wants a family of launch vehicles, scaled to fit medium and heavy payloads headed for LEO or Geosynchronous Transfer Orbit.

In addition, USAF wants to "standardize the interfaces" between rockets and satellites, so any US military satellite can be carried by the launchers available. This will increase flexibility and eliminate the possibility that the entire military space effort could be shut down if a particular kind of vehicle developed a flaw that grounded it. The EELV program also calls for most of the processing of rockets to take place off-pad, freeing the launchpads—which are in limited supply—to be used as much as possible for launch and not be tied up waiting for one.

While the Air Force originally

Ever since the Space Age began, the Air Force has wanted a craft that could quickly get to orbit and land like an airplane. This drawing of the Martin SV-5D, an unmanned lifting body tested in the 1960s, was the pre-cursor to the X-24A, a manned vehicle flight-tested from 1969 to 1971. USAF and NASA flew various lifting body concepts, but they proved too technically ambitious for the time. What goes around comes around, though; the Soviet space pro-gram test flew a sub-scale craft very much like the X-24, and NASA is evaluating a similar craft, built by Scaled Composites, as an Inter-national Space Station emergency crew return vehicle.

planned to select a single contractor from among the entries in the competition, it decided late last year to carry two companies into production: Boeing with its Delta IV variants and Lockheed Martin with its Atlas and Titan follow-ons. The companies will compete on a per-launch basis. A test of medium-lift variants will take place in Fiscal 2002, and the heavy-lift versions are set to fly in Fiscal 2003, with a full operational capability by Fiscal 2005. Earlier flights are definitely possible, given that both Boeing and Lockheed Martin had planned to pursue their respective vehicles with or without a "win" in the EELV competitions and given that the demand for launch services is starting to overtake the number of rockets available.

The program would, not coincidentally, help US companies reclaim their dominance of the satellite launch business. American firms, which once seemed unbeatable in commercial space, now have only 36 percent of the annual launch market of around $2.8 billion. The *Challenger* accident in 1986, which forced a two-year shutdown in shuttle operations and left the US scrambling for expendable alternatives, allowed the European Arianespace consortium to take over leadership in lift services. China and Russia also have captured a very significant chunk of the market.

The Next Phase

The Air Force was expected to announce details of the next phase of the EELV program this fall, including how it will save money while maintaining two unique launch vehicle production lines. The project is expected to carry the bulk of USAF satellites into the 2015–20 era, when it is hoped that a thoroughly Reusable Launch Vehicle will be available.

NASA has taken the lead on this longer-term solution. While the space shuttle orbiter and its large external solid boosters can be used again after extensive refurbishment, its huge external liquid fuel tank is discarded on every flight, and turnaround time has never bested two months. NASA and the Air Force want a system which consumes nothing but fuel and parts and with a re-fly window measured in days, not weeks.

The anticipated system for the RLV is the Lockheed Martin VentureStar. This lifting-body design is expected to loft 50,000 pounds to Low Earth Orbit—compared to the shuttle's 51,000-pound maximum—at only about $1,000 a pound in the middle of the next decade. The VentureStar will take off vertically, using the liquid hydrogen and liquid oxygen in its vast internal fuel tanks, orbit, then return to a runway landing. It can be flown autonomously, remotely, or by an onboard crew.

It's an ambitious undertaking. To reduce risk and prove the technologies involved, a half-scale demonstrator called the X-33 is being built and will fly next year on suborbital flights of up to Mach 15. The main thing to be proven with the X-33 is that its power plant—the linear aerospike engine—will work. Though conceived in the 1970s as a space shuttle motor, it was ruled out for that program in favor of conventional rocket motors, considered less risky at the time.

Now, Lockheed believes, the technology for a practical aerospike engine is available; the company has flown the concept aboard an SR-71 test bed.

The linear aerospike is described as an "inside out" rocket motor, with fuel combustion taking place outside of a central core. The concept eliminates the weight of rocket bell exhausts and much of the plumbing involved with today's rockets, thus saving weight and cost, and should be more reliable than a standard rocket motor.

About 15 test flights of the X-33 are planned from Edwards AFB, Calif. Shorter-duration flights will end with a landing at Michael Army Air Field at the Army's Dugway Proving Grounds in Utah, while longer flights will conclude at Malmstrom AFB, Mont. Most of the flight tests will average a week apart, but the program calls for demonstrating a turnaround time of two days at least once. The suborbital flight to Utah will take about 15 minutes while the trip to Malmstrom will take 24 minutes.

The Air Force is interested in both VentureStar and the X-33 as possible launch vehicles for its own more routine operations in space but will not commit to the system for some time, waiting to see that the concept delivers on its promises. The X-33 does have a small payload bay, measuring 5 feet by 10 feet.

Spaceplane No More

"We envision a Space Operations Vehicle system," according to Air

Force Space Command requirements chief Brig. Gen. Brian A. Arnold. The term "system" denotes that USAF has dropped the idea of an all-in-one military spaceplane and is now pursuing a building-block approach that will involve different types of vehicles.

The fundamental element "will be the Space Operations Vehicle," Arnold explained. The SOV will be an entirely reusable, single-stage-to-orbit spacecraft "which could go to Medium [Earth Orbit] or geosynchronous orbit," he said.

While the SOV could carry a mission payload and sensors, it probably would be used chiefly "as a truck," Arnold said, to carry aloft satellites or what is termed a Space Maneuver Vehicle. It would have a high sortie rate as well as interchangeable payloads tailored to the mission—not unlike changing the pods or ordnance on a combat aircraft.

The SMV would be a smaller vehicle capable of performing "any number of missions," he added, from spot surveillance of a touchy region to refueling or repairing a satellite to orbiting a specialized, short-lived "smallsat" for a special mission. Its key capabilities will be "launch, return, and reuse on demand," Arnold said.

"We're talking about the operational concepts," and a mission need statement will soon be in the offing, Arnold noted. However, "the key is to be cheaper and more responsive" than today's satellites and launch vehicles.

Having such a capability would make it possible to build cheaper military satellites, he noted, since today's orbiting reconnaissance "battleships" must have multiple redundant systems and a large supply of maneuvering propellant. That's because once on orbit, it's both difficult and highly expensive to retrieve or resupply them with the space shuttle. With the ability to get to space on short notice would come the option of making satellites with less redundancy and less propellant, making them cheaper to build and thus cheaper to launch. An SMV would allow a quick satellite refueling or replacement in a crisis.

A constellation of small "cheapsats," as they are also known, would also degrade more gracefully under failure or attack than a single, massive platform. The SMV could routinely "replenish the constellation," Arnold said.

Satellites being launched by the Air Force today are not configured for on-orbit servicing, Arnold said, but the availability of SOVs in the future may swing design in that direction.

Checking Things Out

The availability of an SMV would make it possible to look over a foreign satellite, and possibly knock it out, if it carried mechanisms to blind or destroy US assets in space. Also being looked at as an SOV payload is the Orbital Transfer Vehicle—a satellite that would perform a "tug" mission, moving satellites to higher or lower orbits or bringing them to an SOV or SMV for repair or refueling.

The X-33 or VentureStar could well be the basis of the Air Force's SOV, Arnold said, if the concept proves successful. A derivative of the smaller X-33 in particular is interesting to the Air Force because it will fly sooner and, being smaller than the VentureStar, may be more suitable to quick-reaction military missions.

The Air Force is also testing a 90-percent-scale version of an SMV called the X-40A, built by Boeing. The SMV demonstrator, which is 22 feet long, has been air-dropped and recently demonstrated an autonomous landing in a crosswind. A full-scale version could carry a 1,200-pound payload into space, frequently change its altitude and inclination, or orbit, and stay in space for about a year. The vehicle could ride to space either on an X-33 derivative, VentureStar, or an Expendable Launch Vehicle.

President Clinton exercised a line-item veto of funding for an Air Force spaceplane earlier this year, amid concerns that the US was "weaponizing" space and laying the grounds for a new arms race.

Estes noted, though, that "the kinds of technologies resident in the development of a Space Operations Vehicle ... are the kinds of things that I've been asked to look at in doing my space control mission." Continued research—without deployment, because "we don't need it right now"—is essential, Estes said, since "there are certain capabilities ... that are important for us to understand, so when it comes time to deploy systems to do space control,

Seen here being drop-tested by a UH-60 Black Hawk is the X-40A, a Boeing concept for a Space Maneuver Ve-hicle. In this test, the craft flew to an autonomous landing in a crosswind. The Air Force envisions orbiting 30-foot-long SMVs up to 22,000 miles for a variety of missions: inspecting foreign satellites for hostile capabilities, fixing or refueling friendly satellites, or conducting spot reconnaissance of world hot spots. The unmanned SMV might remain in orbit as long as a year before re-entering the atmosphere, making a runway landing, and being used again.

In this artist's concept, a Lockheed Martin Skunk Works X-33 variant gives an SMV a piggyback ride to Low Earth Orbit. The X-33 program could yield both a large Reusable Launch Vehicle twice its size as well as a smaller, military version like this one. While the Air Force sees such a Space Operations Vehicle as being able to carry some sensors and perhaps do on-orbit refueling, its primary mission would be as a "truck," carrying SMVs into space.

we make decisions that are right for the country."

As he was wrapping up his tenure as the dual-hatted chief of both US and Air Force Space Command, Estes said he was working closely with the White House and the Pentagon to continue exploring SOV technology without ignoring Clinton's intent.

"We're trying to be true to what the President told us to do," Estes said, "but also [to] have enough latitude to understand the technology well enough to make an informed decision about what's right for the country in terms of doing the space control mission, ... a mission we have been given by the President."

Given the capabilities afforded by a spaceplane type of vehicle, such as the ability to protect friendly satellites, to conduct "negation-type missions ... with directed energy systems, or through less offensive kinds of things," for short-duration reconnaissance, bringing a satellite back for repair, or "refueling a satellite to get longer use out of [it] ... then for national security purposes, ... a maneuvering vehicle in space ... makes some sense," Estes asserted.

No Treaty Constraints

He also pointed out that the US has "signed a treaty that says we won't put weapons of mass destruction in space, but we've signed no treaty that says we won't weaponize space."

If for no other reason than to aggressively chase down the cost of getting into orbit, Estes said SOV research is worthwhile. Given a "fixed amount of money to do things in space," the Air Force can do far more if it only has to spend "15 to 20 percent" on getting to orbit "instead of 50 percent." Anticipating such needs and having ready answers when asked "is what you pay your military for," he added.

Another RLV concept in development is called the X-34, built by Orbital Sciences. This vehicle, derived from the company's successful Pegasus launcher, would be carried to high altitude by the company's L-1011 wide-body ex-airliner. Released from the plane, the X-34's engines would take it the rest of the way to Low Earth Orbit, where the vehicle would deploy a satellite and return to an autonomous landing on a runway.

The X-34, a liquid-fueled vehicle, would also be fully reusable, Arnold said. Systems like the X-34 will be increasingly in demand because the majority of commercial satellites are getting smaller, lighter, and going only to LEO, though many at a time are being launched to create large constellations.

A funded SOV program as such doesn't exist, Arnold noted, as the Air Force is narrowing down the missions it would perform and defining the need for such a vehicle.

"We're in the ... requirements definition and ... military utility analysis" phase of the effort, he said, with an eye toward a system's usefulness and affordability. The first draft of the operational requirements document, which is the cornerstone of any new program, is to be down on paper this fall, he noted. A mission need statement for the SMV isn't expected for another year yet, Arnold forecasted. The Boeing X-40 project is to help the Air Force understand what is possible and to reduce risk if the program goes forward, he added.

Ultimately, for the vast majority of space systems, "we would like to get out of the business of launch," Arnold asserted. The Air Force would prefer to simply hire a launch company and deliver a payload for launch, rather than maintain its own vehicles and rocket infrastructure. Part of what will make this possible will be the development of the standardized interface between satellites and launch vehicles, so rocket companies can simply bid for the launch contract without any modifications to the vehicle.

As with any road map, the plan for launch vehicles is constantly shifting. The shuttle era, after 17 years of operations, is in middle age, and NASA is beginning to think seriously about its next steps, bearing in mind that, in addition to its sizable manifest of satellites to launch, it must build the International Space Station.

In September, NASA awarded five contracts to industry to develop a space transportation architecture that will lay out how the US will get people and cargo into space after the retirement of the four workhorse orbiters circa 2010. The contractors, which include Boeing, Lockheed Martin, Orbital Sciences, Space Access LLC, and Kelly Space and Technology, will examine whether the shuttles will have to be refurbished for extended service or whether NASA can go directly to derivatives of the X-33 and X-34. ▪