ASE VISION
INFORM. INVOLVE. COLLABORATE.

ASPEN/PITKIN COUNTY AIRPORT

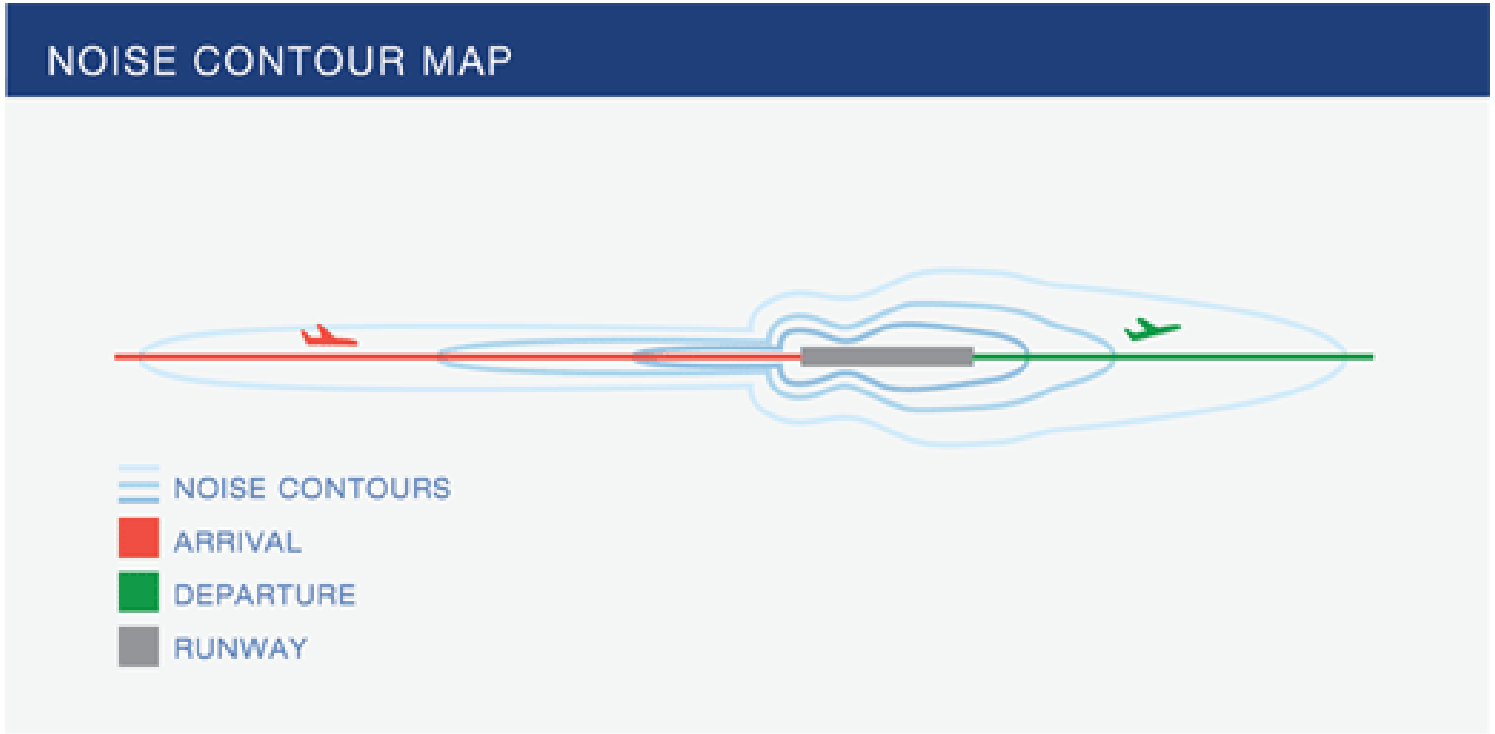
Visioning Committee

Air Quality and Noise

January 23, 2020

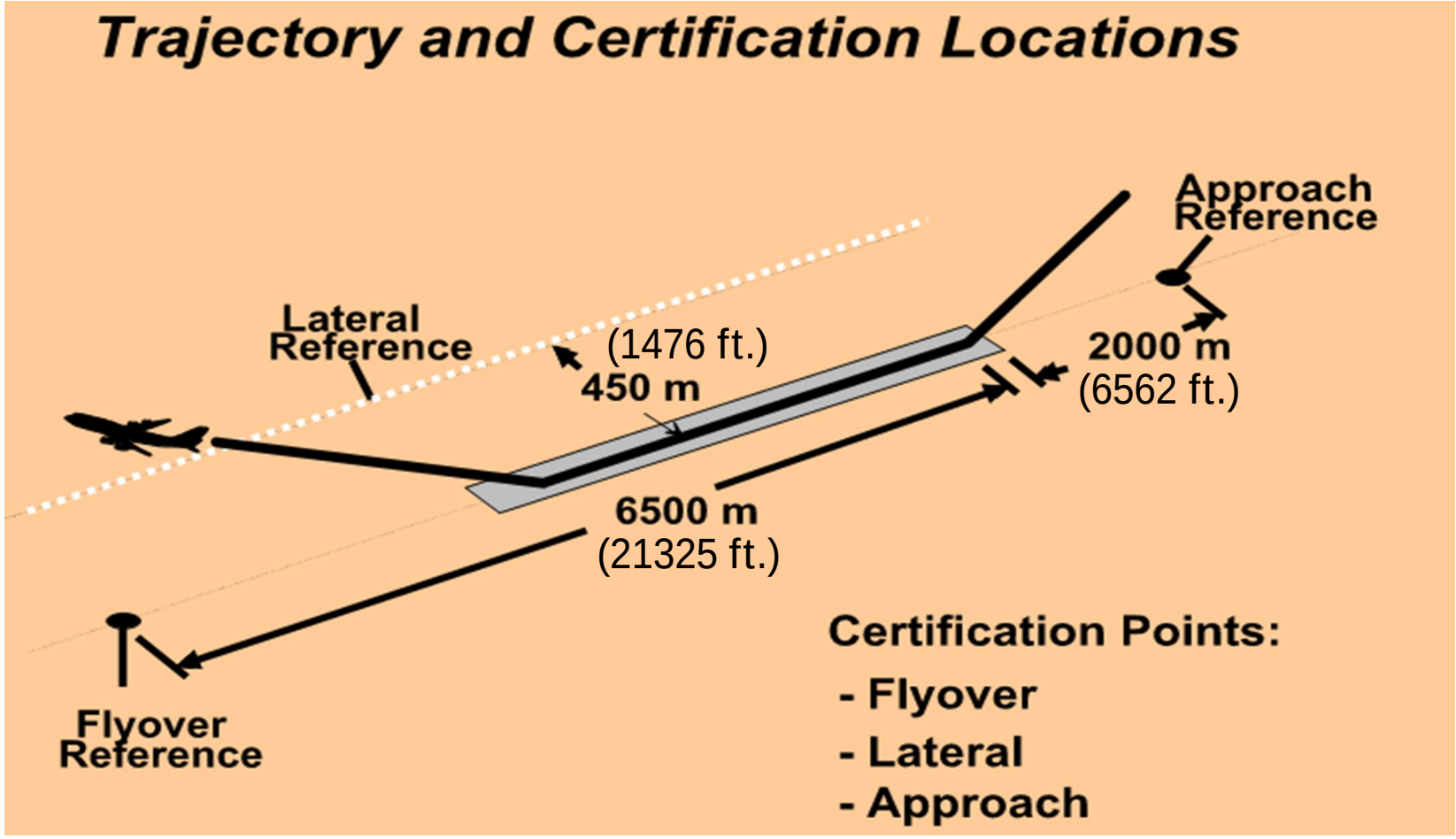
Noise Data

Noise is evaluated on intensity, duration, and area impacted



Source: FAA – Noise Contour Map

ICAO Aircraft Certification - Noise Reference Points



ASE Fly Quiet/Fly Clean Program

- One of the early airports operating such a program
- Field measurements conducted for over a decade
- Fleet Noise Quality (FNQ) is how quiet an aircraft is compared to the Stage 2/3 Certification
- Addresses FNQ and high noise events with a bi-annual report
  - Best Operators (more than 30 departures per year, and less than 30)
  - Poor Operators/Most Improved
- Field Measurements: DNL, SEL, Stage 2/3 aircraft, FNQ Fleet Noise Quality

AIRCRAFT DESCRIPTION

Aircraft: Cessna Citation
Manufacturer: CESSNA
ARTS Name: C750
No. of Engines: 2
Type: J

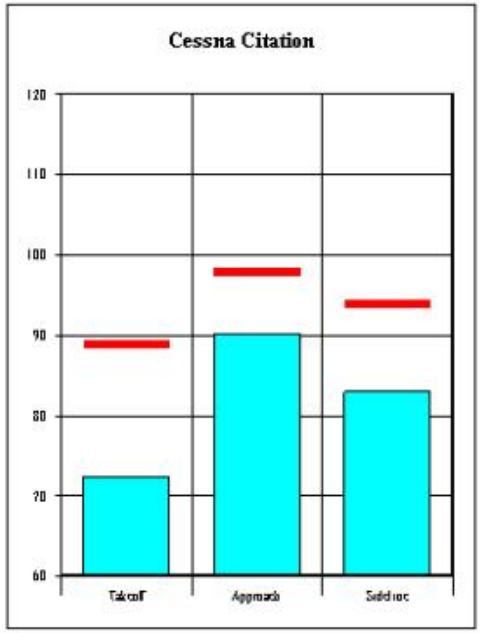
AIRCRAFT SERIES DESCRIPTION

Series: 750 CITATION X
Engines: AE3007C
Bypass Ratio: 5.3
Thrust: 5,000

	Weight	Flaps
Takeoff:	35,700	15
Approach:	31,800	35

FAR 36 NOISE LEVELS

	Takeoff	Approach	Sideline
FAR 36 Limit (EPNdB):	89	98	94
Aircraft Level (EPNdB):	72.3	90.2	83
FAR 36 Stage:	3		



Example Fleet Quality

AIRCRAFT DE

Aircraf Beech Jet
Manufacturer: BEECH
ARTS Name: BE40
No. of Engines: 2
Type: J

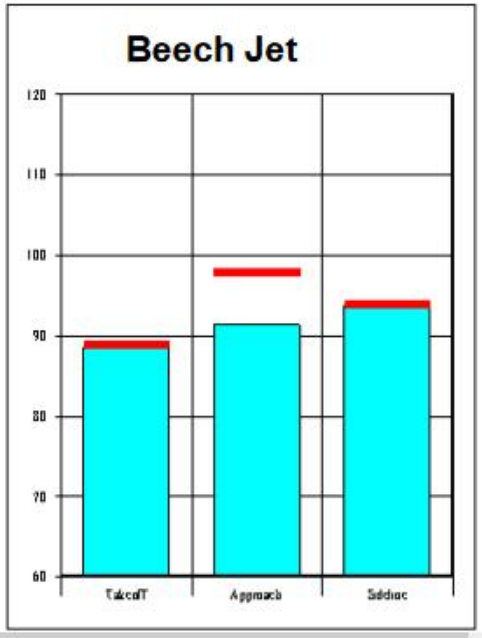
AIRCRAFT SERIES DESCRIPTION

Series: BEECHJET 400
Engines: JT15D-5
Bypass Ratio: 2.1
Thrust: 2,900

	Weight	Flaps
Takeoff:	15,780	10
Approach:	14,220	30

FAR 36 NOISE LEVELS

	Takeoff	Approach	Sideline
FAR 36 Limit (EPNdB):	89	98	94
Aircraft Level (EPNdB):	88.6	91.4	93.7
FAR 36 Stage:	3		



Single operators had more than 10 operations with a perfect Fly Quiet score of 10

Name	2017	2016	2015
Madrone Advisors LLC			
AS Aspen LLC			
Walton S Rawlings			
Coral Air LLC			
Morgans Mach One Machine			
Potomac Street Partners LLP			
N A Citation LLC			
Bemidji Aviation Services Inc			
Papa Grande Aviation LLC			
Bank of America NA			
C510 Aviation LLC			
Cho Oyu LLC			
Perugia Air LLC			
Skybank LLC			
525 CJ LLC			
ARSHE Holdings LLC			
Beeson John S			
Central Copters Inc			
Halrive Air LLC			
J M Thomas Forest Products Co			
Lift Aviation LLC			
Lone Trout Mt LLC			
RBL Aviation LLC			
SACJ LLC			
Saturn of Kansas City Inc			
SDI Leasing LLC			

ASPEN/PITKIN COUNTY AIRPORT

2017

Operators with at least 6 Departures per year with a Fly Quiet Score of 0

Tail Number	Aircraft Type	Registered Owner	State	Dep	FQ Score	High Events
N540EA	GLF3	JETMARK AVIATION LLC		7	0.0	1

Other Operators with a Fly Quiet Score of 0 or High Noise Level Event

N124EP	GLF3	WHITEHORSE AIR LLC		9	0.0	0
N36PN	GLF2	B&G LEASING LLC		5	0.0	0
N171AM	GLF3	FLORIDA JET SERVICE INC		4	0.0	0
N654YS	SBR1	FRYS ELECTRONICS INC		3	0.0	0
N975RG	GLF3	RG AVIATION LLC		3	0.0	2
N150RJ	FA50	COOK CANYON (GP) LLC		2	3.6	1
N360MB	GLF3	N 360 MB LLC		2	0.0	0
N36JE	GLF3	JEL AVIATION LLC		2	0.0	0
N513SK	FA50	WELLS FARGO BANK NORT...		2	3.6	1
N705JC	SBR1	ORLEY JOHN C TRUSTEE		2	0.0	0
N205JA	FA50	BALLENGEE AVIATION LLC		1	3.6	1
N218MD	GLF3	NE 1 LLC		1	0.0	0
N36PN	GLF3	B&G LEASING LLC		1	0.0	0
N530GA	GLF2	EG AIR LLC TRUSTEE		1	0.0	0
N919KM	GLF3	DOUBLE X LLC		1	0.0	0

Single Operator with Low Score

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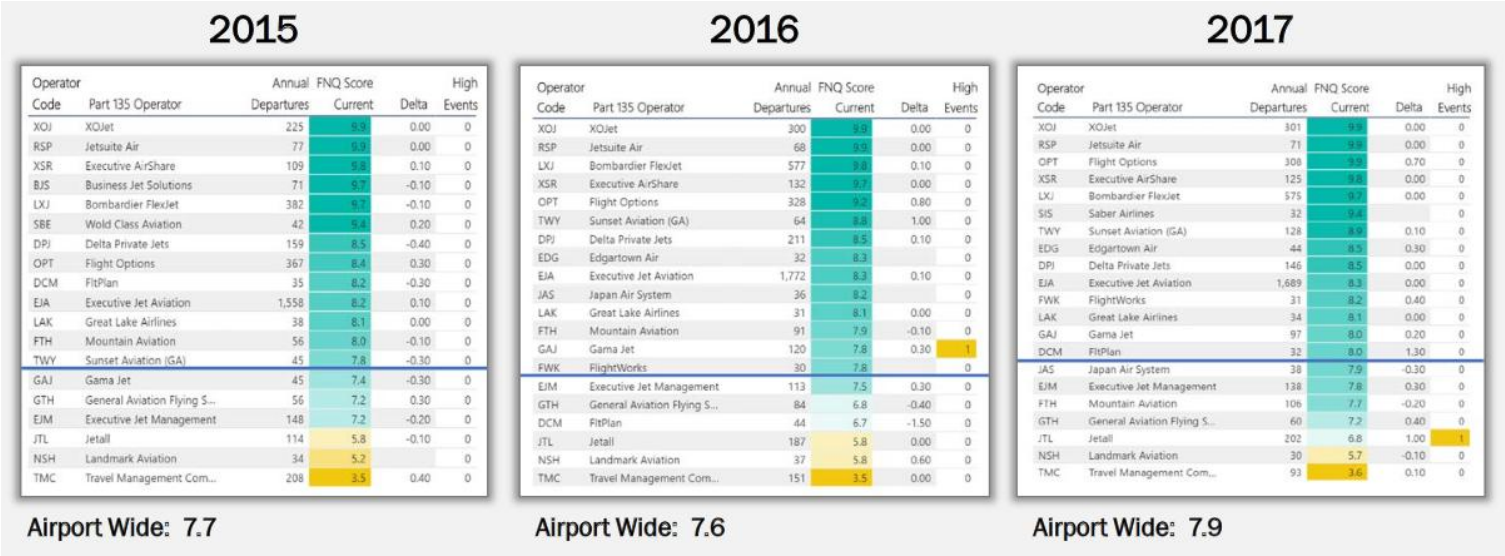
2017 Annual Noise Performance - results

- DNL Noise Levels
  - 925 acres in the 55 DNL
  - 51.5 DNL (Woody Creek)
- Number of Events Above 90 SEL (single event sound exposure level)
  - 0.1 events per day
- Stage 2 Mix – 0.4%
- Fleet Noise Quality
  - 7.9 (airport wide)



2015

Operator Code	Part 135 Operator	Annual Departures	FNQ Score Current	Delta	High Events
XOJ	XOJet	225	9.9	0.00	0
RSP	Jetsuite Air	77	9.9	0.00	0
XSR	Executive AirShare	109	9.8	0.10	0
BJS	Business Jet Solutions	71	9.7	-0.10	0
LXJ	Bombardier FlexJet	382	9.7	-0.10	0
SBE	Wold Class Aviation	42	9.4	0.20	0
DPJ	Delta Private Jets	159	8.5	-0.40	0
OPT	Flight Options	367	8.4	0.30	0
DCM	FltPlan	35	8.2	-0.30	0
EJA	Executive Jet Aviation	1,558	8.2	0.10	0
LAK	Great Lake Airlines	38	8.1	0.00	0
FTH	Mountain Aviation	56	8.0	-0.10	0
TWY	Sunset Aviation (GA)	45	7.8	-0.30	0
GAJ	Gama Jet	45	7.4	-0.30	0
GTH	General Aviation Flying S...	56	7.2	0.30	0
EJM	Executive Jet Management	148	7.2	-0.20	0
JTL	Jetall	114	5.8	-0.10	0
NSH	Landmark Aviation	34	5.2		0
TMC	Travel Management Com...	208	3.5	0.40	0

Airport Wide: 7.7

2016

Operator Code	Part 135 Operator	Annual Departures	FNQ Score Current	Delta	High Events
XOJ	XOJet	300	9.9	0.00	0
RSP	Jetsuite Air	68	9.9	0.00	0
LXJ	Bombardier FlexJet	577	9.8	0.10	0
XSR	Executive AirShare	132	9.7	0.00	0
OPT	Flight Options	328	9.2	0.80	0
TWY	Sunset Aviation (GA)	64	8.8	1.00	0
DPJ	Delta Private Jets	211	8.5	0.10	0
EDG	Edgartown Air	32	8.3		0
EJA	Executive Jet Aviation	1,772	8.3	0.10	0
JAS	Japan Air System	36	8.2		0
LAK	Great Lake Airlines	31	8.1	0.00	0
FTH	Mountain Aviation	91	7.9	-0.10	0
GAJ	Gama Jet	120	7.8	0.30	1
FWK	FlightWorks	30	7.8		0
EJM	Executive Jet Management	113	7.5	0.30	0
GTH	General Aviation Flying S...	84	6.8	-0.40	0
DCM	FltPlan	44	6.7	-1.50	0
JTL	Jetall	187	5.8	0.00	0
NSH	Landmark Aviation	37	5.8	0.60	0
TMC	Travel Management Com...	151	3.5	0.00	0

Airport Wide: 7.6

2017

Operator Code	Part 135 Operator	Annual Departures	FNQ Score Current	Delta	High Events
XOJ	XOJet	301	9.9	0.00	0
RSP	Jetsuite Air	71	9.9	0.00	0
OPT	Flight Options	308	9.9	0.70	0
XSR	Executive AirShare	125	9.8	0.00	0
LXJ	Bombardier FlexJet	575	9.7	0.00	0
SIS	Saber Airlines	32	9.4		0
TWY	Sunset Aviation (GA)	128	8.9	0.10	0
EDG	Edgartown Air	44	8.5	0.30	0
DPJ	Delta Private Jets	146	8.5	0.00	0
EJA	Executive Jet Aviation	1,689	8.3	0.00	0
FWK	FlightWorks	31	8.2	0.40	0
LAK	Great Lake Airlines	34	8.1	0.00	0
GAJ	Gama Jet	97	8.0	0.20	0
DCM	FltPlan	32	8.0	1.30	0
JAS	Japan Air System	38	7.9	-0.30	0
EJM	Executive Jet Management	138	7.8	0.30	0
FTH	Mountain Aviation	106	7.7	-0.20	0
GTH	General Aviation Flying S...	60	7.2	0.40	0
JTL	Jetall	202	6.8	1.00	1
NSH	Landmark Aviation	30	5.7	-0.10	0
TMC	Travel Management Com...	93	3.6	0.10	0

Airport Wide: 7.9

Air Quality and Climate

- Aviation emissions typically represent less than 5% of a region's criteria pollutant emissions
- The GAO noted that aviation represents 3% or less of US Greenhouse Gas emissions
- Emissions inventories:
  - Criteria pollutants: 2008, *2012, 2017**, 2015, *2023, 2028, 2033*
  - Greenhouse gases: 2006, 2011, 2014, 2017

*2010 EA , italics represent forecasts 2018 EA italics represent forecasts

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Airport Emissions Inventories

Table 4.1-3 Project Related Emissions						
	Annual Operational Emissions (tons per year)					
Year/Scenario	CO	VOC	NOX	Sox	PM10	PM2.5
2015/Existing Conditions	302.2	45.4	42.8	6.9	2.2	2.2
2023						
No Action	263.4	41.5	41.8	7.1	2.2	2.1
With Terminal Alt 1 or Alt 2	263.1	41.5	41.7	7.1	2.2	2.1
Project-related change (Alt 1 & 2)	-0.3	0	+0.1	0	0	0
2028						
No Action	263.8	48.3	32.8	6.1	2.0	2.0
With Terminal Alt 1 or Alt 2	263.6	48.2	32.9	6.1	2.0	2.0
Project-related change (Alt 1 & 2)	-0.2	-0.1	+0.1	0	0	0
With Airfield Improvements	258.3	43.2	39.5	6.8	2.0	2.0
Project-related change	-5.5	-5.1	+6.7	+0.7	0	0
With COMBINED Terminal and Airfield projects	258.1	43.1	39.4	6.8	2.0	2.0
Project-related change	-5.7	-5.2	+6.6	+0.7	0	0
2033						
No Action	263.1	53.8	24.1	5.2	1.9	1.9
With Terminal Alt 1 or Alt 2	263.0	53.7	24.1	5.2	1.9	1.9
Project-related change (Alt 1 & 2)	-0.1	-0.1	0	0	0	0
With Airfield Improvements	266.0	42.3	50.2	7.9	2.1	2.1
Project-related change	+2.9	-11.5	+26.1	+2.7	+0.2	+0.2
With COMBINED Terminal and Airfield projects	265.8	42.2	50.2	7.9	2.1	2.1
Project-related change	+2.7	-11.6	+26.1	+2.7	+0.2	+0.2

Source: BridgeNet Consulting, May 4, 2017

2018 EA for the Proposed Runway and Terminal Area Improvements

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2010 EA For the Runway Extension

Pollutant	Aircraft Operational Emissions: No Action	800 Ft Extension	1,000 Ft Extension	Project-Related Change: 800 Ft Extension	1,000 Ft Extension
Year 2012					
Carbon Monoxide	362.3	364.8	365.5	2.5	3.2
Volatile Organic Compounds	88.5	89.5	89.8	1.0	1.3
Nitrogen Oxides	49.9	50.1	50.1	0.2	0.2
Sulfur Oxides	7.6	7.7	7.7	0.1	0.1
Particulate Matter (PM_{10})	2.4	2.4	2.4	< 0.1	< 0.1
Particulate Matter ($PM_{2.5}$)	2.4	2.4	2.4	< 0.1	< 0.1
Year 2017					
Carbon Monoxide	344.2	346.8	347.6	2.6	3.4
Volatile Organic Compounds	92.6	93.7	94.0	1.1	1.4
Nitrogen Oxides	48.9	49.0	49.1	0.1	0.2
Sulfur Oxides	8.0	8.1	8.1	0.1	0.1
Particulate Matter (PM_{10})	2.5	2.5	2.5	< 0.1	< 0.1
Particulate Matter ($PM_{2.5}$)	2.5	2.5	2.5	< 0.1	< 0.1

Pollutant	Passenger Surface Travel Emissions: No Action	800 Ft Extension	1,000 Ft Extension	Project-Related Change: 800 Ft Extension	1,000 Ft Extension
Year 2012					
Carbon Monoxide	50.6	3.3	53.9	3.3	3.3
Volatile Organic Compounds	2.2	0.2	2.4	0.2	0.2
Nitrogen Oxides	4.0	0.3	4.3	0.3	0.3
Sulfur Oxides	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Particulate Matter (PM10)	0.1	< 0.1	0.2	< 0.1	< 0.1
Particulate Matter (PM2.5)	< 0.1	< 0.1	0.1	< 0.1	< 0.1
Year 2017					
Carbon Monoxide	47.8	3.1	50.9	3.1	3.1
Volatile Organic Compounds	1.9	0.1	2.0	0.1	0.1
Nitrogen Oxides	2.7	0.2	2.8	0.2	0.2
Sulfur Oxides	< 0.1	0.0	< 0.1	0.0	0.0
Particulate Matter (PM_{10})	0.1	< 0.1	0.1	< 0.1	< 0.1
Particulate Matter ($PM_{2.5}$)	< 0.1	0.0	< 0.1	0.0	0.0

Source: Aircraft: BridgeNet Consulting, July 2009 using EDMS 5.1; Ground travel: Synergy Consultants, August, 2009 using EDMS 5.1

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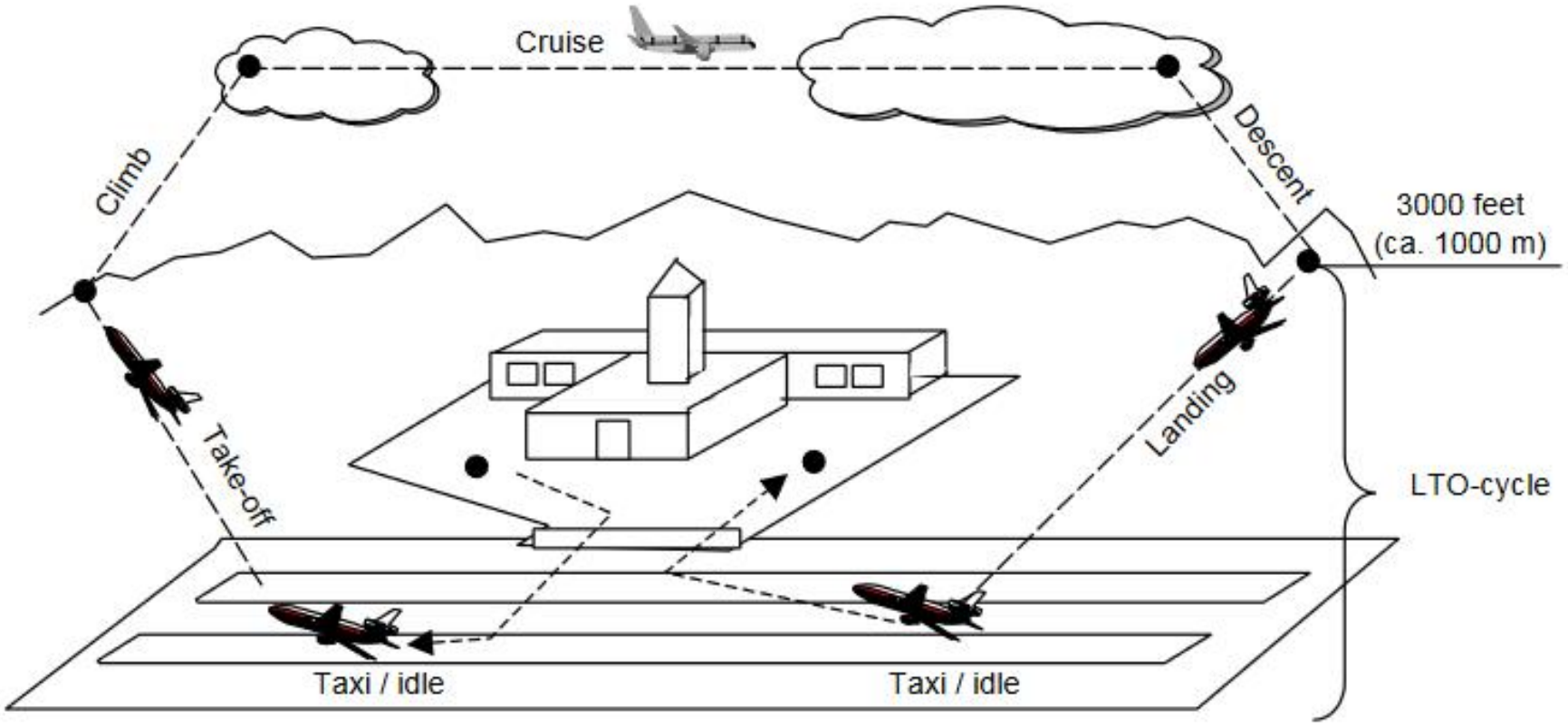
LTO – Landing and Takeoff Cycle



Health effects

- ***Ozone (O_3)*** – When volatile organic compounds and nitrogen oxides accumulate in the atmosphere and are exposed to the ultraviolet component of sunlight, the pollutant ozone is formed. Ozone is a pulmonary irritant that affects the respiratory mucous membranes, other lung tissues, and respiratory functions. Exposure to ozone at certain concentrations can result in symptoms such as tightness in the chest, coughing, and wheezing, and can trigger an attack or exacerbate the symptoms of asthma, bronchitis, and emphysema. Elevated concentrations of ozone also interfere with the ability of a plant to produce and store food, damage the leaves of trees, and reduce crop and forest yields.

- ***Nitrogen Dioxide (NO_2)*** - When combustion temperatures are extremely high, as in aircraft engines, boilers, furnaces, or automobile engines, nitrogen gas from the atmosphere and from fuel will combine with oxygen gas to form various oxides of nitrogen. Of these oxides of nitrogen, nitrogen dioxide is the most significant air pollutant. Nitrogen dioxide is a lung irritant capable of producing pulmonary edema at high concentrations, and exposure to elevated concentrations can lead to respiratory illnesses such as bronchitis and pneumonia. Nitrate particles and nitrogen dioxide can also block the transmission of light, reducing visibility in urban areas.

- ***Carbon Monoxide (CO):*** carbon monoxide is a colorless and odorless gas that is a product of incomplete combustion. At elevated concentrations, this pollutant can have cardiovascular and central nervous system effects. Carbon monoxide is absorbed by the lungs and reacts with hemoglobin to reduce the oxygen-carrying capacity of the blood. At moderate concentrations, carbon monoxide has been shown to aggravate the symptoms of cardiovascular disease. It can also cause headaches and nausea, and in extremely high concentrations, can lead to coma and death.

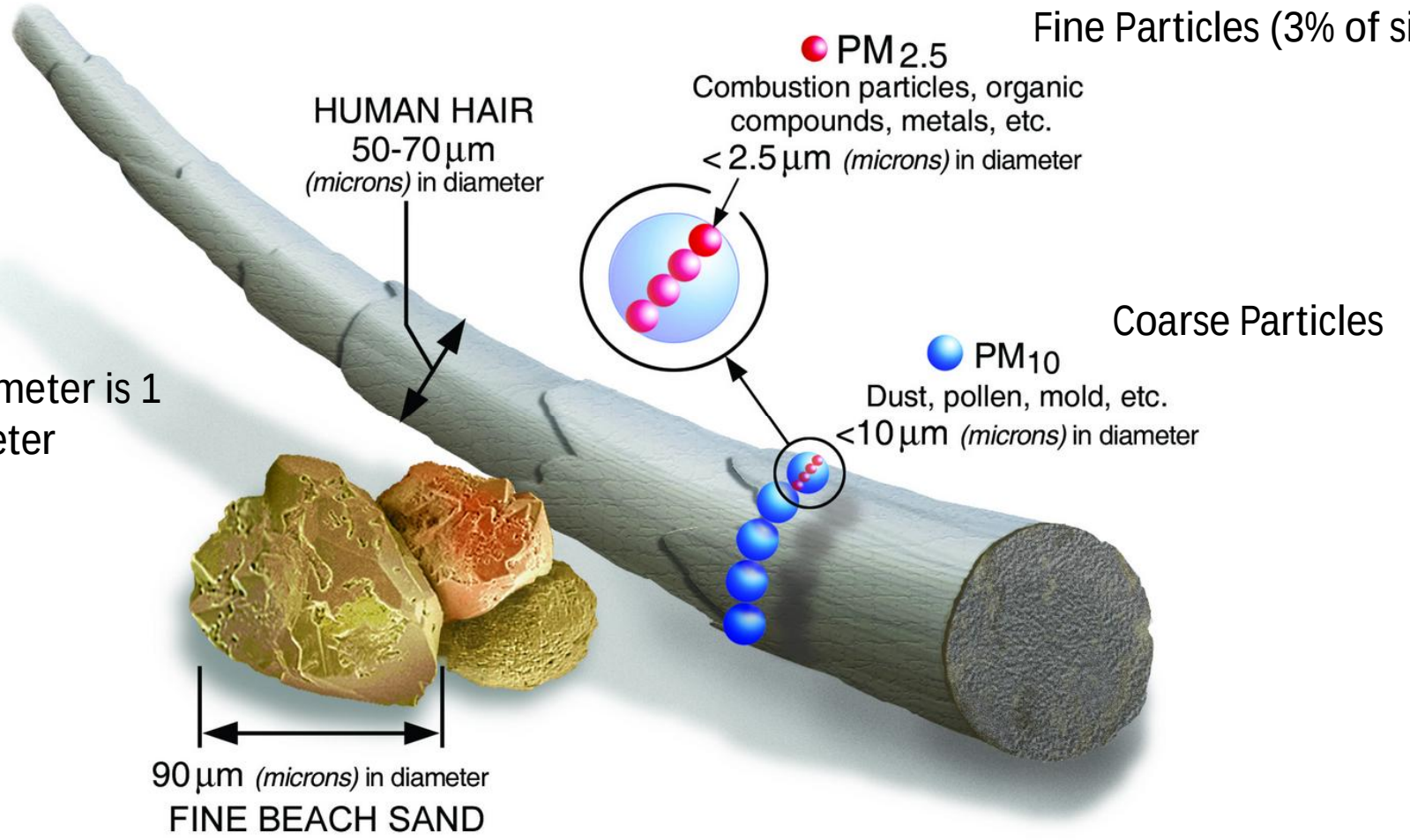
- ***Particulate matter (PM)***: Typical sources of particulate matter are combustion of fossil fuels, industrial processes involving metals and fibers, fugitive dust from wind and mechanical erosion of soil, and photochemically produced particles (complex chain reactions between sunlight and gaseous pollutants). Particulate matter is made up of small solid particles and liquid droplets. Particles 2.5 microns or smaller have been associated with increased respiratory diseases such as asthma, bronchitis, and emphysema, cardiopulmonary disease and cancer. Particulate matter is also a major cause of reduced visibility.

- ***Sulfur Dioxide (SO2):*** Sulfur dioxide is a colorless gas that is formed when fuels containing sulfur com[pounds are combusted. Sulfur dioxide can cause irritation and inflammation of tissues with which it comes into contact. Inhalation of elevated concentrations can cause irritation of the mucous membranes, bronchial damage, and can exacerbate pre-existing respiratory diseases.

- ***Lead (Pb)***: Lead is a stable compound that accumulates in the environment and in living organisms, it can interfere with the maturation and development of red blood cells, affects liver and kidney functions, and disturbs enzyme activity.

Particulate Matter Size Comparison

Fine Particles (3% of size of human hair)



Coarse Particles

Micron or micrometer is 1 millionth of a meter

Source: USEPA, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

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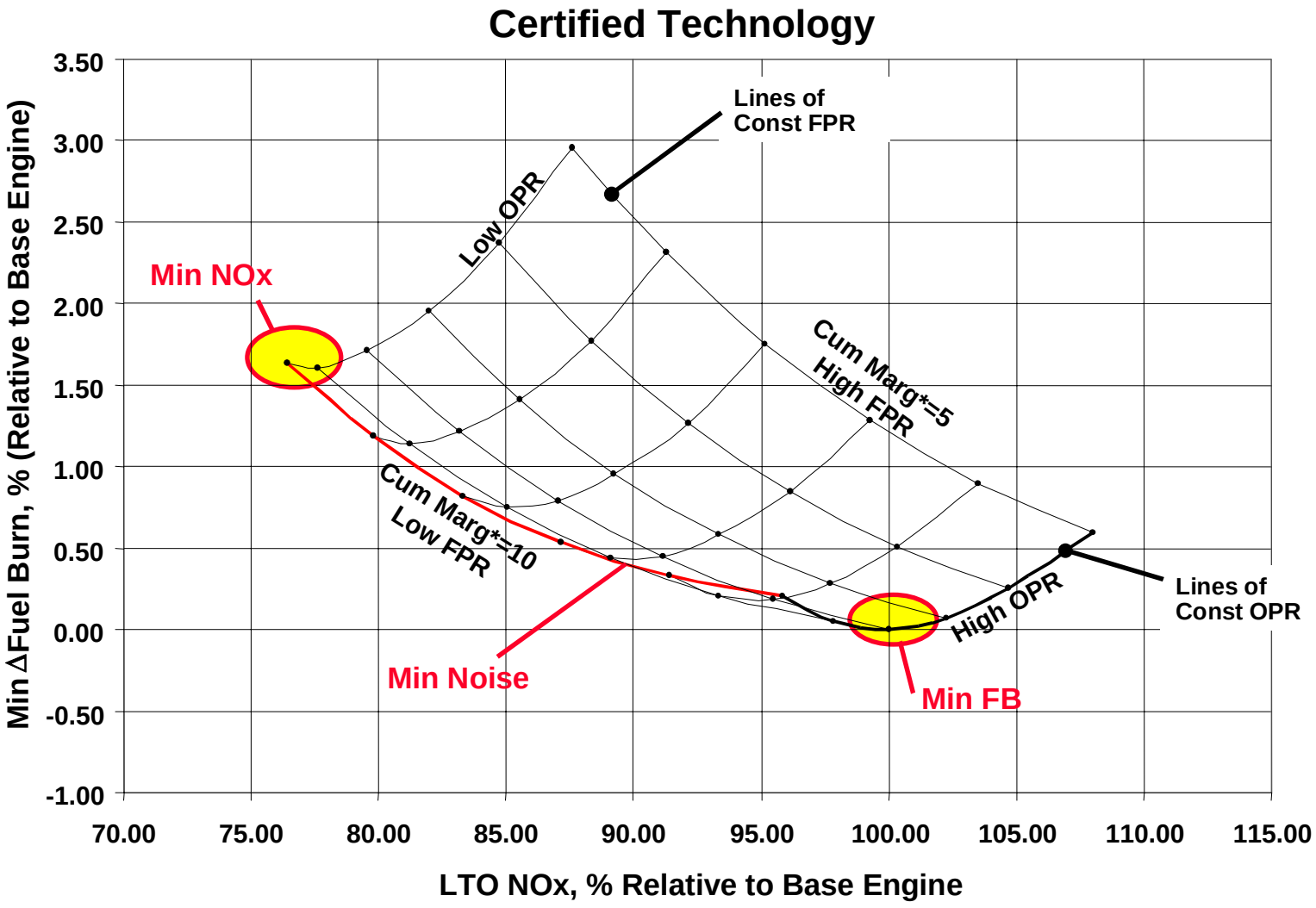
Tradeoffs of Fuel Burn, NOx, and Noise



Engine Carpet Plot: Narrow-body Aircraft – Presentation at the CAEP/6 WG3 Long Term Technology Goals Task Group.

Engine Carpet Plot: observations

- The relative size of carpets is dictated by range of engine parameters (Fan Pressure Ratio, Overall Pressure Ratio)

- There are significant trades among parameters within a given technology (e.g. fuel burn/CO_2 vs NOx or noise)

- Narrow-body and wide-body results are similar
  - Decisions to minimize/maximize one parameter significantly affect what might be achieved by other parameters
  - Safety, mission, and extremes of operating conditions cannot be ignored or minimized

Teterboro (TEB) Airport Measurements

Pollutant	Frequency	Instrument / Data Source
VOCs/Carbonyls	1 / 6 days	ATEC Toxic Air Sampler
VOC (Open Path)	Continuous	Cerex Environmental UVSentry
PM2.5	Continuous	MetOne Beta Attenutation Monitor (E-BAM)
Black Carbon	Continuous	Magee Scientific Aethalometer
Wind (speed/dir)	Continuous	RM Young Anemometer
Traffic Count	Continuous	Wavetronix SmartSensor 105
Airport Operations	Continuous	Landing/Take-Off Records Provided by TEB

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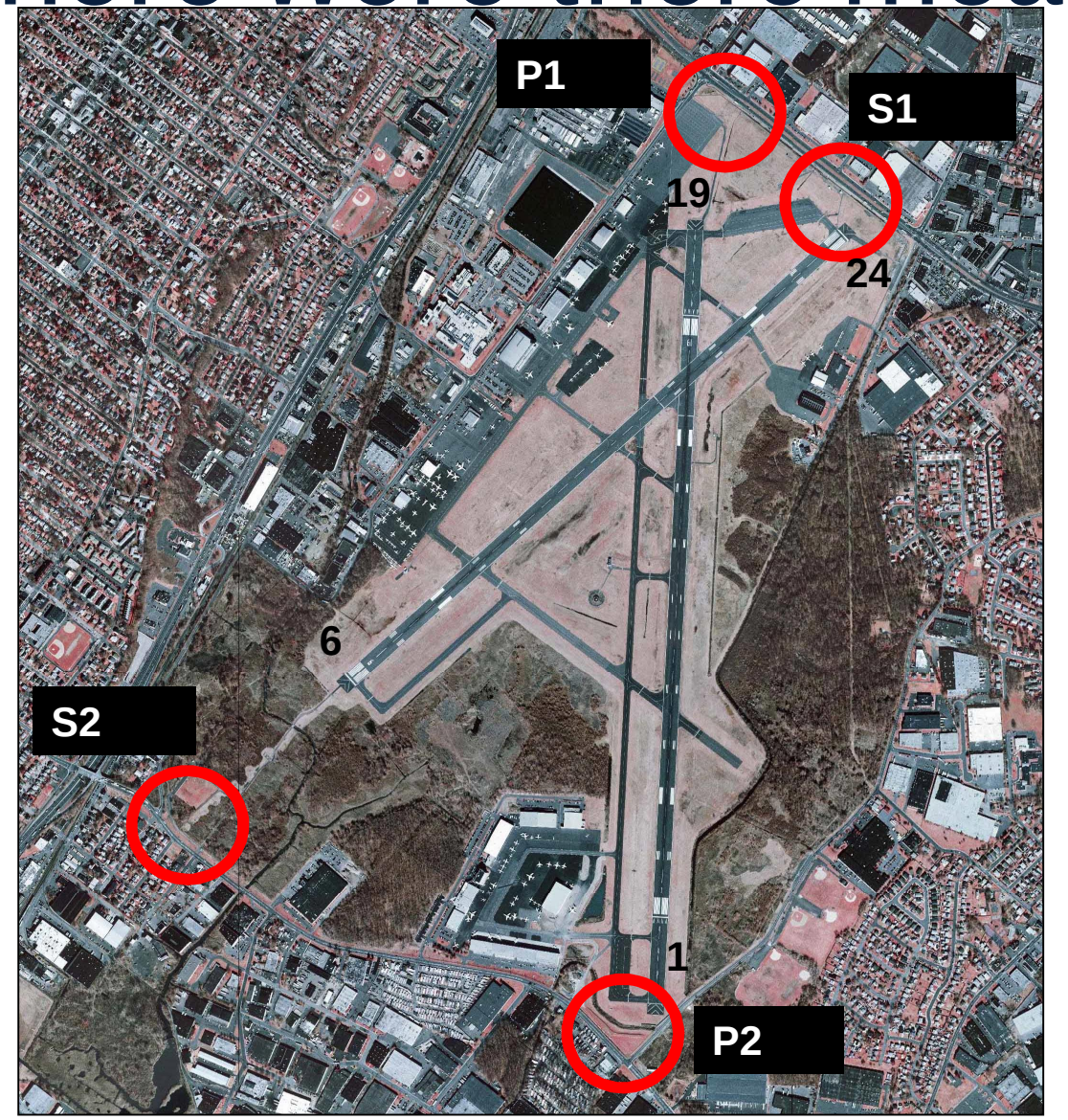
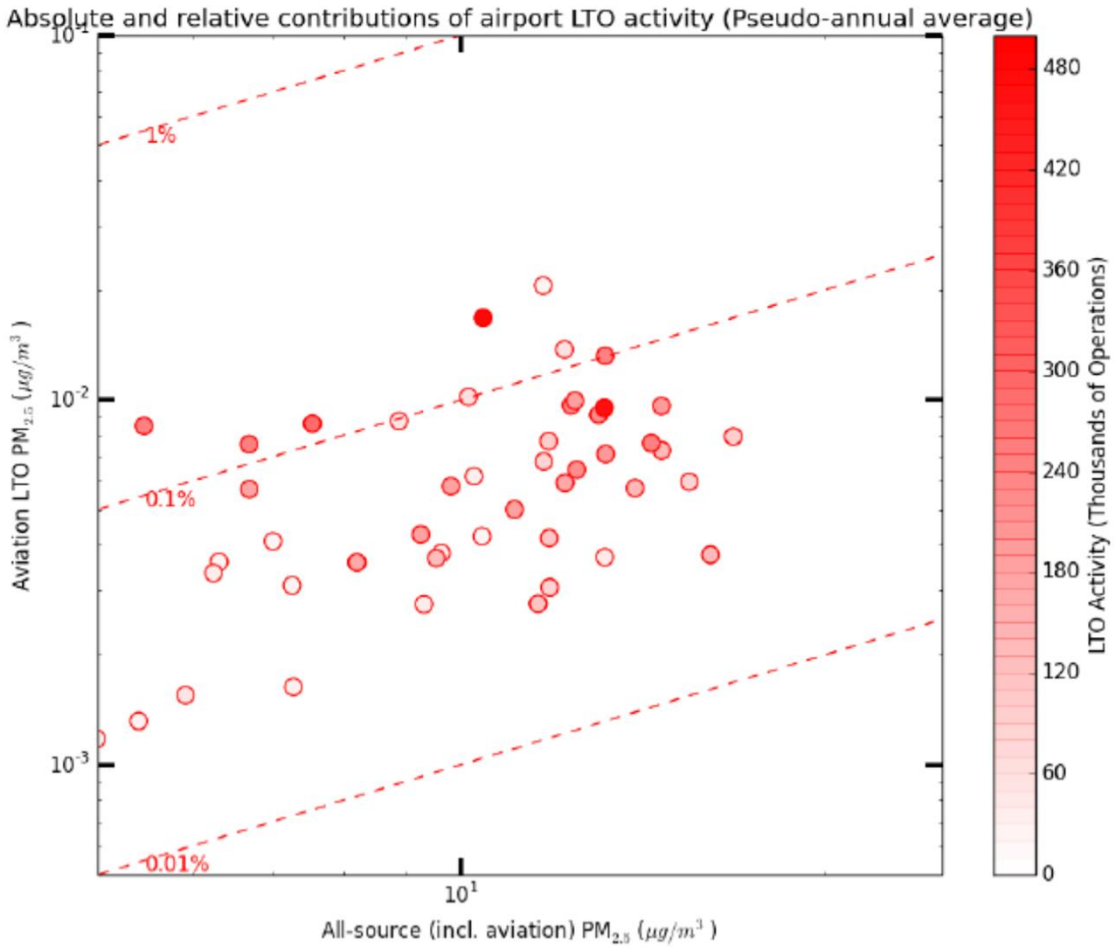
Where were there measurements



Airport contributions: Absolute and Relative



- But highest LTOs not largest $PM_{2.5}$

VOC and carbonyl samples (TFGreen)

VOC and carbonyl samples collected using ATEC Model 2200-2 Toxic Air Sampler

Four independent channels – two for VOCs, two for carbonyls

VOC samples collected in SUMMA canisters

Carbonyl samples collected on Sep-Pak cartridges

Monitoring Equipment – Example UFP

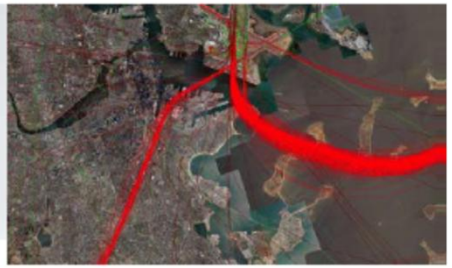
Study Design – Monitoring Instruments

UFP Conc	Met	BC	Flight Activity

http://tsi.com/environmental-particle-counter-3783/

https://mendipweather.co.uk/davis-vantage-pro2-weather-stations/

https://aethlabs.com/



Source attribution

- Definition:
  - Formal quantitative assessment of the amount of ambient air pollution that can be attributed to a given source or source sector
- Two general approaches:
  - Measurement-based
  - Dispersion modeling-based
- Challenges for ultrafine particulate matter (UFP):
  - High spatiotemporal variability
  - Complex pollutant dynamics
  - Multiple contributing sources/source sectors
  - Lack of ambient monitoring infrastructure
  - Limitations in emissions inventories (particle number vs. mass)
  - Limitations in dispersion models

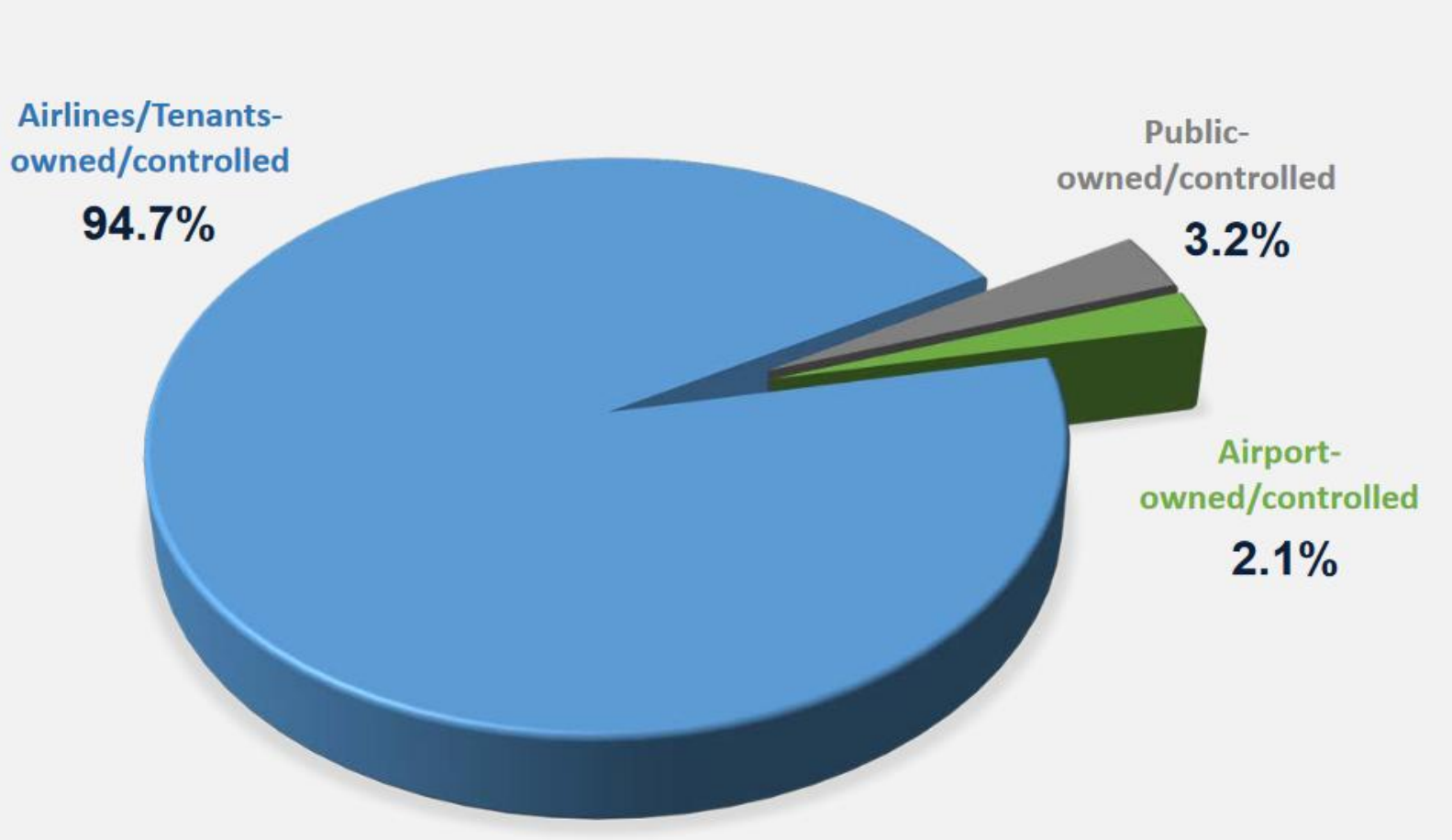
Measurement-based

- What does it take to do it well?
  - Measurements with high fidelity at high temporal resolution
  - Sufficient spatial coverage
  - Source activity and meteorological data with equivalent temporal resolution and spatial coverage
  - Study design that can minimize possibility of confounding
  - Regression-based statistical approaches that can leverage source terms to determine source contributions that vary in time and space
- In the case of aviation, this means:
  - << 1 min average measurements (of UFP and other pollutants)
  - Real-time flight activity data
  - Simultaneous measurements at multiple locations at distances from major roadways and other combustion sources

GHG

- Pitkin County was one of the first airports to prepare a full airport wide emissions inventory in the U.S.
- Follows airport industry protocols and supports the work of the Canary Initiative
- Emissions identified based on ownership and control
  - Airport owned or controlled
  - Tenant owned or controlled
  - General public owned or controlled
- Airport emissions inventories for 2006, 2011, 2014, 2017

2017 Airport-Related Emissions (81,566 metric tons CO2)



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Aspen Pitkin County Airport CO2 Emissions

User/Source Category	2017 CO2 (tons/year)	Percent of User	Percent of Total
Airport-owned/controlled			
Facilities/Stationary Sources	1,334	77.2%	1.6%
Ground Support Equipment	256	14.8%	0.3%
Ground Access Vehicles			
Passenger vehicles (on-airport roads)	15	0.9%	0.0%
Hotel shuttles (on-airport roads)	6	0.3%	0.0%
Rental Cars (on-airport roads)	6	0.4%	0.0%
Airport Employee Commute (all roads)	111	6.4%	0.1%
Subtotal	**1,728**	**100.0%**	**2.1%**
Airlines/Tenants/Aircraft Operator-owned/controlled			
Aircraft			
Approach	3,357	4.3%	4.1%
Taxi/Idle/Delay	2,503	3.2%	3.1%
Takeoff	10,183	13.2%	12.5%
Climbout	2,556	3.3%	3.1%
Residual/Cruise/APU	54,281	70.3%	66.5%
Sub-total	72,879	94.4%	89.3%
Ground Support Equipment	4,319	5.6%	5.3%
Ground Access Vehicles			
Tenant GAV	0	0.0%	0.0%
Tenant Employee Commute (all roads)	29	0.0%	0.0%
Stationary Sources	0	0.0%	0.0%
Subtotal	**77,227**	**100.0%**	**94.7%**
Public-owned/controlled			
Passenger Vehicles (off-airport roads)	584	22.4%	0.7%
Rental Car Travel (on-airport roads)	2,022	77.4%	2.5%
Hotel Shuttles (off airport roads)	6	0.2%	0.0%
Subtotal	**2,612**	**100.0%**	**3.2%**
Total	**81,566**		**100%**

Note: In 2017, the Airport's aircraft emissions in the LTO were calculated using AEDT, the FAA's new emissions model.

ASPEN/PITKIN COUNTY AIRPORT

ASE VISION