Benefits Assessment for Tailored Arrivals

A Year at San Francisco (Dec 3rd 2007 – Dec 31st 2008)

2009 Environmental Working Group Operations Standing Committee

July 28 – 29, 2009

Kevin Elmer

Tailored Arrival Environmental Criterion

1. Data analysis included Tailored Arrivals flight candidates
   - ANA8, ANZ8, JAL2, JAL880, QFA73, SIA16, UAL (1404, 34, 72, 74, 76, 78, 830, 838, 852, 856, 856D, 858, 862, 870, 872, 886, 888, 892, 9816, 9822)
   - Flights that arrived via Woodside (OSI) or Point Reyes (PYE)
2. Primary data source: radar data from the SFO ANOMS8 system
   - 6 days (1/03/08, 1/24/08-1/26/08, 2/23/08 and 11/01/08) were missing due to ANOMS8 outages
3. Flights sorted by
   - Tailored Arrivals sort criteria using ATS clearances and ADS-C reports
   - Analysis of ANOMS8 radar data to verify and refine the initial sorting
4. Fuel consumption calculations:
   - For low speed performance below 10,000 ft altitude, using the Boeing Climbout Program (BCOP)
   - Above 10,000 ft altitude, using the Boeing INFLT tool for cruise & descent.
   - Vertical profile generated from BCOP and INFLT was matched to the mean descent paths of the collective ANOMS8 radar data
   - Common start point at cruise

Tailored Arrival Environmental Criterion, Cont.

5. Tailored Arrivals (TA) sort criteria, using ATS clearances and ADS-C data
   - Non participating - Opted out of procedure or were ineligible
     Note: As ineligible flights are included in the above statistics, numbers should not be interpreted as pilot participation in Tailored Arrivals
   - Partial Tailored Arrival – Met SOME of the TA criteria
   - Full Tailored Arrival – Met ALL of the TA criteria

6. Environmental Criterion: Radar data shows no more than ONE Level Flight Segment and that is no more than ½ Nmi.

7. Evaluated all the ANOMS8 data to check if met Environmental Criterion including Non-Tailored Arrivals.

SFO Tailored Arrival Environmental Statistics

Data Collected	Total Flights*	% of Total Eligible Flights
Non-TA**	**3027**	**70%**
Partial TA	**675**	**16%**
Tailored Arrival	**391**	**9%**
Bad-Holding or Wrong Runway	**223**	**5%**
Not Eligible (Routed through PYE)	**1235**	**N/A**

* ANOMS8 Data collected for **5551** Total Flights from December 4, 2007 to December 31, 2008

** Non-TA included non-participating flights and data collected prior to TA start date

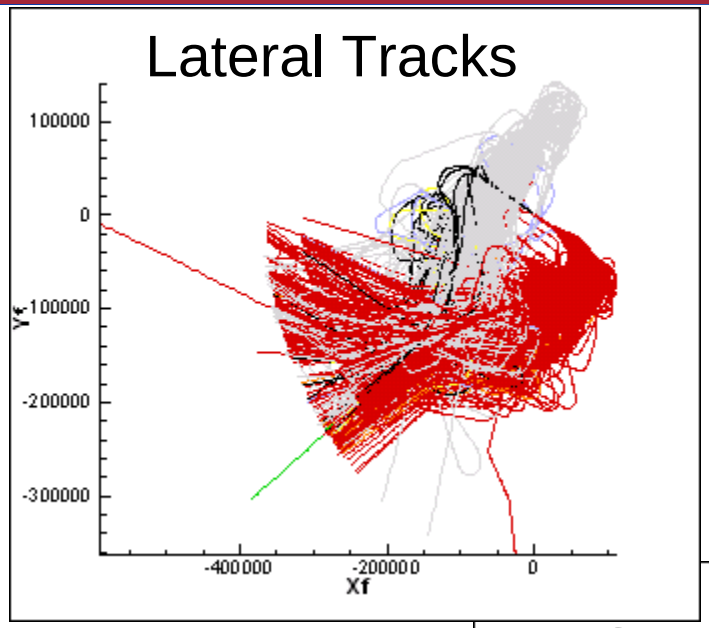
Airline Tailored Arrival Environmental Statistics

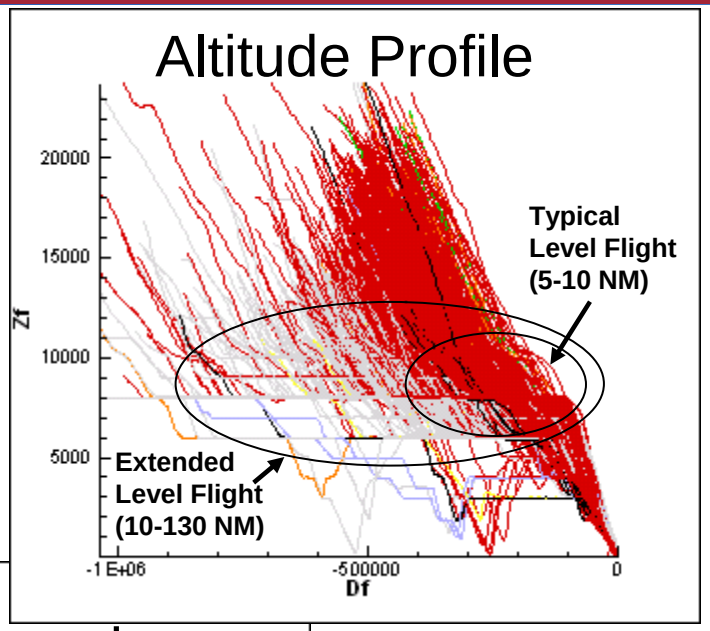
Airline	Airplane	# Tailored Arrivals	# Requested TA**	% ENV*
Air New Zealand	777-200ER	80	246	**33%**
United Airlines	777-200ER	182	376	**48%**
United Airlines	747-400	104	345	**30%**
Japan Airlines	747-400	9	33	**27%**
Qantas	747-400	16	67	**24%**

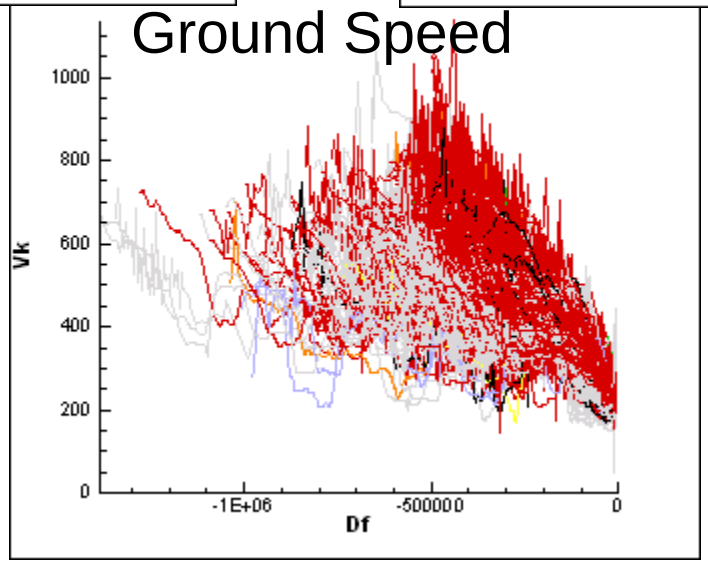
* Env – Met Criterion for Environmental Performance

** Total of Full TA and Partial TA – These are the total flights that requested the TA

SFO Airport Noise Monitoring System (ANOMS 8) Data



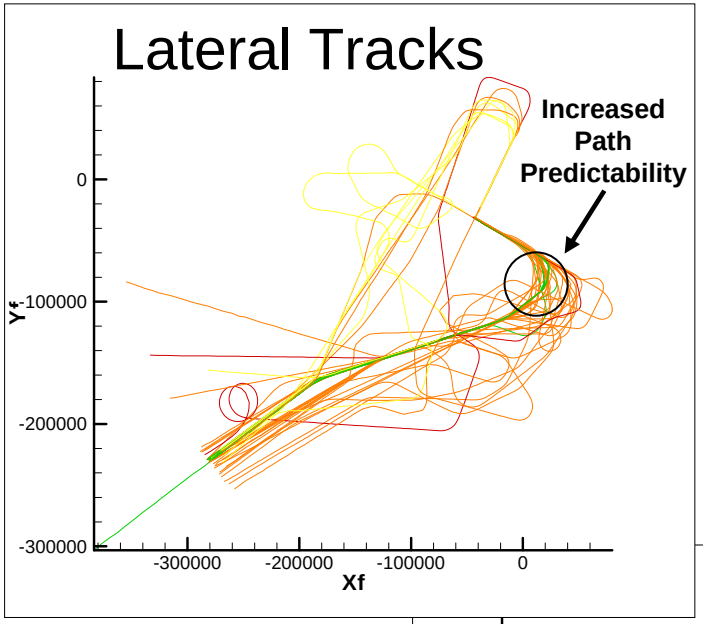


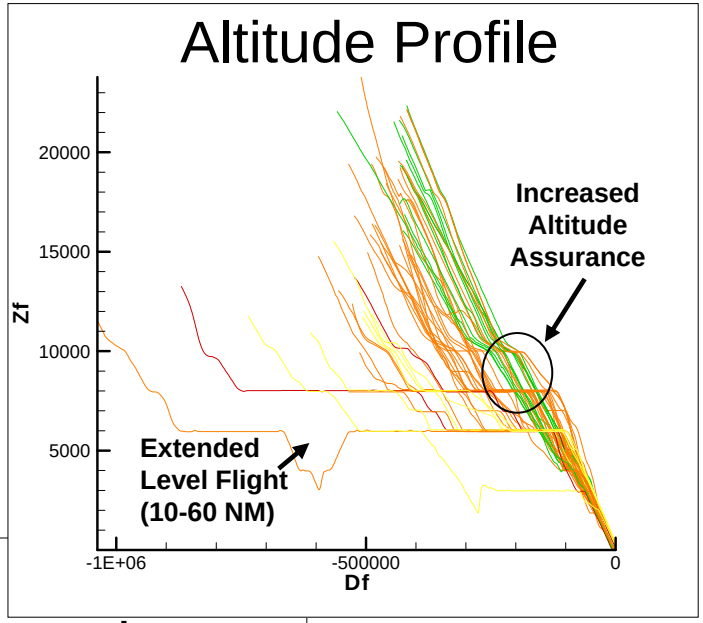


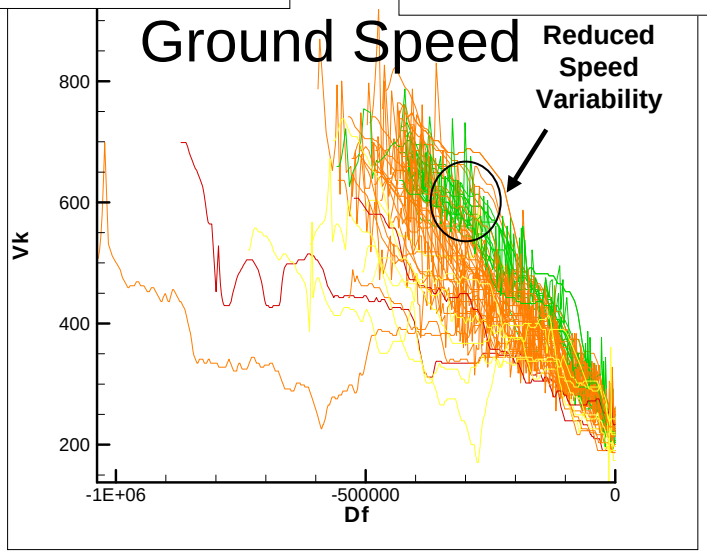
Baseline Arrivals

RW28R
RW28L
RW19L
Full TA
Partial TA

SFO Airport Noise Monitoring System (ANOMS 8) Data, Cont.

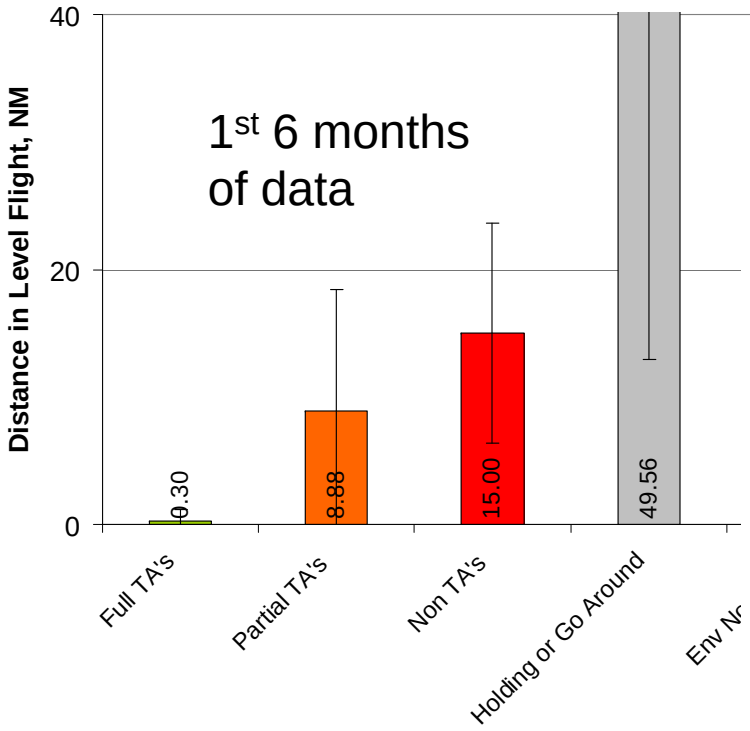


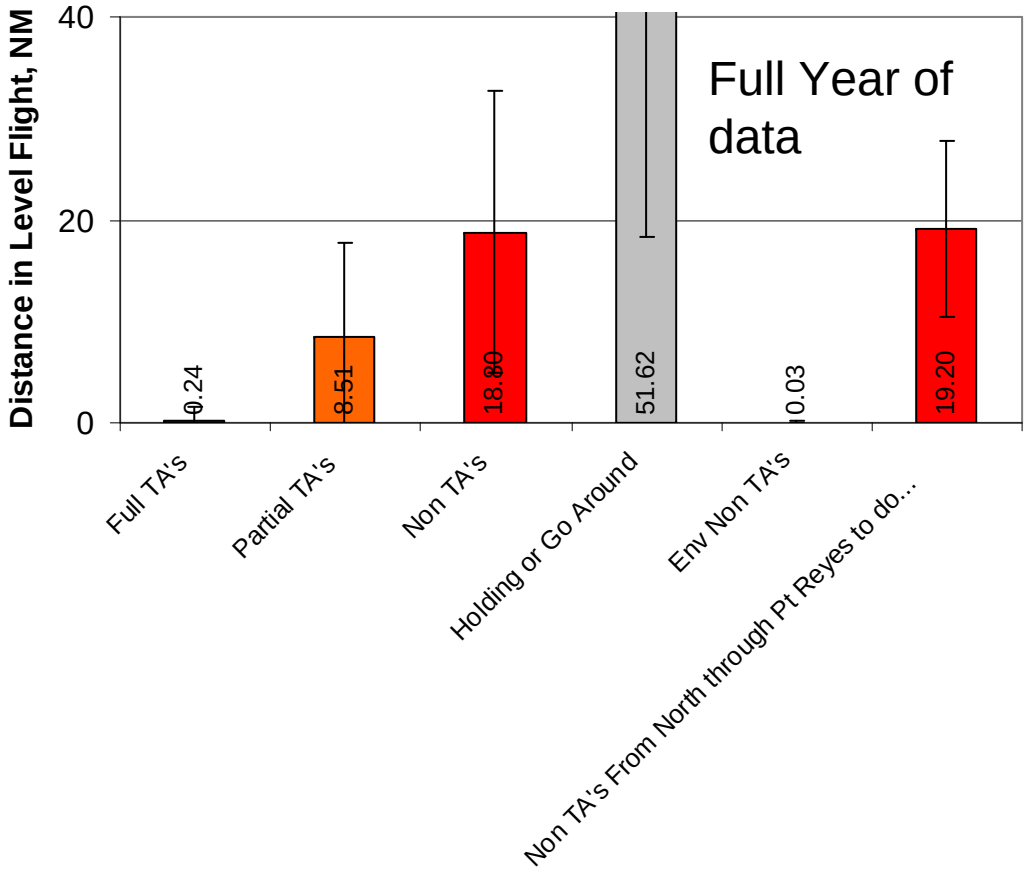




Full TA
Partial TA
Partial TA
RW19L

Low Altitude Level Flight (Mean & Std Dev)





Fuel Consumption (Cruise to Top of Descent to Landing)

	777-200	747-400
Non-TA	3,410 lbs	6,470 lbs
Partial TA	2,900 lbs	5,650 lbs
Full TA	1,980 lbs	3,670 lbs

Fuel Saving from Tailored Arrival per Flight

	777-200	**747-400**
Full TA	**1,430 lbs**	**2,800 lbs**
Partial TA	**510 lbs**	**820 lbs**

- Fuel consumption was calculated using the Boeing Climbout Program (BCOP) for low speed performance below 10,000 ft altitude.
- Fuel consumption above 10,000 ft altitude was calculated using the Boeing INFLT tool for cruise and descent.
- The vertical profile generated from BCOP and INFLT was matched to the mean descent paths of the collective ANOMS8 radar data.

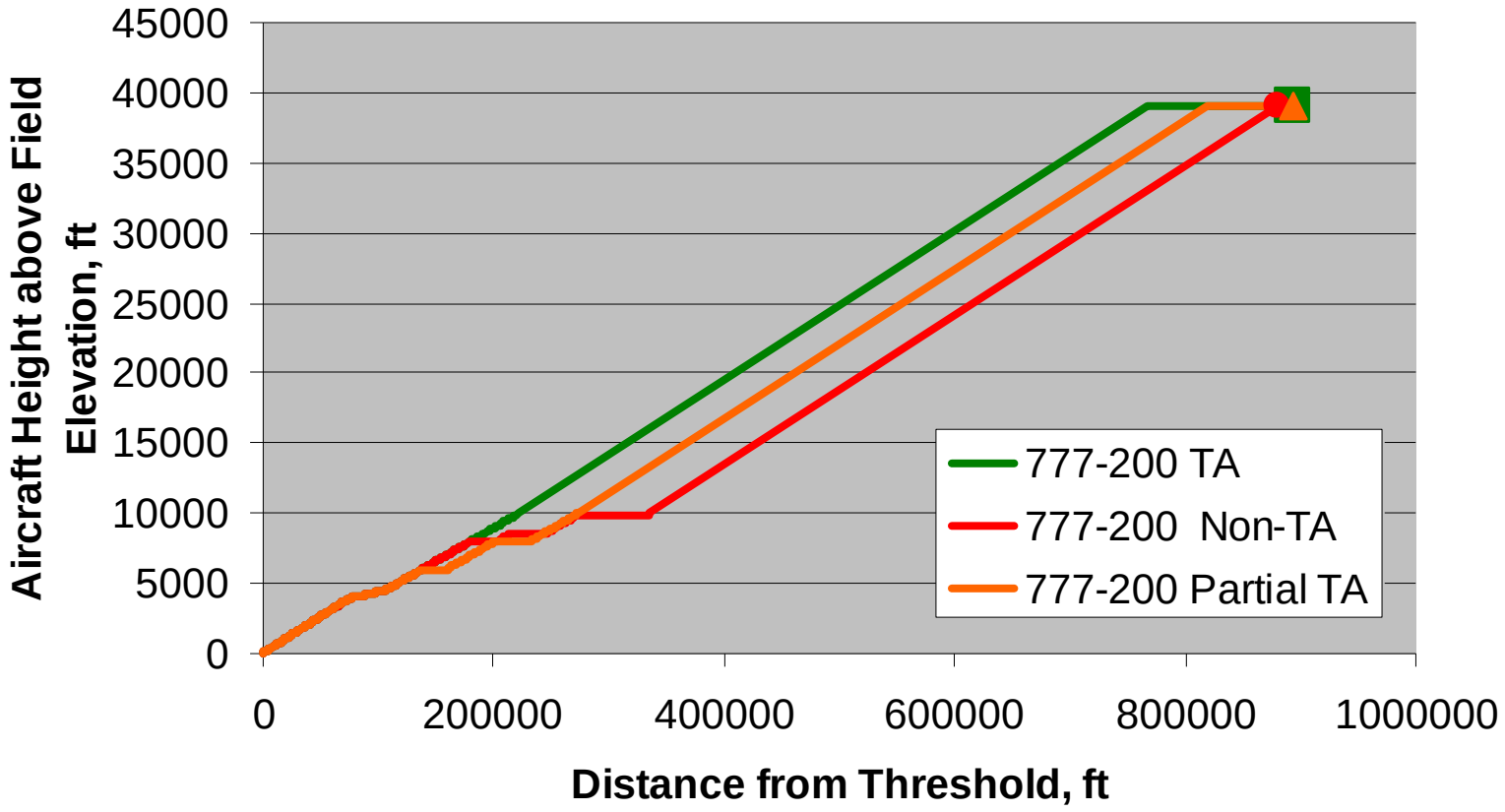
* Estimates derived from GE90-85B and PW4056 engine data

Fuel Consumption (Cruise to Top of Descent to Landing), Cont

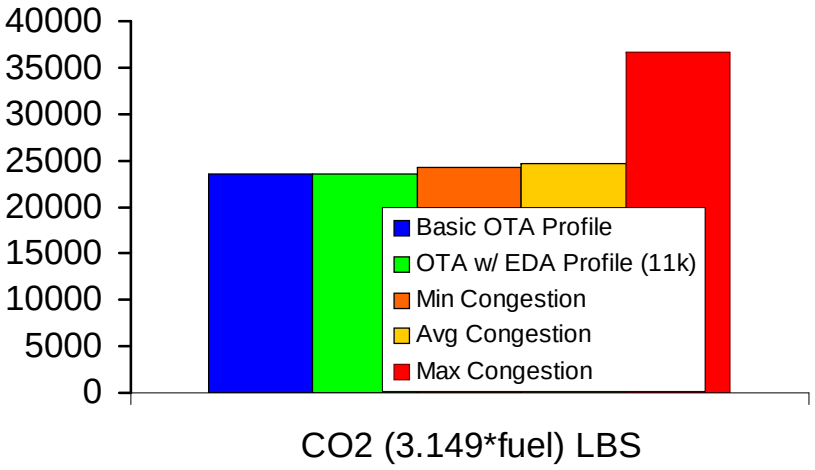
Estimated Actual Fuel & CO2 Savings from SFO Tailored Arrivals

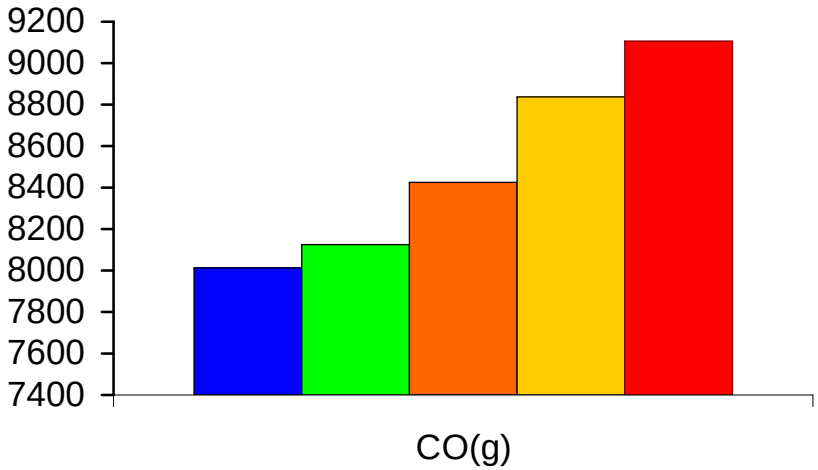
Airline	Airplane	Fuel / CO_2 Saved (lbs)	Fuel / CO_2 Saved (kgs)
Air New Zealand	**777-200ER**	Fuel: 328,900 CO_2: 1,037,680	Fuel: 162,785 CO_2: 513,585
United Airlines	**777-200ER**	Fuel: 509,080 CO_2: 1,606,147	Fuel: 251,962 CO_2: 794,941
United Airlines	**747-400**	Fuel: 915,600 CO_2: 2,888,718	Fuel: 453,164 CO_2: 1,429,731
Japan Airlines	**747-400**	Fuel: 86,800 CO_2: 273,854	Fuel: 42,960 CO_2: 135,540
Qantas	**747-400**	Fuel: 159,600 CO_2: 503,538	Fuel: 78,992 CO_2: 249,219

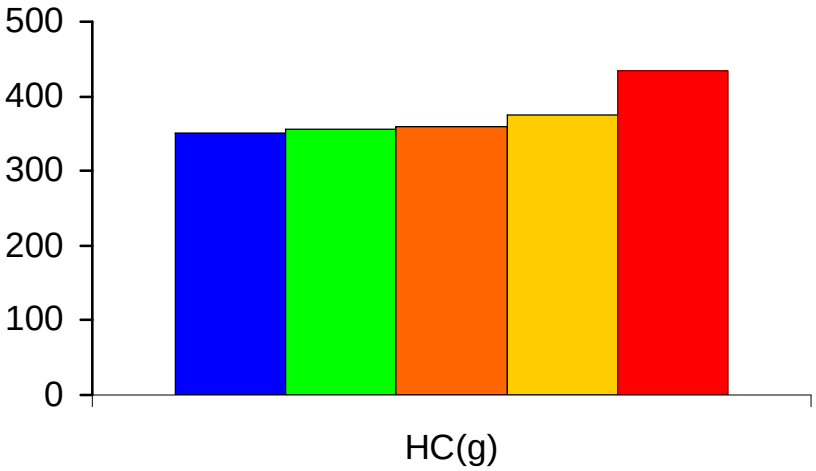
Trajectory Comparison from Boeing Performance Software

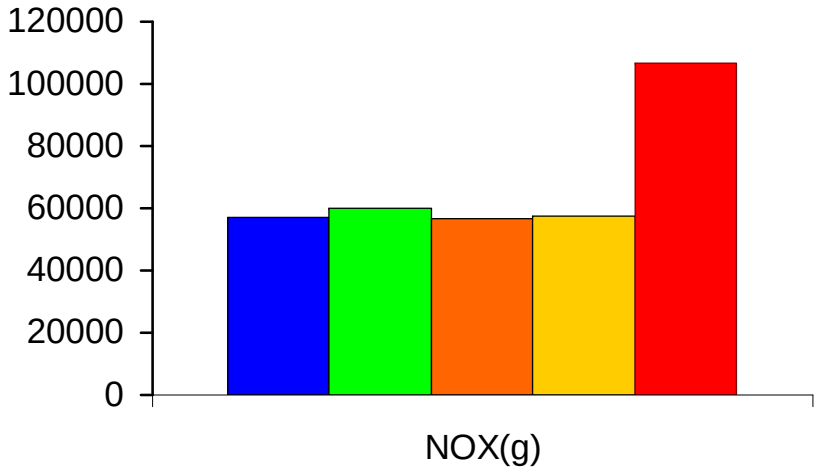


Emissions Analysis - CREAN to the Runway

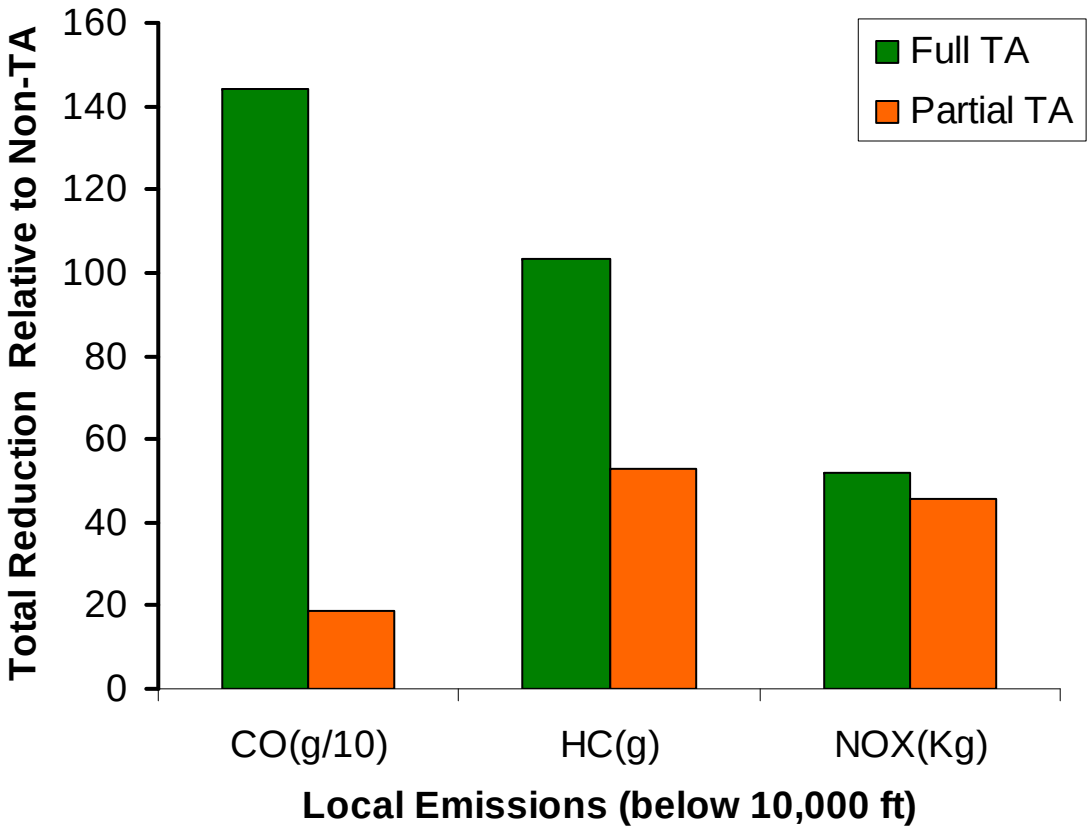




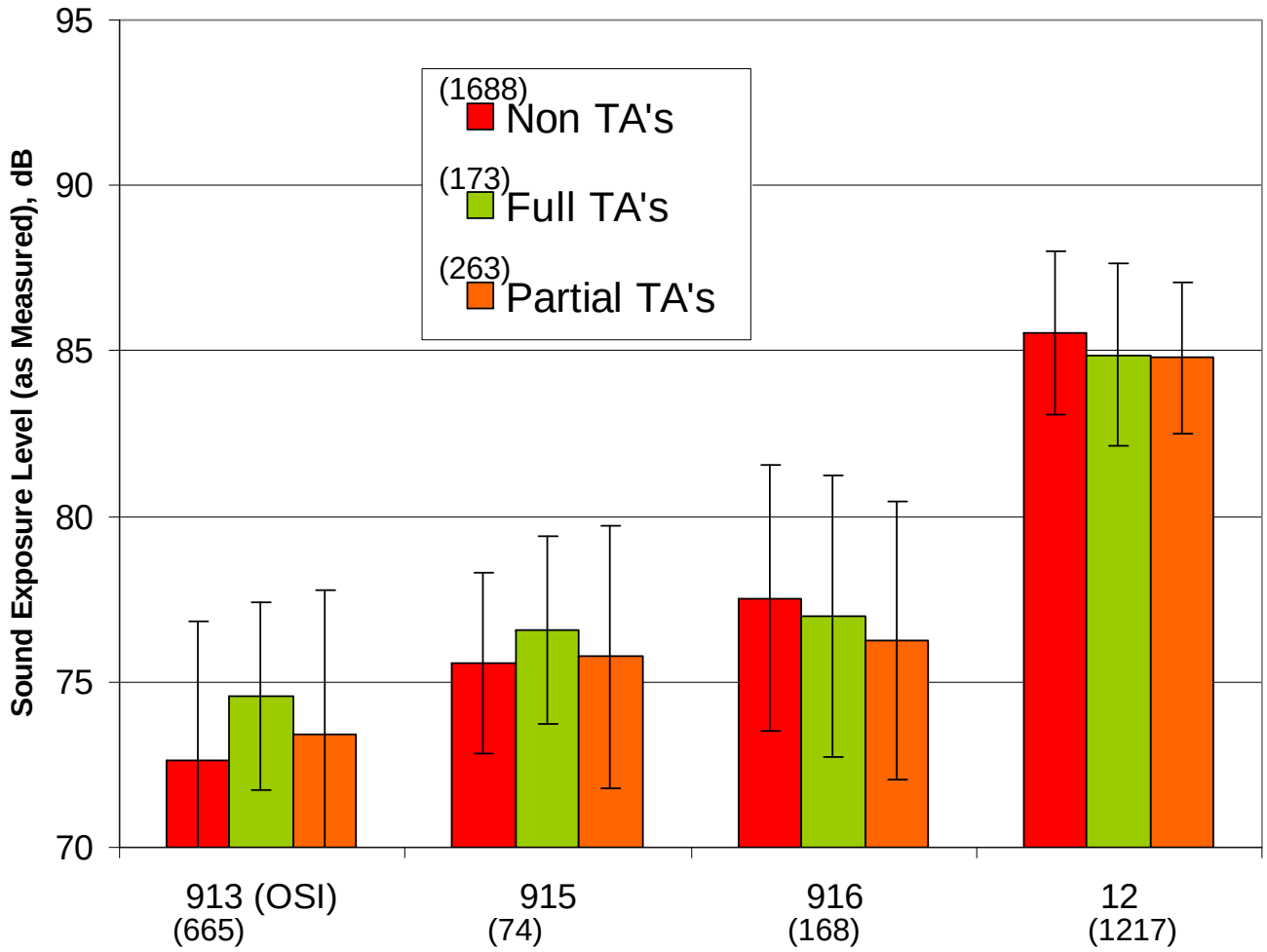




Emissions Analysis - (10,000’ to Landing)

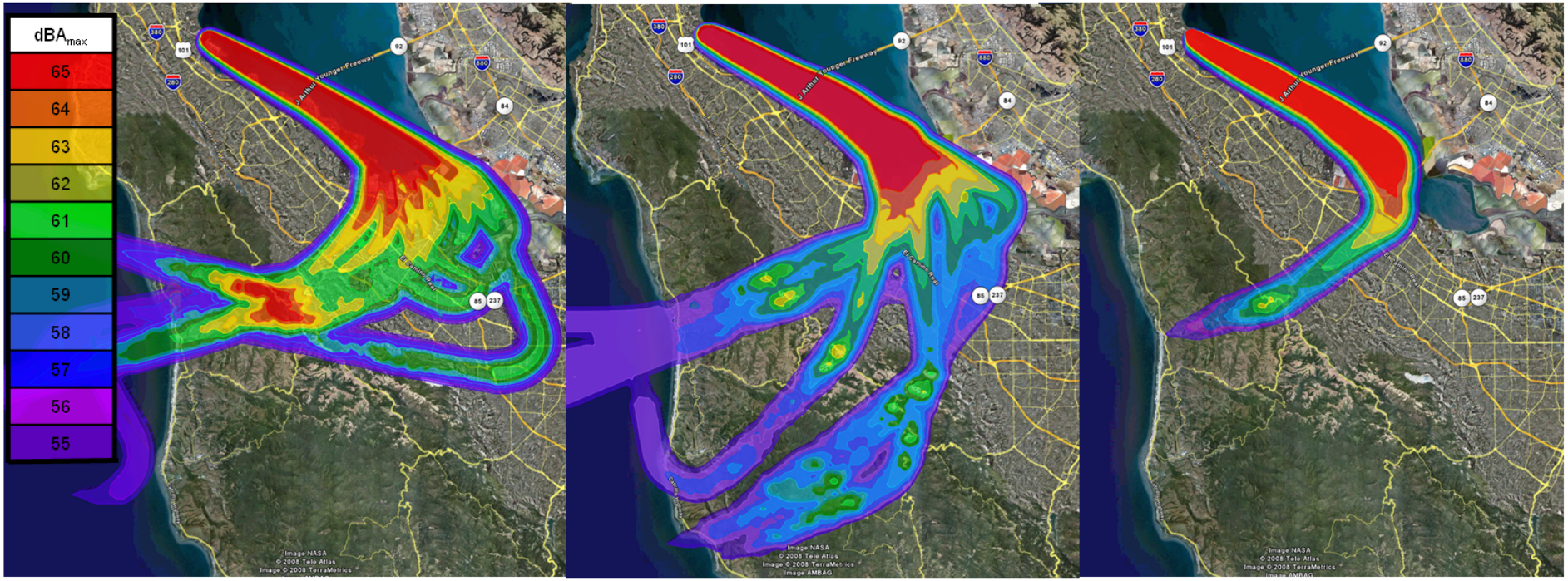


Noise Measurement Comparison- SEL (As Measured)



Sample Size
(2124)

Noise Contour Comparison- 20 Flights per Scenario

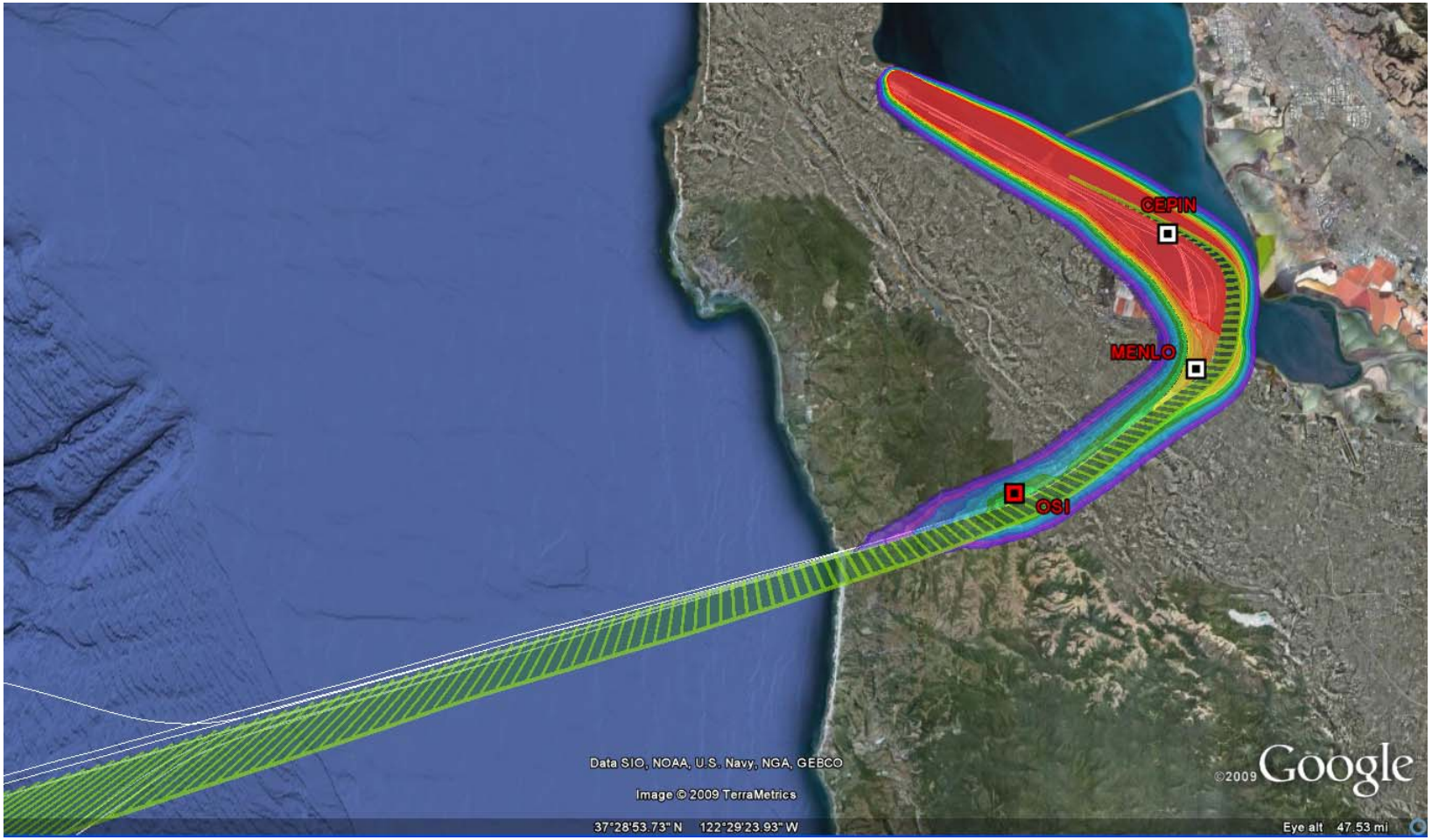


Non Tailored Arrival

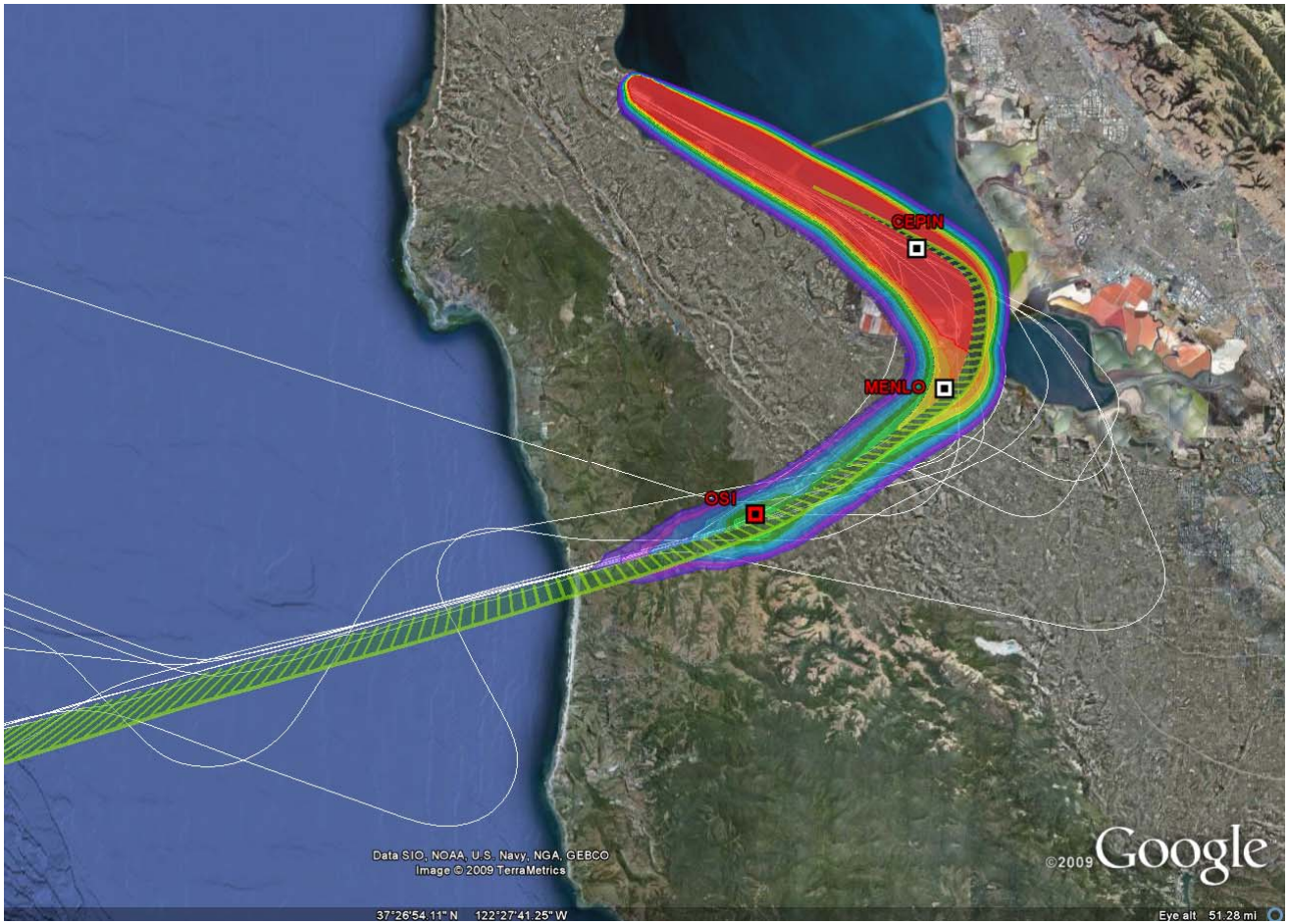
Partial Tailored Arrival

Tailored Arrival

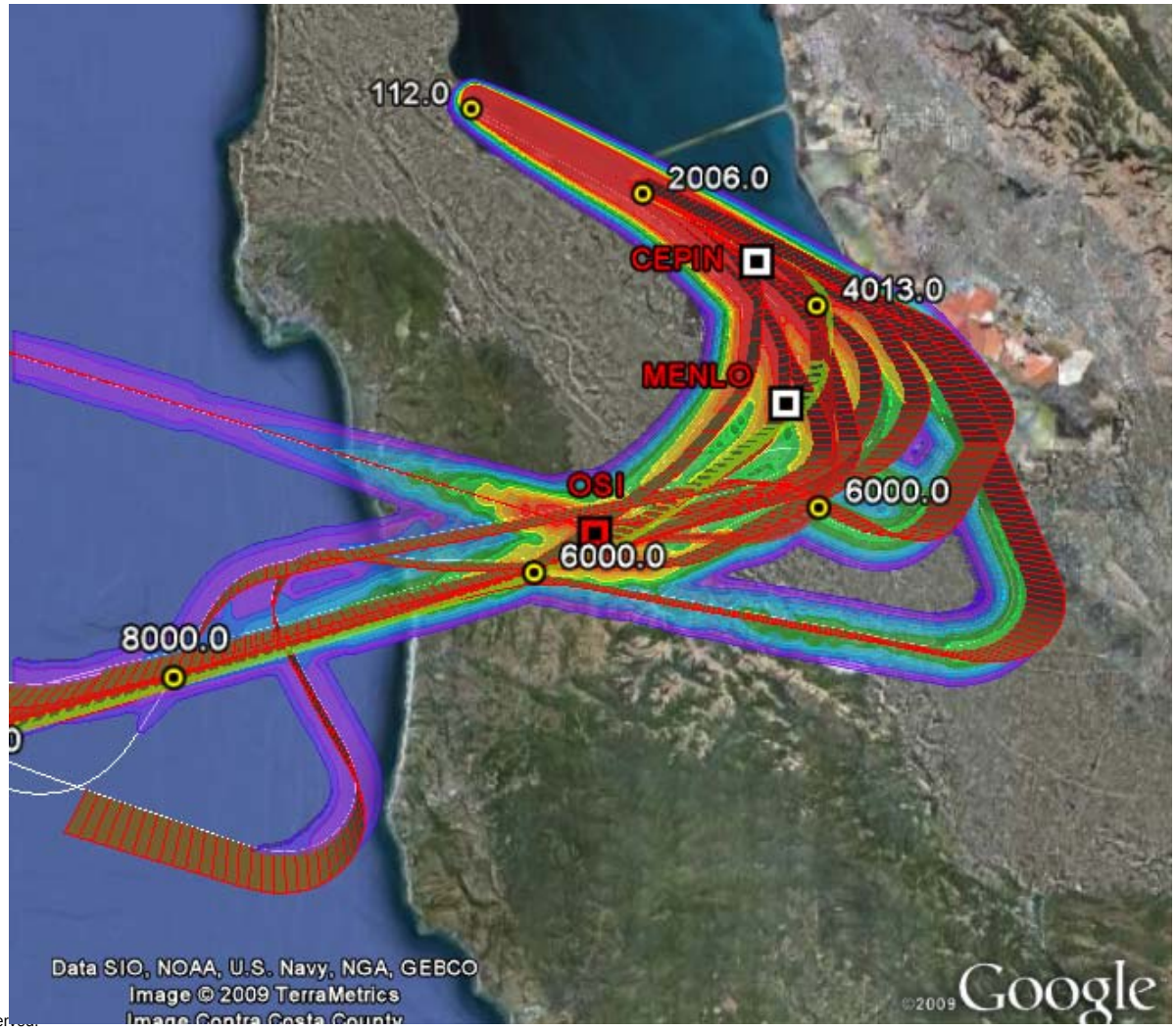
Full TA Scenario



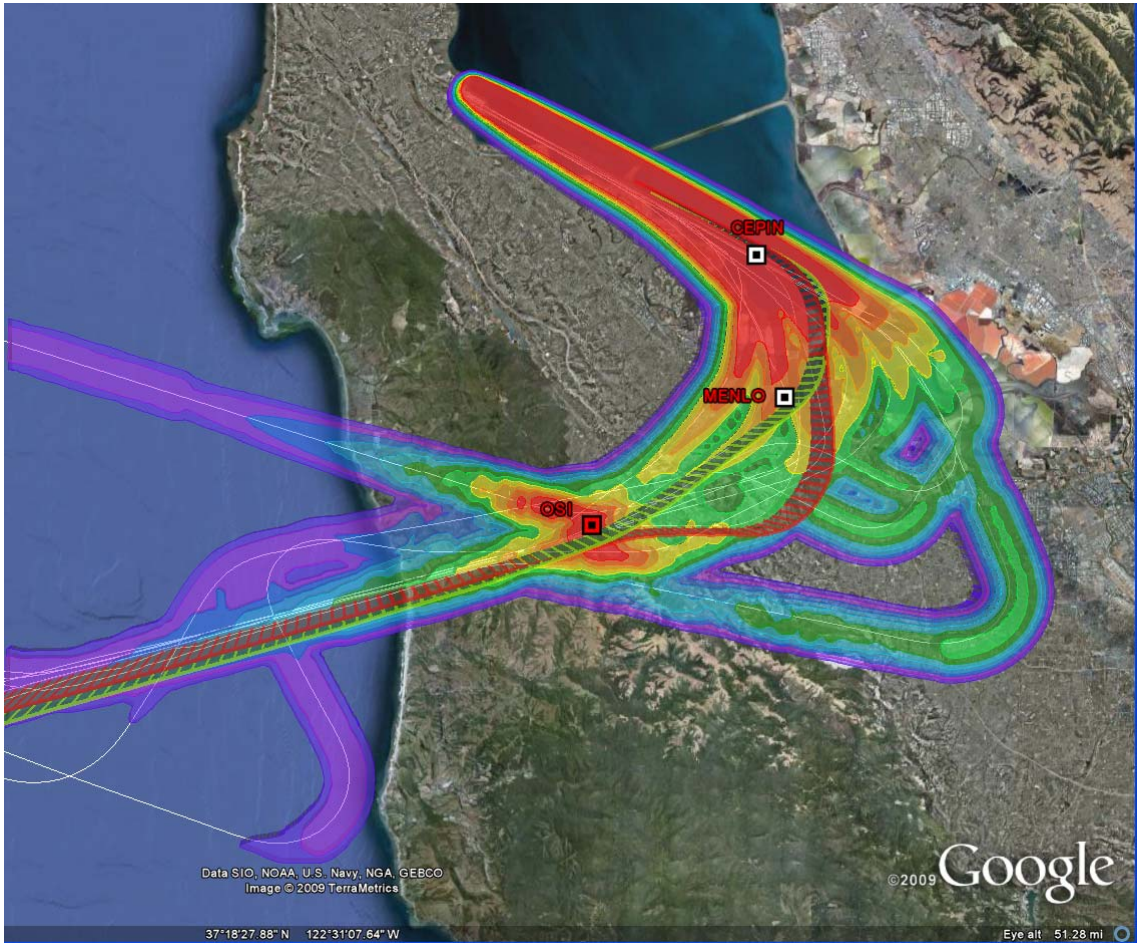
Full TA Scenario with Non TA Track Overlay



Non TA Scenario



Full TA / Non TA Comparison



Summary

First Year of Tailored Arrivals Operations at San Francisco

- **Fuel Saved**
  - **1,999,980 lbs (989,863 kgs)**
- **CO2 Emissions Saved**
  - **6,309,937 lbs (3,123,016 kgs) Fuel Saved**
- **Noise Impact**
  - **No Significant Change at a few temporary measurement sites**
  - **Reduction in noise exposure area can be significant**
- **Air Quality**
  - **Overall reduction CO, HC, and NOx (From TOD or 10,000')**