by Daryl O'Dowd

CONTRAILS VERSUS CHEMTRAILS

An interesting take on aircraft ice crystal plumes

As air traffic increases, contrails are having a greater and greater effect on the Earth's weather, and there are some interesting advantages to the phenomena

Condensation trails are not a natural phenomena. Copious quantities of water vapor and particulate matter are needed to cause the condensation-freezing processes that result in an ice crystal plume behind an aircraft at high altitude.

Fuel additives likely impact the hygroscopic nature of carbonaceous exhaust particles and may increase or even decrease the efficacy of the process. Minimizing or mitigating contrails would be a tactical advantage in military operations to prevent observation of aircraft. From a civilian or commercial perspective, contrails allow ready identification of aircraft in high level flight and potentially reduce the risk of mid-air conflict. While spreading contrails do reduce incoming shortwave radiation much like natural cirrus shields, currently less than 0.2% of the earth's surface is contrail-affected, suggesting that the global energy balance is negligibly impacted by aircraft contrails.

In 1996, a think-tank paper entitled *Weather as a Force Multiplier: Owning the Weather in 2025* was written for consideration by the US Air Force (USAF). The 44-page treatise made numerous projections as to how military weather control would be executed, including the use of UAVs at high altitude to release chemicals to alter cloud and airmass properties. The term chemtrail (chemical trail) entered the public lexicon to describe such atmospheric tampering and became a catalyst for public concern over any aircraft-produced trail in the atmosphere.

Contrail formation process

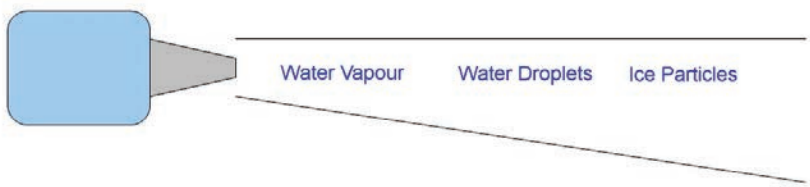
Condensation trails (or contrails) are water/ice plumes stretching behind any aircraft – jet or propeller – operating at flight levels where the ambient temperature is typically -40ºC or colder. Critical to the creation of contrails, brief or persistent, is the need to have a source of water vapor as well as a physical substrate onto which the water vapor can condense. Aircraft engines, turbine engines in particular, provide both in quantity. For every kilo of fuel consumed, 1.4kg of water vapor can be produced. A Boeing 747 at cruise speed and altitude will have a typical mid-flight fuel burn of 21,800 lb/hour and will eject approximately 6.1 lb (2.75kg) of water vapor a second.

The exhaust plume also contains incompletely burned hydrocarbon particles (soot) that encourage the phase change of the engine exhaust water vapor, first to liquid then to ice. Initially these particles act as cloud condensation nuclei (CCN) and provide a site for water vapor to condense as the exhaust plume entrains environmental air and begins to cool.

Almost immediately these droplets freeze into ice crystals, the limit for supercooled liquid water being approximately -40Cº. An aircraft operating at warmer temperatures may initially generate a liquid droplet condensation trail, but as the vapor pressure over liquid water is greater than over ice, the plume will preferentially form ice crystals at the expense of water droplets.

Whether these ice crystals – proto-cirrus particles – persist is a function of the environmental temperature and humidity at the point of injection. Critical to concealing military or stealth aircraft, especially during the day, contrail formation was initially investigated in Germany in 1941, and later detailed tables and charts (still in use) were created for the USAF in 1953.

Contrail formation. Engine water vapor condenses on soot particles and then freezes as entrained air cools the exhaust plume



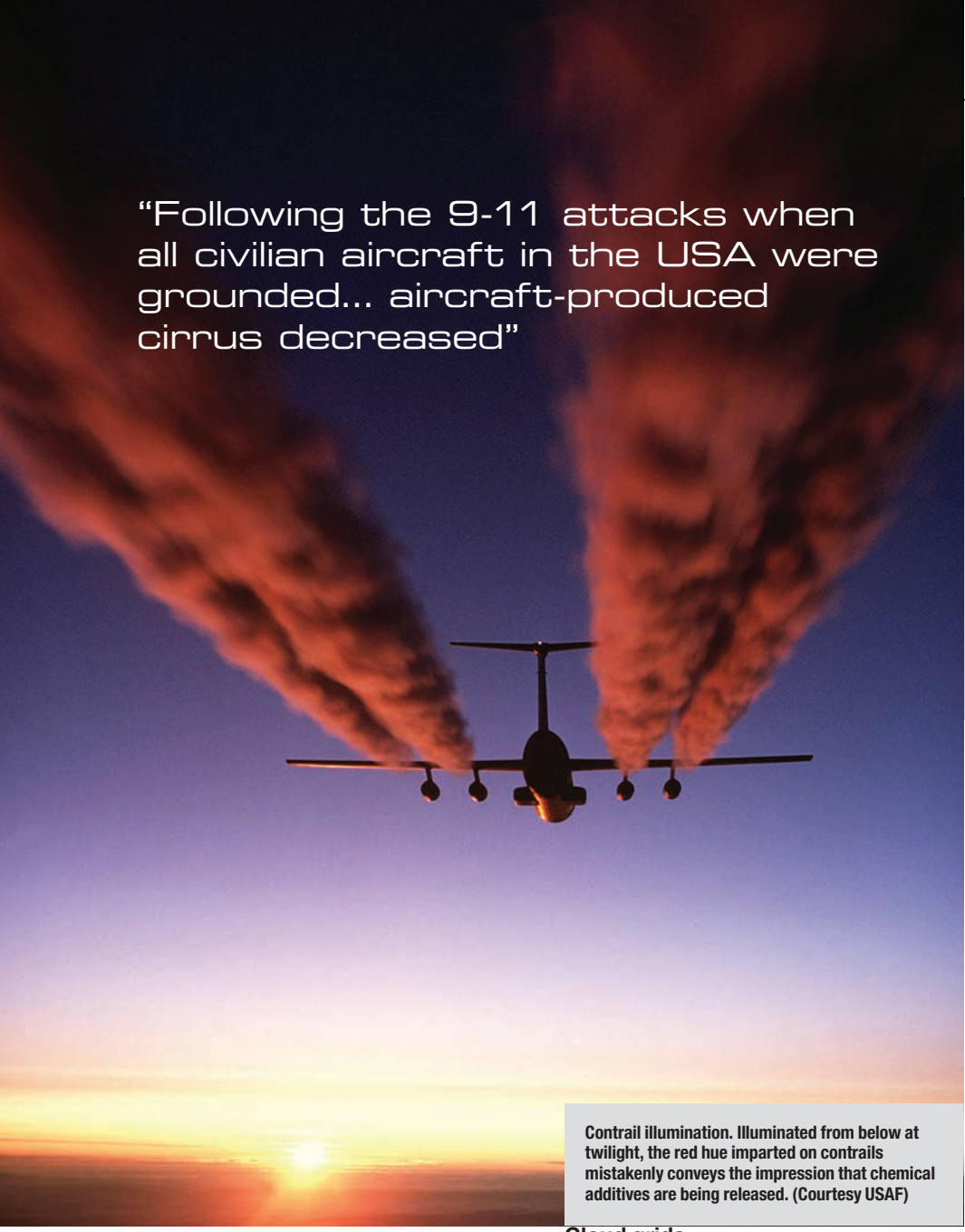
$$C_{12}H_{26} + 37/2\ O_2 \rightarrow 12\ CO_2 + 13\ H_2O$$

Above: Kerosene combustion. Shown are the ideal products for the burning of dodecane – a common kerosene component. For each kilo burned, up to 1.4kg of water vapor is produced

At its simplest, where the local atmosphere at the aircraft level is considered to be humid – this threshold varying with temperature, dew point, and pressure (altitude) – then a contrail will persist. It will grow and spread as water vapor in the surrounding natural atmosphere deposits directly on the ice substrate. Where the atmosphere is dry – often seen during widespread subsidence associated with a stagnant upper ridge or broad high pressure zone (e.g. Azores High) – the ice in the plume will rapidly sublimate and the contrail will end a wingspan or two behind the aircraft.

Fuel, additives, and soot

The majority of turbine powered aircraft flying at altitude use either a kerosene-based fuel (Jet A, Jet A-1, JP-8) or a naphtha-kerosene blend (Jet B). In addition, and potentially important in the effectiveness of soot as CCN, are fuel additives designed to reduce corrosion, icing, static build-up, and fungal or bacterial growth. The efficacy of the soot particles in first acting as CCN, capturing water vapor, and then second as potential ice nucleator, facilitating the further conversion of supercooled droplets to ice. This may be a function of the additives imparting surface characteristics on the soot.



Contrail illumination. Illuminated from below at twilight, the red hue imparted on contrails mistakenly conveys the impression that chemical additives are being released. (Courtesy USAF)

As the number of aircraft movements increases, so does the potential for contrails. Daily, there are more than 85,000 aircraft flights within the USA and as many as 30,000 IFR movements within the Eurocontrol zone. Commercial aircraft are usually constrained to follow designated high-level airways or a limited number of North Atlantic Tracks (NAT Tracks) and it's not unusual for busy airspace intersections to have 70 or 80 aircraft passages per hour. On airways with reduced vertical separation minima (RVSM) in place (FL290 to FL410) the aircraft density can be even higher.

This concentration of aircraft at altitude has given rise to a number of contrail cloud phenomena – cloud grids, spreading cirrus shields, red plumes, and sudden contrail absences – which have inadvertently fueled chemtrail speculation.

Cloud grids

Aircraft moving on west-east flight corridors inevitably must intersect north-south traffic routes. When conditions support contrail formation, the resulting intersected contrail symmetry can be very conspicuous. When the airmass is also moving, new contrails are continuously added in a fixed location, but drift downwind resulting in parallel cloud tracks or an interlaced cloud grid. To the layman unaware of flight routing, this symmetry may suggest that a deliberate cloud-seeding exercise is underway.

Where humidity is high, contrails, even isolated ones, may naturally grow from background atmospheric vapor and gradually spread across the entire sky. This was demonstrated in the 72 hours following the 9-11 attacks when all civilian aircraft in the USA were grounded and aircraft-produced cirrus decreased. The transition from a handful of contrails to a full covering of cirrus, often within a few hours, can appear suspicious to the layman unaware that water vapor is not uncommon at higher altitudes.

Red contrails and absence

Illuminated from below by deeply scattered dawn or dusk light, persistent contrails can have a strong red hue and suggest that chemical injection is being undertaken. Viewed from above, however, these same contrails would appear grey or white.

The presence of contrails on some days and their complete absence on others – entirely the consequence of natural atmospheric variations of humidity and temperature in both the vertical and horizontal – mistakenly suggests an ability to control the contrail effect at will.

Condensation trails have been present in the atmosphere for more than 75 years. However while cirrus, and aircraft-produced cirrus in particular, can effect the local radiation balance, it is estimated that less than 0.2% of the globe is contrail-affected. While contrails may be considered to be a nuisance by the military, they may have a civilian cockpit safety value in calling attention to nearby aircraft in flight. To the meteorologist they offer a simple tool to estimating upper atmosphere moisture advection, as well as high-level wind speed and direction systems. ▮

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CLOUD SEEDING

Commercial cloud seeding operations have been undertaken since the 1950s. Currently, projects to increase rain and snowfall or suppress hail are executed in more than 20 countries, including France, the USA, Canada, Greece, Thailand, Argentina, and Australia. Some projects use low-cost, ground-based systems to seed wide areas, often for winter snow enhancement. Others use aircraft to target specific clouds – flying in the updrafts at cloud base or within growing convective towers – to suppress hail. However, no commercial seeding is undertaken at contrail altitudes.