How the Predator UAV Works

Photo courtesy U.S. Air Force
Predator UAV

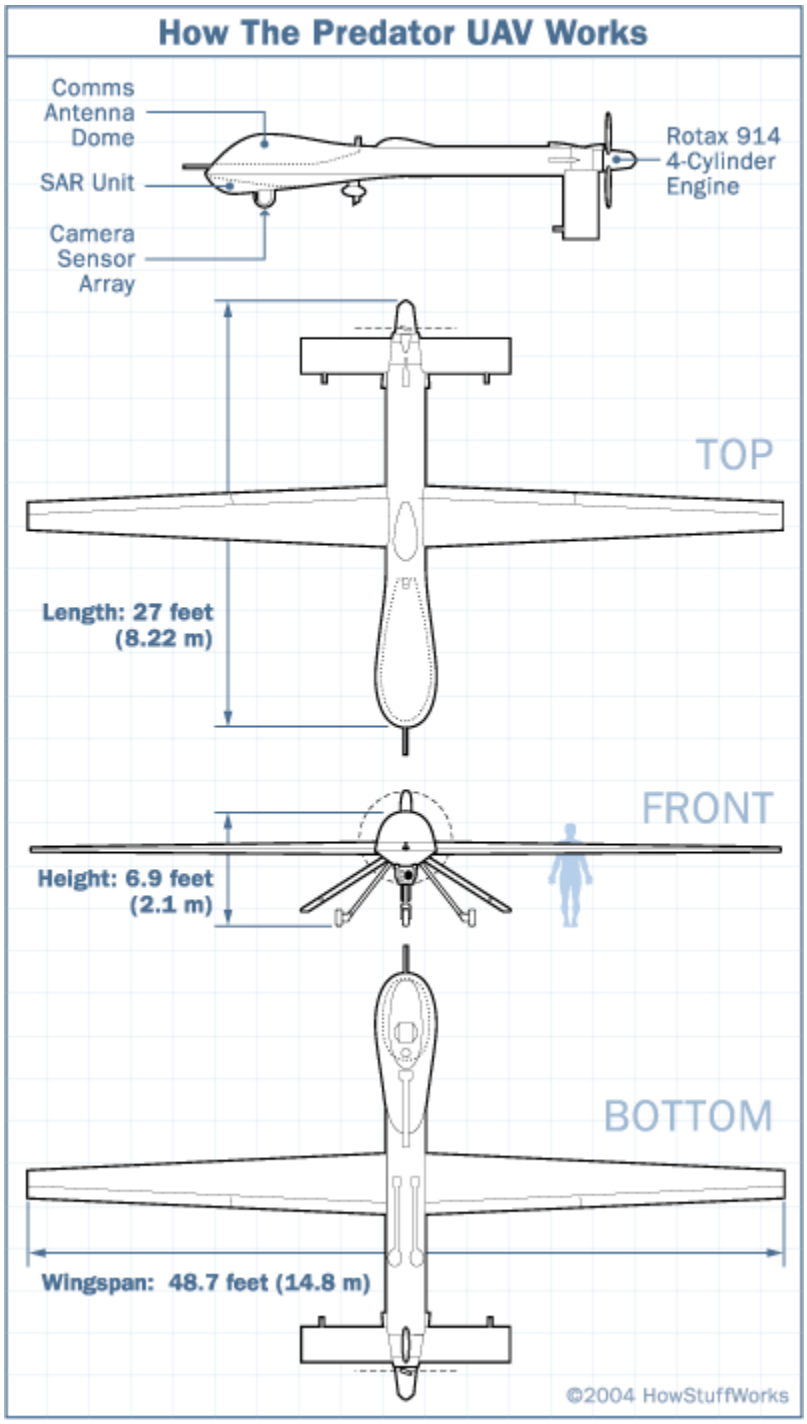
Military commanders use tactics and strategy in combat to inflict as much damage on the enemy while trying to risk as few personnel and resources as possible. This principle was at the heart of the development of the RQ-1 and MQ-1 **Predator Unmanned Aerial Vehicle**.

These high-tech aircraft, controlled by a crew miles away from the dangers of combat, are capable of reconnaissance, combat and support roles in the hairiest of battles. In a worst-case scenario, if a Predator is lost in battle, military personal can simply "crack another one out of the box" and have it up in the air shortly -- and that's without the trauma of casualties or prisoners normally associated with an aircraft going down.

In this article, we will look at the Predator UAV's flight system, sensors, weapons and crew, and how the military is using Predators to keep personnel safer both in the air and on land.

Under the Hood

The Predator UAV is a medium-altitude, long-range aircraft that operates much like any other small plane.


How The Predator UAV Works
Comms Antenna Dome
SAR Unit
Camera Sensor Array
Rotax 914 4-Cylinder Engine
TOP
Length: 27 feet (8.22 m)
FRONT
Height: 6.9 feet (2.1 m)
BOTTOM
Wingspan: 48.7 feet (14.8 m)
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A **Rotax 914**, four-cylinder, four-stroke, 101-horsepower engine, the same engine type commonly used on snowmobiles, turns the main drive shaft. The **drive shaft** rotates the Predator's two-blade, variable-pitch pusher propeller. The rear-mounted propeller provides both drive and lift. The remote pilot can alter the pitch of the blades to increase or decrease the altitude of the plane and reach speeds of up to 135 mph (120 kts). There is additional lift provided by the aircraft's 48.7-foot (14.8-meter) **wingspan**, allowing the Predator to reach altitudes of up to 25,000 feet (7,620 meters). The slender **fuselage** and **inverted-V tails** help the aircraft with stability, and a single **rudder** housed beneath the propeller steers the craft.

The fuselage of the Predator is a mixture of carbon and quartz fibers blended in a composite with Kevlar. Underneath the fuselage, the airframe is supported by a Nomex, foam and wood laminate that is pressed together in layers. Between each layer of laminate, a sturdy fabric is sandwiched in to provide insulation to internal components. The rib work of the structure is built from a carbon/glass fiber tape and aluminum. The sensor housing and wheels are also aluminum.

Photo courtesy U.S. Air Force

An airman works on the Predator's Rotax 914 engine.

The edges of the wings are titanium and are dotted with microscopic **weeping holes** that allow an ethylene glycol solution to seep out of internal reservoirs and breakdown ice that forms on the wings during flight.

The Predator UAV uses run-of-the-mill mechanical systems. A 3-kilowatt starter/alternator supplies the craft's electronics with power; this is supplemented with auxiliary battery power. Forward and aft fuel tanks house rubberized fuel bladders that are easy to fill through gas caps located at the top of the fuselage. An operator starts the engine by attaching the umbilical cord of a Starter/Ground Power Cart to the aircraft's starter-control connector, located in the ground panel on the outside of the plane. An operator stops the engine by hitting a kill switch just behind one of the wings on the side of the plane.

For the Engine

- The Predator's two fuel tanks combined carry up to 600 pounds of 95-octane to 100-octane reciprocating aircraft engine fuel.
- The Predator uses 7.6 liters of standard motor oil for lubrication.
- In addition to venting, conventional automotive antifreeze is used to cool the engine.
- Two 8-pound, 14-amp-hour Ni-Cad battery packs are housed in the fuselage for backup power in case the engine or alternator fails.

A Look Inside the Predator

As an aircraft, the Predator UAV is little more than a super-fancy remote-controlled plane. But this simple design lends itself well to the Predator's intended functions. Below you can see the placement of components:

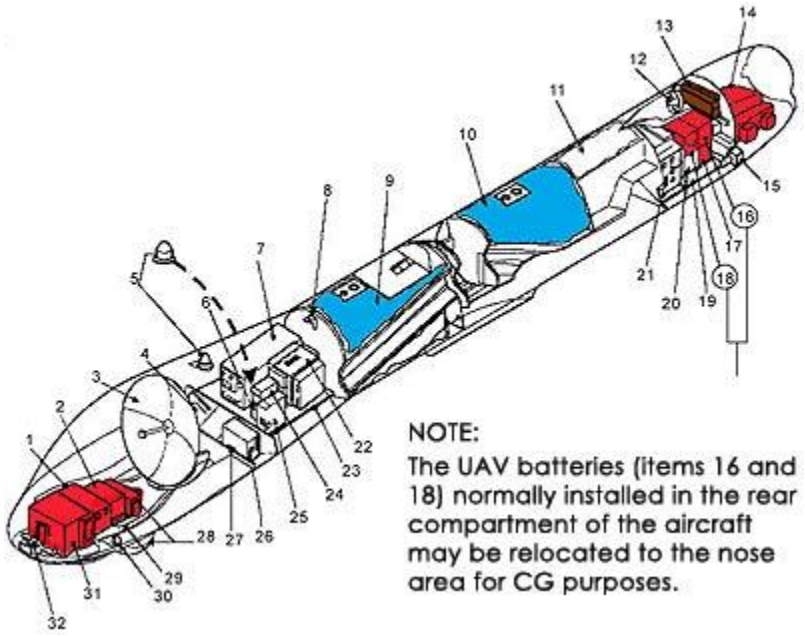

Image courtesy AFCESA

1. **Synthetic Aperture Radar (SAR) Antenna**
2. **Inertial Navigation System/GPS**
3. **Ku-Band Satellite Communications Antenna**
4. **Video Cassette Recorder**
5. **GPS Antennas (Left and Right)**
6. **APX-100 Identification Friend or Foe Transponder**
7. **Ku-Band Satellite Communications Sensor Processor Modem Assembly**
8. **C-Band Upper Omnidirectional Antenna Bracket**
9. **Forward Fuel Cell Assembly**
10. **Aft Fuel Cell Assembly**
11. **Accessory Bay**
12. **Engine Cooling Fan**
13. **Oil Cooler/Radiator**
14. **914F Engine**
15. **Tail Servo (Left and Right)**
16. **Battery Assembly #2**
17. **Power Supply**
18. **Battery Assembly #1**
19. **Aft Equipment Bay Tray**
20. **Secondary Control Module**
21. **Synthetic Aperture Radar Processor/AGM-114 Electronics Assembly**
22. **Primary Control Module**
23. **Front Bay Avionics Tray**
24. **ARC-210 Receiver/Transmitter**
25. **Flight Sensor Unit**
26. **Video Encoder**

27. **De-ice Controller**
28. **Electro-Optical/Infrared Sensor/AN/AAS-52(V)1 Electronics Assembly**
29. **Front Bay Payload Tray**
30. **Ice Detector**
31. **Synthetic Aperture Radar (SAR) Receiver/Transmitter**
32. **Nose Camera Assembly**

In the next sections, we'll see how this unassuming aircraft can use its special features to tilt the balance of combat.

Spy in the Sky

The RQ-1 is the reconnaissance version of the Predator UAV. The letter 'R' is the U.S. Defense Department signature for an aircraft designated for reconnaissance. 'Q' is a designation for unmanned or automated weapons or vehicles.

The simple and lightweight design of the Predator's fuselage allows it to carry a payload of up to 450 pounds (204 kg) in addition to the weight of its 100-gallon (378.5-liter) fuel tank. This large fuel tank and the nice gas mileage afforded by the Predator's light weight are great assets for a reconnaissance aircraft. The Predator can stay in the air monitoring enemy positions for up to 24 hours fully loaded.

Photo courtesy U.S. Air Force

The RQ-1 uses a set of nose cameras to "see" on missions.

The RQ-1 uses some of the most sophisticated monitoring equipment available today:

- Full-color nose camera that the pilot uses primarily to navigate the craft
- Variable aperture camera (similar to a traditional TV camera) that functions as the Predator's main set of "eyes"
- Variable aperture infrared camera for low-light and night viewing
- Synthetic aperture radar (SAR) for seeing through haze, clouds or smoke

Every camera in the plane's forward bank can produce full-motion video and still-frame radar images.

Photo courtesy U.S. Air Force
An airman cleans the lens pilots use to fly the MQ-1 Predator.

The RQ-1 can give real-time imagery of the enemy position to a command post well before the first troops or vehicles arrive. This kind of information allows field commanders to make quick and informed decisions about troop deployment, movements and enemy capabilities. Of course, the greatest advantage of using the Predator is that it has all the advantages of a traditional reconnaissance sortie without ever exposing the pilot to a hostile environment.

In Battle

The only thing better than having a robotic airplane assist forces in making decisions about how to fight a battle is to have a robotic airplane actually fight the battle for you. That is where the **Predator UAV MQ-1 Hunter/Killer** comes into play. Replacing the camera array with the **Multispectral Targeting System** (MTS) and loading the Predator with two Hellfire missiles transforms this battlefield spotter into a deadly automated combatant. The 'M' in MQ-1 is the Defense Department designation for **multipurpose aircraft**; by adding the MTS and Hellfire missiles to the Predator, it truly becomes a multifunctional battle aircraft.

Photo courtesy U.S. Air Force
The MQ-1 Hunter/Killer awaits orders.

The MTS includes the AGM-114 Hellfire missile targeting system, electro-optical infrared system, laser designator, and laser illuminator. All of these components give the Predator and its operators multiple ways to acquire a target in any combat environment. The Predator fires a laser or infrared beam from the MTS ball located near the nose of the plane. This laser can be used in two ways:

- The beam lands on the target and pulses to attract the laser seekers at the end of each Hellfire missile.
- The on-board computer uses the beam to makes calculations about trajectory and distance.

Sensors bundled in the MTS also calculate wind speed, direction, and other battlefield variables to gather all of this data into a firing solution. This process is known as "painting the target." Once a target is painted, the MQ-1 can unleash its own missiles to destroy the target or send the firing solution to other aircraft or ground forces so they can destroy it.

Photo courtesy U.S. Air Force

A Predator MQ-1 comes in for a landing after firing one of its Hellfire Missiles.

Predator Utility

The battlefield effectiveness of the MQ-1 has been tested in several recent conflicts, including those in Afghanistan, Bosnia, Kosovo, Iraq, and Yemen.

The Predators have flown into combat alongside manned warplanes, have provided air support to ground forces, and have attacked areas where enemy air defenses have not been fully suppressed. They could also be used in areas that are traditionally too dangerous to send in manned aircraft, such as open ocean environments or biologically or chemically contaminated environments. And even loaded with the MTS, the Predator MQ-1 is capable of effective battlefield reconnaissance.

Photo courtesy U.S. Air Force

Perhaps the most infamous use for the combat version of the Predator is in **stealthy aerial assassinations**. On February 7, 2002, the CIA used an armed Predator to attack and destroy a convoy of SUVs transporting suspected al Qaeda terrorists. On November 3, 2002, the CIA used a Predator to launch a Hellfire missile into a car in Yemen, killing Qaed Senyan al-Harthi, the al-Qaeda leader thought to be responsible for the bombing of the USS Cole. Though this application of the Predator is rare, none of these missions would have been possible using conventional methods without risking the lives of U.S. troops.

Behind The Wheel

According to the U.S. Defense Department, "The Predator is a system, not just an aircraft." This is because of the unique way the Predators are deployed and controlled.

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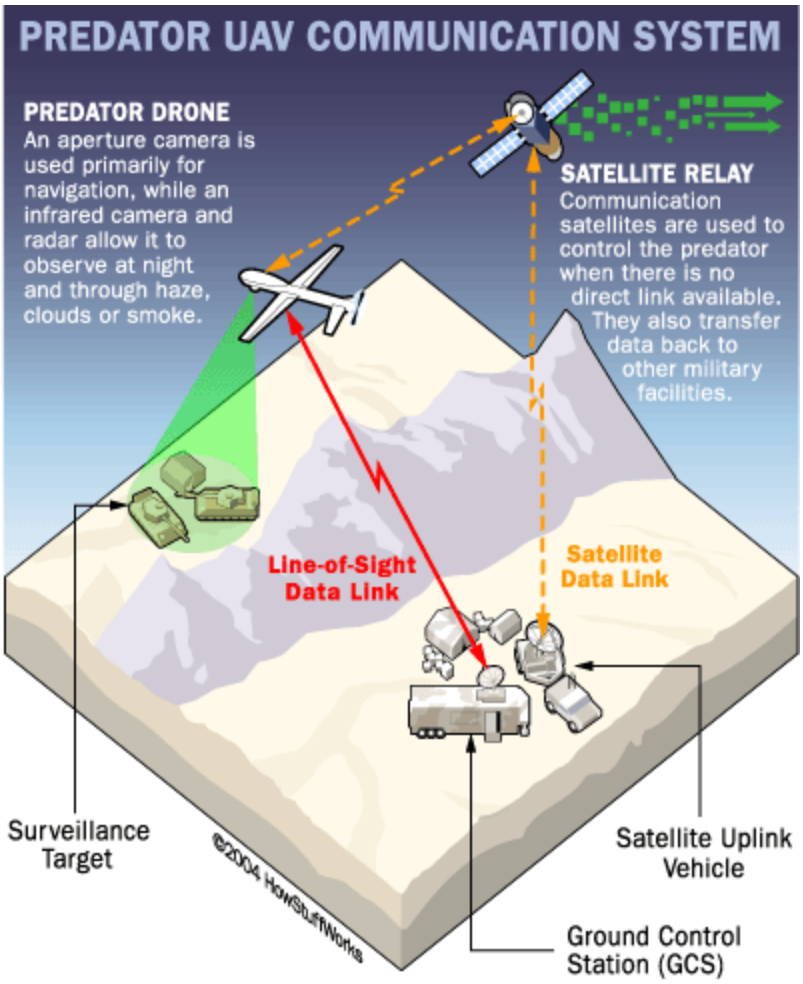
Predator UAV remote pilot station

A fully operational system consists of **four Predators** (with sensors), a **ground control station** (GCS) that houses the pilots and sensor operators, and a Predator **primary satellite-link** communication suite.



On the ground, there are the techs and support personnel normally associated with aircraft. The whole show takes about 82 personnel to run successfully. This fully integrated team is capable of using the four aircraft for 24-hour surveillance within a 400-nautical-mile radius of the ground control station.

The Predator can run autonomously, executing simple missions such as reconnaissance on a program, or it can run under the control of a crew. The crew of a single Predator UAV consists of one pilot and two sensor operators. The pilot drives the aircraft using a standard flight stick and associated controls that transmit commands over a **C-Band line-of-sight data link**. When operations are beyond the range of the C-Band, a **Ku-Band satellite link** is used to relay commands and responses between a satellite and the aircraft. Onboard, the aircraft receives orders via an L-3 Com satellite data link system. The pilots and crews use the images and radar received from the aircraft to make decisions about controlling the plane.

Predator aviators have described piloting the aircraft as flying an airplane while looking through a straw. This is quite a change from driving a conventional aircraft from the cockpit. Predator pilots have to rely on the onboard cameras to see what's going on around the plane. For the crew, it's a trade-off between the disadvantage of limited visibility and the definite plus of personal safety.

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On The Road

One of the greatest things about the Predator system is that the whole thing is fully transportable. The aircraft breaks down into six pieces that are transported in a huge crate called the **coffin**. The coffin contains:

- The fuselage
- Wings
- Tail surfaces
- Landing gear
- The propulsion system
- Two payload/avionics bays

A dissembled Predator loaded into a "coffin" for transport

The largest component in the system is the GCS. The **GCS** has wheels that allow it to be rolled onto transports. The Predator **primary satellite link** consists of a 20-foot (6.1-meter) satellite dish and support equipment. This can also be broken down. The coffin, GCS, and satellite link all fit in the cargo hold of a C-130 Hercules or C-141 Starlifter. This is how they are moved around from mission to mission. Once on site, a single Predator can be reassembled by a crew of four in under eight hours.

Photo courtesy U.S. Air Force
A fully assembled Predator ready for flight

The flexibility and ease of transport designed into the system allows personnel to rapidly deploy an entire four-aircraft Predator system anywhere in the world. Currently, the 11th and 15th Reconnaissance Squadrons, Indian Springs Air Force Auxiliary Field, oversee all Predator operations.

The Future

New variations on the Predator are being created to expand its capabilities. By modifying the airframe and expanding the wing span to 86 feet (26 meters), they will be able to fly the new Predator variations at up to 50,000 feet (15,240 meters). The new model is called the **MQ-9 Altair**. It will be used during peace time for scientific and atmospheric research. The U.S. Navy and Coast Guard will have their own versions of the new Predator that are used for surveillance and reconnaissance.

The Predator is not the only UAV deployed by the U.S. military. The RQ-2 Pioneer, RQ-3 Dark Star, RQ-4 Global Hawk, RQ-5 Hunter, RQ-6 Outrider, and RQ-7 Shadow have all been used in a reconnaissance capacity since the early 1990s. The Predator and its variations are, however, the only UAVs with a combat role and the UAVs most capable of flying into battle alongside manned warships.

Photo courtesy U.S. Air Force

With the proliferation of remotely-operated and automated combat units, the trend in military technology seems to be moving toward missions carried out by automated warriors, with the flesh-and-blood controllers battling safely from behind computer terminals. For more information on the Predator and other remotely-controlled aircraft, check out the links on the next page.

Lots More Information

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- The Air Force Civil Engineer Support Agency
- DefenseLINK: Predator UAVs Prove Their Worth in War Against Terrorism
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- Wikipedia: RQ-1 Predator
- CDI Terrorism Project: Q&A on the use of Predator in Operation Enduring Freedom
- Space Daily: Yemen al-Qaida Attack Appears to be Work of Unmanned CIA Plane - November