AIR AND SPACE SYSTEMS AND CAPABILITIES

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Weapon Guidance Systems

Air -to-Air Missiles (AAMs)

The basic subsystems of any AAM are the seeker, the warhead, and the rocket motor. The seeker steers the fins on the rocket motor to guide the warhead to the target. AAMs are usually categorized by the method the seeker uses to guide the missile.

AAM Guidance Systems

Infrared (IR)-seeking AAMs track targets by sensing the heat energy radiating from the target--especially from its jet engines. IR AAMs are considered "passive": That is, IR AAM seekers don't transmit energy. They track energy that radiates from the target naturally. Current AF example: AIM-9 Sidewinder.

Semi-Active Radar (SAR) AAMs have seekers that are sensitive to radar energy that doesn't radiate from the target naturally. For SAR AAMs to work, the target needs to be illuminated by the same kind of radar energy tracked by the seeker. They are called "semi-active" because they can't transmit this energy themselves: The aircraft that fired the missile must use its radar to illuminate the target, and the SAR seeker follows the radar energy that reflects off of the target. In order for SAR AAMs to work, the firing aircraft's radar must stay "locked" on the target until the missile detonates. Current AF example: AIM-7 Sparrow.

Active Radar AAMs have seekers that can both sense and transmit the radar energy that illuminates the target. All the firing aircraft's radar has to do is designate the target: Once the aircraft's radar tells the AR missile which target to track, the pilot can "launch and leave" the AAM. Current AF example: AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM).

Air-to-Surface Weapons

There are many kinds of air-to-surface weapons, such as bombs that fall by the force of gravity alone, without guidance systems; glide bombs, which can be steered to the target; and Air-to-Surface Missiles (ASMs), which have guidance systems and are powered by rocket motors or jet engines (as in cruise missiles and anti-ship missiles).

Air-to-Surface Weapon Guidance Systems

Active Radar: Same function as Active Radar AAMs. Current AF example: AGM-84 Harpoon (an anti-ship missile).

Radar-Homing: The seeker is tuned to receive the radar frequency of an enemy radar--like those used to aim Surface-to-Air Missiles (SAMs). These seekers are "passive": like IR AAM seekers, they don't transmit energy. They simply home in on enemy radar transmissions. Current AF example: AGM-88 High-speed Anti-Radiation Missile (HARM).

Television (TV) or **Imaging Infrared (IIR)**--both known as **Electro-optical (EO):** The seeker has either a "normal" (daylight) TV camera or an IIR camera (which sees heat energy). The seeker transmits video to the aircraft. The crewmember watching the monitor steers the missile to the target. Current AF Example: AGM-130 (a rocket-powered variant of the 2,000-pound GBU-15 glide bomb, which is also EO-guided).

Laser (also known as **Semi-Active Laser**): Works like a Semi-Active Radar AAM seeker, except laser seekers are sensitive to laser light, instead of radar transmissions: The firing aircraft (or special operations forces on the ground) must designate the target by illuminating it with a laser beam. The seeker senses the reflected laser light and homes in on the target. Current AF Example: the 2,000-pound GBU-27 glide bomb.

Inertial Navigation System (INS): This system is very similar to INS used to navigate aircraft. INS uses gyroscopes (similar to spinning tops) and accellerometers, which can sense and measure the weapon's maneuvers. The seeker uses this flight direction information to keep the weapon on the proper course. Current AF example: AGM-129 Advanced Cruise Missile (a nuclear weapon).

Global Positioning System (GPS): GPS guidance is sometimes called "GPS/INS" because in some cases an INS system is used as a backup in case the GPS system is jammed. In addition comparing INS and GPS data allows for better accuracy. The seeker is programmed to strike a specific latitude and longitude coordinate. The seeker receives GPS updates on its own location, altitude, and velocity from GPS satellite transmissions, and steers the weapon to strike the pre-programmed target. In addition to seeker systems designed specifically for GPS guidance, GPS systems are being integrated into several laser-guided weapon's seekers to increase accuracy in bad weather. Current AF Example: the 2,000-pound GBU-31 glide bomb--a Joint Direct Attack Munition (JDAM).

Defense Support Program (DSP)

Distinguishing Characteristics:

- 4 short, nearly-square solar panels, arranged as though they were an open box's folding lids
- Telescope-shaped shield covering the infrared sensor equipment

Capabilities:

- Can detect space orbit launches, missile weapon launches, and nuclear detonations
- Sensitive enough to provide some early warning of Iraqi attacks from mobile SCUD launches
- Can feed data to early warning systems via secure communication links directly to Cheyenne Mountain and commanders in the field in a matter of seconds

Limitations:

- Limited design life (approximately 3 years)--requires frequent purchases & launches to maintain the constellation (up to 10 satelllites)
- Requires geosynchronous orbit (very high--22,000 miles): Expensive launch requirement

DSP being deployed by the Space Shuttle. From the Shuttle's cargo bay, an Inertial Upper Stage booster (which is also used on Titan IV) carried the DSP to a geosynchronous orbit.

Defense Meteorological Satellite Program (DMSP)

Distinguishing Characteristics:

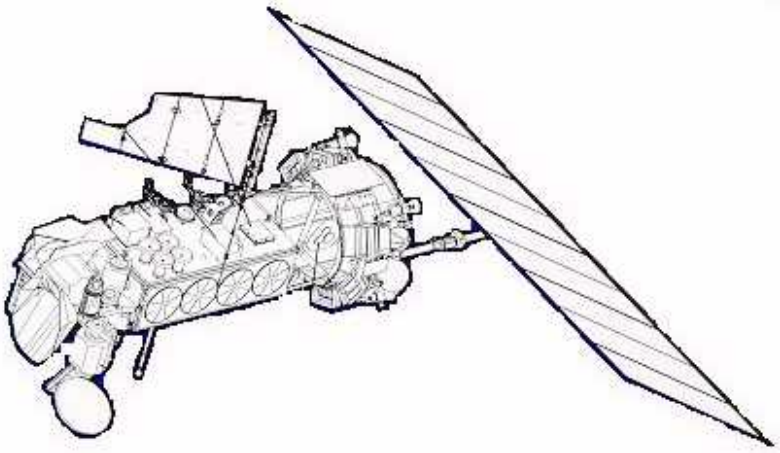
- 1 long, rectangular solar panel pivots from a control arm attached to the middle of the panel

Capabilities:

- Provides high-resolution visual & infrared imagery of cloud cover over an area 1,600 nautical miles wide, day or night
- DMSP satellites pass over each ground point in their orbit at the same local solar time each day
- Can measure atmospheric vertical profiles of moisture and temperature
- Can also measure local charged particles and electromagnetic fields (commonly called "space weather") to assess the impact of the ionosphere on ballistic-missile early warning radar systems and long-range communications
- Can monitor global auroral activity so we can predict the effects of the space environment on military satellite operations

Limitations:

- Imagery is black & white only (no color photos)
- Requires special decryption equipment for downloading imagery



Schematic of DMSP satellite.

Global Positioning System (GPS)

Distinguishing Characteristics:

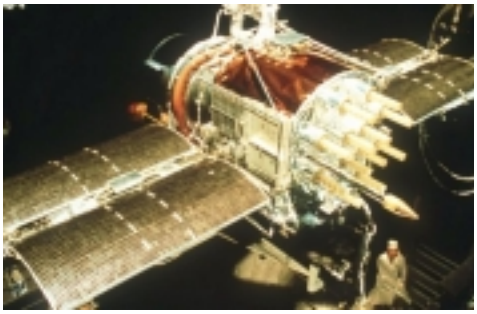
- 2 rectangular solar panels (1 on each side)
- Solar panels attached with the long side adjacent to central body
- Several antennas/transmitters installed on a circular face

Capabilities:

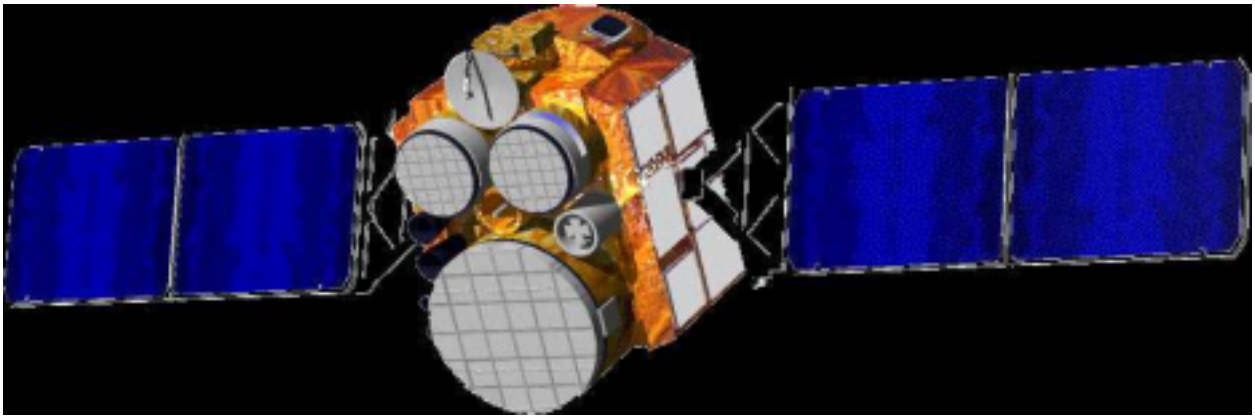
- Can provide precise latitude, longitude, altitude, time, and velocity data from any point on the globe, 24 hours a day, in all weather conditions
- Can also detect nuclear detonations
- Can be used to guide certain air-to-surface weapons to targets with extreme precision
- Each point on Earth's surface is covered by a minimum of 4 GPS satellites

Limitations:

- Worldwide transmissions are extremely susceptible to jamming
- Transmissions previously available only to the military are now available worldwide



Defense Satellite Communication System (DSCS)



Distinguishing Characteristics:

- 2 rectangular solar panels (1 on each side)
- Solar panels attached with the short side adjacent to central body
- Several receivers & transmitters arranged on the face pointing towards Earth

Capabilities:

- DoD's communications workhorse--constellation of 10 satellites is in orbit
- Can handle a lot of communication "traffic"
- Provides Super High Frequency (SHF) communications, which are much more resistant to jamming than UHF communications
- Provides secure computer connections for the Global Command and Control System
- Carries the majority of DSN telephone conversations (including secure phone calls)
- Can disseminate Emergency Action Messages (EAMs) to strategic nuclear forces

Limitations:

- Associated ground equipment is complex and expensive

DSCS being built (above) and deployed by the Space Shuttle (left).

Military and Strategic Tactical Relay (MILSTAR)

Distinguishing Characteristics:

- 2 extremely long rectangular solar panels (seen "on edge" here)
- Solar panels attached with the short side adjacent to main chassis, and the long sides perpendicular to the main chassis
- Receiver dish hangs from one end, a spherical apparatus (stearable antenna) from the other

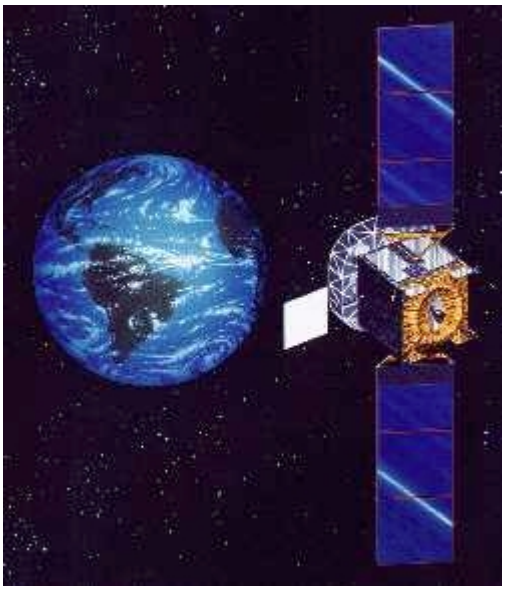
Capabilities:

- Provides survivable communications for command and control of warfighting forces
- Can transmit and receive secure and jam-resistant Extra High Frequency (EHF) signals
- Can crosslink transmissions from EHF to Ultra High Frequency (UHF)

Limitations:

- Susceptible to fluctuations in the space environment ("space weather")
- Requires geosynchronous orbit (very high--22,000 miles): Expensive launch requirement
- Both MILSTAR and its associated ground equipment are extremely expensive

Ultra High Frequency (UHF) Follow-On ("UFO")



Distinguishing Characteristics:

- 2 rectangular solar panels (1 on each side)
- Solar panels attached with short side next to main body
- Cube-shaped main body
- White, square-shaped device projects from one side
- Antennas are located in a round "fenced-off" area (facing the Earth, in this picture)

"UFO" being built.

Capabilities:

- Navy's new 10-satellite constellation (11 in two years) that provides global communications for all Services
- Orbits in pairs in four different locations above the Earth for global coverage
- Has 39 UHF communications channels
- Has Extremely High Frequency (EHF) package for secure, jam-resistant communications
- Has Global Broadcast Service (GBS) package for one-way, high data-rate communications
- Each satellite has an orbital operational life of 14 years with an on-orbit storage life of 4 years
- Can operate for 30 days without ground contact, if necessary

Limitations:

- UHF communications are highly susceptible to jamming

National Systems ("Spy Satellites")

Distinguishing Characteristics:

- None: The NRO released this "reconnaissance satellite" photo, but almost all information about these assets and their missions is classified

Capabilities:

- Mostly classified, but here's how the National Reconnaissance Office (NRO) defines the missions of two NRO directorates:

-- Imagery Intelligence (IMINT)

The NRO IMINT Systems Acquisition and Operations Directorate is responsible for the development and operation of imagery satellites that serve the National Command Authority, the Intelligence Community and our military forces. Specific Directorate functions include the development of reconnaissance technology for new systems capabilities; the acquisition of spacecraft and supporting ground-based systems; and the management of the day-to-day operations related to imagery collection, processing, production, and distribution.

-- Signals Intelligence (SIGINT)

The NRO SIGINT Acquisition and Operations Directorate is responsible for the development of SIGINT satellites serving the National Command Authority, military forces, and the intelligence community by providing additional intelligence collection from space.

Limitations:

- Very expensive--and some satellites were destroyed in failed launch attempts
- Some require geosynchronous orbits (very high--22,000 miles): Expensive launch requirement
- Incomplete coverage: Geosynchronous orbit is too far away to capture the best imagery, so "spy satellites" are sometimes launched in lower orbits--but that means we can't always have continuous coverage of any one location—however, they take advantage Molniya Orbits allowing them to linger over a target for longer periods of time

Pegasus

Distinguishing Characteristics:

- Carried by a commercial aircraft
- Has wings and both vertical and horizontal tail surfaces

Capabilities:

- Pegasus is used to launch scientific satellites for the Air Force, the Ballistic Missile Defense Organization, DoD, and NASA
- Can launch 1,050 pounds to low earth orbit
- Offers relatively inexpensive access to space

Limitations:

- All other launch systems can carry heavier payloads

Once dropped, the Pegasus rocket ignites and steers towards orbit.

Atlas

Distinguishing Characteristics:

- Payload capsule is bigger than Delta's and smaller than Titan's
- Sometimes has 4 solid rocket boosters attached to the first stage

Capabilities:
- Atlas is used to launch DSCS and UHF Follow-On satellites, as well as some National Systems
- Can have 4 solid-rockets boosters attached to the first stage for additional capability
- Can employ Centaur upper stage booster (in payload capsule) to achieve geosynchronous orbit
- Can launch about 14,500 pounds to low earth orbit and 6,100 pounds to geosynchronous orbit

Limitations:
- Will be replaced by the Evolved Expendable Launch Vehicle

Delta

Distinguishing Characteristics:

- Payload capsule is usually smaller than both Atlas' and Titan's
- 9 solid rocket boosters attached to the first stage (usually)

Capabilities:

- Delta is used to launch GPS satellites and commercial payloads into low-earth, polar, and geosynchronous orbits
- Can launch up to 11,100 pounds to low earth orbit, or up to 8,420 pounds to polar low earth circular orbit, or up to 2,000 pounds to geosynchronous orbit

Limitations:

- Will be replaced by the Evolved Expendable Launch Vehicle

Titan

Titan IV

Titan IV

Titan II

Distinguishing Characteristics:

- Titan II doesn't have solid rocket boosters
- Titan IV has 2 large solid rocket boosters
- Titan IV's payload capsule is much larger than both Delta's and Atlas'
- Size of Titan IV's payload capsule depends on whether or not an additional upper stage booster is installed

Capabilities:

- Titan II is used to launch DMSP and other weather satellites
- Titan II can launch 4,200 pounds into polar low earth circular orbit

- Titan IV is used to launch DSP, MILSTAR, and some National Systems
- Titan IV is flexible: Can be launched with no upper stage, or with either a Centaur or an Inertial Upper Stage booster, depending on payload and desired orbit
- Can launch up to 47,800 pounds to low earth orbit & up to 12,700 lbs. to geosynchronous orbit

Limitations:

- Will be replaced by the Evolved Expendable Launch Vehicle

Space Transportation System (STS) (Space Shuttle)

Distinguishing Characteristics:

- Orbiter combines a large cargo bay and reentry-proof heat shield on a delta-winged high-speed glider for controlled, yet unpowered landings

Capabilities:

- Our only currently operational re-useable launch system
- Has launched several satellites, including DSCS and DSP

Limitations:

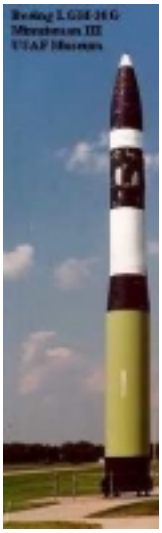
- Although the heat shield tiles protect during re-entry, they are very sensitive to exposure to debris: When carried on a modified 747 to maintenance or launch facilities, it can't fly through precipitation or thick clouds

- Extremely expensive (in the 2 billion dollar price range)

- Each mission is extremely expensive, too

LGM-30G Minuteman III

Capabilities:
- Can deliver 3 independently-targeted warheads with great accuracy



Distinguishing Characteristics:

- 3-stage rocket
- First stage is wider than the rest (unlike Peacekeeper)
- "Hot-launched": Ignition occurs in the silo, and the missile flies out through its own flame and exhaust (unlike Peacekeeper)

Limitations:
- Hot-launch technique used to launch Minuteman effectively destroys the silo--silo can't be reused
- Once they're launched, they can't be recalled (like bombers can)
- Under the terms of the second Strategic Arms Reduction Treaty (START II), all Minuteman systems will be allowed to carry only 1 warhead
- Warhead is inferior to Peacekeeper warhead, so the Air Force plans to modify Minuteman to carry warheads (1 each missile) from Peacekeeper missiles that will be retired due to START II
- Maintenance can be very dangerous--requires special protective clothing
- Due to age, the Minuteman system will require extensive refurbishment of missiles, launch facilities, and support equipment

(Left:) This Minuteman's "hot-launch" created a smoke ring from the silo.

Launch Control Center of older variant, Minuteman II.

Recently-developed protective clothing for Minuteman III maintenance.

LGM-118A Peacekeeper

Capabilities:
- Can deliver 10 independently-targeted warheads with greater accuracy than any other ballistic missile
- Cold-launch technique doesn't destroy the silo--silo can be reused

Distinguishing Characteristics:

- 4-stage rocket
- All stages are the same width (unlike Minuteman)
- "Cold-launched": Peacekeeper is forced out of its silo by steam pressure--Ignition occurs at an altitude of about 80 feet (unlike Minuteman)
- Protected inside its silo with nine rows of Teflon-coated polyurethane pads, which fall away after Peacekeeper is launched

Limitations:
- Although cold-launch technique doesn't destroy the silo, assembling Peacekeeper in its silo is a difficult, time-consuming task
- Once they're launched, they can't be recalled (like bombers can)
- Under the terms of the second Strategic Arms Reduction Treaty (START II), all Peacekeeper systems are scheduled to be retired

(Left:) Multiple-warhead reentry vehicle being assembled for Peacekeeper.

Missile launch crew turning the launch keys.

Peacekeeper after ignition. Notice the Teflon-coated polyurethane pads falling off.

KC-135 Stratotanker

Distinguishing Characteristics:

- Based on Boeing 707 airframe; similar to basic commercial airliner
- 4 engines on wing pylons (unlike KC-10)
- Refueling boom on underside of aft fuselage
- Can also be configured with additional wing-mounted hose-and-drogue refueling pods

Capabilities:

- Refueling boom can be fitted with hose-and-drogue system
- Wings can be fitted with hose-and-drogue refueling pods; with these pods, KC-135 can refuel Navy, Marine, NATO, and allied aircraft that use the drogue system, and (in the same mission) aircraft (such as Air Force aircraft) with refueling receptacles that require the boom
- Can also carry cargo (83,000 pounds max) or up to 57 passengers
- Long unrefueled range & time aloft
- Can also be air refueled by KC-10 or another KC-135: Increases range, minimizes forward basing requirement, and preserves vital fuel supplies in the theater of operations
- To upgrade the aging fleet, all KC-135 will get integrated INS/GPS navigation systems
- Large inventory (547 aircraft)

Limitations:

- Unarmed and slow--vulnerable to attack
- Currently, only some have been fitted with wing-mounted hose-and-drogue pods
- If the refueling boom is fitted with the hose-and-drogue system, the KC-135 can't be used to refuel Air Force aircraft that require the boom

KC-135 refuels F/A-18 Hornet with a drogue fitted to the boom.
(Note that the F/A-18's refueling probe is retractable. Some aircraft--like the EA-6B Prowler and several helicopters--can't retract their refueling probes.)

KC-10 Extender

Distinguishing Characteristics:

- Based on DC-10 airframe; similar to commercial airliner
- 3 engines (2 on wings, 1 on tail)
- Refueling boom on the underside of the aft fuselage

Capabilities:

- Fitted with both drogue and boom refueling equipment on the underside of the aft fuselage, so KC-10 can refuel Air Force, Navy, Marine Corps, and allied nations' aircraft in the same mission
- Some also include wing-mounted drogue systems to increase simultaneous capability
- Can carry almost twice as much fuel as the KC-135
- Can also carry 170,000 pounds of cargo and up to 75 passengers--much more than KC-135
- Long unrefueled range & time aloft
- Can also be air refueled by KC-135 or another KC-10: Increases range, minimizes forward basing requirement, and preserves vital fuel supplies in the theater of operations

Limitations:

- Unarmed and slow--vulnerable to attack
- Limited inventory (59 aircraft)

KC-10 refuels EA-6B Prowler with a drogue from its integral hose reel/drogue unit, located in the tail. Note that the boom is stowed.

KC-10 with wing-mounted hose-and-drogue refueling pods simultaneously refuels F/A-18 Hornet and EA-6B Prowler.

C-130 Hercules

Distinguishing Characteristics:

- 4 turboprop engines (propellers driven by jet engines)
- Short, cylindrical fuselage
- Low horizontal stabilizer (tail doesn't look like a "T")

Capabilities:

- Can use short, rough runways--prime transport for troop/equipment airdrops in hostile areas
- Can carry a maximum of 45,000 pounds of cargo or up to 92 passengers
- Can also be configured to medevac up to 74 litters
- More than 40 variants--easily adaptable to perform many military and civilian missions

MC-130P Combat Shadow flies clandestine missions to provide air refueling for special operations helicopters--flies mostly at night to reduce probability of detection and attack.

Limitations:

- Slow, and size & shape make it easy for enemy radars to detect: Vulnerable to attack
- Some variants are armed, but none carry air-to-air missiles: Unable to destroy enemy fighters
- Standard cargo C-130 variant isn't air-refuelable (some special mission variants are refuelable)

WC-130 is a weather reconnaissance variant flown by the Air Force Reserves. The redesigned nose houses special weather equipment and radar.

HC-130 is an extended-range combat search and rescue variant It can stay aloft 18 hours and extend the range of combat search and rescue helicopters by providing air refueling

Variants of the C-130 (continued)

MC-130E/H Combat Talon is equipped with terrain-following and terrain-avoidance radar--can transport and resupply special operations forces, and can locate small drop zones more accurately and airdrop troops and cargo faster than possible for a standard C-130.

AC-130 Gunship can use a television sensor, infrared sensor, and radar to identify targets day or night, in any weather, and can destroy them with machine gun, 40mm cannon, and 105mm cannon.

EC-130H Compass Call can jam and disrupt enemy communications--note the web of antennae above and below the tail.

EC-130E Commando Solo is an airborne television and radio studio, used for psychological operations (PSYOPS). Note the special X-shaped antenna attached to the vertical stabilizer. Commando Solo is flown only by the Air National Guard's 193d Special Operations Wing, Harrisburg, PA.

Controllers on board an EC-130E Airborne Battlefield Command and Control Center (ABCCC).

EC-130E Airborne Battlefield Command and Control Center (ABCCC).

Note: Both the ABCCC and Commando Solo share the designator "EC-130E."

C-5 Galaxy

Distinguishing Characteristics:

- Entire nose section hinges open
- Largest DoD aircraft
- Similar in appearance to the smaller C-141 (but much larger)

Capabilities:

- Only AF transport with front-and-rear loading doors--can load and off-load simultaneously, since the nose and aft doors open to the cargo compartment's full width & height and there are full-width drive-on ramps at each end for loading double rows of vehicles
- Only AF transport that can carry virtually every piece of Army combat equipment--including such heavy oversized items as the 74-ton mobile scissors bridge
- Landing gear struts can "kneel down" to facilitate loading directly from truck bed levels
- Crew accommodations include a rest area for 15 people, simplifying relief crew logistics
- Can carry a maximum of 291,000 pounds of cargo or up to 340 passengers
- Can air-drop platforms weighing up to 42,000 pounds

Limitations:

- Long runway requirements, especially when fully loaded with cargo and fuel
- Poor reliability and maintainability history
- Scheduled for retirement this decade
- Unarmed and slow--vulnerable to attack

C-5 crew unloading an Army UH-60L Black Hawk helicopter.

C-141 Starlifter

Distinguishing Characteristics:

- Similar in appearance to the C-5 (but much smaller)
- Fuselage is slender in proportion to its length (more so than C-5)

Capabilities:

- Can carry a maximum of 69,000 pounds of cargo (more in wartime) or up to 200 passengers
- Can also be configured to medevac up to 103 litters & 14 medical personnel
- Holds the world record for heavy cargo air drops: 70,195 pounds

Limitations:

- Unarmed and slow--vulnerable to attack
- Can't carry some of the heaviest items that the C-5 can carry
- Aging airframes--increasing trouble with reliability and maintainability
- Scheduled for retirement this decade

C-141 deploys flares to protect itself from attack from heat-seeking missiles.

C-17 Globemaster

Distinguishing Characteristics:

- Air Force's only large transport aircraft with winglets (small vertical extensions of wingtips)

Army paratroopers prepare to jump from a C-17.

Capabilities:

- Can back up (taxi in reverse), thanks to engines' thrust-reversing capability
- Can operate in relatively short, narrow airfields previously restricted to C-130s
- Even on such small airfields, able to turn around, using three-point turn & its ability to back up
- Can carry a maximum of 170,900 pounds of cargo or up to 102 passengers
- Can also be configured to medevac up to 48 litters & 54 medical personnel (or passengers)
- Can air-drop platforms weighing up to 60,000 pounds

Limitations:

- Unarmed and slow--vulnerable to attack
- Can't carry some of the heaviest items that the C-5 can carry

(Left:) C-17 crew and Army personnel unload a Bradley Fighting Vehicle at Tuzla, Airfield, Bosnia-Herzegovina.

F-15C Eagle / F-15E Strike Eagle

(F-15C)

Distinguishing Characteristics:

- 2 parallel vertical stabilizers (or, "tails") perpendicular to the wings
- No wingtip missile rails
- 2 engines
- 2 rectangular inlets--top edge extends almost to canopy's midpoint
- F-15C has 1 seat (but there is a 2-seat trainer variant)
- F-15E has 2 seats

Capabilities:

- Both: High speed and maneuverability, superb thrust-to-weight ratio--excellent dogfighters
- Both models have an internal gun and can carry a wide variety of air-to-air missiles
- F-15E can also carry any air-to-surface weapon in AF inventory (nuclear & conventional)
- F-15E uses the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) system (2 pods) to fly at low altitudes and attack ground targets at night and in bad weather

Limitations:

- Enemy radar can detect F-15 easier than it can detect other fighters, due to F-15's size & shape
- When carrying a heavy load of bombs, F-15E loses some of its maneuverability
- Carrying more weapons--or lighting the engine's afterburner to increase performance--decreases any fighter's range and duration: "The tougher the fight, the shorter the flight."

F-15C Eagle--the single-seat variant. Note: F-15 has no wingtip missile rails.

F-15E Strike Eagle: Note the 2-person cockpit (includes Pilot and Weapon Systems Officer) and darker paint scheme than F-15C.

F-16C/CJ Fighting Falcon

(F-16C)

Distinguishing Characteristics:

- 1 vertical stabilizer ("tail")
- Wingtip missile rails
- 1 engine
- 1 mouth-shaped inlet underneath the forward fuselage
- 1 seat (except for 2-seat trainer)

Capabilities:

- High speed and maneuverability--an excellent dogfighter
- Multirole aircraft--can attack both air and surface targets
- Relatively small size plus some stealthy shaping help decrease the maximum range at which enemy radar (air or ground) can detect and track the F-16
- Both models have an internal gun and carry both air-to-air missiles and air-to-surface weapons
- Both models use the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) system (2 pods) to fly at low altitudes and attack surface targets at night and in bad weather
- F-16CJ is also specially fitted to deploy High-speed Anti-Radiation Missiles (HARM) to attack enemy surface-to-air missile (SAM) sites: HARM homes in on the SAM site's radar emissions

Limitations:

- Short range and endurance ("Relatively small size" means limited internal fuel capacity)
- Unable to carry as many varieties of air-to-surface weapons as the F-15E
- If the enemy turns off the ground radar, HARM loses its guidance (and misses the target)

LANTIRN system on a Fighting Falcon. The 2 pods hang below the engine inlet.

F-16CJ: The missile next to the drop tank is a High-speed Anti-Radiation Missile (HARM).

F/A-18C Hornet / F/A-18E Super Hornet

(F/A-18C Hornet)

Distinguishing Characteristics:

- 2 vertical stabilizers (tails) in a "V" shape (not parallel)
- Wingtip missile rails
- 2 engines
- 2 inlets located beneath the wing root forward extensions
- F/A-18C Hornet has round inlets
- F/A-18E Super Hornet has rectangular inlets
- F/A-18E is larger than F/A-18C
- Both: 1 seat (except for 2-seat trainers)

Capabilities:

- Flown by the Navy and Marine Corps
- Can operate from aircraft carriers as well as bases and expeditionary airfields
- High speed and maneuverability--an excellent dogfighter
- Multirole aircraft--can attack both air and surface targets (which include ships)
- Both models have an internal gun and carry both air-to-air missiles and air-to-surface weapons, including most of the weapons Air Force fighters carry (which also include anti-ship missiles)
- Both models use a Navy system similar to the Air Force's Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) to fly at low altitudes and attack surface targets at night and in bad weather
- Both models are also specially fitted to deploy High-speed Anti-Radiation Missiles (HARM) to attack enemy surface-to-air missile (SAM) sites: HARM homes in on SAM site radar emissions
- F/A-18E Super Hornet replaces the now-retired A-6 Intruder, and will replace the F-14 Tomcat

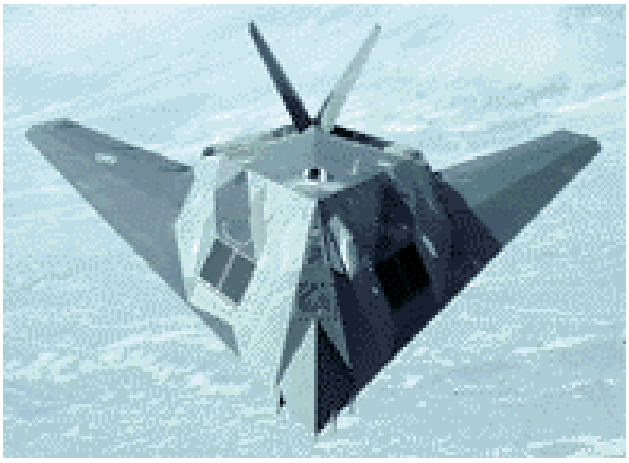
Limitations:

- Limited range and endurance (F/A-18C's is even less than the F-16's)
- If the enemy turns off the ground radar, HARM loses its guidance (and misses the target)

F/A-18C Hornet on an aircraft carrier. Note its round engine inlet.

F/A-18E Super Hornet: Note its rectangular engine inlet.

F-117 Nighthawk



Distinguishing Characteristics:

- 2 small vertical stabilizers (tails) in a "V" shape (not parallel)
- No external weapons or rails
- Engine inlets and nozzles are masked
- Straight leading edges
- Intersecting flat surfaces give the F-117 a uniquely angular shape

Capabilities:

- Shaped to be as stealthy as possible--painted with special coatings, too (like the B-2)
- All weapons carried in internal weapons bays to minimize radar reflection (like F-22 and B-2)
- Above features--plus "masked" engine inlets and nozzles--help F-117 avoid detection from both enemy radars and heat-seeking systems
- Sophisticated navigation & attack systems reduce pilot workload: F-117's automated mission planning system & autopilot can be programmed to avoid known threats on the way to the target
- Can carry a variety of air-to-surface weapons

Limitations:

- Very slow, and not very maneuverable: Vulnerable to attack, if detected
- Requires highly-detailed mission planning to avoid all potential threats on its way to the target
- Can attack only at night--relies solely on stealth technology and darkness for defense
- Carries only air-to-surface weapons: Unable to destroy enemy fighters
- F-117's stealthiness will momentarily decrease for the short time its weapons bay is open
- Limited weapons bay space--typically carries only 2 2,000-pound bombs
- Requires special maintenance to keep its special coatings in good condition

Side view (above) shows F-117's peculiar shape.

(Left:) F-117's straight leading edges and triangular silhouette stand out against the daytime sky.

A-10 Thunderbolt

Distinguishing Characteristics:

- 2 parallel vertical stabilizers (or, "tails")--one on each end of a rectangle-shaped horizontal stabilizer
- Unswept (straight) rectangular wings
- 2 large engines attached to the upper half of the rear fuselage
- Large multi-barreled gun protrudes from the nose of the A-10

Capabilities:

- Can loiter over target area up to 2 hours unrefueled (depending on distance to base or refueling)
- Can loiter longer & maneuver better at slow speeds than F-16--supports troops closer than F-16
- 30mm nose cannon can destroy tanks a mile away--carries 1,350-rounds; fires 65 per second
- Can carry gun pods for additional firepower, plus a wide variety of air-to-surface weapons
- With pods, can perform some electronic self-protection jamming against enemy radar
- Can carry heat-seeking air-to-air missiles to destroy enemy fighters within visual range
- Can survive heavy ground fire--titanium shielding protects pilot; self-sealing fuel tanks
- Can operate at night with night vision goggles

Limitations:

- Can't carry radar-guided air-to-air missiles--can't destroy enemy fighters beyond visual range
- Vulnerable to attack by enemy fighters and ground fire, due to low top speed

A-10 firing its 30mm gun (above) and an air-to-surface missile (below).

A-10s carrying air-to-air missiles (on the outermost pylon).

EA-6B Prowler

Distinguishing Characteristics:

- Big pod on top of vertical stabilizer
- Unretractable refueling probe centered in front of windscreen
- 2 canopies, 1 in front, 1 in back
- Crew of 4 sits in pairs, side-by-side
-Teardrop-shaped fuselage (when viewed from the side)
- 2 engines with oval-shaped inlets

Capabilities:

- Flown by the Navy and Marine Corps (with some Air Force crewmembers)
- Can operate from aircraft carriers as well as bases and expeditionary airfields
- Can fly in bad weather, and has a longer unrefueled range than many fighters
- Can support all electronic countermeasures (ECM) and jamming missions DoD-wide
- Specially fitted to deploy High-speed Anti-Radiation Missiles (HARMs) to attack enemy surface-to-air missile (SAM) sites: HARM homes in on the SAM site's radar emissions
- Zone ECM suppresses enemy air defenses, providing umbrella of protection over strike aircraft, ground troops, and ships by jamming enemy radar, electronic data links, and communications
- Can obtain tactical electronic intelligence within the combat area for further analysis

Limitations:

- Operates at low altitudes in enemy airspace, at relatively low speeds: Vulnerable to attack
- Carries only HARMs: Unable to destroy enemy fighters

EA-6B refuels from a KC-10. In addition to a fuel tank and ECM pods, this Prowler carries a HARM.

Note the distinctive teardrop-shaped fuselage.

B-52 Stratofortress

Distinguishing Characteristics:

- 8 engines--4 nacelles with 2 engines each, on underwing pylons
- Long, tube-shaped fuselage
- Wide wingspan; swept-back wings
- Special wingtip landing gear keeps wingtips from dragging on runway
- Radomes installed behind the tail
- Infrared and optical equipment in pods under the "chin"

Capabilities:

- Fully loaded, B-52 has much longer unrefueled range than a loaded B-1 or B-2
- Can carry both conventional and nuclear air-to-surface weapons
- Can carry weapons both internally and externally (on underwing pylons)--can launch cruise missiles from these pylons at high altitudes, then descend and drop bombs at low altitudes
- Can deploy sea mines in a naval support mission
- Can perform some electronic self-protection jamming against enemy radar
- Can fly at low altitudes with night vision goggles & the infrared/TV equipment in the chin pods

Limitations:

- Size and shape make it easy for enemy radars to detect
- Slow, and not very maneuverable: Vulnerable to attack
- Carries only air-to-surface weapons: Unable to destroy enemy fighters
- Requires a longer runway than the B-1 and B-2 need
- Advancing age is driving up maintenance costs and support requirements

- (Above:) B-52 with full flaps for additional lift at take-off. Note (right) retracting wingtip landing gear. Also note the weapons hanging on pylons attached to the wings (between the fuselage and the engines).

B-1 Lancer

(B-1 with wings swept back; venting fuel.)

Distinguishing Characteristics:

- Swing-wing design: swept back at high speeds; forward for low speed, take-off, & landing; middle for cruise
- 4 engines--2 nacelles with 2 engines in each, underneath fuselage
- Tapered, "coke-bottle" fuselage (when viewed from the side)

Capabilities:

- Swing-wing and special shape reduce aerodynamic drag--our only supersonic heavy bomber
- Can carry both conventional and nuclear air-to-surface weapons
- Can carry heavier weapons load than the B-2 or B-52 can
- Can avoid enemy radar detection significantly better than B-52 can, due to its special shape
- Can perform some electronic self-protection jamming against enemy radar
- Can fly at low altitudes with automatic terrain-following radar system
- Can carry external weapons (but we use B-52 for these weapons, instead)

Limitations:

- Very poor reliability and maintainability record; chronic shortage of spare parts
- Easier to detect than B-2--relies on a towed decoy for protection from radar-homing missiles
- Carries only air-to-surface weapons: Unable to destroy enemy fighters

(Above:) B-1 with wings spread for low-speed flight.

(Left:) B-1 dropping bombs and deploying a flare for protection against heat-seeking missiles.

B-2 Spirit

Distinguishing Characteristics:

- "Flying wing" design
- No vertical stabilizer (tail)
- No external weapons or rails
- Engine inlets & nozzles are "masked," and on upper surface
- Straight leading edges
- Straight trailing edge segments
- Trailing edge segments are parallel with each other
- Upper & lower wing body is rounded & smoothed

Capabilities:

- Shaped to be as stealthy as possible--painted with special coatings, too (like the F-117)
- All weapons carried in internal weapons bays to minimize radar reflection (like F-117 & F-22)
- Above features--plus "masked" engine inlets and nozzles--help B-2 avoid detection from both enemy radars and heat-seeking systems; can attack previously impenetrable defenses
- Can carry both conventional and nuclear air-to-surface weapons--up to 16 2,000-pound bombs
- Requires fewer crewmembers (2 total) than B-1 (4 total) and B-52 (5 total)

Limitations:

- Slow, compared to fighters, and not very maneuverable: Vulnerable to attack, if detected
- Carries only air-to-surface weapons: Unable to destroy enemy fighters
- B-2's stealthiness will momentarily decrease for the short time its weapons bay is open
- Can attack only at night--relies solely on stealth technology and darkness for defense
- Requires special maintenance to keep its special coatings in good condition

Note the roundness of B-2's upper & lower body.

Note the alignment of leading edges and trailing edge segments of the B-2.

E-3 Sentry--Airborne Warning and Control System (AWACS)

Distinguishing Characteristics:

- Large, rotating radar dome installed 11 feet above aft fuselage
- Airframe based on KC-135

Capabilities:

- Can perform airborne surveillance, early warning, target identification and tracking, weapons control, air battle management, and communications functions for a wide battlespace
- Jam-resistant radar--has performed successful missions in enemy electronic countermeasures
- Can stay aloft for about 11 hours, unrefueled
- Can track low-flying targets at a range of more than 200 miles (farther for higher targets)
- Can also provide position and tracking information on enemy ships
- Can track the location and status of friendly aircraft and naval vessels
- Can provide direct information needed for interdiction, reconnaissance, airlift, and close-air support for friendly ground forces; can also direct friendly fighters to intercept enemy aircraft

Limitations:

- Unarmed and slow--vulnerable to attack

E-3 crewmembers at their stations.

E-4 National Airborne Operations Center (NAOC)

Distinguishing Characteristics:

- Airframe based on Boeing 747
- Teardrop-shaped radome attached to the upper fuselage, just forward of the wings

Capabilities:

- E-4B is National Command Authorities' (NCA) National Airborne Operations Center (NAOC)
- Provides a highly-survivable command, control, and communications center to direct US strategic forces and execute Emergency War Orders by the NCAs in the event of national emergency or destruction of ground-based command and control centers
- Contains 6 functional areas: NCA work area, conference room, briefing room, operations team work area, communications control area, and technical control and rest area
- Crew may include up to 114 people, including a joint-service operations team, ACC flight crew, maintenance and security component, and communications team
- Has electromagnetic pulse (EMP) protection--equipment can function in nuclear war conditions
- Has satellite communications system for worldwide communications
- At least one E-4B and staff are always on alert
- Also supports the Federal Emergency Management Agency (FEMA) when a natural disaster occurs--E-4B flies FEMA response team to the disaster site and serves as the command and control center until the FEMA team can set up their own equipment: Cuts down response time
- Can stay aloft for about 12 hours, unrefueled

Limitations:

- Unarmed and slow--vulnerable to attack

Note the radome on the upper fuselage.

The Boeing 747-based E-4B is much larger than the KC-135.

E-8 Joint Surveillance and Target Attack Radar System (Joint STARS)

Distinguishing Characteristics:

- 40-foot-long canoe-shaped radome under the forward fuselage
- Airframe based on KC-135

Capabilities:

- Can locate, identify, and track enemy and friendly ground forces in all weather conditions
- Supports targeting and attack operations, including attack aviation and naval & field artillery
- Radar can operate in several modes, providing wide area surveillance, moving target indicator, sector search, radar imagery, and bomb damage assessment
- Can detect targets at ranges up to 150 miles, depending on operating mode
- Can provide a 120-degree field of view covering almost 20,000 square miles
- Has some limited ability to detect helicopters, rotating antennas, and low, slow-flying aircraft
- Can relay real-time information via a secure jam-resistant surveillance and control data link to the Army's mobile Ground Station Modules and AH-64D Apache Longbow attack helicopters
- Can also relay to other ground command, control, communications, computers and intelligence (C4I) nodes beyond line-of-sight via ultra high frequency satellite communications
- Jam-resistant radar--can perform successful missions in enemy electronic countermeasures
- Can stay aloft for about 11 hours, unrefueled

Limitations:

- Unarmed and slow--vulnerable to attack

Army intelligence specialist receiving real-time data from E-8 over Bosnia.

E-8 and two of its partners in ground combat: the Ground Station Module and Apache.

U-2 Dragon Lady

Distinguishing Characteristics:

- Long, tube-shaped fuselage
- Long, unswept (straight) wings
- Special wingtip landing gear keeps wingtips from dragging on runway
- 1 engine with oval-shaped inlets on each side of the fuselage
- Can carry long, tube-shaped reconnaissance pods on each wing

Capabilities:

- Can fly at extremely high altitudes (above 70,000 feet)
- Can stay aloft, unrefueled, for over 14 hours--can fly more than 4,500 miles unrefueled
- Can carry a wide variety of sensors and cameras, providing continuous day and night, all-weather area surveillance and reconnaissance, including multi-sensor photography and electro-optic (that is, video), infrared, and radar imagery

Limitations:

- Unarmed; limited speed and maneuverability--vulnerable to attack from high-altitude fighters
- Vulnerable to attack from modern high-altitude surface-to-missiles (SAMs)

U-2 carrying pods with reconnaissance and surveillance equipment.

RC-135 Cobra Ball / Combat Sent / Rivet Joint

Rivet Joint

Distinguishing Characteristics:

- Airframe based on KC-135
- Extended nose or tail radome
- Rectangular radomes on both sides of the forward fuselage

Capabilities:

- Can perform highly-specialized reconnaissance missions worldwide:
- Rivet Joint can work with E-3 AWACS during combat to provide direct, near-real-time electronic warfare support & reconnaissance data to theater commanders and combat forces
- Rivet Joint also loiters near battlefields to provide data on enemy air defense systems to assist crews of F-16CJ aircraft with their Suppression of Enemy Air Defense (SEAD) mission
- Combat Sent can measure and analyze foreign electronic and infrared (IR) equipment
- Cobra Ball can track missile launches with wide-area IR sensors, long-range optical telescopes, and advanced systems that can locate missile launch 250 miles away & calculate its impact point

Limitations:

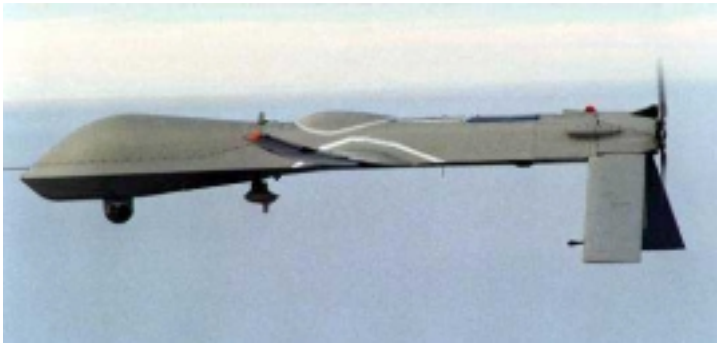
- Unarmed and slow--vulnerable to attack

RC-135 Rivet Joint

RC-135 Combat Sent. Note the smaller nose, and extra tail radome.

RC-135 Cobra Ball. Note the bar-shaped side radomes (instead of one rectangular radome).

RQ-1A Predator



Distinguishing Characteristics:

- 2 rectangular vertical stabilizers (tails) in a downward-pointing "V"
- Another short rectangle in between the 2 tails, pointing straight down
- "Pusher" propeller behind the tail
- Teardrop-shaped forward fuselage
- Long, thin, rectangular wing

Capabilities:

- Remotely piloted--can fly in high-risk areas without endangering crewmembers
- Can loiter 25,000 feet high (usually 10,000 to 15,000) at point 1,000 miles away (usually 500)
- Can fly 80 mph & loiter far longer than U-2--can remain aloft 40 hours, & on-station over 24
- Carries a variety of equipment: electro-optical (for real-time video), infrared (to locate heat concentrations) and synthetic aperture radar (to see targets through clouds or foliage)
- Can transmit television-quality videos by satellite within 2 seconds to 34 stations worldwide, including allied & US forces' headquarters, NATO, UN forces, USAFE, and the Pentagon
- Can capture still photographic images from the video
- Has already performed several successful missions, including NATO force protection, search and rescue, target acquisition, battle damage assessment, and peacekeeping support
- Can send real-time intelligence directly to cockpits to help aircrews prepare attacks

Limitations:

- Not autonomous, like Global Hawk: Requires full-time hands-on flight control by ground crew
- Generally designed for permissive environment: Vulnerable to enemy attack
- Its navigational coordinate system isn't precise enough to be used as a reference for targeting GPS-guided bombs--Predator can help target GPS bombs only when its imagery is matched with satellite images and digital terrain data

Air Vehicle Operator's station in the Predator's ground control van.

Note the short, rectangular tail surface between the downward-pointing "V" tails.

RQ-4A Global Hawk

Distinguishing Characteristics:

- 2 vertical stabilizers (tails) in a upward-pointing "V" (unlike Predator)
- 1 jet engine & inlet on top of fuselage
- Whale-shaped forward fuselage
- Long, narrow wings

Capabilities:

- Remotely piloted--can fly in high-risk areas without endangering crewmembers
- Can fly farther & nearly as high as U-2--loiters over 67,000 feet high at point 3,450 miles away
- Can fly 400 mph & loiter far longer than U-2--can remain aloft 40 hours, & on-station over 24
- Can fly autonomously from takeoff to landing--missions can be pre-programmed
- Can survey an area the size of Illinois (40,000 square miles)--larger area than E-8 can survey
- Radar can operate in several modes, providing wide area surveillance, radar imagery, moving target indicator (tracks targets as they move on the ground)--also uses infrared sensors & video
- Can downlink imagery directly to Air Force, Army, Navy, & Marine units in the field or at sea
- Users can provide re-tasking requests directly from the battlefield via a common data link
- Control can pass back and forth between launch & recovery units and a mission control element

Limitations:

- Larger than Predator; not designed for stealth: Vulnerable to enemy detection
- Not yet operationally deployed--still in flight-test phase
- Expensive: Program has already exceeded projected costs

UH-60A/L Black Hawk / HH/MH-60G Pave Hawk

Distinguishing Characteristics:

- Non-retractable landing gear
- Horizontal stabilizer below the tail rotor--extends to both sides
- Black Hawk: no refueling probe
- Pave Hawk has a semi-retractable refueling probe

Capabilities:

- Black Hawk, operated by Army, typically doesn't have special operations equipment installed, such as the equipment on Pave Hawk (listed below)--Army uses Black Hawk for troop transport
- Can perform all-weather, nighttime, low-level, long-range, undetected missions in enemy areas
- Can perform combat search & rescue, and can transport & resupply special operations forces
- Can follow terrain contours and avoid obstacles by using forward-looking infrared sensor, along with night vision goggles and compatible displays in the cockpit
- Can integrate on-board navigation equipment with off-board computers and intelligence via over-the-horizon satellite communications
- Can detect enemy radar and missile threats and dispense chaff & flares (radar & heat-seeking missile countermeasures) in either automatic, semi-automatic, or manual modes
- Can carry 2 machine guns--either 7.62mm or .50 caliber, or one of each
- Can extract people or 8,000 pounds of cargo without landing by using external cargo hook
- Can transport 11-14 troops or 6 litters
- Much faster than Pave Low

Limitations:

- Much shorter unrefueled range than Pave Low
- Can't perform electronic self-protection jamming against enemy radar
- Requires highly-detailed mission planning to avoid threats

Black Hawk--note lack of refueling boom.

Close-up of the .50 caliber machine gun on Special Operations Pave Hawk.

MH-53 Pave Low

Distinguishing Characteristics:

- Retractable landing gear
- Large "wheel pants" on both sides of fuselage to house landing gear
- Horizontal stabilizer is near the tail rotor's center--extends only to right side (viewed from behind)
- Semi-retractable refueling probe

Capabilities:

- Largest and most powerful helicopter in Air Force inventory
- Can perform all-weather, nighttime, low-level, long-range, undetected missions in enemy areas
- Can perform combat search & rescue, and can transport & resupply special operations forces
- Can follow terrain contours and avoid obstacles by using terrain-following/terrain-avoidance radar and forward-looking infrared sensor, along with a projected map display in the cockpit
- Can perform some electronic self-protection jamming against enemy radar
- Can integrate on-board electronic warfare and jamming equipment with off-board computers and intelligence via over-the-horizon satellite communications
- Equipped with armor plating for protection against ground fire
- Can carry 3 machine guns--either 7.62mm or .50 caliber, or a combination of both
- Can extract people or 20,000 pounds of cargo without landing by using external cargo hook
- Can transport 38 troops or 14 litters
- Has much longer unrefueled range than Pave Hawk

Limitations:

- Much slower than Pave Hawk
- Requires highly-detailed mission planning to avoid threats

Pave Low using hoist and stretcher to pick up troops during a rescue evacuation exercise.