May 1998 Cover Story
Edwards Home Page

The Air Force has entered a new era – that of the "uninhabited aerial vehicle," or UAV.

As we near the 21st century, military casualties have become increasingly unacceptable. Ever since U-2 pilot Gary Powers was shot down over the Soviet Union in 1960, the high risk of using manned aircraft for reconnaissance over hostile territory has been crystal clear. Powers was returned alive – but others were not so lucky.

It has already been determined that the answer lies in the use of "uninhabited," high-flying and nearly invisible UAVs that can stay airborne for long periods.

UAVs can carry payloads ranging from reconnaissance equipment to missiles

UAVs, which usually are operated remotely from a ground or air station, have no human or animal pilots. They can carry payloads ranging from reconnaissance equipment to missiles. And because a traditional cockpit and canopy are not necessary, these "robocraft" can take a variety of odd shapes, most often resembling exotically-lethal insects.

This is the look of the future.

Technology catches up

The idea of using robots for spying, as well as combat (known as UCAVs), is not new. It's just that technology has finally caught up with science fiction. As costs for high-tech equipment spiral downward, UAVs will not only be expendable, but also relatively inexpensive.

As a result, UAVs are not only becoming acceptable, but desirable.

Two aircraft undergoing intensive development and testing at Edwards Air Force Base include DarkStar and Global Hawk, both reconnaissance vehicles.

But the Air Force isn't the only service seriously considering increased usage of UAVs. The Army, Navy and Marines are also examining new uses of UAVs in future missions.

There's the Joint Tactical UAV Project underway, in which all the services are working together to refine and develop new aircraft for future mission requirements. The craft have already proven highly effective in recent conflicts, including the Gulf War and Bosnia. In addition, NASA has been using UAVs to do high altitude research on the atmosphere.

Information science
UAVs can feed live information to other sensor platforms and to ground stations where the data can be collated and forwarded to headquarters. They can provide uninterpreted imagery directly to troops on the ground or to pilots in the cockpit for a real-time update on enemy activity. They can look over hills, observe staging areas and serve as radio relays and target designators, providing unprecedented visibility of the battlefield or others areas of interest.

In a 1996 report, the Air Force Scientific Advisory Board identified nine mission areas in which UAVs may be used, six of which involve carrying weapons. Some of these future uses resemble science fiction more than today's military strategy.

Imagine these scenarios, taking place sometime around, possibly, 2025:

- A hypersonic, transatmospheric aerospace plane capable of overflying any location in the world and returning to base in less than two hours.
- A high altitude, global range, very low observable combat UAV which can loiter indefinitely over hostile territory.
- A very large global range transport capable of providing emergency humanitarian aid without exposing an aircrew to danger.

Human intervention
The report stressed that remotely-piloted systems should not be viewed as a way to replace humans. Inevitably, human intervention will "save the day" when something unexpected happens during flight. An experienced "pilot" at the controls could make all the difference in the success of the mission.

The study states: "In short, the human is not replaced by automation, but is freed from simple and boring tasks to accomplish those functions most suited to human intellect."

Background **A sampling of systems**

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About Edwards – History

In a report by the Air Force Scientific Advisory Board, it was recommended that the Air Force pursue the development of uninhabited combat aerial vehicles (UCAVs).

An artist's rendering of a UCAV launching missiles

Most technologies necessary for platforms, propulsion, avionics and mission systems are sufficiently mature to provide initial UCAV capabilities.

By 2005, UCAVs can be weaponized using existing weapon systems and the addition of "hypervelocity kinetic energy penetrators," a specific family of warheads.

New warhead technologies – namely intermetallic high temperature self-propagating synthesis reaction incendiary and "flying plate" concepts – can provide the UAV the ability to deliver compact weapons capable of inflicting devastating damage to a large variety of fixed and moving targets.

One definition of a UCAV is "a returnable, controllable, responsive cruise missile, while others think of them more as a "fighter aircraft without a pilot."

Yet it has not yet been determined that UCAVs will operate like piloted aircraft.

As a result, researchers are trying to figure out how to do combat flight operations without a pilot on board. Basic questions that could affect the ultimate cost and complexity of the system are being asked:

- Do we need to operate from a runway?
- Must the UCAV fly over and among civilians?
- Does it need to fly in formation?
- Is air refueling necessary?
- Must it drop expensive smart munitions?

In an article by Andrew A. Probert in the Winter 1997 issue of *Air Power Journal*, the author postulates that if the above questions are asked, the answers will come back negative.

"A resulting system will more closely resemble a cruise missile rather than a piloted aircraft in terms of size, cost, and method of launch, except that it will drop its warhead and come back for a quick turnaround for another mission," he writes.

Probert suggests that desirable UCAV attributes would include affordability, lethality, survivability, supportability, deployability, flexibility, and responsiveness. His conclusions follow:

Affordability
Since aircraft cost is roughly proportional to size, the vehicle should be as small as possible. And since range and payload determine size, vehicle and operational concepts that minimize required range and payload weight would have an advantage in unit production cost.

To minimize range requirements, one should free the UCAV from runways and airfields to allow forward basing. It could rocket-launch from a truck, like the old "ground launched cruise missile." But how could one recover it in the field? Perhaps it could land in any open field on air bags, rather than wheels, that would inflate immediately prior to touchdown. A slow final approach similar to that used in short takeoff and landing, as is demonstrated by the Freewing Tilt-Body technology, operations would minimize bounce and roll.

To minimize payload weight requirements, one should use small bombs in UCAVs and minimize the onboard sensor suite. A cheap UCAV that drops an expensive smart bomb wouldn’t help overall affordability, so the system should be able to precisely deliver cheap, unguided munitions.

To minimize the number of personnel required to operate UCAVs, one should make each vehicle as autonomous as possible, while maintaining the flexibility to react to the fluid mission environment. Remote teleoperation would be impractical and costly. A controller/operator should be able to give orders to multiple UCAVs, with each UCAV having the onboard smarts to generate and fly an appropriate trajectory, given the mission’s constraints and the current situation.

Lethality
Piloted aircraft must stand off for survivability, making guided munitions necessary. A small UCAV could take advantage of low signature and high maneuverability to safely release cheap, unguided ordnance very close to the target. With no humans aboard to black out, G-force levels could be increased. If a “smart” bomb’s terminal guidance package were on the UCAV, the vehicle could be used to provide smart guidance for a “dumb” bomb until

reaching very close range, at which point the UCAV would release the unguided ordnance and snap into a high-G escape maneuver. The short range at release would ensure accuracy.

Survivability
One should expand survivability to include the time between flights, since forces should not be vulnerable to attack while on the ground. Given the threat posed by enemy cruise missiles, runway-based strike assets will be vulnerable to cruise missile attack. Dispersed basing schemes would make UCAVs harder to locate and attack.

One should also note the difficulty in shooting down a cruise missile flying at very low altitude. The same problem would apply to the enemy in attempting to shoot down our UCAVs. For that reason, UCAVs should have the capability to navigate and attack from very low altitude, if necessary for survivability.

Supportability
UCAVs should be easy to maintain in the field. They should be modular and reliable so that when parts do break, one can simply throw the modules away. Remaining serviceable modules could be matched to make a functional UCAV.

Deployability
When the air expeditionary force arrives, the reception may not be friendly. For that reason, UCAVs should be able to arrive by air and launch a strike prior to landing. This means launching from the wing of a B-52 or from the back of a C-17. Further, one should provide only a minimum of support gear and personnel. The number of UCAV controllers and control stations per UCAV should be kept small.

Flexibility
Single-purpose systems should be avoided. Commanders in chief would like their in-theater systems to be able to respond to any need. UCAVs shouldn't be designed with only one mission in mind.

Responsiveness
A UCAV would take full advantage of the "system of systems" and "information dominance." Reliance on off-board sensors would minimize the onboard sensor suite requirements as well as provide greater situation awareness and flexibility. A UCAV and its operator would be aware of the updated battle situation and be able to adjust to changes in threats or weather. The target might be changed at the last moment by command and control.

A UCAV battle manager or controller wouldn't be capable of replanning the details of each UCAV mission for each threat update off the network broadcast. Consequently, the UCAV must have significant autonomous capability to respond to threat updates and replan its mission in flight within the constraints of its fragment of the air tasking order and fuel availability. A robust onboard flight-management capability would help to minimize the data-link bandwidth required. The operator would also need to have the ability to immediately assume direct manual control over the UCAV's flight path to respond to real-time maneuvering requirements.

Affordable UCAV concept
Considering these desirable attributes, an affordable UCAV would be capable of dispersed forward basing, as well as air and sea launch. An operator controlling multiple UCAVs would direct them to targets. Reconnaissance assets would provide the operator with target imagery and coordinates. The UCAV would precisely drop small, cheap bombs from low altitude using onboard terminal guidance seekers.

With this concept, one does not need to develop technology to permit many of the flying operations performed by pilots. That is, UCAVs don't need to do the following:

Operate from airfields
Such a requirement would introduce questions of how to safely move them around an airfield in large numbers, before and after flight, among piloted aircraft.

Fly among civilians
There are concerns about how a UCAV would "see and avoid" other air traffic, a requirement for all piloted aircraft in controlled airspace in visual conditions. A small UCAV designed for deployment by means other than its own power would have no need to fly over and among civilians.

Fly in formation
Pilots fly in formation to reduce the air-traffic-control burden, for mutual support in visual and sensor search, and for offensive coordination. These requirements do not apply to UCAVs. They wouldn't fly through busy airspace or have to land on a busy runway when operating from remote forward sites. Off-board assets that make up the system of systems would supply mutual support in sensor coverage. And the remote human UCAV controller would handle strike coordination.

Air refuel
For deployment, UCAVs could be carried under the wing of a B-52, in a C-17, or on a boat—or they could be prepositioned. Forward basing (land or sea) or air launch would extend the combat range. The use of small bombs and limited sensors would reduce payload weight and extend range.

Drop smart munitions
Survivability and lethality would be achieved through small size, low altitude, and maneuverability, rather than by standoff weapon delivery. Close-in weapon release would

assure the accuracy of unguided ordnance.

Information from the web site of the College of Aerospace Doctrine, Research and Education was used in this story.

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About Edwards – History

The eeriest image to come out of the Gulf War was the view of Iraqi soldiers running out of bunkers waving white flags.


The use of UAVs during Operation Desert Storm proved that they can be decisive in battle

They were not waving them wildly at soldiers on the ground. Nor were they waving them at pilots in helicopters.

The Iraqis were actually surrendering to a UAV which carried nothing more deadly than a black-and-white video camera.

But what the Iraqis knew was that the video pictures were being watched in real time by the gunners on the U.S. battleships who were targeting them with massive 16-inch guns.

Not surprisingly, the Iraqis nicknamed the UAVs "flying death."

Pioneer success
The most widely-used UAV by the U.S. military has been the Pioneer.

The Pioneer's operational history includes its success during Operations Desert Shield/Desert Storm. The Army, Navy and Marine Corps commanders lauded the UAV's effectiveness, as six operational units from three services flew more than 300 combat missions.

The documented success of Pioneer in supporting combat operations and providing the battlefield commander critical intelligence information established the utility and importance of UAVs in combat.

Pioneer was praised as "the single most valuable intelligence collector" by Lt. Gen. Boomer, Marine Corps Central Command Command Element Headquarters, and "unequivocally outstanding" by the Marine Expeditionary Force G-2.

Pioneer proved that the utility of the UAV can be decisive in future battles. Navy assets were extremely successful in target selection, spotting naval gunfire and battle damage assessment, while the battleship's 16-inch guns destroyed enemy targets and softened defenses along the Kuwaiti coastline.

The Marines successfully used Pioneer to direct air strikes and provide near real-time reconnaissance for special operations. The Army had great success with battle damage assessment, area searches, route reconnaissance and target location.

10,000 flight hours
Between 1985 and 1994, Pioneer units logged more than 10,000 flight hours. The Navy has deployed Pioneer on four battleships and two amphibious low probably of detection (LPD) ships supporting worldwide operations in Africa, Northern Europe, the North Atlantic, the Western Pacific, Korea, the Mediterranean and contingency operations in the Persian Gulf.

The Marines have successfully integrated Pioneer support with Weapons and Tactics exercises, Kernel Blitz exercises and U.S. Customs Service operations supporting drug interdiction missions. The Army has utilized Pioneer in support of exercises at the National Training Center as well as other weapons exercises.

As the Department of Defense's System enters the Army and Marines inventory, Pioneer systems will be transitioned to additional Navy amphibious LPD class vessels. A total of eight amphibious low probably of detection installations are currently planned for the Pioneer system. To date, Pioneer air vehicles have logged more than 12,000 flight hours with the Navy, Army and Marines.

Information from the web sites of Hugh McDaid, author of "Robot Warriors, and "Teledyne Ryan Aeronautics, were used in this story.

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About Edwards - History

UAV deployments to Bosnia, in support of joint and combined operations, is one of the major UAV success stories.

In Bosnia, Predator provided long-dwell video surveillance and continuous coverage of roads to detect weapons movement

In Bosnia, UAVs demonstrated how they can contribute vital information to enhance tactical operations and strategic decision-making.

Predator deployment

The first deployment of Predators over Albania, from July through November 1995, was essentially an "off-the-shelf" demo configuration, which included an electro-optical/infrared sensor, C-band line-of-sight and UHF satellite beyond-line-of-sight data links.

Despite two early losses, the Predator system and its operators showed steady improvements in operational practices, supportability in the field, liaison with other in-theater agencies and the military utility of imagery products. Ad hoc taskings sometimes produced better mission results than planned "point target" taskings, and several additional steps assured better image quality.

Despite its early limitations for all-weather operation, Predator helped determine the course of the Bosnia conflict.

During September 1995, after several diplomatic and operational initiatives to relieve shelling and intimidation of civilian enclaves, especially in Bosnia's Sarajevo-Gorazde area, NATO forces resorted to active bombing to bring the warring factions to the negotiating table. Many previous agreements to remove field weapons from the area had been broken, but NATO forces could not hold the violators responsible without confirmation.

With Predator, however, weapons movements became subject to long-dwell video surveillance and continuous coverage of area roads showed no evidence of weaponry being withdrawn. This single resource thus gave NATO commanders the key piece of intelligence that underlay their decision to resume the bombing campaign that, in turn, led to the Dayton, Ohio, peace accord signed in December 1995.

Pioneer deployment

During their 10-year history of supporting contingency operations world-wide, Pioneers have deployed three times in support of Bosnia, twice afloat and once on land.

Navy VC-6 Pioneer systems have supported Sixth Fleet operations in the Mediterranean and Adriatic Seas since 1994. Most recently, one system deployed aboard USS Shreveport (August 1995 through February 1996) and flew three missions over Bosnia. Another deployed aboard USS Austin in July 1996 in support of fleet operations, and is available for contingencies ashore as needed.

On June 12, 1996, the 1st Marine UAV Squadron deployed one Pioneer system to Tuzla, Bosnia, to support peacekeeping operations. They flew more than 30 missions before returning to the United States in October 1996.

Today, Pioneer is the Department of Defense's only marinized UAV for the near term to support contingencies.

Information from the web site of the Defense Airborne Reconnaissance Office was used in this story.

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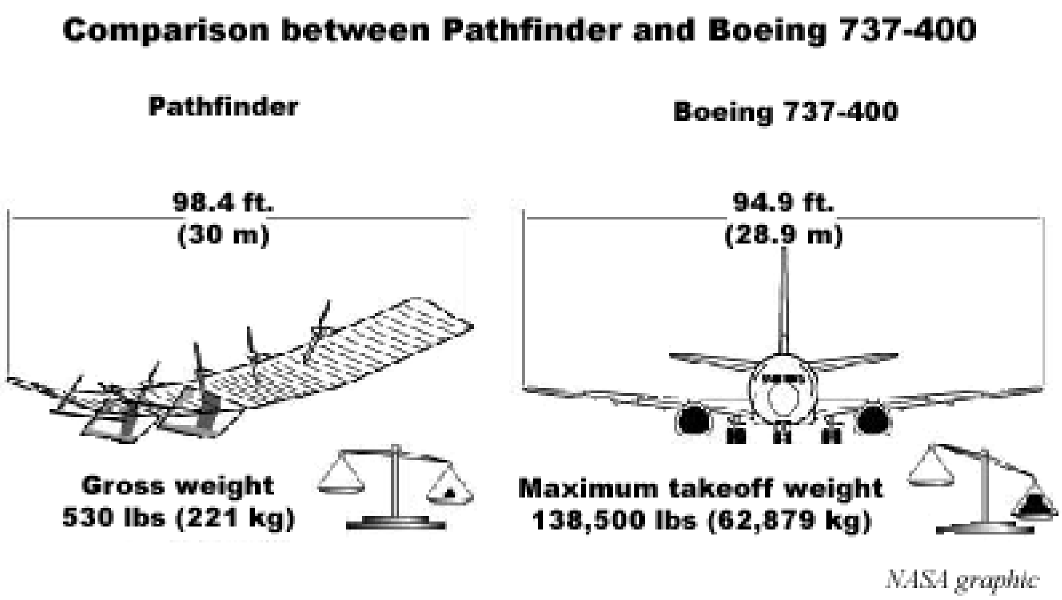
About Edwards – History

Uninhabited aircraft are an excellent way of exploring many strange and dangerous areas of the atmosphere, as well as collecting necessary data about the environment.

Satellites are too high and aircraft too low or short on duration. These also affect the fragile makeup of the molecules which need to be examined. Because it is difficult to get constant data from high up in the stratosphere, what was needed was a very high flying -- yet slow -- aircraft, which can stay aloft for days.



NASA's Environmental Research Aircraft and Sensor Technology (ERAST) program, led by the NASA Dryden Flight Research Center at Edwards Air Force Base, aims to develop aeronautical technologies that will lead to a new family of remotely-piloted vehicles that will fly:

- Slower, at subsonic speeds, as slow as 15 mph (24.1 kilometers per hour)
- Higher, at altitudes as high as 100,000 feet (30 kilometers)
- Longer, for continuous missions lasting as long as 96 hours

The vehicles in the ERAST program are executing this unusual mission. One of these vehicles, the Pathfinder, has already flown to more than 71,000 feet during a series of trials in Hawaii.

Such long-duration, high-altitude UAVs can be used in upper-atmospheric science missions to help collect, identify and monitor environmental data to assess global change. They also could carry telecommunications equipment to high altitudes, serving much like satellites for a fraction of the cost of putting a traditional satellite in space.

With the help of the science community, the ERAST project office has outlined the following three flight profiles for future aircraft that would meet the needs of the high-altitude, remotely piloted aircraft users:

- **Centurion** -- a ultra high-altitude (100,000 feet (30 kilometers)) aircraft that can accommodate a small payload (200 pounds (91 kilograms)).
- **Alliance 1** -- a high-altitude (85,000 feet (26 kilometers)) vehicle with an endurance of more than four hours. The aircraft will carry a moderate payload (330 pounds or 150 kilograms).
- **Helios** -- an ultralong-duration (more than 96 hours), high-altitude (65,000 feet or 20 kilometers) vehicle.

For operational missions, the desired cost would be about $5,000 per flight hour, meaning ERAST-developed vehicles would provide an affordable "air taxi" for science payloads.

At the heart of the ERAST program, which is sponsored by NASA's Office of Aeronautics, are several areas of research and development, including aerodynamics, performance, propulsion, structures, materials, avionics and sensor technology.

The ERAST Alliance Council, a unique government-industry alliance, is investigating those technology areas.

The ERAST Alliance Council was created by a Joint Sponsorship Research Agreement to allow NASA and its industry partners to share information and develop and execute coordinated research and development plans. ERAST program managers hope the team atmosphere of the project will enhance the U.S. remotely piloted vehicle industry by strengthening the companies involved in the program and making them experts in unique RPV technology. This in turn would foster a strong commercial industry.

ERAST aircraft

The ERAST alliance partners currently are working with four vehicles -- Perseus B, Pathfinder, Demonstrator-2 and Altus – to test technologies necessary to develop the other remotely piloted, high-altitude aircraft still on the drawing board, like Centurion, Helios and Alliance 1.

For each of the four technology-demonstrator aircraft, a pilot on the ground flies the vehicle watching instruments or a display of real-time video footage gathered from an aircraft-mounted video camera.

The ERAST program began in 1993 and is slated to end in 2002. Dryden is the NASA Center of Excellence for Atmospheric Flight Operations.

Information from the web site of NASA's Dryden Flight Research Center was used in this story.

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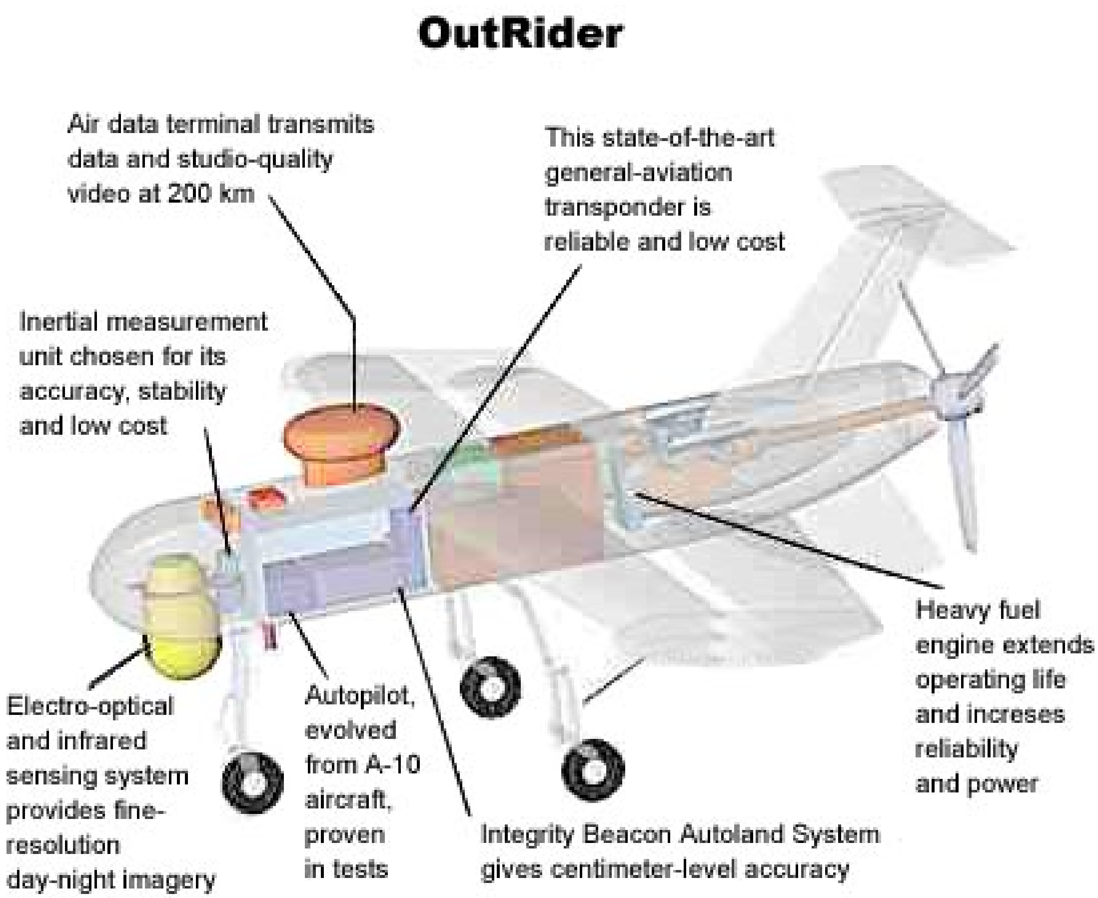
About Edwards – History

UAVs have significant potential to enhance the ability of the Air Force to project combat power in the air war.

UAVs have the ability (range, persistence, survivability and altitude) to provide significant surveillance and observation data economically, compared with current manned aircraft approaches.



UAVs can be cheap because, without the need to carry life support, instruments, and escape systems for a pilot, they can be any size and can stay aloft or violently maneuver far beyond the limits of human endurance. The absence of aircrew cuts significantly into life-cycle cost

UAVs have the potential to accomplish tasks that are now, for either survivability or other reasons, difficult for manned aircraft, including counterair (rupturing runways and attacking aircraft shelters), destroying or functionally killing chemical warfare/biological warfare manufacturing and storage facilities and suppression of enemy air defenses.

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About Edwards – History

When the Firebee was used during the Vietnam War, it was known as a "remotely-piloted vehicle"

The acronym "UAV" can stand for a number of things, depending upon which military organization or aerospace developer is using it. In earlier years, these vehicles were called "RPVs" – remotely-powered vehicles.

Most UAV developers refer to them as "Unmanned Aerial Vehicles" or "Unmanned Aerospace Vehicles."

The Army, Navy and Marines refer to them as "Unmanned Aerial Vehicles" – but the Air Force prefers the more politically-correct "Uninhabited Aerial Vehicles."

Like many terms in the English language, "UAV" will most likely become a new word, its origins lost to memory.

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ABOUT EDWARDS – HISTORY

Charles Kettering, a young U.S. Army engineer and inventor from Dayton, Ohio, decided that the airplane didn't need a pilot to drop a bomb or torpedo.

The Army gave Charles Kettering the money to build the first guided missile, precursor to UAVs

His idea that this could be performed automatically, using a clockwork device to shear the wings off and let the explosive drop, lead him to develop the Kettering Aerial Torpedo.

Kettering sat on the board of directors of the Dayton-Wright Co. in 1917, when the the U.S. Army gave him the money to build 50 of the first guided missile, a precursor to today's cruise missiles and UAVs.

Nicknamed "Bug," the aerial torpedo was launched from a dolly running down a track pointed precisely in the direction of the target. With a fuselage made of wood laminate and papier-mâché, the Bug was guided to the target by a system of internal preset vacuum-pneumatic and electrical controls. After a predetermined length of time, an electrical circuit would close and shut down the engine. The wings would then be released, and the fuselage and warhead would fall on the target.

Initial tests were successful, but World War I ended before the Bug could be used in combat. After the war, the Air Service conducted additional tests, but the lack of funds in the 1920s halted development. A reproduction of the Bug now hangs in the U.S. Air Force Museum at Wright-Patterson Air Force Base, Ohio.

The Hollywood connection

Reginald Denny is best known to the world as a film matinee leading man of the 1930s and '40s in films such as "Rebecca" and "Mr. Blandings Builds his Dream House" with Myrna Loy and Cary Grant.

But Denny was also a multi-talented aviation enthusiast. He demonstrated his first radio-controlled drone the RP-1 to the U.S .Army in 1935. In 1938 the RP-2 was demonstrated. A year later, the RP-3 was built.

In November 1939, the RP-4 prototype was completed. The U.S. Army ordered 53 of these drones, giving them the designation of OQ-1. The U.S. Army Air Corps supported Denny's efforts to prove the practicality of the target drone aircraft.

The Radioplane RP-5A (OQ-2, TDD-1) started rolling off the production line at the San Fernando Valley Airport in June of 1941. Radioplane produced a total of 14,891 drones for the U.S. Army Air Corps and the U.S. Navy from 1941 through 1945.

In 1952, Radioplane became the Radioplane Division of Northrop Aircraft, Inc. Later the Radioplane Division became known as the Ventura Division, Northrop Corporation..

Denny died on June 16, 1967, at age 75.

A Radioplane RP-5A was donated by the Northrop Ventura Division to the Western Museum of Flight in Hawthorne, Calif., where it is currently on display. The aircraft bears the tail number of 248. A total of 3,865 of this series of drones was produced.

World War II
During the Second World War, Nazi Germany's "buzz" bombs or "doodlebugs," revealed a new technology: compact axial flow turbo-jet.

After the war, the United States incorporated the German advances with the new field of electronics and came up with Teledyne Ryan Q-2.

This squat, noisy remotely piloted vehicle became the basis for a new generation of high speed targets and reconnaissance vehicles.

Information from the web site of the Western Museum of Flight was used in this story.

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About Edwards – History

Russian-built surface-to-air missiles made photo reconnaissance missions in piloted U-2s or SR-71s an exceedingly dangerous occupation over North Vietnam.

The solution, much to the disbelief of many top officers in the Pentagon, came in the form of an under funded unit of contractors and military who managed a successful reconnaissance operation using UAVs, then called "remotely-piloted vehicles."

During the Vietnam War, the Firebee target was modified to fly autonomous, pre-programmed, long-range reconnaissance missions

Aircraft were lost but no pilots were killed or taken prisoner.

The Firebee

One of the contractors, Teledyne Ryan Aeronautics, modified its basic Firebee target to fly autonomous, pre-programmed, long-range reconnaissance missions. Twenty-eight special purpose variants were ultimately developed to gather photographic, infrared and electronic intelligence information, to carry out electronic countermeasures and to act as decoys in probing enemy defenses.

During the Vietnam War, more than 1,000 unmanned Ryan 'Lightning Bug' RPVs carried out 3,435 sorties on extremely hazardous round-trip missions of up to 1,400 nautical miles, sparing the lives of scores of pilots of manned aircraft and freeing them for other missions. These flights were supported by a cadre of on-site civilian Ryan technicians and specialists who helped keep the birds flying. These vehicles were the forerunners of today's modern UAVs.

The success of the Ryan Firebee-based reconnaissance drones in Vietnam whetted the military appetite for even more sophisticated unmanned vehicles, designed from the ground up for better performance and specialized capabilities.

The Compass Arrow

The Ryan-built Compass Arrow, first of the second generation of UAVs, was designed for high-altitude, low-detectability reconnaissance. It flew at 78,000 feet and incorporated many early 'stealth' techniques. It could fly a 2,000-mile mission, self-navigated by a Doppler Inertial guidance system and on-board computer. Twenty eight were produced, but after rapprochement with Red China in the early 1970s, they did not become operational.

Compass Cope-R was another Ryan high-altitude, long-range research vehicle designed for long endurance reconnaissance. It took off and landed on conventional runways. Only two were built. One set a world endurance record in 1974 of 28 hours and 11 minutes for unmanned, unrefueled flight.

But Firebees were not out of the picture. A Model 147S was also successfully converted to carry and fire guided missiles. In a version called Pathfinder (different from NASA's Pathfinder), it carried a laser designator and a low-light-level TV camera. It tested and proved the concept of using unmanned strike vehicles to soften up a target prior to manned aircraft attack.

Information from the web site of Teledyne Ryan Aeronautics was used in this story.

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About Edwards – History

Pioneer development began in the 1980s when U.S. military operations in Grenada, Lebanon and Libya identified a need for a UAV

The Pioneer system provides real-time intelligence and reconnaissance capability to the field commander.

This highly mobile system provides high quality video imagery for artillery or naval gun fire adjustment, battle damage assessment and reconnaissance over land or sea.

The development of the Pioneer began in the early 1980s, when U.S. military operations in Grenada, Lebanon and Libya identified a need for an on-call, inexpensive, unmanned, over-the-horizon targeting, reconnaissance and battle damage assessment capability for local commanders.

The first Pioneers
As a result, in July 1985, the Secretary of the Navy directed the expeditious acquisition of UAV systems for fleet operations using nondevelopmental technology. A competitive fly-off was conducted and two Pioneer systems were procured in December 1985 for an accelerated testing program to be conducted during 1986.

The initial system delivery was made in July 1986 and subsequently deployed on board the battleship USS Iowa in December 1986. During 1987, three additional systems were delivered to the U.S. Marine Corps, where they were operationally deployed on board low probability of detection (LPD) class vessels as well as with several land-based units.

The system became a joint service program in 1990 when the U.S. Army fielded its Pioneer system.

In 10 years, Pioneer has flown nearly 14,000 flight hours and supported every major U.S. contingency operation to date. It flew 300-plus combat reconnaissance missions during Persian Gulf operations in 1990-91. Since September 1994, it has flown in contingency operations over Bosnia, Haiti and Somalia; most recently it flew in Task Force Eagle and IFOR operations, again over Bosnia.

Subsystems
5 Air Vehicles
1 Ground Control Station
1 Portable Control Station
4 Remote Receiving Stations (max)
1 Truck-Mounted Launcher

Key operational factors
Sensors: electro-optical or infrared
Deployment: Multiple*
C-130/C-141/C-17/C-5 sorties; also shipboard
Radius: 185 km (100 nm)
Endurance: 5 hours
Max Altitude: 4.6 km (15,000 ft)
Cruise Speed: 120 km/hr (65 kts)

*Depends on equipage and duration
Flight Data

Program status
Pioneer continues to operate as the Department of Defense's first operational UAV system. Currently, there are nine systems in the active force: the Navy operates five, the Marine Corps three, and one is assigned to the Joint UAV Training Center at Ft. Huachuca, Ariz.

The Navy system at Patuxent River Naval Air Station, Maryland, supports software changes, hardware acceptance, test and evaluation of potential payloads and technology developments to meet future UAV requirements. An additional 30 Pioneers were delivered from September 1995 through November 1996, along with continuing support kit and spares procurement. These aircraft are in the Option 2 Plus configuration, which has slight increases in air vehicle weight and fuel capacity.

A third extension of the Pioneer force's operational life is being planned through 2003, until tactical UAV systems are fielded and able to meet tactical-level UAV requirements.

Information from the web sites of the Pioneer UAV, Inc., and the Defense Airborne

Reconnaissance Office were used in this story.

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About Edwards - History

Early in the 1990s, the Pentagon attempted to develop a classified, high-flying, large-payload, stealthy, autonomous, modest-cost UAV to eventually substitute for the U-2 and SR-71.

Known as Tier III, the program proved too great a challenge, and the requirement was broken down into two segments.

Tier III Minus

The Tier II Plus Global Hawk is intended to be a long-range, high-altitude reconnaissance "workhorse"

The top half of the high-altitude/ endurance segment, called Tier III Minus, is the Lockheed Martin DarkStar. The vehicle, which looks like a flying saucer with its wings on backwards, will fly at over 45,000 feet and have either electro-optical or synthetic aperture radar sensors. With a range of over 500 nautical miles, DarkStar will be able to fly surreptitiously over hostile territory and remain there for more than eight hours.

The prototype DarkStar crashed on its second flight due to the flight control system not adequately dealing with ground effect, but fixes have been developed that are expected to prevent the problem from recurring. The DarkStar flies autonomously from takeoff to landing, assisted by the Global Positioning System.

Tier II Plus

The second segment, known as Tier II Plus, is the Teledyne Ryan Global Hawk. Intended as the long-range, high-altitude reconnaissance "workhorse," the Global Hawk flies higher and faster than DarkStar, with a heavier payload, but is not as stealthy.

Global Hawk has a range in excess of 3,000 nautical miles at 65,000 feet, with an on-station endurance of 24 hours. Comparable in size to the U-2, it will have electro-optical, Synthetic Aperture Radar and infrared sensors.

Both systems will get a two-year shakedown. For now, plans call for building a total of four DarkStars (which includes the crashed vehicle) and five Global Hawks, down from six and eight, respectively. Both systems use common ground stations, of which two will be procured.

Information from the web site of the Air Force Association was used in this story.

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About Edwards – History

The DarkStar, currently being tested at NASA's Dryden Flight Research Center at Edwards Air Force Base, was designed to satisfy a goal of the Defense Airborne Reconnaissance Office to supply responsive and sustained data from anywhere within enemy territory, day or night, in all types of weather.

The DarkStar is being developed to supply responsive and sustained data from anywhere within enemy territory, day or night, in all types of weather

Developed by Lockheed Martin Skunk Works and Boeing Defense and Space Group, DarkStar has a wing span of 69 feet and is designed to fly above 45,000 feet at subsonic speeds on missions lasting more than eight hours. Unlike other UAVs, its guidance system is fully self-contained – actually more like a sophisticated automatic pilot. Remote control from a ground or air station is not necessary.

Designated as a Tier III Minus vehicle, DarkStar's operational flight parameters are classified. The vehicle will be capable of sustained high altitude surveillance and reconnaissance over high threat areas. It will operate at ranges of up to 500 nautical miles from the launch area and be able to loiter over the target area for greater than eight hours at altitudes in excess of 45,000 feet. This UAV will be capable of carrying either an electro-optical or Synthetic Aperature Radar payload, which will be interchangeable in the field.

The UAV will employ both wideband line-of-sight and moderate bandwidth satellite communications. In addition, the UAV includes launch and recovery elements, and a processing display system.

DarkStar arrived at the Dryden Flight Research Center on Sept. 14, 1995. On March 29, 1996, the craft made its first 20-minute flight, reaching an altitude of 5,000 feet and completing basic flight maneuvers.

DarkStar crashes

On April 22, 1996, during its second flight, DarkStar released brakes and throttled up normally while taking off from one of the Edwards runways. The main gear lifted off and the aircraft continued to accelerate on the nose wheel (as it did on its maiden flight). The aircraft started an oscillation in pitch either just before or after liftoff. Lift-off occurred at approximately 3,000 feet from the start of the takeoff roll.

Immediately after liftoff, the aircraft pitched up to almost 90 feet, attaining more than 100 feet before it rolled off to the left. It crashed and burned about 80 feet to the north of the runway, at the 2,000 feet remaining marker. The orange "Black Box" was apparently thrown free of the fire and a data tape in good health was recovered. In addition, telemetry data was being logged on the ground.

Information from the web sites of Lockheed Martin and Boeing Defense and Space Group were used in this story.

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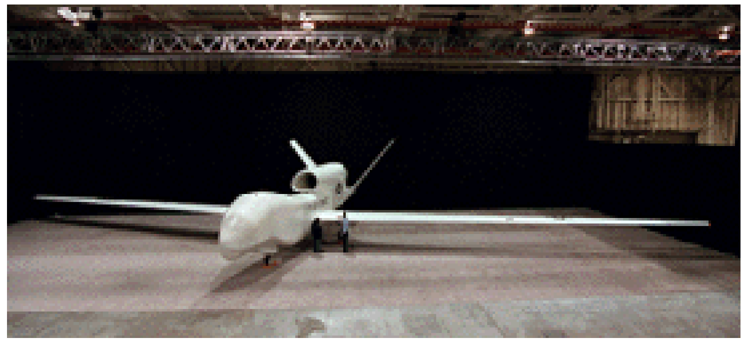
About Edwards – History

In its decision to develop the next generation of high altitude endurance UAVs, the Department of Defense defined its need for a plane that was durable and reliable, and could relay vital information from locales where traditional reconnaissance techniques could not be applied.



Global Hawk has a wingspan of 116 feet

Enter "Global Hawk," designated as a Tier II Plus vehicle, developed by Teledyne Ryan Aeronautical and selected by the Department of Defense in May 1995.

Affordable and low risk

The Global Hawk program will provide military commanders with an affordable, low risk system to meet the requirements for real-time electronic imagery of large geographic areas. The UAV will fly autonomously at high altitudes over long distances and remain on station for prolonged periods of time. It will carry a payload of synthetic aperture radar, infrared and electro-optical sensors linked electronically through a worldwide satellite communications system to its ground control and information processing station.

The plane will be able to obtain high resolution imagery in near real time, through adverse weather, day or night.

Optimized for low-to-moderate threat conditions, The Global Hawk can accomplish long endurance reconnaissance missions where range, endurance and persistent coverage are paramount. The vehicle, with its 116-foot wingspan and 44-foot length, carries both synthetic aperture radar and electro-optical and infrared sensors.

The Global Hawk system will be able to survey, in one day, an area equivalent to the state of Illinois (40,000 square nautical miles), while providing imagery with a three-foot resolution. Alternatively, the system can provide more detailed (one-foot resolution), 'spot' images if needed. For a typical mission, the Global Hawk system can fly to a target area 3,000 nautical miles away, and stay airborne for 24 hours collecting data before returning. It flies at altitudes up to 65,000 feet.

First flight
More than 1,000 military and civilian dignitaries and employees watched as the Global Hawk was unveiled Feb. 20, 1997, at Teledyne Ryan Aeronautical's San Diego facility.

According to Lt. Gen. George K. Muellner, Principal Deputy Assistant Secretary of the Air Force, Acquisition: "Global Hawk represents, and in some ways actually epitomizes, the way we must do our business in order to provide ... the joint war fighter with a technological edge on the battlefield.

"Here we've seen a case where the best and the brightest of government and industry effectively have teamed together, collaborated to make this happen, kept a focus on cost and kept a focus on the war fighter's needs," he said.

"Global Hawk is an aggressive push of technology to the war fighter ... an opportunity for us to get the cycle time down to where the technology is still on the (leading) edge when it actually gets into the war fighter's hands.

"This system clearly has the potential to become a dominant weapons system in the 21st century, and the U.S. Air Force is determined to make that happen."

Funding
Global Hawk is funded by the Defense Airborne Reconnaissance Office (DARO) and managed by the Defense Advanced Research Projects Agency (DARPA). Global Hawk, which is now undergoing final software integration and testing, will begin flight testing by fall of 1998. Following the completion of flight testing near the end of 1998, the new reconnaissance system, to be flown by the Air Force, will start operational user demonstrations with the U.S. Atlantic Command.

"There always comes a moment in time when a door opens and lets the future in," said Dr. Paul G. Kaminski, Under Secretary of Defense for Acquisition and Technology as he quoted noted author Graham Greene during remarks delivered at the start of the ceremony. "Today, I think we are seeing such a door opened. Global Hawk will help U.S. forces and our allies achieve information dominance well into the 21st century."

According to Under Secretary of Defense, Acquisition & Technology Paul G. Kaminski: "Global Hawk will become a strategic asset that is capable of providing our tactical commanders with the ability to see the big picture, to see it broadly and to see it clearly.

"It will be the vanguard of a whole new generation of unmanned aerial reconnaissance and surveillance vehicles (which) will allow U.S. commanders to turn inside an adversary's decision-making cycle time to see and act before an adversary can act," he said.

Information from the web site of Teledyne Ryan Aeronautical was used in this story.

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About Edwards – History


The Predator is 27 feet long with a wingspan of approximately 49 feet

On Jan. 31, 1997, the Air Force's 11th Reconnaissance Squadron unveiled the Predator UAV to the public at Indian Springs Air Force Auxiliary Field.

The Predator, designated as a Tier II medium altitude endurance UAV, is 27 feet long with a wingspan of approximately 49 feet. With a loiter time of up to 40 hours and a maximum ceiling of 25,000 feet, these reconnaissance vehicles can operate in high risk areas without the risk to an aircrew.

Produced by General Atomics Aeronautical Systems, the UAV's real-time imagery can be relayed to combined air operations centers or joint intelligence centers via satellites to provide information to commanders on the ground so they can make accurate and timely decisions.

The first Predators

The 11th Reconnaissance Squadron received its first two Predator UAVs in November 1996. Each UAV costs less than $3 million. The squadron, which belongs to the 57th Wing at Nellis Air Force Base, Nevada, will eventually receive 45 of the vehicles.

The Predator started out as an off-the-shelf endurance system to satisfy CIA requirements for intelligence gathering over Bosnia. It has subsequently emerged from the black world of espionage into the hands of the Air Force, performing the same mission.

Technically, it straddles the tactical UAVs intended for short-range missions, and the high-endurance programs such as Global Hawk and DarkStar. It continues to be used over Bosnia, and its operations have been an important learning experience for the U.S. armed services providing information about many technical and tactical issues such as satellite up-links, autonomous base recovery and new sensor technologies.

Capabilities
It incorporates electro-optic, infrared, and synthetic aperture radar sensors, and transmits imagery in real time to its ground control station. It was designed for a 500-nautical mile radius and an endurance in excess of 24 hours on-station, while operating at altitudes from 15,000 to 25,000 feet.

The Predator has been used in various training exercises, demonstrations and operational deployments as an Advanced Concept Technology Demonstration (ACTD). The ACTD process is intended to allow a user to evaluate the military utility of a new technology before committing to a major acquisition effort.

At the end of the ACTD period (in the case of Predator, 30 months), the user provides a military utility assessment of the system. If it is assessed to have military utility, the formal acquisition process can begin. If only a few systems are needed, the ACTD assets can be modified or retrofitted and fielded in limited quantity. If the system has little military utility, the program terminates.

Like the Pioneer, procurement has been extended much beyond original plans due both to its own successes, as well as the failure of other programs that were supposed to replace it.

Information from the web sites of the Institute of Defense Analysis and the Defense Airborne Reconnaissance Office were used in this story.

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Many other nations have recognized the utility of UAVs and are moving rapidly to develop their own capabilities. This offers an opportunity and a challenge. The opportunity will come from our ability to develop and field a family of UAVs that will set the standard for performance in their class while remaining affordable.

The challenge is that our UAV systems will need to interoperate with those of our allies and coalition partners to be effective in future contingency operations.

The Hermes 450, designed by the Israeli company Silver Arrow, can perform 20-hour endurance missions at altitudes of more than 20,000 feet

Israel

The Israelis were one of the first to go full-scale into the UAV business. Surrounded on all sides by enemies and needing to multiply their forces by applying technology, the Israelis initially used Vietnam vintage Firebees in the Yom Kippur war with considerable success.

Israel has long been the preeminent developer of tactical UAVs, but with many more countries beginning to develop UAVs, its position has diminished. During the past year, the Israeli government attempted to consolidate the two main Israeli UAV firms, IAI's Malat Div. and Silver Arrow. But in the face of union resistance, it had to settle for a compromise solution under which both firms will jointly market their designs for the export market.

Israel continues to be an innovator in this field. Its Harpy antiradar drone is one of the first weapons of its kind in the world, and the first to be widely exported. Harpy is in the gray world between UAVs and missiles. It loiters over the battlefield with a passive radar seeker, and once an enemy radar is detected, it flies into it, destroying it with a small warhead.

Western Europe

UAV development efforts in Western Europe have experienced many of the same problems as their American counterparts, compounded by more serious funding problems. The Franco-German Brevel program has dragged on in fits and starts over the past decade due to funding problems and the unsynchronized requirement debates of the two partners. At the moment, production for France appears to be moribund due to budget shortfalls, though Germany may acquire the system eventually. Instead, France has opted for a low-cost, off-the-shelf alternative, the Crecerelle. The Crecerelle has proven to be attractive to export customers as well, serving as the basis for the new Dutch Sperwer, and for a new Swedish program.

Britain

Britain's Phoenix UAV has again emerged from the ashes of near cancellation and is in production after a long series of delays. Switzerland took a more conservative route and based its new Ranger UAV on Israeli technology. Italy has an ambitious UAV program with its Mirach Meteor effort, but it remains to be seen whether the budget will permit fulfillment of this program. Spain has entered the UAV arena with its new SIVA program, and a related civil effort called ALO. Several NATO navies have expressed interest in a navalized UAV, but little serious work has been done outside of Germany with its Seamos program.

Both Britain and France have expressed interest in a strategic high-endurance system for intelligence gathering, and this may come in the form of a purchase from the United States rather than a local development effort.

Central and Eastern Europe

UAV programs have also sprung up in central and eastern Europe. Russia has a long standing interest in UAVs, though many of their vehicles were secret until recently. The Russian army has begun to deploy a new tactical UAV system called the Sterkh, and the air force has several programs underway including a new Tupolev air vehicle to replace its Reys system.

The Czech Republic has developed the Sojka system, and has been offering it on the world export market.

Japan

Japan has an active UAV program with both military and civil aspects. A helicopter drone is under development, both as a possible army surveillance platform, and as a possible agricultural sprayer.

India

India has a number of UAV development efforts, though its recent purchase of Israeli UAVs suggests that these have not been entirely fruitful. Iran has been attempting to develop a UAV industry, and some of its UAVs were used operationally in 1997 to shadow U.S. Navy operations in the gulf.

Information from the web sites of Aviation Week and Space Technology and the Defense Airborne Reconnaissance Office were used in this story.

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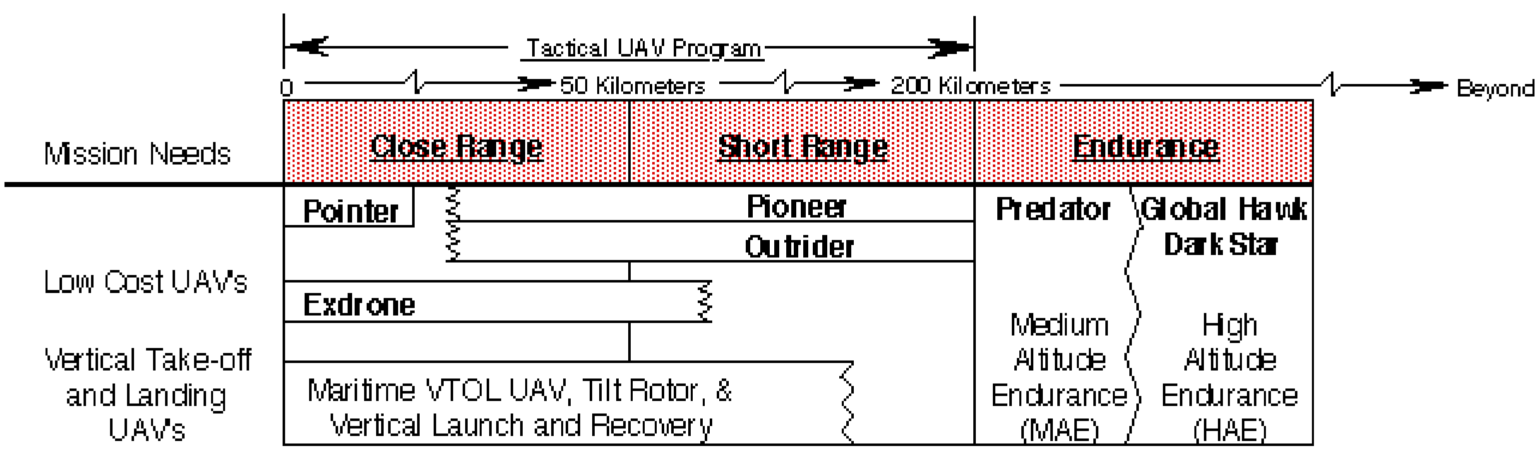
About Edwards – History

Since the very beginnings of aviation, the idea of a "remotely-piloted vehicle" has never been far from the minds of inventors and military strategists. The development of UAVs over the years has focused on target and training drones and, as technology has become more sophisticated, reconnaissance vehicles.

At last, the technologies used in UAVs have matured, and the costs to developing them have gone down, in comparison to the alternatives.

Categories of UAVs



NASA graphic

The Air Force Scientific Advisory Board reviewed the current Air Force roles and missions and determined how UAVs might contribute to the significant capabilities that already exist in manned systems.

The study group considered a number of factors, including platform characteristics, degree of autonomy in flight management, reliability and maintainability, deployment, strike versus support, survivability, weapons integration and human factors, among others.

Future missions may include combat missions, in which UAVs fly to the target, drop their weapons, and return to base.

The first nine missions listed below were selected as being critical to Air Force needs.

- Countering weapons of mass destruction
- Theater missile defense
- Attacking fixed targets
- Attacking moving targets

- Jamming
- Suppressing enemy air defenses
- Collecting intelligence, surveillance and reconnaissance
- Supporting communications and navigation
- Air-to-air combat
- Base defense
- Strategic attack
- Space control
- Special operations
- Area denial
- Decontamination and defoliant dispensing
- Combat search and rescue
- Refueling tanker
- Cargo transport
- Global positioning system augmentation
- Information warfare
- Humanitarian assistance

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ABOUT EDWARDS - HISTORY

Micro Aerial Vehicles, or MAVs, are currently in development by a number of companies and educational institutions and may eventually be the size of hummingbirds or smaller.

An "electromechanical multimode" micro UAV is being developed by Robert Michelson and his design team at the Georgia Tech Research Institute

MAVs will be capable of carrying small video cameras which weigh just a few ounces.

The job of MAVs will be to enter buildings and, using pheromone sensors, find specific humans and watch them. Some speculate that they may even carry a deadly poison in a sting.

MAV technologies are supported by the Defense Airborne Reconnaissance Office (DARO). UAV work represents roughly 30 percent of DARO's overall budget, which also funds operations of the SR-71, U-2, and RC-135 Rivet Joint aircraft.

MAVs defined

DARO defines an MAV as one measuring less than 6 inches in any dimension, yet carrying a miniaturized payload, simple avionics and a communication link sufficient to perform needed missions. Following an MIT Lincoln Laboratory proposal, a November 1995 Defense Advanced Research Projects Agency workshop explored concepts and technologies to accelerate the development of this UAV type.

Many challenges were identified for MAVs, from their physics of flight to integration of even simplified functions developing an "airplane on a chip"; however, their 6-degree-of-freedom flexibility offers high military potential in constrained operating environments, such as within urban areas or supporting small unit operations.

The Defense Advanced Research Projects Agency project is focusing on critical flight-enabling technologies (e.g., aerodynamics, flight control, navigation, and propulsion); integration strategies that maximize range-payload performance and mission utility; and near-term operational concepts, with an emphasis on those that lend themselves to early operational demonstration.

Information from the web sites of the Defense Airborne Reconnaissance Office and the Georgia Tech Research Institute were used in this story.

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About Edwards – History

The Eagle Eye Tiltrotor UAV system by Bell Helicopter Textron has passed the government's test readiness review and was shipped to Yuma, Ariz., in March 1998, to begin the aggressive three-month, 50-hour U.S. Navy-managed UAV flight demonstration program.

The Bell Helicopter Eagle Eye is currently undergoing a U.S. Navy-managed UAV flight demonstration program

The purpose of the flight test program is to evaluate the Eagle Eye UAV system's potential to meet established government vertical take-off and landing UAV objective requirements. During the three-month test flight period the Eagle Eye is scheduled to fly approximately 37 sorties to achieve a minimum of 50 flight test hours. The flight test program includes the following elements:

- Manual hover using an external operator
- Conversion to airplane mode with an external operator
- Local area manual control with both internal and external operators
- Altitude envelope expansion
- Airspeed envelope expansion
- Fuel consumption evaluation
- Automated modes including waypoint following
- Mission profiles with real time forward-looking infrared (FLIR) TV imaging provided to the ground control station

Mission potential will be demonstrated by flying the government's mission profiles while employing the baseline FLIR System's Ultra 3000 FLIR/TV payload.

Testing

The tests will exercise the Eagle Eye system's dual redundant, fully integrated, ground control, digital data link, ring laser gyro based inertial navigation and payload systems. The built-in-test capability and health-monitoring system, which evaluates all critical flight control components, will be used to help keep maintenance requirements to a minimum.

The Eagle Eye demonstrator aircraft is 7/8 scale of the production air vehicle. That vehicle is designed to be able to take-off and land vertically, fly at up to 200 knots carrying a 200-pound payload 110 nautical miles to an objective area. Once there it can remain for three hours while transmitting real-time day and night imagery, return to ship and land itself, even in high winds and sea states.

Successful completion of the Yuma flights is expected to lead to future land and shipboard testing of Eagle Eye integration with the Unmanned Common Automatic Recovery System and the Tactical Control Station. The program is on cost and schedule.

Information from the web site of Textron Bell Helicopter was used in this story.

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About Edwards – History

The U.S. Marine Corps is required to detect minefields and obstacles on beach zones and craft-landing zones, and to provide near real-time information of those regions to expeditionary force commanders via command, control, communications, computers and intelligence systems during amphibious assault operations.

COBRA is a UAV-based optical sensor system used by the Marines to detect minefields

The Coastal Battlefield Reconnaissance and Analysis (COBRA) system is a UAV-based optical sensor system.

COBRA minefield reconnaissance
COBRA is flown during pre-assault operations over proposed landing areas between 500 and 1,100 feet of altitude.

Near real-time terrain information and easily visible characteristics are provided by the forward-looking surveillance camera. If data links allow, transmission of mine detection data is down-linked to the ground processing station for immediate processing. If no down-link is available, video data can be extracted from an onboard cassette after the UAV lands.

System description
The COBRA system includes two down-looking, spinning-filter wheel, multi-spectral video cameras with overlapping adjacent fields of view for a wide swath; a forward-looking surveillance video camera; and the COBRA Tactical Information Display Subsystem. Position and time are encoded on all video channels. Any one video channel down-linked during the mission and decoded in real time provides the position track of the aircraft plotted in real time on any digital satellite, airborne image or digital map.

This real-time track, coupled with real-time, down-linked, forward-looking, surveillance video serves as a navigational aid to the aircraft pilot and the COBRA system operators during the mission. The multi-spectral imagery is post-processed in the COBRA Tactical Information Display Subsystem ground station that automatically co-registers the multi-spectral imagery from both cameras and stitches together a 1-second data set that covers an area of about 50 meters by 50 meters; detects mine-sized spectral anomalies; and statistically determines whether the decision area is a minefield.

Concept of operations

The COBRA subsystem's mission is envisioned to provide minefield detection support to the Marine Expeditionary Force and Marine Air Ground Task Force staffs during amphibious assault operations. This reconnaissance and analysis provides the capability to exploit gaps in the enemy's barriers, obstacles and minefields.

The information can verify enemy intentions, plans and defensive strength and will help the operational commanders determine the best mix of breaching and clearing techniques. During a deployed coastal battlefield reconnaissance mission, it is projected that COBRA will gather intelligence on mines, minefields and beach obstacles by analyzing collected multi-spectral images from the video subsystem.

The cameras will be carried by a UAV that can be launched from, and recovered on, a battle group ship. Multi-spectral images will be datalinked to the battle Group for analysis and employment in landing force plans. During the Advanced Concept Technology demonstrations, COBRA will be mounted on a Cessna 172 aircraft. The Cessna will fly at 500 to 1,100 feet of altitude and cover all candidate landing areas, normally in 150-yard depth by 200-yard length units.

Information from the web site of Joint Countermine Advanced Concept Technology Demonstration was used in this story.

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About Edwards – History

The Cypher UAV is able to fly "hands-off," instead of being flown directly by a ground operator

What you are looking at is not science fiction. It is the Cypher UAV.

Flight demonstrations of the Cypher technology demonstrator aircraft are currently being conducted by the Sikorsky Aircraft Corp. for both military and civil applications.

These demonstrations include capabilities such as ground and naval surveillance, communications relay and countermeasures missions, as well as such non-defense roles as counter-narcotics, ordnance disposal, forestry, utilities, law enforcement and search and rescue.

Specifications
The Cypher UAV is 6.5 feet in diameter. It combines the efficiency of a ducted airstream with a coaxial advancing blade concept rotor system. The rotors and the circular shroud surrounding them will share in providing lift. Powered by a 50-horsepower class engine, Cypher will be able to cruise at 80 knots, for up to three hours, with a ceiling of 8,000 feet.

Cypher shares both automatic target detection and fly-by-wire flight control systems with the Boeing Sikorsky RAH-66 Comanche helicopter being developed for the Army.

As an autonomous, or "smart" air vehicle, Cypher holds position and navigates using a differential Global Positioning System. The air vehicle is able to fly “hands-off,” instead of being flown directly by a ground operator.

It also demonstrated an ability to land remotely, camera-directed by its onboard television, on slopes of as much as 15 degrees. Confined area operations showed it taking off and landing between obstructions about 12 feet apart.

A safer design

The enclosed rotor concept developed by Sikorsky is safer than exposed UAV rotor systems. The Cypher design, with the rotor system inside a shroud, minimizes the hazard of exposed high speed rotor blades to ground personnel.

The Cypher incorporates composite structures, bearingless rotors, fly-by-wire flight controls, advanced avionics.

It is easy to operate and utilizes a centralized computer, called the vehicle mission processor, for execution of flight control laws, vehicle management functions, navigational computations, flight payload management and air vehicle communications.

Cypher's autonomous flight modes are auto take-off and landing, position hover-hold, altitude hold, velocity hold, waypoint navigation and auto return home. Implementation of the return-home mode allows the operator to command the vehicle back to the original launch point – or any other predetermined location – with just the push of a button.

On the ground

The Cypher vehicle is controlled and monitored from an integrated mobile ground station. The entire mission can be planned, executed and monitored from a single system manager display. Vehicle and payload commands, from the system manager, are relayed to the aircraft via a digital telemetry uplink. Aircraft status, mission data, test data and payload video are merged into a single data downlink signal that is transmitted to the control van.

The air vehicle has accumulated about 400 flight hours at Sikorsky's Development Flight Center in West Palm Beach, Fla., and at various U.S.government demonstrations.

Demonstrations

In a demonstration at the Military Operations in Urban Terrain (MOUT) site at Fort Benning, Ga., Cypher flew down streets, landed on a building's roof and strategically placed different payloads.

For the U.S. Army's Autonomous Rotorcraft Testbed (ASRT) program, Cypher – with no operator input – searched and tracked man-size targets. For the U.S. Department of Energy, Cypher used magnetometers to search and locate underground structures and tunnels in

Nevada.

In September 1997, Cypher flew at the Army's Force Protection Equipment Demonstration in Virginia.

Other Cypher demonstrations included flights at Indiana's Jefferson Proving Ground for detection of unexploded ordinance and the Army Military Police School at Fort McClellan, Ala., where the UAV took part in a drug interdiction exercise.

Information from the web site of the Sikorsky Aircraft Corporation was used in this story.

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ABOUT EDWARDS – HISTORY

The Sentry features a pneumatic launcher, which permits launches from confined, restricted or unimproved sites

Constructed of lightweight composite materials, the STM-5B Sentry is a small UAV with a carbon fiber airframe that is very resilient and damage tolerant, providing an extended service life for the entire vehicle system.

The complete Sentry package includes a pneumatic launcher, which permits launches from confined, restricted or unimproved sites; and a ground control station for mission planning, input, monitoring and in-flight profile amendment. Recovery methods include wheels or skids, and an optional parafoil precision approach/landing system, providing the capability of recovering the aircraft in small or unimproved landing areas.

Applications for the vehicle system include tactical short range optical/electronic surveillance, radio relay, a fully autonomous low altitude target drone, and as an inexpensive training system designed to maintain operational currency for larger, more expensive-to-operate air vehicles.

The Sentry is equipped with a digital flight control system, which is programmable for routine and special mission parameters.

The integral mission computer directs the flight control system to fly the aircraft from launch to en route altitude, to the target and through the target flight profile. It then returns the aircraft to base for recovery. Mission profile programming changes can be made in flight from the ground control station. The computer will activate and control payload electronic equipment to perform in-flight telemetry and other functions, as the mission dictates.

Payload options include real time video as standard equipment, with forward-looking infrared and other optical sensors available as options. Uplink and downlink functions are performed with S-Band (2.1-2.3 ghz) equipment, which can be modified with customer supplied equipment.

Information from the web site of the S-TEC Corp. was used in this story.

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About Edwards – History

General Atomics' Altus vehicle, like the D-2, is verifying technologies that would lead to a long-duration (12 to 72 hours), high altitude vehicle that could carry science payloads. Current efforts include work on engine integration, flight operations techniques and procedures, lightweight structures, science payload integration and science mission demonstration.

NASA photo

In October 1996, General Atomics' Altus set an endurance record for UAVs carrying science payloads

In October 1996, Altus set an endurance record for RPVs carrying science payloads. The vehicle spent more than 24 hours at the required altitude during a Department of Energy atmospheric-radiation measurement experiment. Altus will be back on flight status in the summer of 1997, after the aircraft's systems are revamped. Modifications will include an upgrade from a single-turbo-charger to a dual-turbo-charger engine.

Aircraft specifications
Take-off weight: approximately 1,632 pounds (740.9 kilograms)
Wingspan: 55.3 feet (16.8 meters)
Length: 21.75 feet (6.6 meters)
Speed: 55.2 to 115 miles per hour (88 to 185 kilometers per hour)

Information from the web site of NASA's Dryden Flight Research Center was used in this story.

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ABOUT EDWARDS – HISTORY

NASA is overseeing the development of the Apex High Altitude Flight Experiment to aid in the design of ultra high-altitude aircraft for the Environmental Research Aircraft and Sensor Technology program.

NASA photo

This computer-generated image depicts the Apex high-altitude research sailplane being developed by Advanced Soaring Concepts

The Apex program will investigate the aerodynamic characteristics of flight at very high altitudes and subsonic speeds. This flight region is not well understood, because wind tunnels cannot provide accurate, low turbulence data for such speeds and altitudes.

Like a sailplane

The Apex test vehicle will be a remotely-piloted, highly-modified aircraft resembling a conventional sailplane. Apex's wingspan will be approximately 41 feet (12.5 meters) and its fuselage length almost 25 feet (7.6 meters).

The vehicle's boron-composite construction will make it extremely lightweight, weighing between 500 and 600 pounds (227 and 272.4 kilograms) on takeoff, yet durable. A high-altitude balloon will lift the aircraft to an altitude of about 115,000 feet (35 kilometers) and release it vertically, nose down. A rocket pack under the aircraft then will fire, allowing the pilot on the ground to command a pullout from the dive.

The Apex will fly horizontally at speeds of about 449 miles per hour (722.4 kilometers per hour), using instruments on its wings to collect data that will allow aerodynamicists and engineers to compare against existing computer codes. Manufacturers use such codes to design wings and other parts of high-altitude vehicles. For example a professor at the Massachusetts Institute of Technology, Cambridge, Mass., used a computer code to design

Apex's airfoil. Results from the flight-test program will be used to refine that code.

Information from the web site of NASA's Dryden Flight Research Center was used in this story.

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About Edwards – History

The D-2 is a high-altitude vehicle capable of carrying science payloads

The Demonstrator-2 (or D-2), built by Scaled Composites is testing technologies that could result in long-duration (12 to 72 hours), high-altitude vehicles capable of carrying science payloads.

Key technology development areas include lightweight structures, science payload integration, engine development and flight-control systems.

Flight tests began Aug. 23, 1994. In late 1996, NASA demonstrated over-the-horizon communication capabilities with the D-2 using the Tracking and Data Relay Satellite System to command and control the aircraft.

Aircraft specifications
Take-off weight: approximately 1,880 pounds (853.5 kilograms)
Wingspan: 66 feet (20.1 meters)
Length: 25 feet (7.6 meters)
Speed: 63.3 to 69 miles per hour (101.8 to 111 kilometers per hour)

Information from the web sites of NASA's Dryden Flight Research Center and Scaled Composites, Inc., were used in this story.

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About Edwards – History

The Freewing Tilt-Body technology, developed by the Freewing Corp., is a highly flexible, advanced multipurpose UAV system which supports NASA remote sensing science and research applications.

The Freewing incorporates a constant aspect free-floating wing and thrust vectoring with only three moving parts

This UAV innovation incorporates a constant aspect free-floating wing and thrust-vectoring with only three moving parts. Modular construction and ease of assembly of the tilt-body concept enables the UAV to be quickly reconfigured so that various performance characteristics can be matched to mission requirements.

Increased stability
The tilt-body concept also provides increased aircraft stability over conventional fixed wing or rotary-wing UAVs, thus providing a more stable platform which is required for precise remote sensing measurements minimizing the need for costly ground processing or elaborate stabilization systems.

The inherent stability of the craft when coupled with a global positioning system and computer-controlled flight path planning will lead to routine, lengthy out-of-site operations. The modular concept allows variations of performance (range, dash speed and cruise speed) to be optimized for mission requirements (payload weight, mission flight time, sensor measurement time, etc.).

Short take-off
The tilt-body concept allows very short take off and landing distances thus enabling operations from very small or confined spaces. This will be especially helpful when trying to launch or recover the UAV from a confined area or for operation on board marine vessels in rough seas. Because of its insensitivity to turbulence and gusts the Scorpion UAV can operate

in conditions that would not be considered practical with existing UAV configurations.

The Scorpion, a vehicle developed in concert with Burt Rutan and Scaled Composites, Inc., is the first such UAV to enter production. This vehicle is the basis of alliances with Matra Bae, NASA, Boeing North American, Battelle Memorial Institute and Texas A&M University, among others.

The Scorpion is a short range UAV that applies the Freewing principle to allow the wing to remain at a constant angle of attack throughout its operating environment.

Information from the web sites of the Freewing Corp. and Scaled Composites, Inc., were used in this story.

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About Edwards – History

Pathfinder is a solar-powered, ultra-lightweight research aircraft developed by Aero Vironment Corp. The vehicle will test very high-altitude and extremely long-duration flight for periods of up to several weeks or months.

NASA photo

NASA's solar-powered Pathfinder lifts of on a flight over Hawaii on July 7, 1997

Key areas of development include solar cell, battery and electric motor technology; flight operations techniques and procedures; structures; flight environment simulation and science mission demonstration. On Sept. 11, 1995, the aircraft reached an altitude of 50,500 feet (15 kilometers), setting a new altitude record for a solar-powered aircraft.

In late 1996, Pathfinder made a successful low-level checkout flight at Dryden to verify new systems onboard the vehicle, and completed additional environmental science missions in 1997.

Aircraft specifications
Take-off weight: approximately 510 pounds (231.5 kilograms)
Wingspan: 99 feet (30.2 meters)
Length: 11 feet (3.4 meters)
Speed: 22.8 miles per hour (36.7 kilometers per hour)

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About Edwards – History

NASA photo

The Perseus high-altitude research aircraft being towed over Rogers Dry Lake at Edwards Air Force Base

Designed and built by Aurora Flight Sciences Corp. Perseus B is a propulsion and performance testbed for the ERAST program. The aircraft is designed to operate in the 65,000-foot (20 kilometer) region and has a duration goal of 96 hours. Perseus B's engine, which is double-turbocharged to offset the thin atmosphere, "breathes" air surrounding the vehicle. The aircraft also features unique tricycle-shaped landing gear.

Perseus B will test engine concepts, lightweight structures, science payload integration and a fault-tolerant flight-control system. Perseus B's maiden flight occurred on Oct. 7, 1994.

Aircraft specifications
Take-off weight: approximately 2,090 pounds (948.9 kilograms)
Wingspan: 61 feet (18.6 meters)
Length: 26.2 feet (8 meters)
Speed: 57.5 miles per hour (92.5 kilometers per hour)

Information from the web site of NASA's Dryden Flight Research Center were used in this story.

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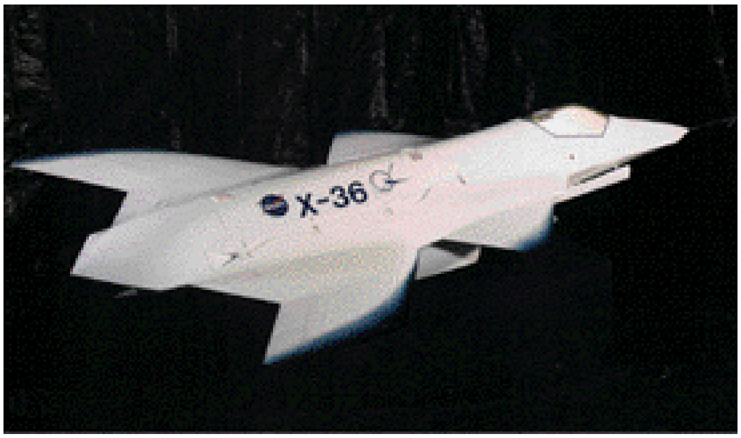
About Edwards – History



The X-36 is a small, remotely-piloted jet designed to fly without the traditional tail surfaces common on most aircraft

The X-36 is a small, remotely-piloted jet designed to fly without the traditional tail surfaces common on most aircraft. Built by McDonnell Douglas' Phantom Works division in St. Louis, Mo., the aircraft are 18 feet long with 10-foot wingspans, 3 feet high and weigh 1,270 pounds each. The aircraft are each powered by a Williams Research F112 turbofan engine that provides 700 pounds of thrust.

During the research, the aircraft were remotely controlled by a pilot in a ground station cockpit, complete with a head-up display. The pilot-in-the-loop approach eliminates the need for expensive and complex autonomous flight control systems.

Fighter maneuvers

Both 28-percent scale aircraft were put through fighter aircraft maneuvers during the scheduled 25-flight program, to gather data on the performance characteristics, especially agility, of tailless, fighter-type aircraft. The project goal discovered enhanced technologies to improve the maneuverability and survivability of future fighter aircraft.

McDonnell Douglas first proposed a tailless research aircraft to NASA in 1989. Following wind-tunnel tests to develop the technical breakthroughs required to achieve agile tailless flight, a cooperative agreement was signed for the X-36. McDonnell Douglas began fabrication of the two aircraft in 1994 following joint funding of the project under a roughly 50/50 cost-sharing arrangement.

The NASA Dryden Flight Research Center shared its experience on the Highly Maneuverable Aircraft Technology (HiMAT) program with NASA's Ames Research Center.

Having completed its flight test program the two X-36 UAVs will be stored in flyable condition at NASA Dryden.

The aircraft have flown a total of 31 flights, achieving speeds of up to 206 knots, an altitude of more than 20,000 feet and more than 40 degrees angle of attack.

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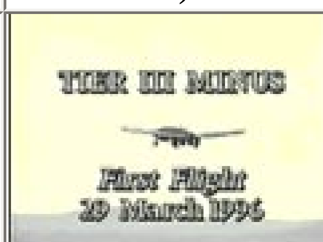
Graphics

U.S. production activity (34 KB)
Synthetic Aperture Radar illustration (72 KB)
Predator payload (15 KB)
Imagery dissemination (149 KB)

Video Footage

Requires Apple QuickTime player and plug-in to be installed

		
Freewing #1 (1,284 KB)*	Freewing #2 (1,071 KB)*	Pathfinder (1,071 KB) **
		
DarkStar #1 (4,096 KB)***	DarkStar #2 (8,044 KB)***	UCAV launch (2,901 KB)

* Freewing video provided courtesy of the Freewing Corp
** Pathfinder video courtesy of NASA
***DarkStar video courtesy of Lockheed Martin Skunk Works

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UAVs: U.S. production activity

U.S. UAV development and production activity

Local	Regional	Endurance	
Shadow 200	Shadow 600	Chiron	Pathfinder
AV Pointer Micro Blimp	Truck	BQM-34	Perseus B
SASS Lite Blimp	Skyeye	Model 324	Raptor
Javelin	Eagle-Eye	Model 350	Theseus
Porter	Aerobot (A24-2)	Model 410	Helios
Tern	Spectre II	GNAT 750	
H-7B	Seabat	Altus 2	
H-7F	S-TEC Sentry		
H-7H	Hunter		
Freewing Tilt-Body			
Huntair			
Prowler			
Flash			
HIT			
Aerobot (FS-24)			
Aerosonde			
Cypher			
XAP			

NASA graphic

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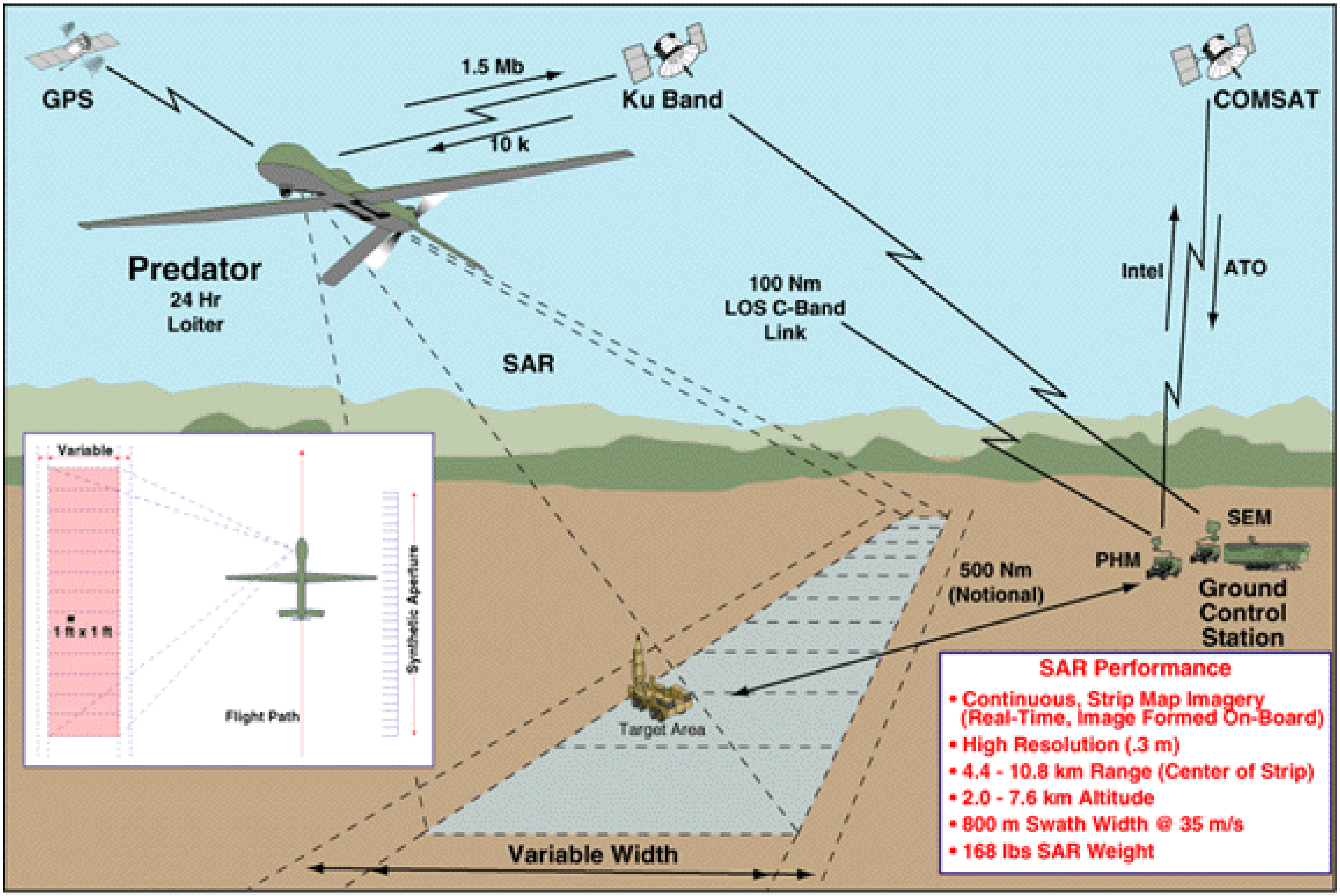
UAVs: Synthetic Aperture Radar



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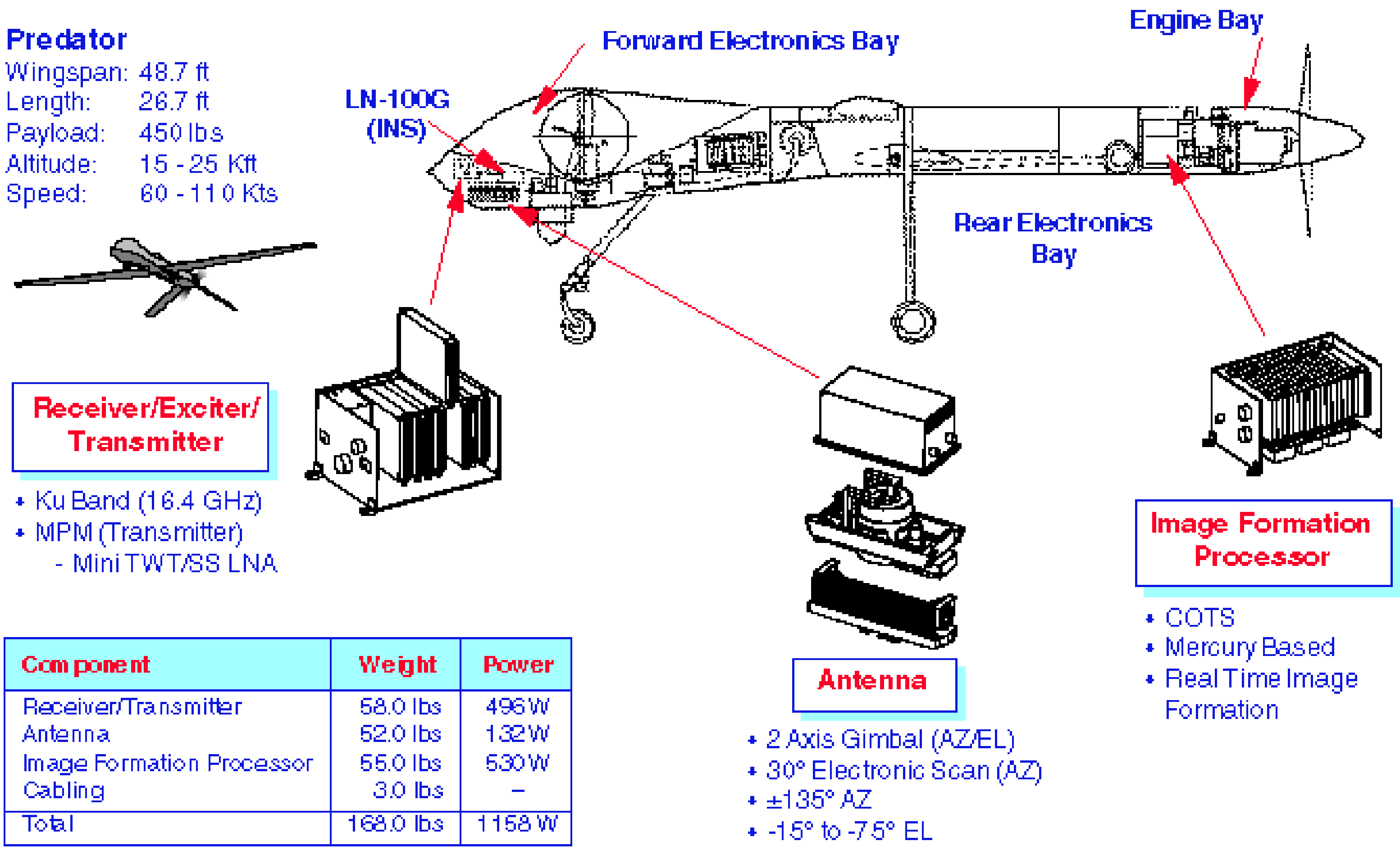
UAVs: Predator payload



Component	Weight	Power
Receiver/Transmitter	58.0 lbs	496 W
Antenna	52.0 lbs	132 W
Image Formation Processor	55.0 lbs	530 W
Cabling	3.0 lbs	–
Total	168.0 lbs	1158 W

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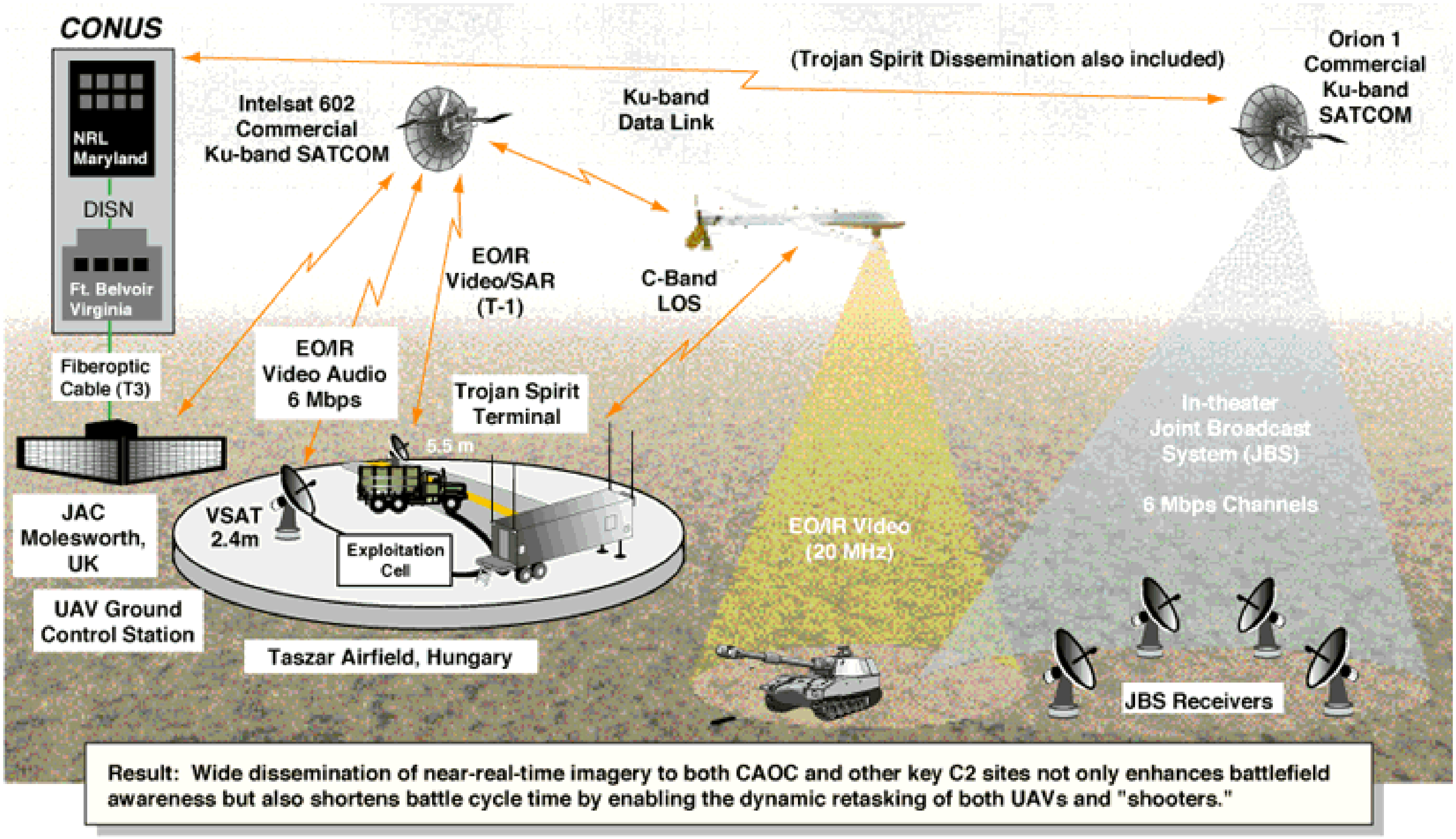
UAVs: Imagery dissemination



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