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Local air quality studies at Dallas International Airport for Seneca project

The primary goal of SENECA (LTO noiSe and EmissioNs of supErsoniC Aircraft) project is to provide a basis for decision making of environmentally friendly supersonic aircraft design taken into account the detailed modelling of the emissions, the LTO noise and the local/global environmental impacts. One of the task of SeNeCa project to perform local air quality tasks for designed SST aircraft. For this purpose, the results of Environment Impact Assessment at Dulles International Airport (DIA) for Concorde were used as reference case.

Concorde Air Quality Monitoring and Analysis Program at US Airports

The experimental investigation was organized at DIA by FAA to test supersonic airplane CONCORD for compliance to air quality requirements as part of Environment Impact Assessment. The air quality monitoring program at DIA to aim the comparisons of ambient concentration with those predicted from published emission indices and model estimates of area of Concorde operations influence based on these results. A two-phase program was used to determine the effect of Concorde emissions on populated areas at and near the Dulles Airport. The first phase was concerned with establishing the impact of the airport (and Concorde) emissions on the surrounding vicinity. The second phase was designed to detect the emissions from single aircraft (started, taxied and took off) before they were diluted sufficiently to become lost in the ambient background.

Six air quality stations and three vertical towers were employed for background and single - event measurements. Background measurements were performed at two main stations; one measuring the airport background and the other measuring the community background. All major pollutants (carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO), nitrogen dioxide (NO₂), ozone (O₃) and particulates), as well as wind direction and speed were measured continuously at these locations. The distance from the taxiing aircraft source at which these emissions blend into the background outlines the "area of influence" of Concorde emissions (conceptually indicated in Fig. 1) [1, 2].

Single-event measurements were used to define the Concorde influence area referred to in Fig.1, and to provide the detailed data for background - pollution analysis. The measurement procedure was to place the monitoring stations downwind of the Concorde movement path and measure the dispersion of the emission plume as it was transported by the wind over these stations. Major emphasis was placed upon monitoring the jet exhaust emissions from a taxiing or taking off aircraft. *Carbon monoxide (CO)* was the "tracer" measured for taxi and engine start idle emissions. *Nitrogen oxides (NO_x)* was the "tracer" for take-off emissions. Vertical pollution measurements were made at five elevations on three vertical towers. The air quality data consists of the following data sets [3, 4]:

- “Single Event” aircraft CO emissions during taxi (*St.No4, St.No5, St.No10, St.No11*)
- “Single Event” aircraft NOx emissions during take-off (*St.No12, St.No13, St.No14*)
- Multipoint three-tower measurements of CO emissions for taxi (*St.No20T, St.No21T, St.No22T, St.No27T, St.No28TT, St.No29TT, St.No30TT, St.No31TT*).

The locations of the monitoring sites at the airport are shown in Fig. 1.

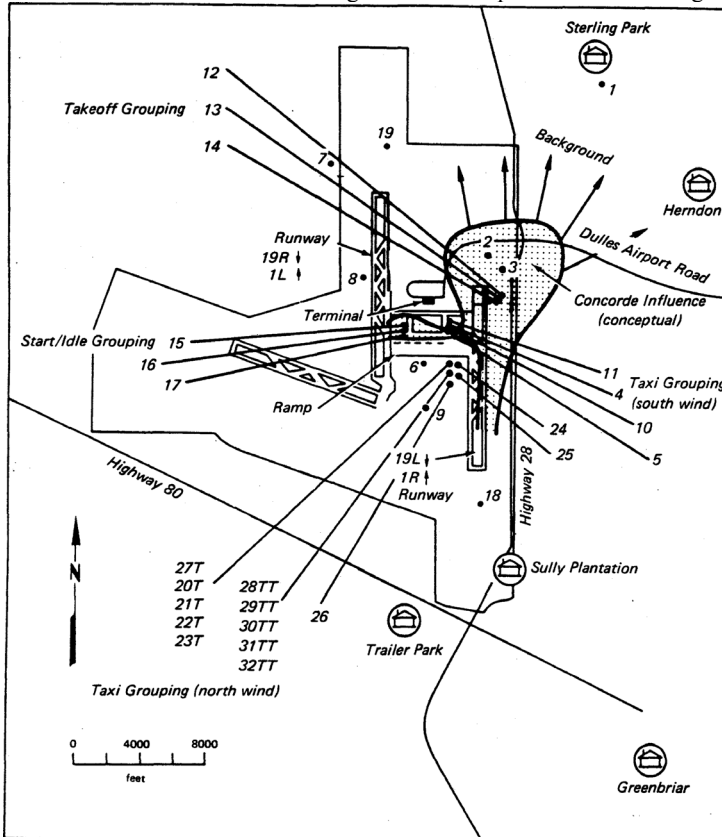


Fig.1. The locations of the monitoring sites at the airport

A major consideration for monitoring site selection was the traffic pattern at the airport. Most commercial aircraft do not operate in the vicinity of the terminal, but rather position themselves at the jet ramp, which is located 2,300 ft south of the terminal. Airplanes move around this ramp in a clockwise direction. For south-wind operations, which are predominant during the summer months, the airplanes usually

proceed from the ramp to takeoff runway 19-left (Fig.1), which ensures the shortest possible taxi distance. For north-wind operation, airplanes proceed from the ramp to runway 1-left, fig.1 [1].

Ground measurements of instantaneous maximum concentrations were conducted at three stations №4, №5, №11 to determine emissions dispersion from aircraft engine at taxi mode, fig.2.

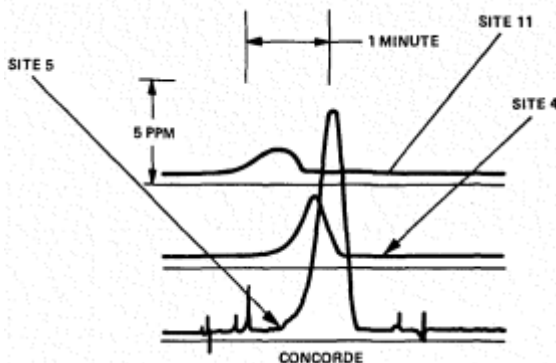


Fig.2. Characteristic plot of CO concentration during taxi

Comparison modelling and measurement results for taxing conditions

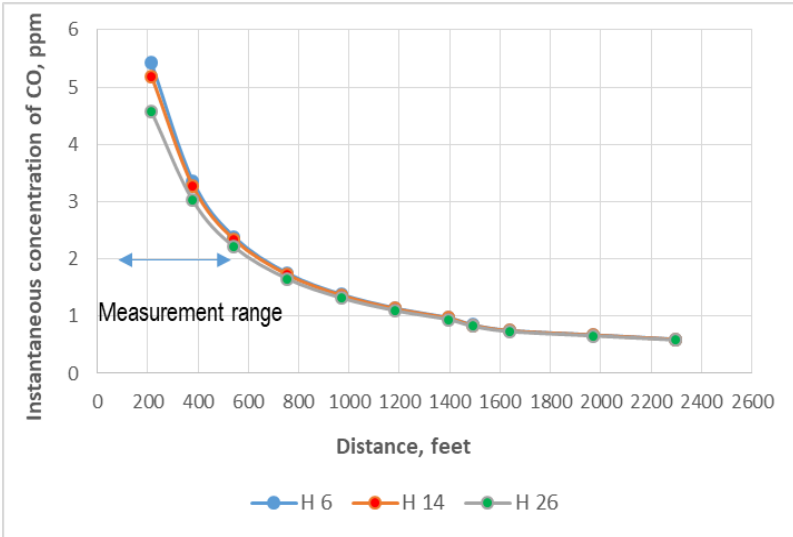
First of all, the parameters of the exhaust gases jet (Archimedes number Ar_0 , height ΔH_a and longitudinal coordinate X_a of buoyancy effect, vertical σ_z and horizontal dispersion σ_x , σ_y) were estimated by PolEmiCa for Concorde and B707 under taxing conditions, table 1. So, PolEmiCa includes the jet parameters influence on concentration distribution in the plume. Dispersion characteristic modeled by PolEmiCa are quite similar to the estimation results by AVAP model.

Table.1

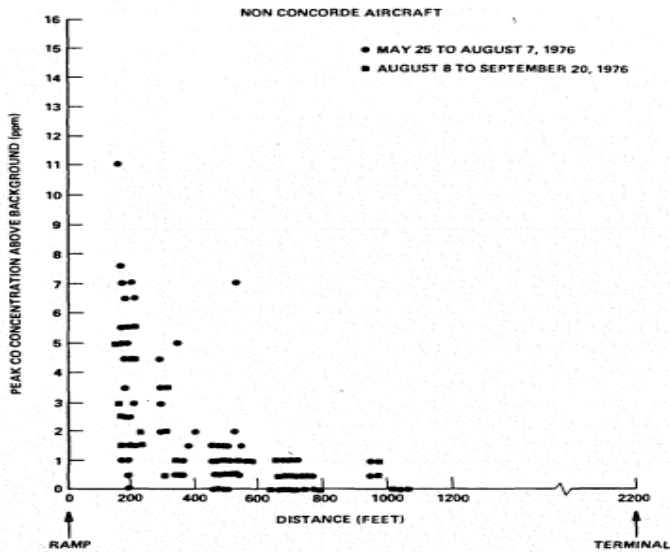
Parameters of exhaust gases jet for B707 and Concorde calculated by PolEmiCa for taxing conditions

AF	Buoyancy effect of jet			Dispersion parameters by PolEmiCa			Dispersion parameters by AVAP	
	Ar0	H, m	Xa, m	σ_x	σ_y	σ_z	σ_y	σ_z
B707	0,0004	2,10	69,89	5,55	19,4	5,54	22,46	3,26
Concorde	0,0003	6,9	147,0	7,97	22,1	8,04	-	-

Modelled results of peak instantaneous concentration CO from one engine of B707 (fig.3, a) at height 14 feet are strong correlated with ground measurement (at the same height) at three stations №4, №5, №11 correspondingly, fig.3, b.



a)



b)

Fig.3. Modelled (a) and measured (b) peak instantaneous concentration of CO from each engine of B707 at height 14 feet for taxi conditions

The peak CO concentration for Concorde is 2,25 times higher than the average concentration of B707 monitored at a location 200 ft downwind from taxing aircraft. Emissions from Concorde (and other airplanes) disperse to background levels before they reach the terminal (2300 feet from the ramp taxiway). The observe trends can be explained by influence the strong buoyancy effect (H), which diluted air contaminants until background values inside the airport area.

Analysis of measured and modelling concentration shows, that Concorde emissions are higher than the concentrations from B707, but due to effects of the jet dynamic effects air pollutants are strongly and quickly diluted until background levels.

Conclusion: this study shows that both the initial plume rise and the jet wake dispersion of air effluents have important effects on pollutant concentration estimates for receptor located within a kilometer of the source pathway. The obtained results will be used for local air quality studies of SST aircraft of SeNeCa project.

References

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