

UMR



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Center of Excellence for Aerospace Particulate Reduction Research

Aircraft PM Emissions from the JETS APEX2 Measurement Campaign

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Cambridge Particle Meeting
Cambridge, UK
May 22, 2006

Overview

❖ Introduction

❖ Dedicated Engine Tests

❖ Overview

❖ Physical characterization of PM emission as a function of engine operating conditions

❖ Comparison with previous APEX measurements

❖ Airport study

❖ Overview

❖ Video

Introduction

- ❖ Sponsors: CARB, NASA, FAA, EPA
- ❖ Participants: AEDC, ARI, CARB, EPA, NASA (GRC, LaRC), UCF, UCR, UMR
- ❖ Observers: GE, Boeing, SWA, OAK
- ❖ Project Manager: Dr. Phil Whitefield (UMR)

Introduction

❖ Instrumentation

- ✓ Cambustion DMS500 (2)
- ✓ DMA
- ✓ TSI CNC
- ✓ CO₂ detector
- ✓ Weather station

❖ Parameters measured (total and non-volatile aerosol)

- ✓ Dgeom – number based geometric mean diameter
- ✓ Sigma – geometric standard deviation
- ✓ Dgeom M – mass (volumetric) based geometric mean diameter
- ✓ EIn – number based emission index
- ✓ Elm – mass based emission index

Dedicated Engine Tests

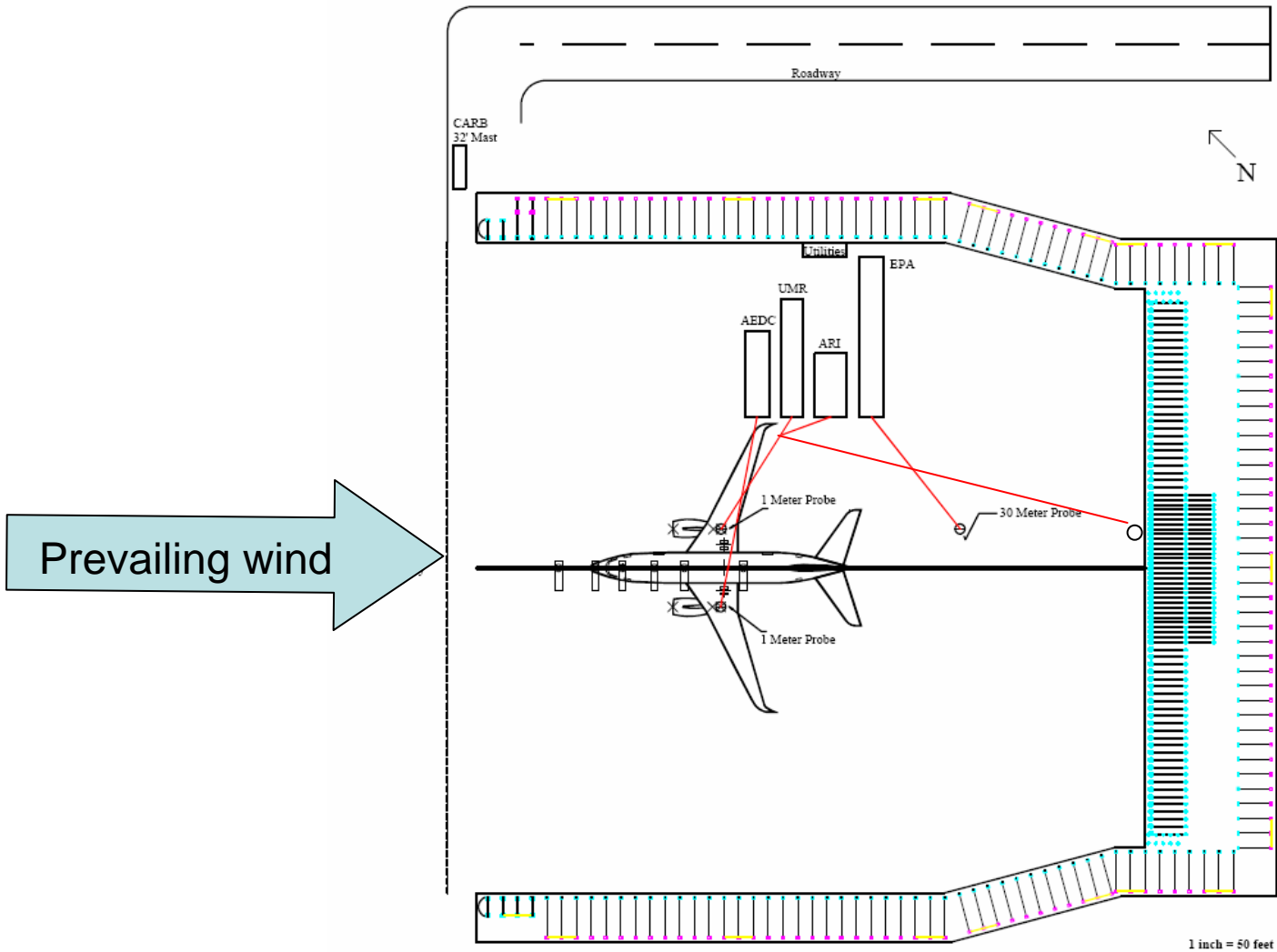
Location: Ground Runup Enclosure,
Oakland International Airport

Period: August 23-25, 2005

Objectives

- Produce the first measurements with state-of-art analytical equipment of speciated total organic gases (TOG) and **particulate matter** (PM) from engines on typical in-use Boeing 737-type commercial aircraft
- Provide data to address critical science questions/issues arising from the 2004 APEX and UNA UNA studies

Test Layout



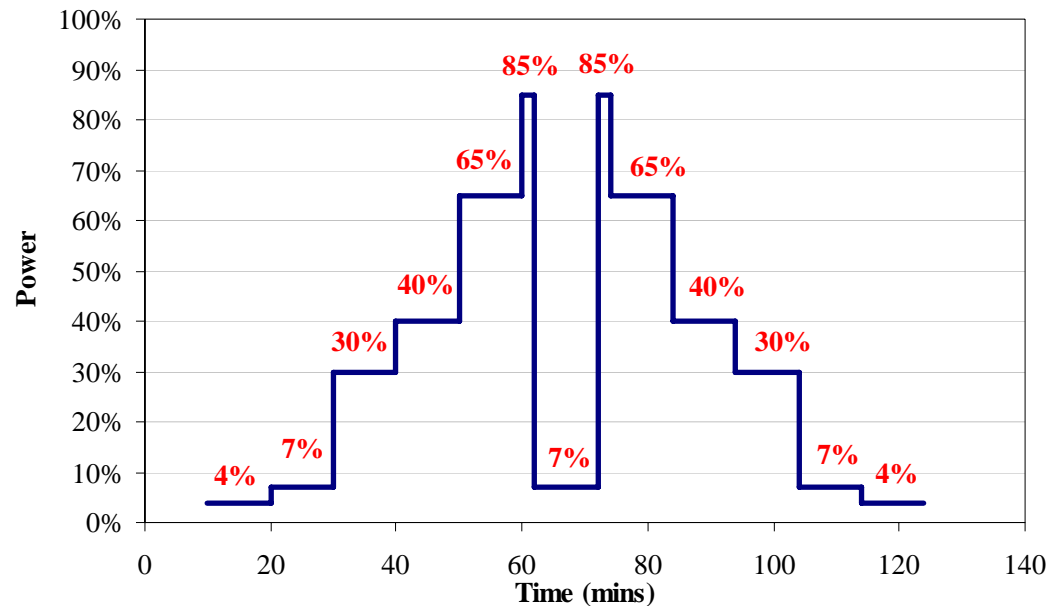
Sampling Probes



Engine Test Overview

Date	Aircraft Tail No	Airframe	Engine
August 23, 2005	N435WN	B737-700	CFM56-7B22
August 24, 2005	N353SW	B737-300	CFM56-3B1
August 24, 2005	N695SW	B737-300	CFM56-3B2
August 25, 2005	N429WN	B737-700	CFM56-7B22

Test Matrix

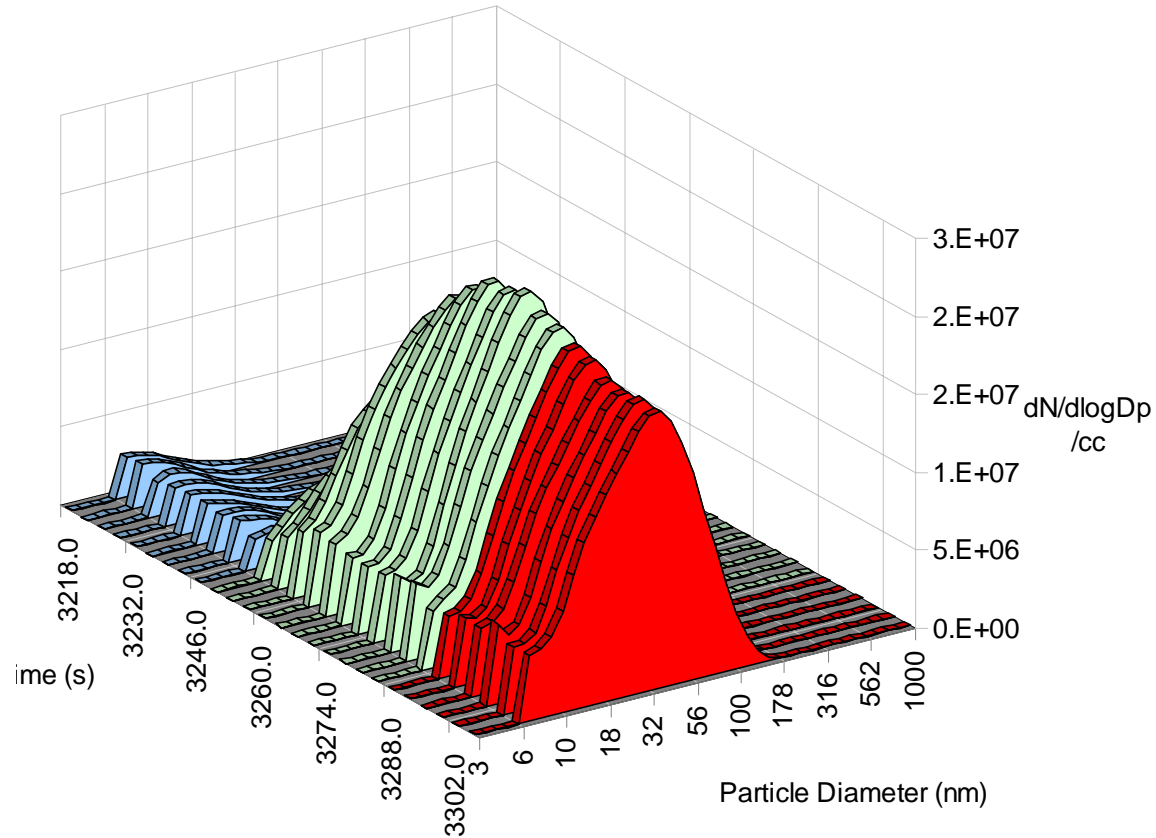
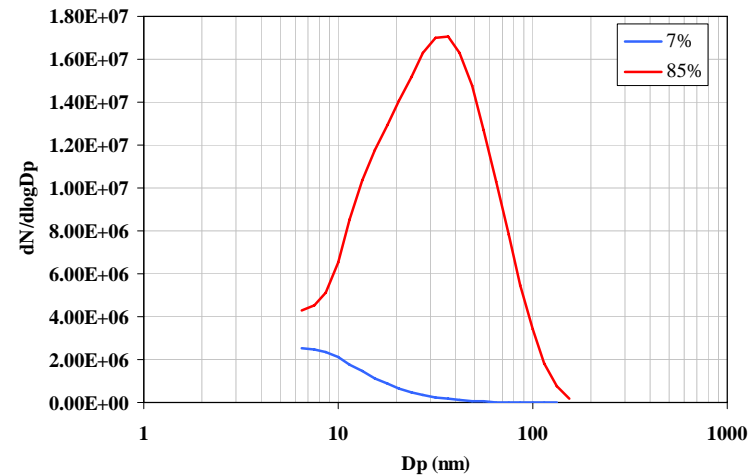


Typical Particle Size Distributions

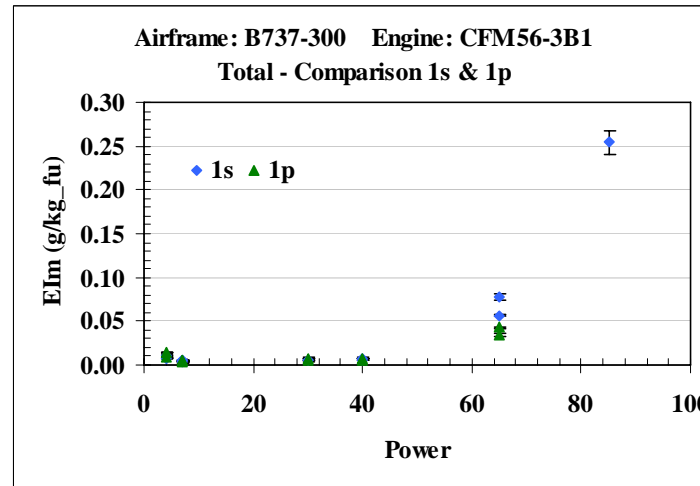
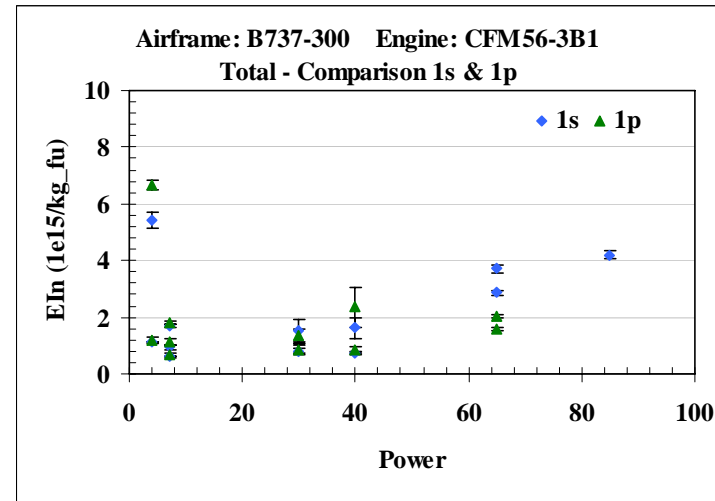
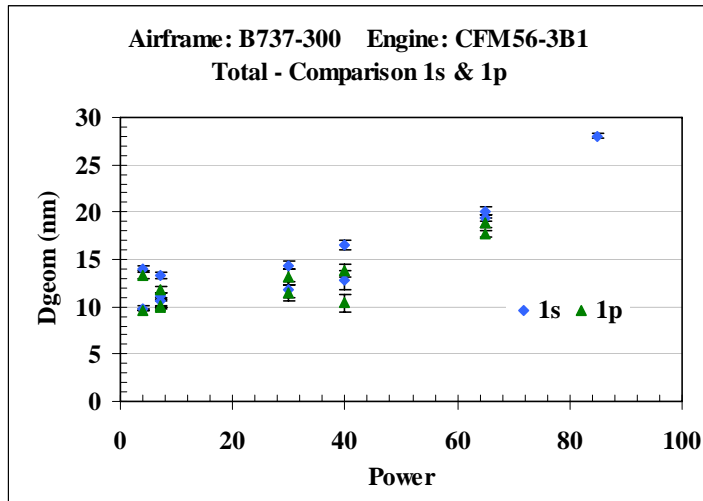
DMS500 Dynamic Particle Spectrum

Dynamic Sp

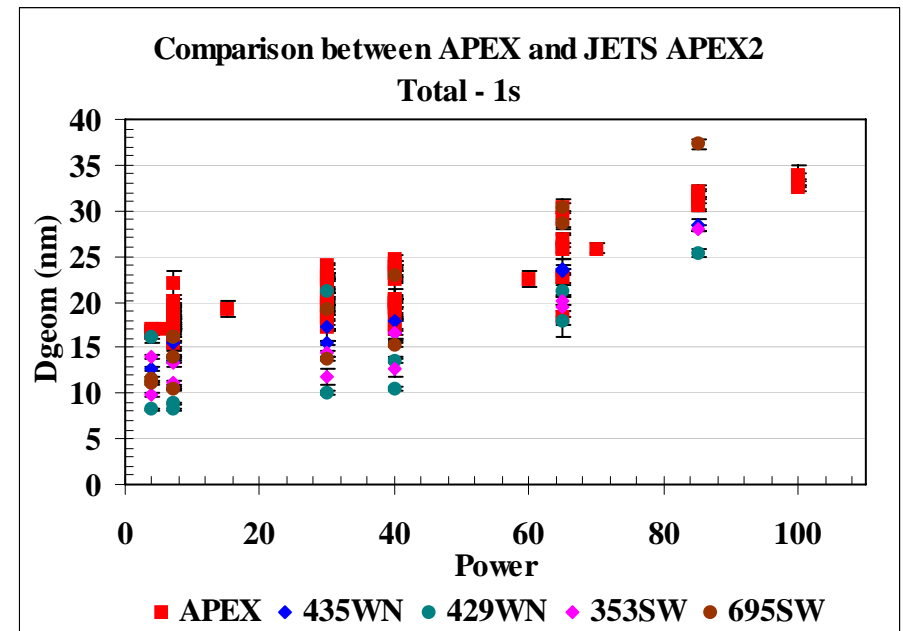
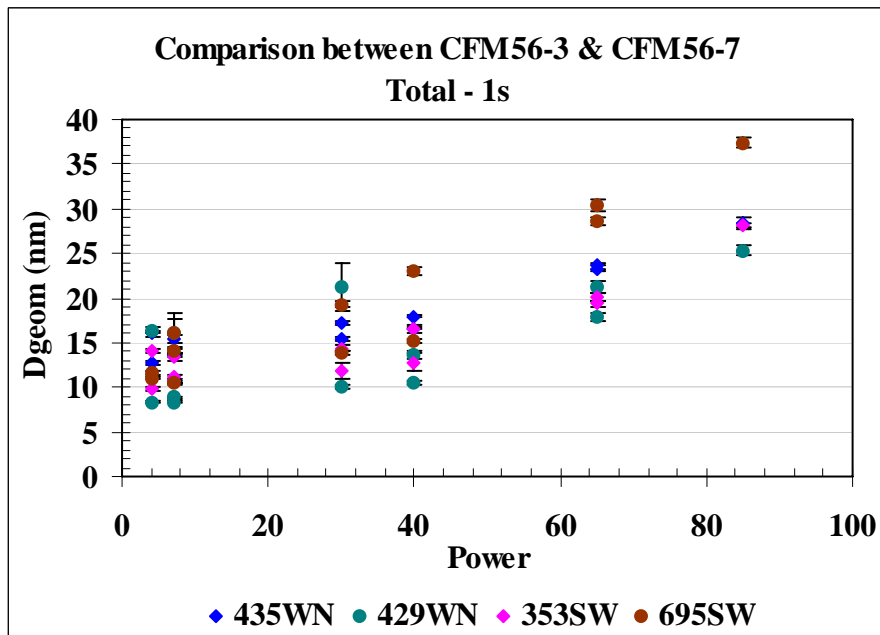
Transition from 7% to 85%



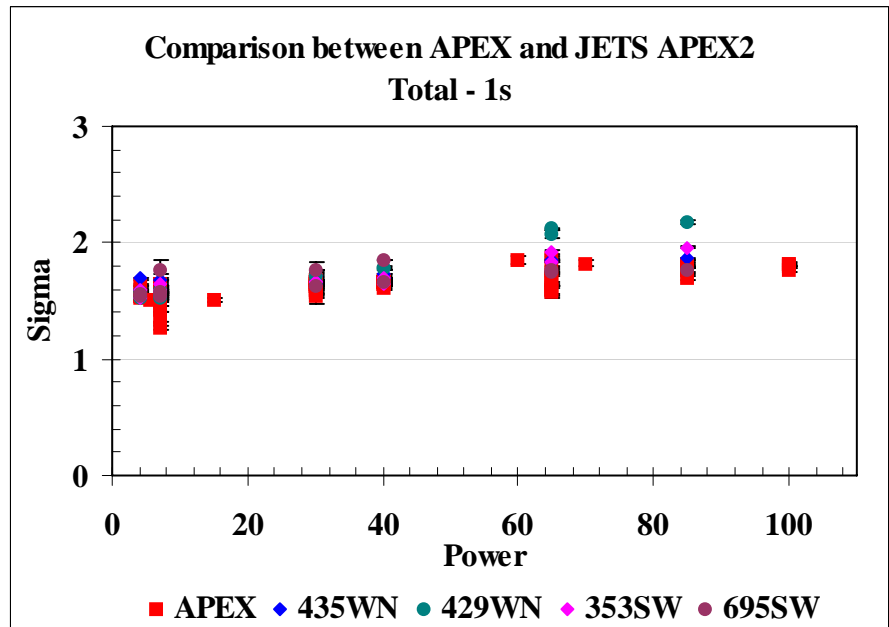
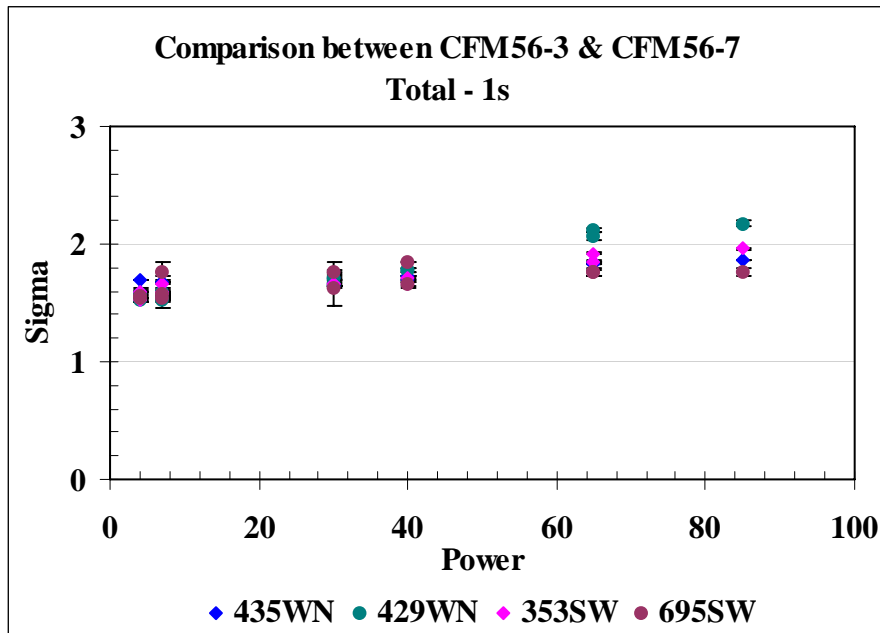
Total aerosol – 1m (s and p)



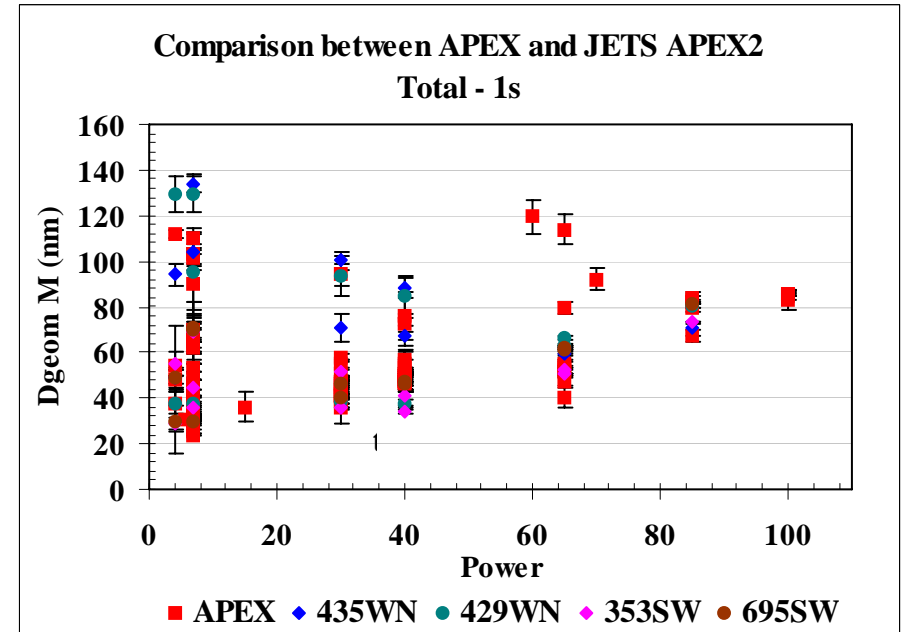
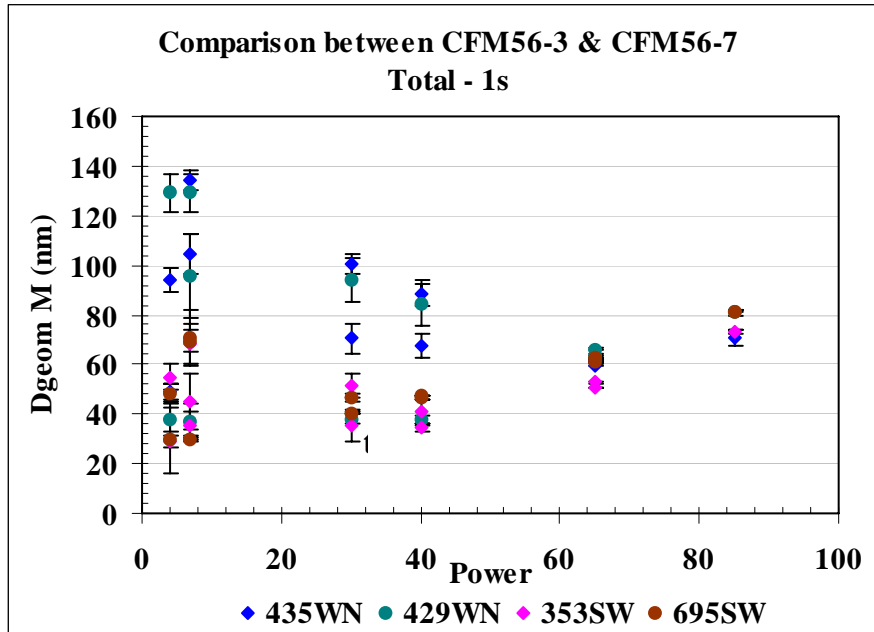
Number based Geometric Mean Diameter (D_{geom})



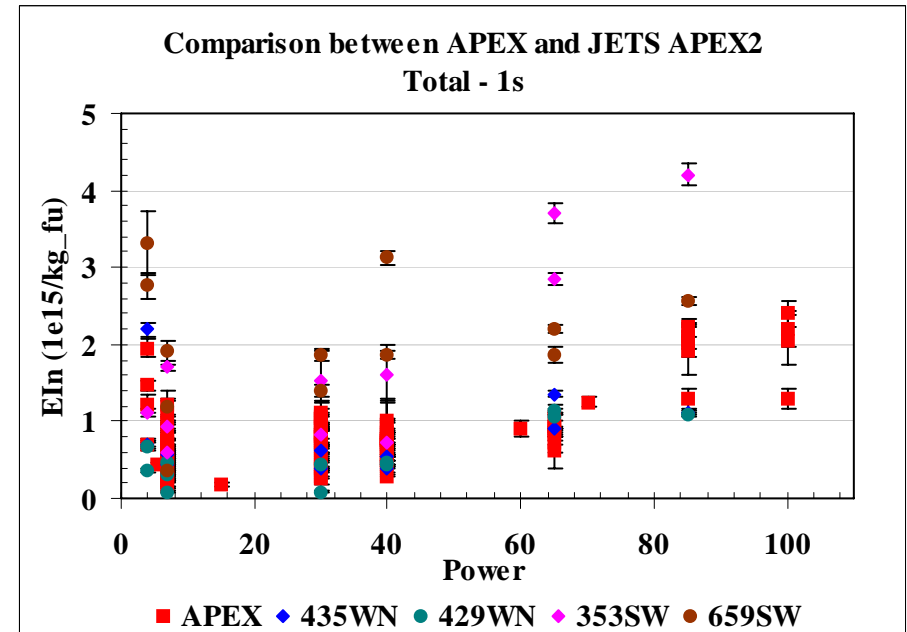
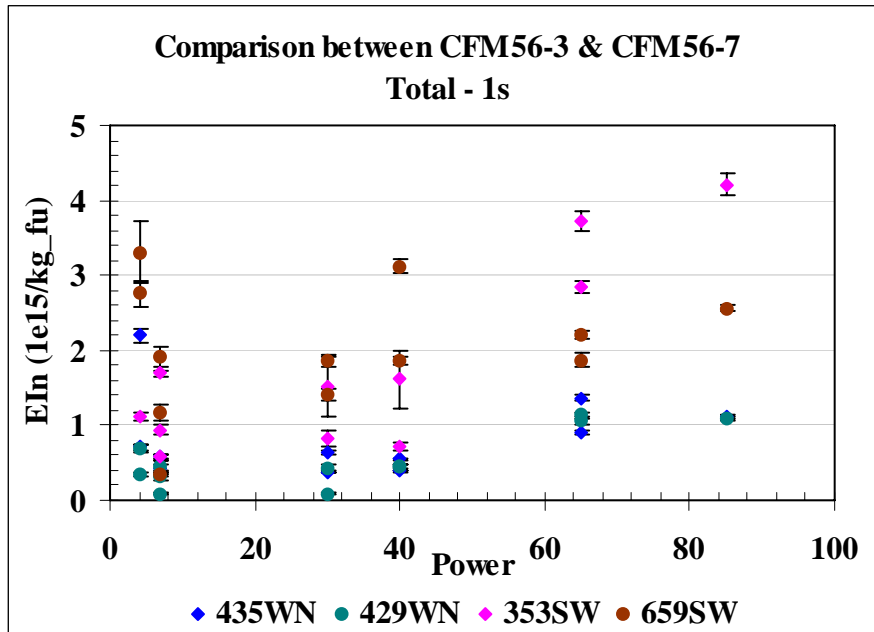
Geometric Standard Deviation (Sigma)



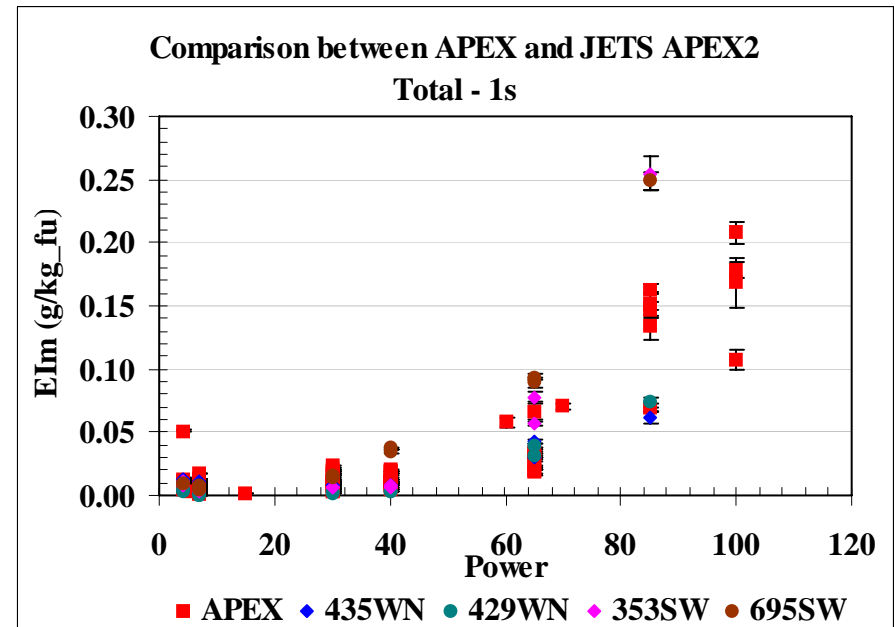
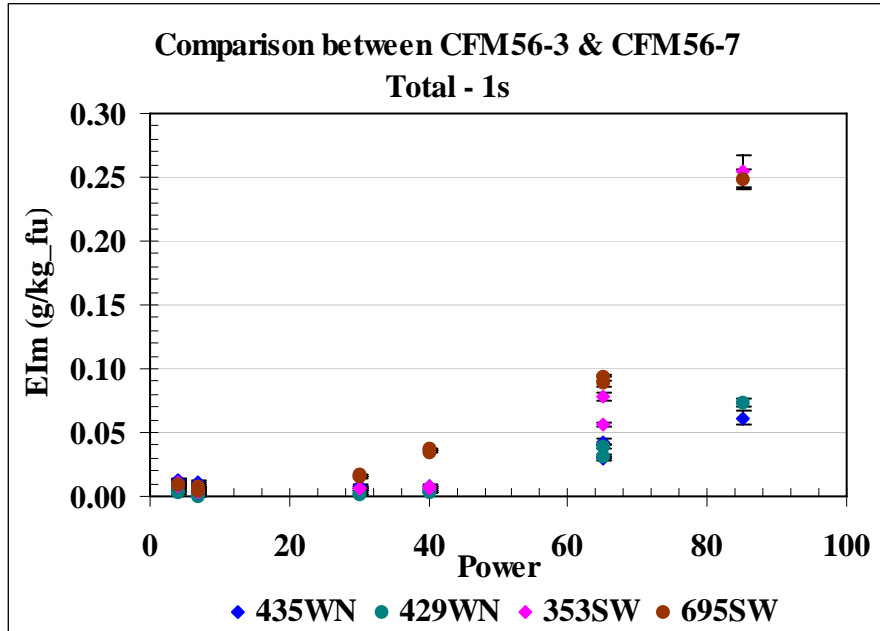
Mass based Geometric Mean Diameter (*D_{geom M}*)



Number based Emission Index (EIn)

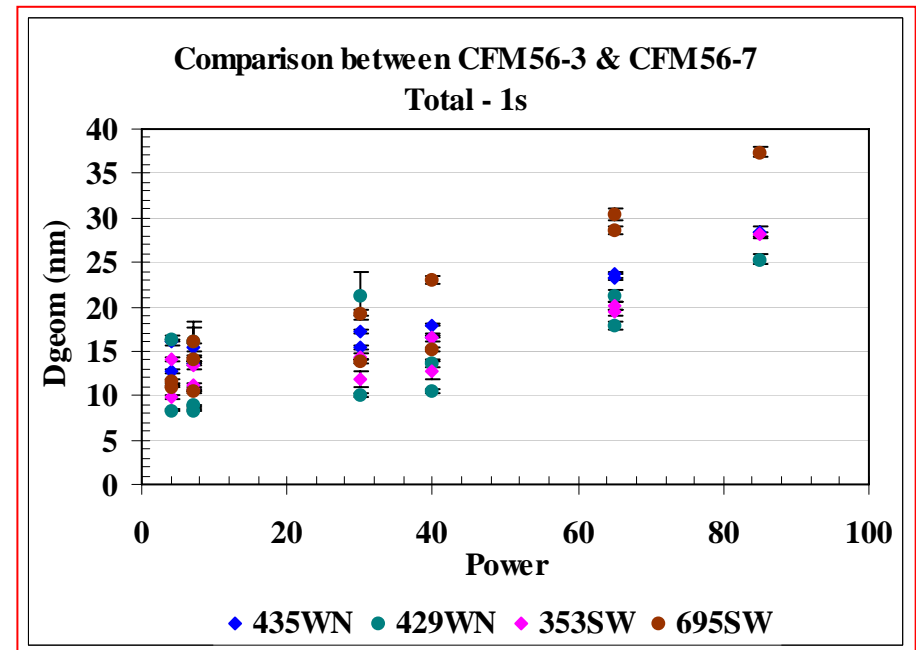
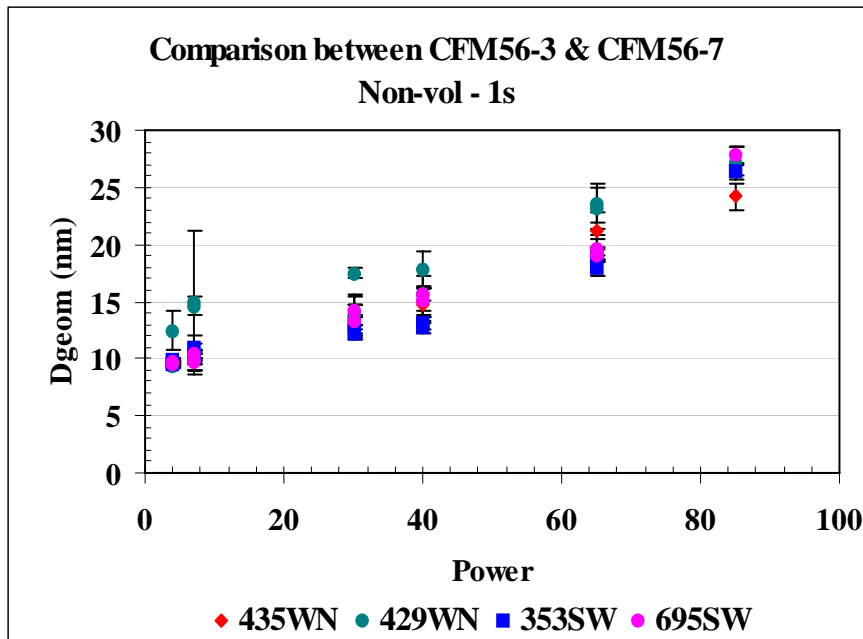


Mass based Emission Index (Elm)

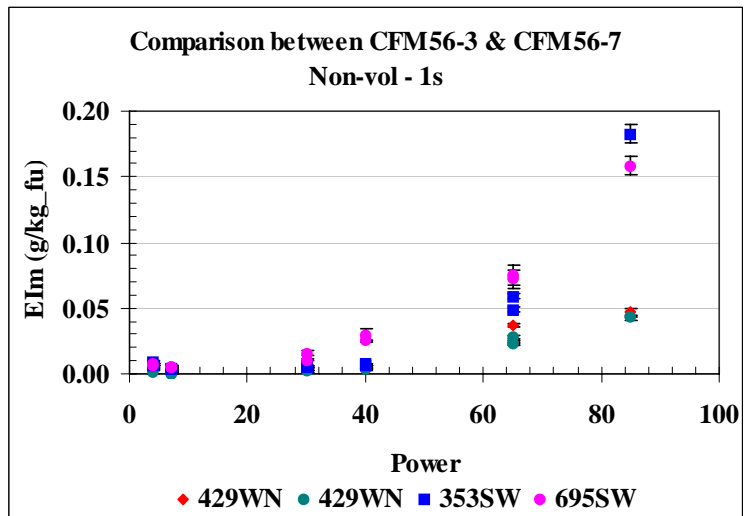
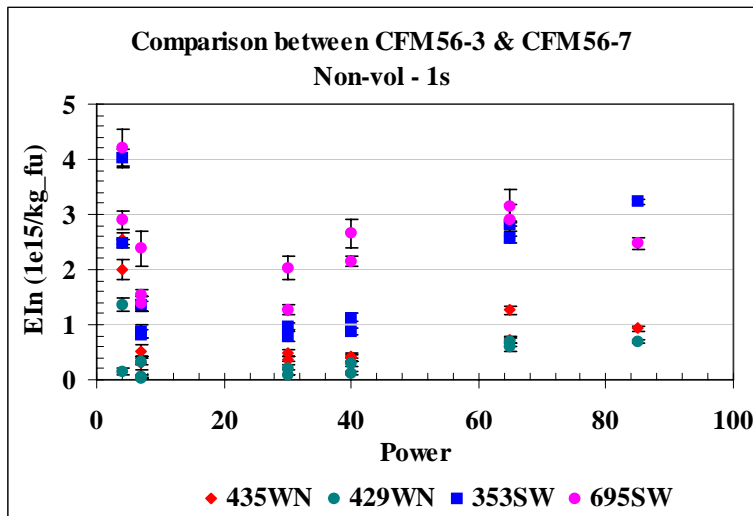
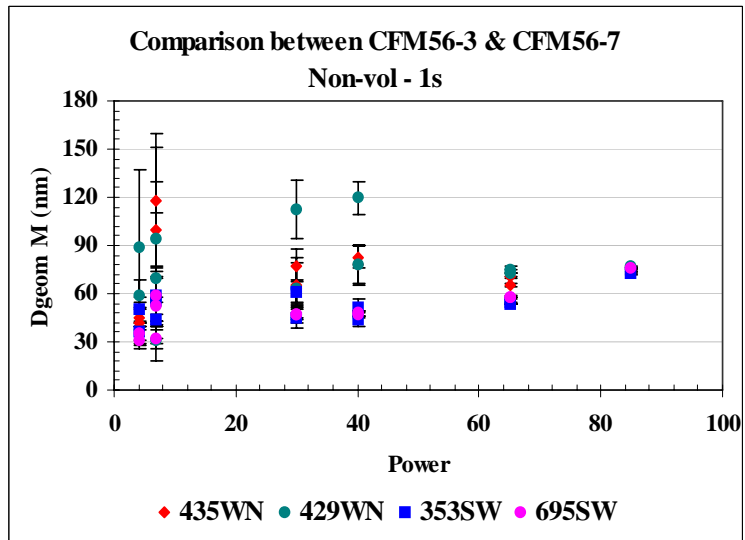
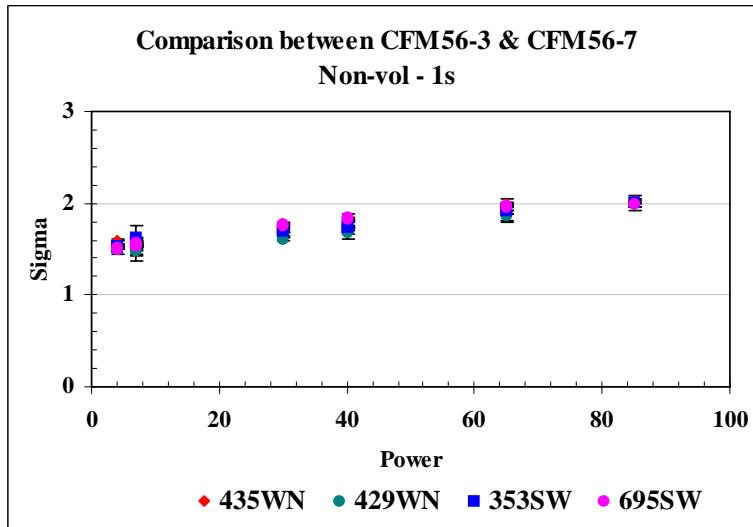


Non-volatile aerosol – 1m

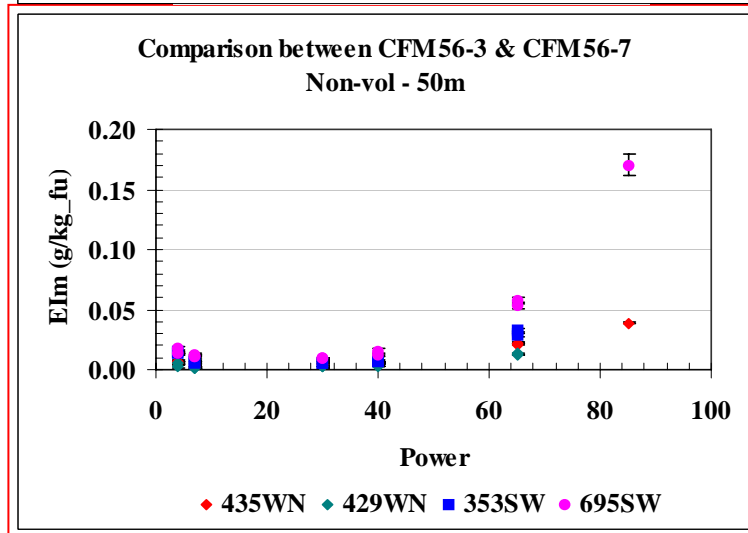
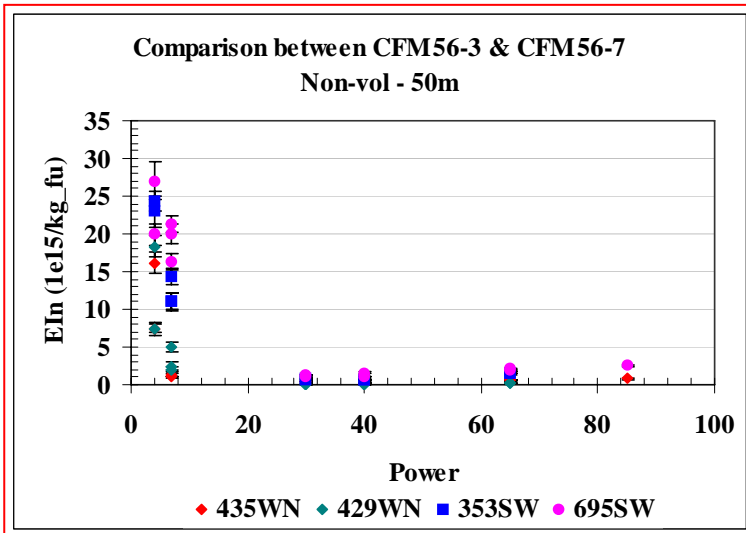
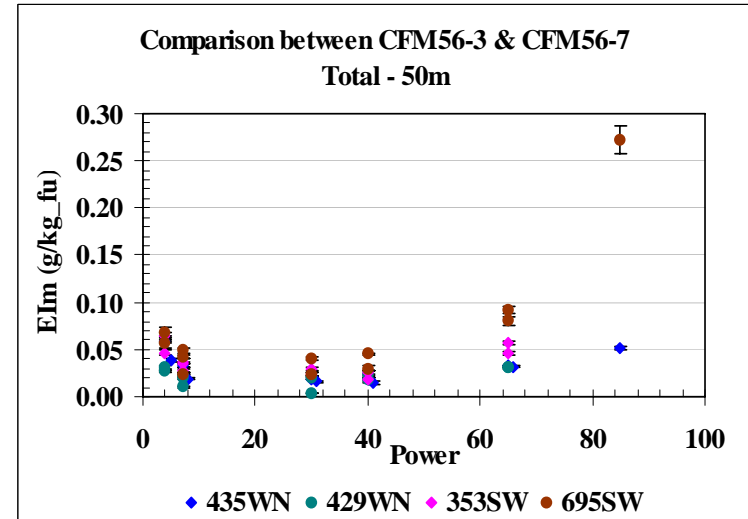
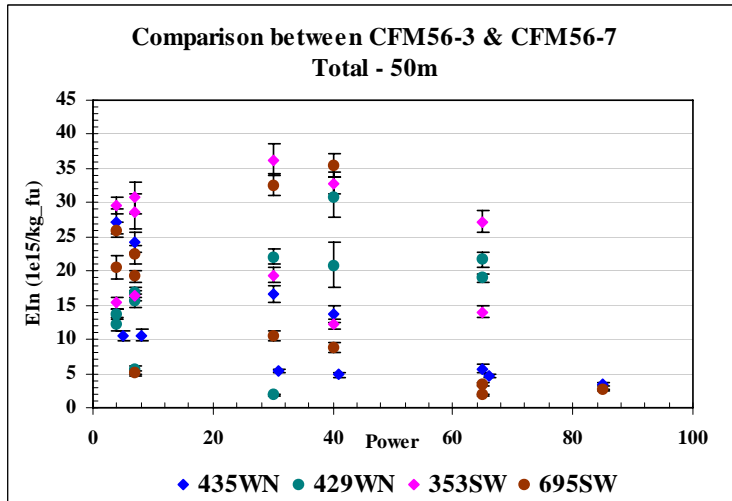
Thermal Discriminator performance evaluation - Schmid et. al. ,
Aerosol Sci. Technol. 2002



Non-volatile aerosol – 1m



50m data

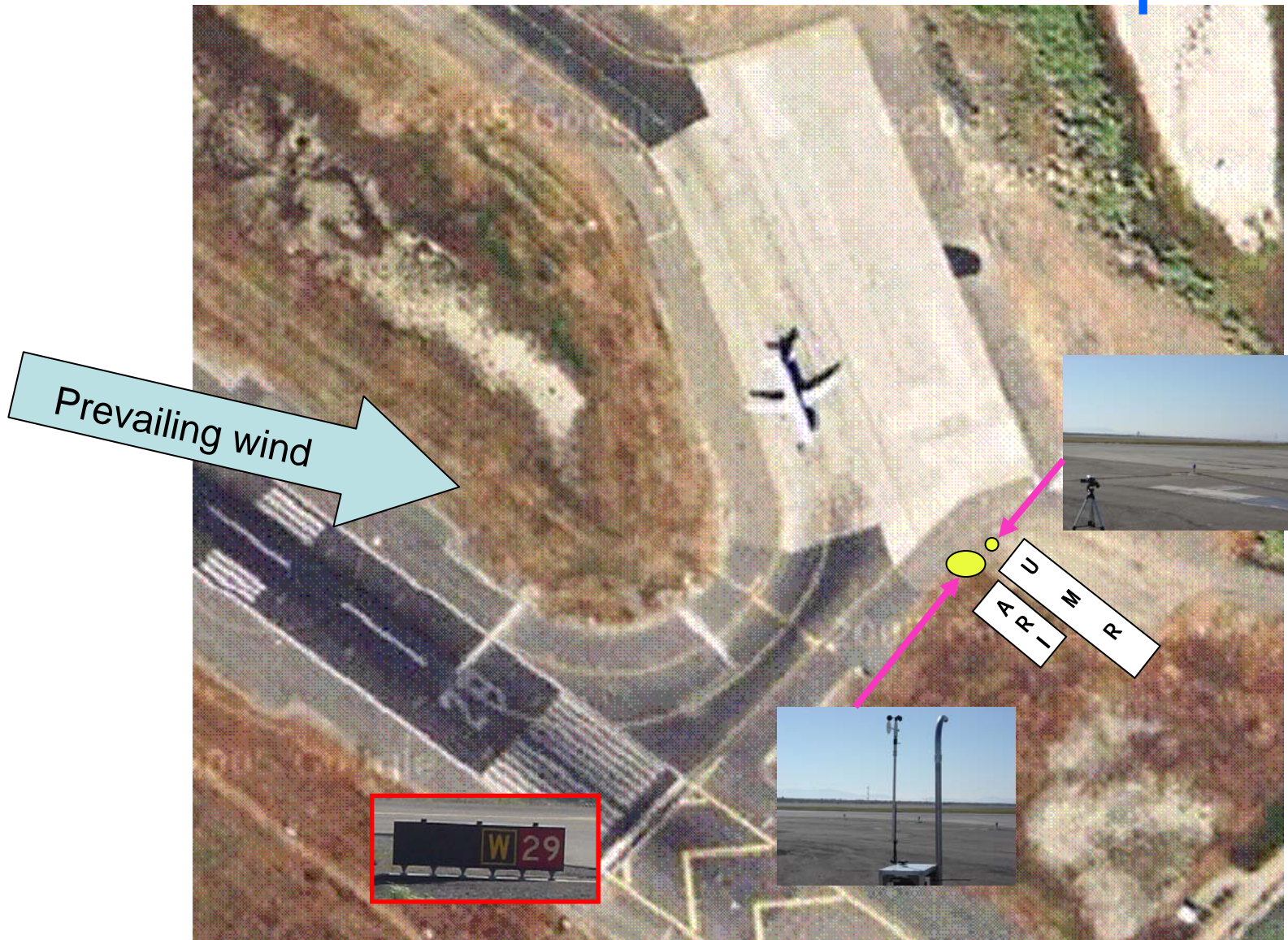


Airport Study

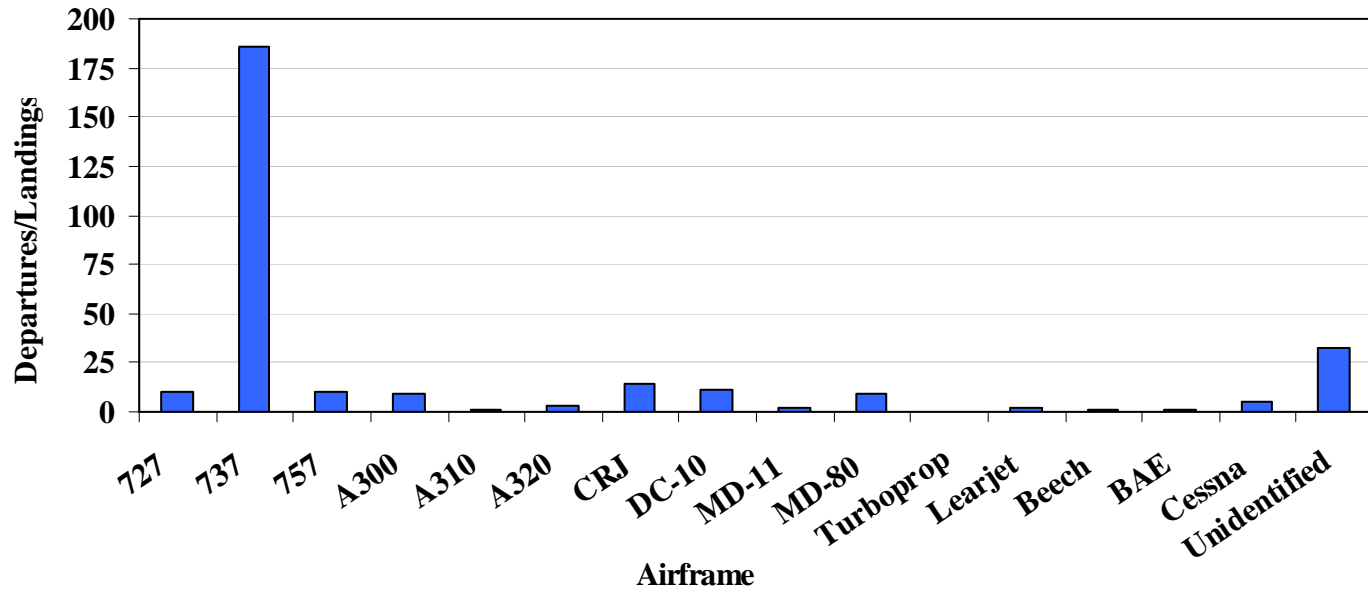
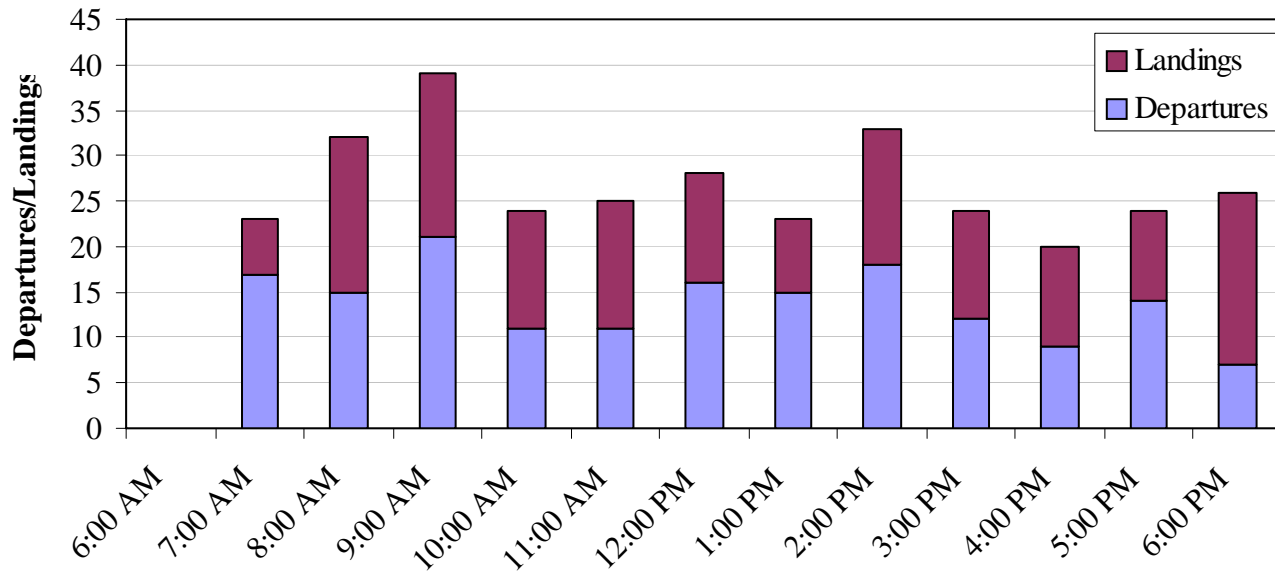
Location: Eastern end of single runway
Oakland International Airport

Period: August 26, 2005

Aerial view – close up

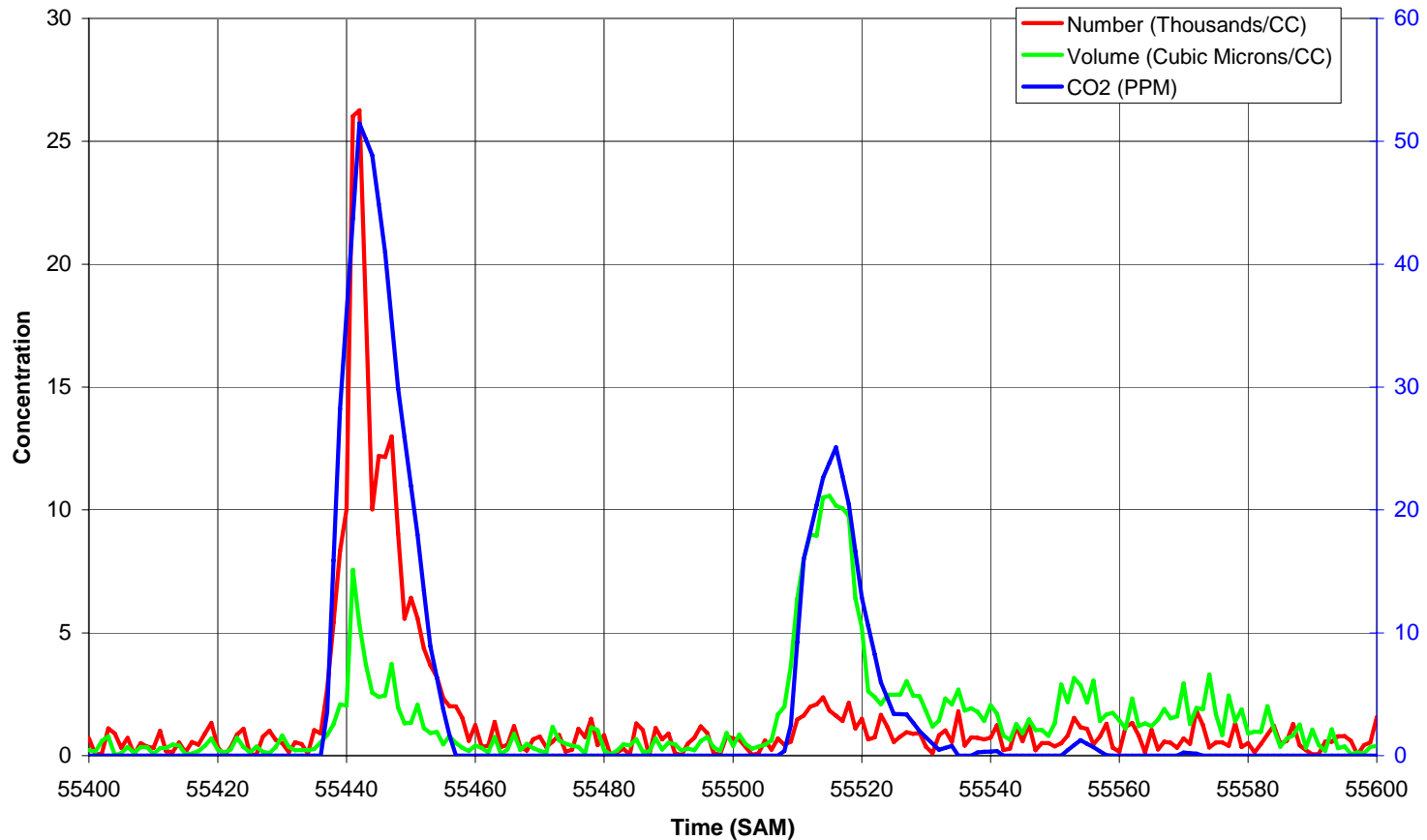


OAK Runway Activity - August 26, 2005



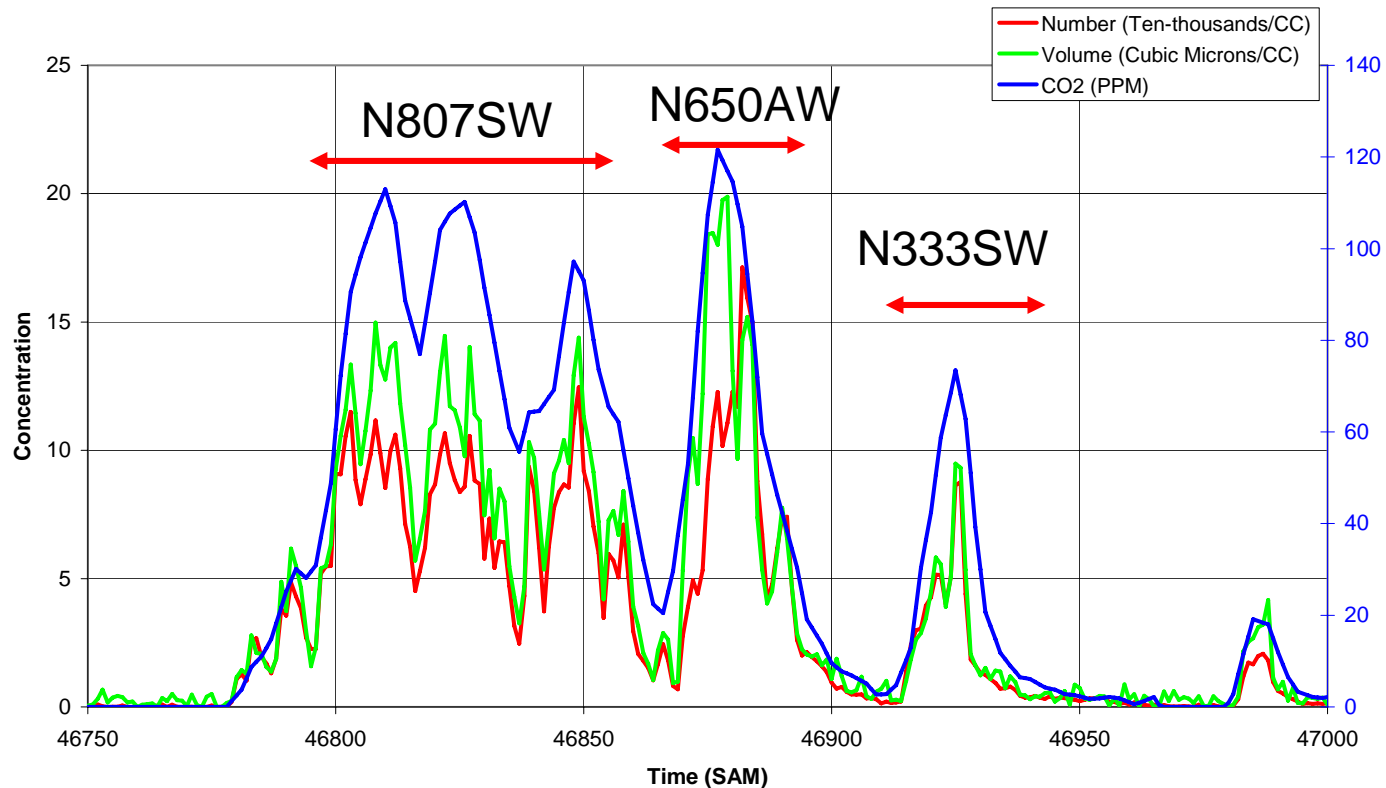
Sample Event – B737

N780AS: Taxi and Take-off
(Boeing 737-400 with CFM56-3B1 Engines)

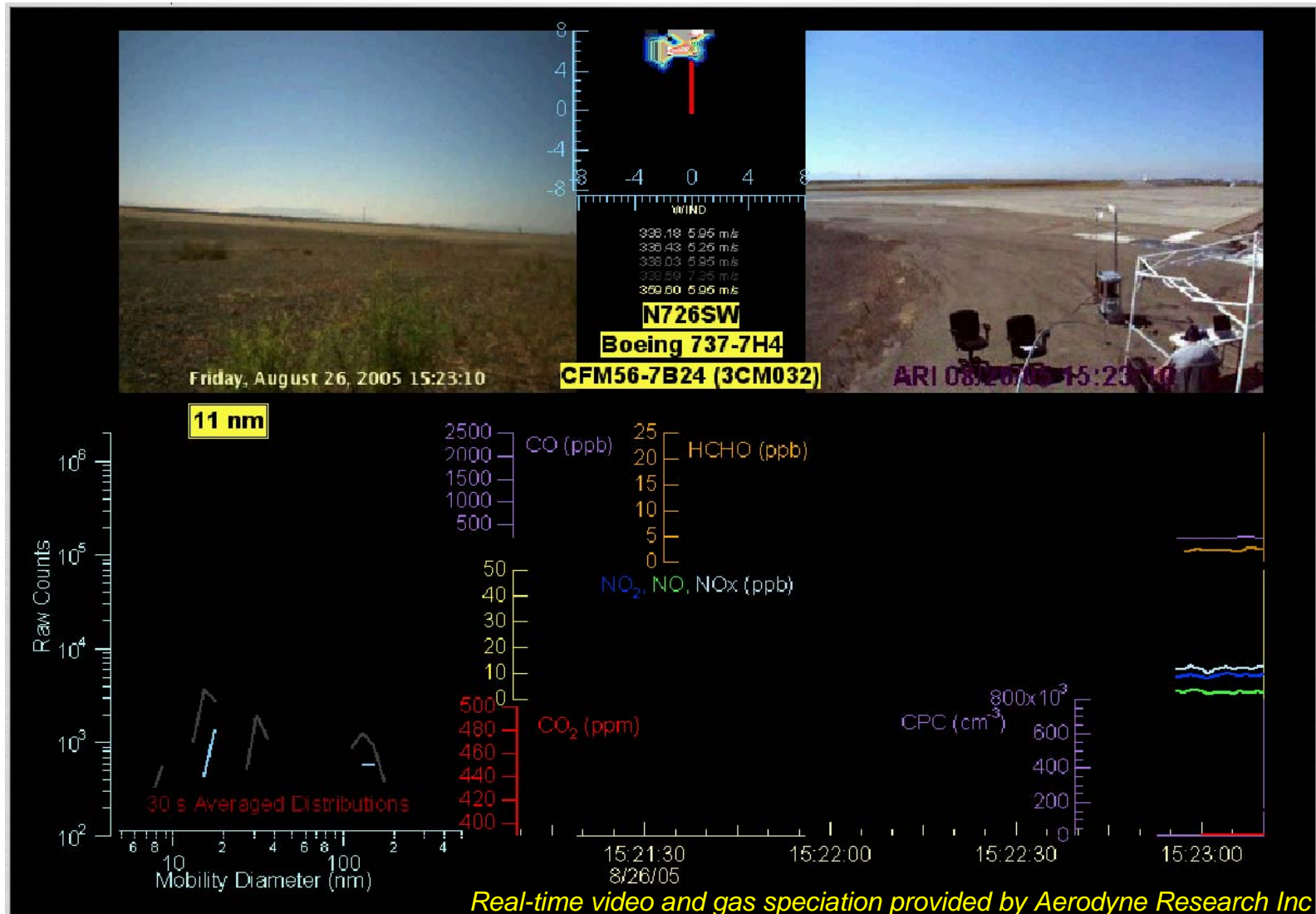


Sample Events - B737, A320, B737

N807SW: Landing, N650AW: Landing, and N333SW: Taxi
(Boeing 737-300, Airbus A320-200, and Boeing 737-300)
(CFM56-3B1 Engines, V2527-A5 Engines, and CFM56-3B1 Engines)



Video



JETS APEX2 Team

