DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

HQ USAF/A3W
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Washington DC, 20330-1490

Montana Clean Resources Committee
216 Kienas Road
Kalispell, Montana 59901

Dear Ms. Johnson,

This is in response to your July 11, 2022 letter to the U.S. Secretary of Defense, Lloyd Austin, regarding military use of weather modification and "chemtrails". The United States Air Force receives a number of such inquiries and welcomes the opportunity to set the record straight.

The U.S. Air Force does not conduct or engage in weather modification in accordance with the Convention on the Prohibition of Military or other Hostile Use of Environmental Modification Techniques (ENMOD) Treaty, ratified in 1980, which is cited in the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3810.01F, Enclosure D, 23 Apr 2019, U.S. Government Policy Regarding Weather Modification. Environmental modification techniques to include the deliberate manipulation of natural processes, the dynamics, composition, or structure of the Earth, including its biota, lithosphere, hydrosphere, and atmosphere are strictly prohibited.

Additionally, what may be perceived as cloud seeding, weather modification, or "chemtrails" emanating from U.S. Air Force aircraft is in reality, condensation trails, or "contrails". Contrails consist of ice particles formed around particulate matter (soot) or aerosol particles in the exhaust gases of turbine or piston engine aircraft. The formation of contrails is dependent on certain atmospheric conditions, primarily relative humidity at the aircraft's altitude. While some contrails last only a few seconds, others can last for several hours if the atmospheric conditions and stability are just right at the level the contrail is formed. On occasion, during military operations and exercises, aircraft will release defensive flares and chaff, or dump fuel during aircraft emergencies, however, these occurrences are rare over U.S. air space. Contrails are simply the by-products of aircraft engines—military, commercial, and private—condensing at high altitudes.

We appreciate your interest in this matter and trust the attached information provided is useful.

Sincerely

CHARLES B. McDANIEL, Brig Gen, USAF
Director of Weather
Deputy Chief of Staff, Operation

CONTRAILS FACTS

The Air Force operates many aircraft and space systems that are constantly interacting with the environment. Atmospheric interactions such as exhaust gases forming contrails, chaff and flares deployment that produce smoke, aerial pest or weed control spraying, or in-flight emergency fuel releases usually have very minor environmental impacts over a very limited geographical area. This site provides basic information and links about contrails, aircraft and space launch exhaust emissions, chaff and flares, aerial spraying, in-flight emergency procedures, and related topics.

Aircraft, engines, chaff, and flares can produce a variety of condensation patterns (or contrails), exhaust plumes, vapor trails, or smoke patterns. The exhaust emissions produced by aircraft and space launch vehicles can produce contrails that look very similar to clouds which can last for only a few seconds or as long as several hours. Vapor trails are formed only under certain atmospheric conditions and create a visible atmospheric wake similar to a boat propeller in water and usually dissipate very rapidly. Chaff and flares produce unique smoke patterns that are visibly different than a contrail but have the same color and appearance as a cloud but which also typically dissipates very quickly. Aerial spraying for pest or weed control and fire suppression are the only Air Force activities which involve aircraft intentionally spraying chemical compounds (insecticides, herbicides, fire retardants, oil dispersants). In the case of an in-flight emergency, jet fuel may be released to lighten the landing weight and minimize the risk of fire if the aircraft should crash.

Background

The US military has played a significant historical role in the development of aircraft and space launch vehicles, airspace management, environmental management, and public land management procedures. In the earliest years of aviation and rocketry and up through the late 1980s, the military owned and operated the majority of the United States aircraft and space launch fleets. Since the end of the 1991 Persian Gulf War, the USAF has been in a drawdown and restructuring mode. In 1990, there were approximately 9,059 aircraft in the Air Force inventory and approximately 6,126 aircraft in 2000. Of the approximately 6,228 aircraft in the USAF fleet in 1998, 4,447 were assigned to active duty Air Force installations and 1,781 were assigned to Guard and Reserve units, usually co-located at municipal airports. For a more detailed discussion on the changing nature of military and civilian aviation, see A Review Of Military Aviation And Space Issues at http://www.felsef.org/dec99.htm.

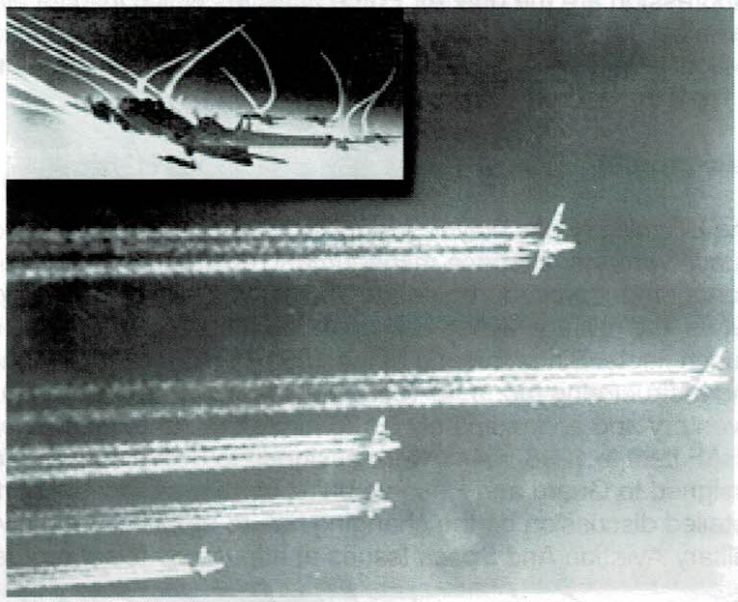
In the 1980s, commercial airline passenger service and satellite telecommunication growth resulted in an increase in civil aircraft and space booster fleets with numbers almost equivalent to the military (total of all services). Future projections for the next 15 years indicate that commercial aviation and space launch fleets will become larger than the military fleet.

The civil aviation fleet is projected to grow from 12,281 aircraft in 1997 to 25,998 in 2017. The assumptions on growth rates and types of aircraft are dependent on many changes in air traffic control, airspace management, and economic growth, but the general trend for civil aviation is increasing capacity by adding more frequent flights with smaller regional jets.

Aircraft fly along specific routes and corridors called the National Airspace System (NAS). The NAS is comprised of the air navigation routes and infrastructure across the United States that supports approximately 60,000 daily flights of commercial, general aviation, and military flights. The FAA is the lead federal agency charged with the operations and maintenance of the NAS. They manage over 5-million square miles of land routes and 23-million square miles of oceanic routes. The FAA must balance the safety and efficiency of the NAS on a daily basis. Many agencies and organizations are involved with the National Airspace System for a variety of purposes: civil air carriers, general aviation, military services, and research organizations. A typical snapshot of daily aircraft operations in the United States is shown below.

In the last ten years, there has been tremendous growth in the number of aircraft operated around the world. The majority of aircraft seen overhead are civilian flights, particularly near large cities. For a more detailed description of the NAS, see A Review Of Military Aviation And Space Issues: Aerospace And Airspace (Part II) at http://www.felsef.org/jan00.htm.

Condensation Trails ("contrails") from Aircraft Engine Exhaust



Contrails (short for "condensation trails") are line-shaped clouds sometimes produced by aircraft engine exhaust. The combination of high humidity and low temperatures that often exists at aircraft cruise altitudes allows the formation of contrails. Contrails are composed primarily of water (in the form of ice crystals) and do not pose health risks to humans. Contrails have been a normal effect of aviation since its earliest days. Depending on the temperature and the amount of moisture in the air at the aircraft altitude, contrails can either evaporate quickly or they can persist and grow. Engine exhaust produces only a small portion of the water that forms ice in persistent contrails. Persistent contrails are mainly composed of water naturally present along the aircraft flight path.

Aircraft engines emit water vapor, carbon dioxide (CO2), small amounts of nitrogen oxides (NOx), hydrocarbons, carbon monoxide, sulfur gases, and soot and metal particles formed by the high-temperature combustion of jet fuel during flight. Of these emittants, only water vapor is necessary for contrail formation. Sulfur gases are also of potential interest because they lead to the formation of small particles. Particles suitable for water droplet formation are necessary for contrail formation. Initial contrail particles, however, can either be already present in the atmosphere or formed in the exhaust gas. All other engine emissions are considered nonessential to contrail formation.

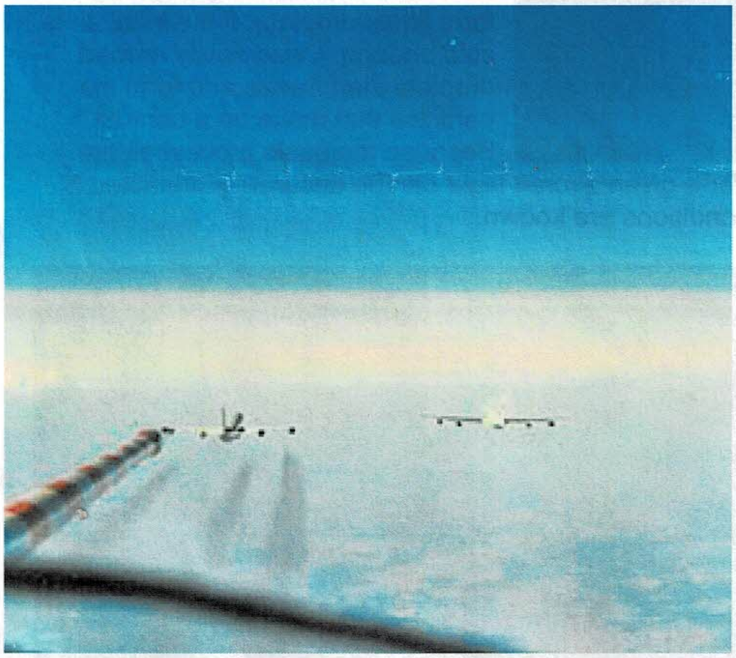
For a contrail to form, suitable conditions must occur immediately behind a jet engine in the expanding engine exhaust plume. A contrail will form if, as the exhaust gases cool and mix with surrounding air, the humidity becomes high enough (or, equivalently, the air temperature becomes low enough) for liquid water to condense on particles and form liquid droplets. If the local air is cold enough, these newly formed droplets then freeze and form ice particles that make up a contrail. Because the basic processes are very well understood, contrail formation for a given aircraft flight can be accurately predicted if atmospheric temperature and humidity conditions are known.

After the initial formation of ice, a contrail evolves in one of two ways. If the humidity is low, the contrail will be short-lived. Newly formed ice particles will quickly evaporate. The resulting contrail will extend only a short distance behind the aircraft. If the humidity is high, the contrail will be persistent. Newly formed ice particles will continue to grow in size by taking water from the surrounding atmosphere. The resulting line-shaped contrail extends for large distances behind an aircraft. Persistent contrails can last for hours while growing to several kilometers in width and 200 to 400 meters in height. Contrails spread because of air turbulence created by the passage of aircraft, differences in wind speed along the flight track, and possibly through effects of solar heating.

Thus, the surrounding atmosphere's conditions determine to a large extent whether or not a contrail will form after an aircraft's passage, and how it evolves. Other factors that influence contrail formation include engine fuel efficiency, which affects the amount of heat and water emitted in the exhaust plume.

Contrails become visible roughly about a wingspan distance behind the aircraft. Contrails can be formed by propeller or jet turbine powered aircraft. During WWII, large formations of bombers left strikingly remarkable contrail formations. Typical contrails are shown below.

The contrails formed by the exhaust at high altitude are typically white and very similar to cirrus clouds. As the exhaust gases expand and mix with the atmosphere, the contrail diffuses and spreads. It is very difficult to distinguish aged contrails from cirrus clouds. It is very difficult to distinguish aged contrails from cirrus clouds. At sunsets, these contrails can be visibly eye-catching and striking as they reflect the blue, yellow, and red spectrum of the reflected sunlight.



Persistent contrails are of interest to scientists because they affect the cloudiness of the atmosphere. Scientists in the United States, Europe, and elsewhere have studied contrail formation, occurrence, and persistence, and research efforts on these topics continue. Shown below is a photo taken from the research aircraft Falcon of the German Aerospace Center (Deutsches Zentrum fh r Luft- und Raumfahrt (DLR) at about flight level 33,300 feet of an Airbus A340 with contrails (left) and a Boeing 707 without contrails (right). This illustrates a scientific effort to evaluate the effects of different engine characteristics on contrail formation.

The Air Force uses a Boeing 707 airframe for the KC-135 refueling and E-3 AWACS aircraft. The KC-135 fleet is in the process of upgrading to newer engines which produce fewer emissions and noise.Scientific research on contrails was recently summarized by an international group of experts. This summary can be found in Chapter 3 of the report, "Aviation and the Global Atmosphere," published in 1999 by Cambridge University Press for the Intergovernmental Panel on Climate Change (IPCC). The report describes current knowledge regarding the effects of aircraft emissions on the global atmosphere. The full report is available from Cambridge University Press and a summary of this report is at www.ipcc.ch.

Wingtip Condensation Trails

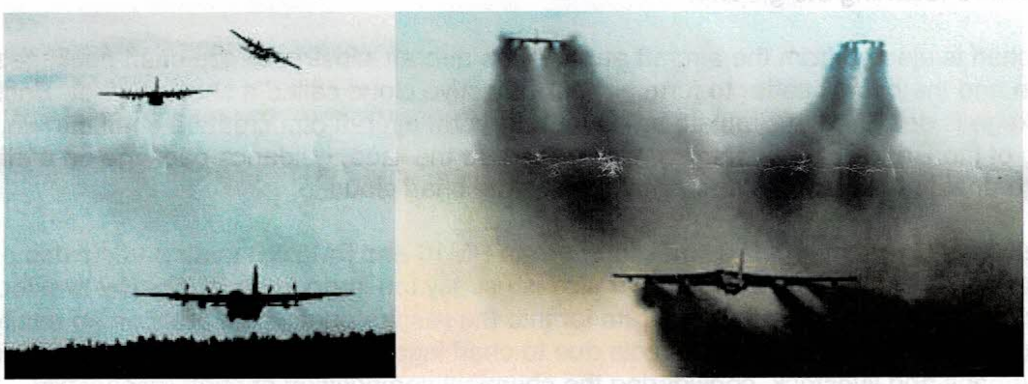
A different type of contrail or condensation trail is caused when a wing surface or winglet causes a cavitation of air in very humid conditions. This results in a unique vapor trail that is not formed due to exhaust gases. The next time you fly in a commercial aircraft through a rain cloud, look for the vapor trails that form over and around the wing. Typical fighter wingtip contrails are shown below.

Exhaust Gases and Emissions

Often, military aircraft can be seen taking off with a black smoke appearing from the engines. This smoke is mainly soot particles, similar to diesel engines. Commercial aircraft also produce the same type of soot particles, but usually not to the same degree as military aircraft. This is for two reasons: the type of fuel and the type of engines.

Most military aircraft use JP-8 jet fuel which is a blend of commercial Jet Aviation Fuel -1 (or Jet A-1) with three extra additives. The additives are used to control ice formation, control biogrowth (molds and slimes), and inhibit corrosion. The military uses these additives because of the unique environments the military operates in, the type of self-sealing fuel tanks used, and the type of metals, plastics, and sealant used on military aircraft. Several specialized aircraft like the SR-71 and U-2 use different fuels than JP-8, but are developed from the same base stock. Fuels research is always ongoing. The newest fuel being brought into production is JP-8+100. Dubbed JP-8+100 because the additive package can increase the thermal stability of military fuel by 100 degrees Fahrenheit, the improved fuel helps prevent gums and deposits that can foul fuel lines.

Military engines are also designed with different performance characteristics than commercial aircraft. Military aircraft and engines also tend to be older and less efficient than commercial aircraft and produce more emissions. Engines are optimized for fuel consumption and power rates at a particular cruising altitude. At take-off, the engines are usually very inefficient and produce more emissions than when at the optimal cruising altitude. Older military aircraft like the B-52 and C-130 can leave a black smoke exhaust even at cruising altitude, while aircraft like the KC-135R with new engines produce an invisible exhaust plume. Typical pictures of aircraft exhaust emission are shown below.



Space launch vehicles and missiles produce a different type of exhaust than aircraft. The propulsion system on military rockets and missiles is usually made of solid rocket fuel. Missiles and rockets produce smoke plumes as a result of the solid fuel burning. The hot gases escaping from the motor can also create contrails, but the smoke and contrail combine to form a single exhaust plume. For more information on Air Force propulsion and fuels programs, see the Air Force Research Laboratory Propulsion Directorate at http://www.pr.afrl.af.mil/.

Chaff and Flares

Chaff and flares are defensive counter measures used on aircraft to confuse radar and heat seeking missiles. Chaff is used as a decoy for radar seeking missiles and is made of glass silicate fibers with an aluminum coating. The fibers are approximately 60% glass fiber and 40% aluminum by weight. The typical Air Force RR-188 chaff bundle contains about 150 g of chaff or about 5 million fibers. The fibers are 25 microns in diameter and typically 1 to 2 cm in length. In 1997, the Air Force used about 1.8 million bundles worldwide.

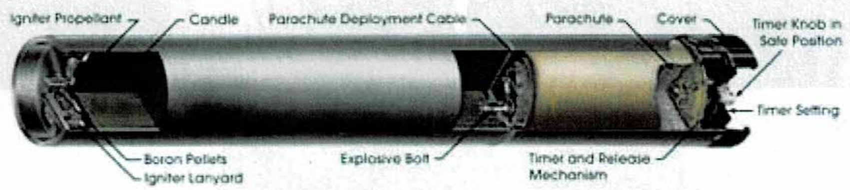
The amount of chaff released worldwide by all of the services is approximately 500 tons per year. Chaff falls to the earth at a settling velocity of approximately 30 cm per second. Atmospheric residence times range from 10 minutes for the majority of chaff released at 100 m to approximately 10 hours for chaff released at 10,000 feet. Chaff fibers experience little breakup before reaching the ground.

After the chaff is ejected from the aircraft and into the aircraft slipstream, the chaff packages burst open and the fibers scatter to form a radar-reflective cloud called a chaff corridor. Each chaff package is designed to simulate an aircraft. Several aircraft can create a chaff curtain, consisting of thousands of false targets, which confuse the radar guidance package on a missile so they are unable to locate the real targets within the chaff cloud.

Virtually all chaff fibers are 10-100 times larger than PM10 and PM2.5, the air particulates of concern for public health. The primary fiber size is usually too large to be inhaled by livestock, but if they are inhaled they do not penetrate far into the respiratory system and can be easily cleared out. The possible nutritional effects due to chaff ingestion and the risk is minimal to nil for both humans and livestock, considering the chemical composition of chaff (essentially identical to soil) and low chaff loading on the environment. Chaff decomposing in water has no adverse impacts on water chemistry or aquatic life.

Flares are of two types: decoy flares that protect aircraft from infrared missiles, and ground illumination flares. Decoy flares are typically made of magnesium that burns white-hot and are designed to defeat a missile's infrared (IR) tracking capability. The intense heat of the pyrotechnic candle consumes the flare housing. Common aerial flares are: ALA-17/B, M-206, MJU-2, MJU-7 A/B, MJU-10/B, MJU-23/B, and RR-119.

Ground illumination flares, are designed to descend by parachute and provide up to 30 minutes of illumination of ground targets or activities. Typical flares are the LUU-1, LLU-5, and LLU-2B. A typical LLU-2B sectional is shown below.



The ground illumination flare enhances a pilot's ability to see targets while using Night Vision Goggles (NVGs). Flares burn at uneven rates and fluctuate in brightness and are not used as frequently as in the past as the intense light interferes with the newer NVGs more sensitive sensors.

The composition and materials of flares used by the military are similar to standard flares used for aerial, highway and marine purposes. (Skyline). While unburned decoy flares falling from high altitude could be dangerous, flares are designed to burn up during the descent (even the aluminum casing is burned).

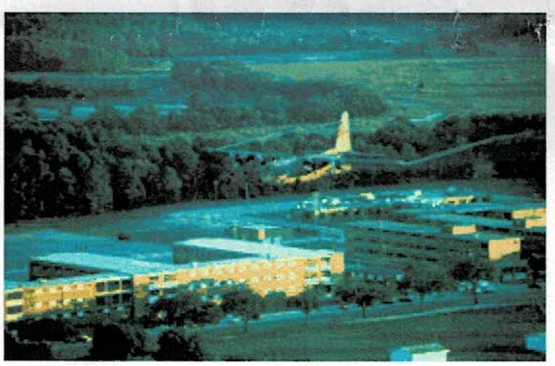
Chaff and flares are deployed on most Air Force aircraft from a common MJU-11 Chaff/Flare magazine that is integrated with the warning receiver (a device that alerts the aircraft a missile has locked onto the aircraft). The magazine has a capacity of 30 RR-188 or 30 M-206 flares.

A very thorough independent description of military systems, equipment, and capabilities is published by the American Federation of Scientists.

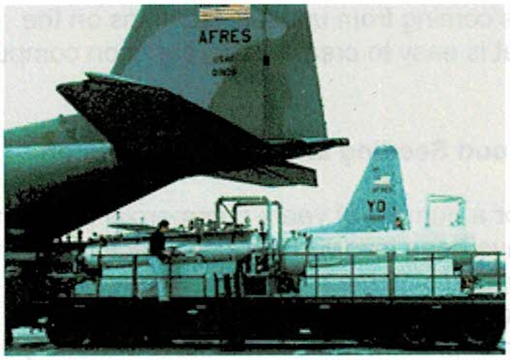
Typical chaff and flare deployments and patterns are shown in the following pictures.

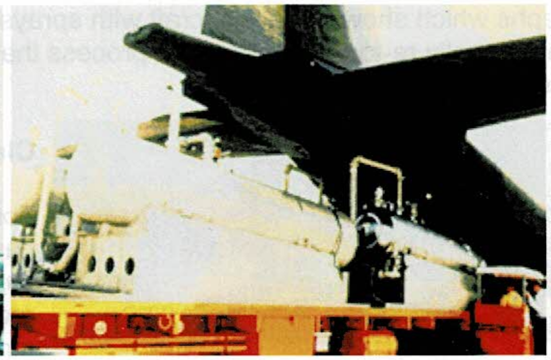
Aerial Spraying

There are some specific uses of commercial, private, and military aviation where chemicals are introduced in the atmosphere. The most common association of aerial chemical release is spraying for insects, either as crop dusting or mosquito prevention measures. These activities are typically performed at low altitude levels and produce a mist spray that drops to the earth's surface.



The only unit in the Air Force capable of aerial spray operations to control disease-carrying pests and insects is the AFRC's 910th Airlift Wing, Youngstown-Warren Air Reserve Station, Ohio (http://www.afrc.af.mil/units/910aw/default.htm). The aerial spray mission uses four specially configured C-130 Hercules shown below. Aerial spraying enables large parcels of land or water to be treated safely, quickly, accurately, and cheaply. This is the only fixed wing aerial-spray capability in the Department of Defense.





The mission started back in World War II, when legions of American GIs fell victim to malaria and dengue fever, diseases spread by mosquitoes. The mission was taken over from the active force in 1973. Although most of the unit's missions are initiated by the Department of Defense, its services are also requested by local, state and other federal agencies and coordinated the Center for Disease Control. The most common missions flown are for mosquito, sand flea and weed control. Several states have also requested support to combat grasshoppers and locusts. Aerial spray missions have been flown in Puerto Rico, Panama, Guam and the Azores.

The chemical compounds used for mosquito control are EPA controlled and the Air Force uses two primary brands; Dibrom and Anvil 10+10. Dibrom is manufactured by AMVAC Chemical Corporation and is classified as a Naled compound. Naled is an organophosphate insecticide that has been in use since 1959. It is used primarily for controlling adult mosquitoes but is also used on food and food crops, greenhouses and pet flea collars. Naled is applied using Ultra-Low Volume sprayers which dispense very fine aerosol droplets which kills the adult mosquito on contact. Naled is applies at a maximum aerial spray rate of 0.8 ounces of active ingredient per acre. Anvil 10+10 is manufactured by Clarke Mosquito Control Products, Inc and is a Sumithren, also known as a Synergized Synthetic Pyrethoid. Anvil 10+10 is applied using Ultra-Low Volume sprayers at a maximum aerial spray rate of 0.62 ounces of active ingredient per acre.

The chemical compounds used for herbicide weed control are EPA controlled and the Air Force uses Dupont Krovar I DF and Dow Agro Sciences Tordon K. Krovar I DF comes in granular form, is mixed with water and applied as an aerosol to control annual weeds at a rate of 4-6 pounds mixed with 40-100 gallons of water per acre. Tordon K is used as a herbicide to control broadleaf weeds, woody plants, and vines on non-crop areas such as forest planting sites, industrial manufacturing sites, rights-of-way such as electrical power lines, communications lines, pipelines, roadsides, railroads, and wildlife openings. Tordon K is applied at a maximum of 2 quarts per acre.

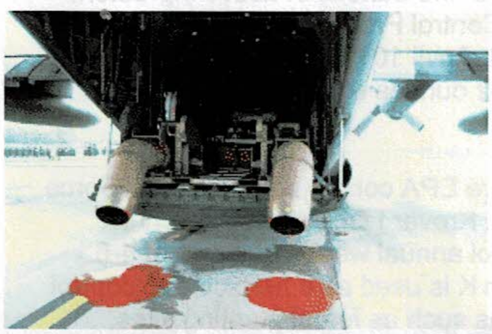
The 910th Airlift Wing has formed an Oil Dispersant Working Group, and is working with industry and government agencies to test aerial spray methods of controlling major offshore oil spills in coastal waters of the United States. The unit has six Modular Aerial Spray Systems (MASS) and four aircraft modified to accept the MAAS. Each MASS has a 2,000 gallon capacity and flow rate are set at 232 gallons per minute. The aircraft flies at 200 Knots Ground Speed at about 100 feet which covers a swath width of 100 feet for an average application rate of flow rate of 5 gallons per acre (variable 3-15 gallons per acre). Total spray-on time for 2,000 gallons lasts about 8 minutes and 30 seconds.

Photographs which show military aircraft with sprays coming from unusual locations on the aircraft are usually re-touched photos (a process that is easy to create using common computer programs).

Cloud Seeding and Fire Suppression

For a number of years commercial companies have been involved in cloud seeding and fire suppression measures. Cloud seeding requires the release of chemicals in the atmosphere in an effort to have water crystals attach themselves and become heavy enough to produce rain. The Air Force does not have a cloud seeding capability.

Fire suppression involves dumping chemicals onto a fire using cargo-type aircraft or helicopters. The 731st Airlift Squadron assigned to the 302nd Airlift Wing, Peterson Air Force Base, CO., is trained in the use of modular airborne fire fighting systems that help firefighting efforts of the U.S. Forest Service by dropping retardant chemicals directly onto fires. The unit's C-130s are loaded with a system designed to airdrop fire-retardant chemicals used in fighting forest fires and fertilizing the forest to generate quick regrowth. The 302nd AW has conducted firefighting response in Colorado, California, Oregon and Idaho.



U.S. forest fires generally occur in desolate, almost inaccessible geographical areas. The U.S. Forest Service turned to air power to help its ground fire fighting units quickly contain and suppress these fires. Over the years, the forest service has developed a highly effective air-attack organization and air tanker fleet to deal with the forest fire emergency.

In 1970, however, numerous catastrophic forest fires erupted in southern California, severely overloading the air tanker fleet's ability to cope with them all. This led to several U.S. Congressmen requesting the U.S. Air Force help the forest service by making military aircraft available as a back-up measure. This in turn led to the development of the Modular Airborne Fire Fighting System (MAFFS). The system is designed to quickly adapt military C-130 aircraft from a military role to a fire-suppression role.

Since 1974, the U.S. Air Force Reserve and Air National Guard units strategically located near high-incident forest fire areas have been equipped with these MAFFS units, and have sent selected aircrews to the aircrew training school for instruction in forest service air operations and procedures.

The MAFFS System is a modular, reusable airborne system for deploying water and fire retardant chemicals from aircraft in flight. It consists of seven airborne modules and one ground air compressor module. The system can be loaded on a C-130 aircraft in two hours, and filled with retardant and compressed air in 15 to 20 minutes. The system is self-contained and requires no aircraft modifications. Each system weighs 10,500 pounds empty, and has a capacity of 2,700 gallons.

The entire load of retardant is discharged over a fire in 6 to 8 seconds.

Other AFRC aircraft shuttle Forest Service personnel and equipment to fire areas when the emergency requires a swift deployment to the fire line. This increased mobility allows more efficient use of Forest Service resources.

In-flight Emergency Fuel Release

Another common, but infrequent, procedure is the release, or venting, of fuel as a safety measure. If an in-flight emergency (IFE) is declared, a pilot will want to land the aircraft with as light a load as possible to prevent the possibility of damaging the aircraft and/or causing a fuel leak on landing. In order to lighten the fuel load a pilot can continue to fly until the fuel is burned or vent the fuel into the atmosphere. Fuel that is released, or vented, typically atomizes into a fine spray as it is released and typically evaporates before it reaches the ground. JP-8 jet fuel released at low altitudes appears as a fine mist and may not volatilize before reaching the ground surface. The release of fuel does not produce a contrail and appears more like a smoke pattern that dissipates quickly.

The "Chemtrail" Hoax

A hoax that has been around since 1996 accuses the Air Force of being involved in spraying the US population with mysterious substances and show various Air Force aircraft "releasing sprays" or generating unusual contrail patterns. Several authors cite an Air University research paper titled "Weather as a Force Multiplier: Owning the Weather in 2025" (http://www.au.af.mil/au/database/research/ay1996/acsc/96-025ag.htm) that suggests the Air Force is conducting weather modification experiments. The purpose of that paper was part of a thesis to outline a strategy for the use of a future weather modification system to achieve military objectives and it does not reflect current military policy, practice, or capability.

The Air Force's policy is to observe and forecast the weather. The Air Force is focused on observing and forecasting the weather so the information can be used to support military operations. The Air Force is not conducting any weather modification experiments or programs and has no plans to do so in the future.

The "Chemtrail" hoax has been investigated and refuted by many established and accredited universities, scientific organizations, and major media publications.

Claims and Facts

Claim: Long-lasting contrails are something new and they have abnormal characteristics.

Fact: Contrails can remain visible for very long periods of time with the lifetime a function of the temperature, humidity, winds, and aircraft exhaust characteristics. Contrails can form many shapes as they are dispersed by horizontal and vertical wind shear. Sunlight refracted or reflected from contrails can produce vibrant and eye-catching colors and patterns. Observation and scientific analysis of contrails and their duration date back to at least 1953.

Appleman, H., 1953. The formation of exhaust condensation trails by jet aircraft. Bulletin of the American Meteorological Society 34: 14-20. Brewer, A.W., 1946. Condensation trails. Weather 1: 34-40.

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Spargo, B.J., Environmental Effects of RF Chaff, Naval Research Laboratory, Washington, D.C., August 31, 1999.

Pike, John, Aircraft Weapon Loads, Federation of American Scientists, 2000.

Aircraft and Contrails. EPA publication number EPA430-F-00-005. 6 pp EPA, 2000. (www.epa.gov/otaq/aviation.htm)

Layman's Library

Contrails - Contrails, or condensation trails, are "streaks of condensed water vapor created in the air by an airplane or rocket at high altitudes."(Webster's Dictionary). Contrails are the result of normal emissions of water vapor from jet engines. At high altitudes, water vapor condenses and turns into a visible cloud. Contrails form when hot humid air from jet engines mixes with the surrounding air in the atmosphere which is drier and colder. The mixing is a result of turbulence generated by the jet engine exhaust. The water vapor in the jet exhaust then condenses and forms a cloud. The rate at which contrails dissipate is entirely dependent upon weather conditions and altitude. If the atmosphere is near saturation, the contrail may exist for some time. Conversely, if the atmosphere is dry, the contrail will dissipate quickly.

Contrail Grid Patterns - Numerous contrails are usually over "air routes", or highways in the sky. Aircraft fly in all different directions at any time, and numerous contrails may seem to "crisscross". Although contrails may appear to cross, the trails can actually be from planes separated by significant altitude and time.

Chaff - Chaff are small bundles of aluminum coated fibers that create a large radar reflection. A radar seeking missile is unable to distinguish an aircraft from the chaff and loses the lock on the aircraft.

Chemtrails - Chemtrails is a term coined to suggest contrails are formed by something other than a natural process of engine exhaust hitting the cold air in the atmosphere.

Ethylene dibromide - Ethylene dibromide, or EDB, is a pesticide that was used commercially before being banned by the Environmental Protection Agency in 1983. During WW II, EDB was used as an additive in aviation gasoline to help stop lead in the aviation gasoline from plating out on valves. Jet fuels, including JP-8 have never contained EDB. Soil samples showing the presence of EDB are most likely residuals from previous use as a pesticide. Webster's dictionary definition of EDB: ": a colorless toxic liquid compound C2H4Br2 that is used chiefly as a fuel additive in leaded gasolines, that has been found to be strongly carcinogenic in laboratory animals, and that was used formerly in the U.S. as an agricultural pesticide -- abbreviation EDB."

JP-8 Jet Fuel - JP-8 jet fuel consists of kerosene, a petroleum distillate fraction purchased to specification. The specification requires that the fuel producer meet a range of chemical and physical properties to ensure proper aircraft operation. Fuel additives are allowed, but are highly controlled. Additives include antioxidants, metal deactivators, corrosion inhibitors, fuel system icing inhibitor, and a static dissipater additive.

Rocket Exhaust - The exhaust plume generated by solid or liquid fueled rockets. Solid rocket motors are usually made of ammonium perchlorate and typically create light colored exhaust emissions. The exhaust is mainly carbon dioxide and water, but may also have high levels of hydrochloric acid formed, but which disperses rapidly. Liquid fuel rockets are generally kerosene and Liquid Oxygen (LOX) and produce an exhaust, which is darker and similar to aircraft exhaust. The exhaust is primarily carbon dioxide and water, but may contain nitrous oxides, sulfides, and soot particles.

Stratospheric Ozone - The ozone formed in the upper atmosphere through the interaction of the sun's energy and oxygen and which provides the natural shielding effect for the earth from UV rays. This ozone layer is susceptible to destruction by chlorinated compounds and is generally associated with the ozone hole over the Antarctic. Ozone in the lower atmosphere and ground level is generally a by-product of motor vehicle fuel combustion that forms NOx as a precursor which then forms ozone. This ozone is often seen as smog in most major cities.

Vapor Trails - The trail formed behind an aircraft as result of air flowing over a surface which creates a cavity in the air, similar to a boat propeller in water.