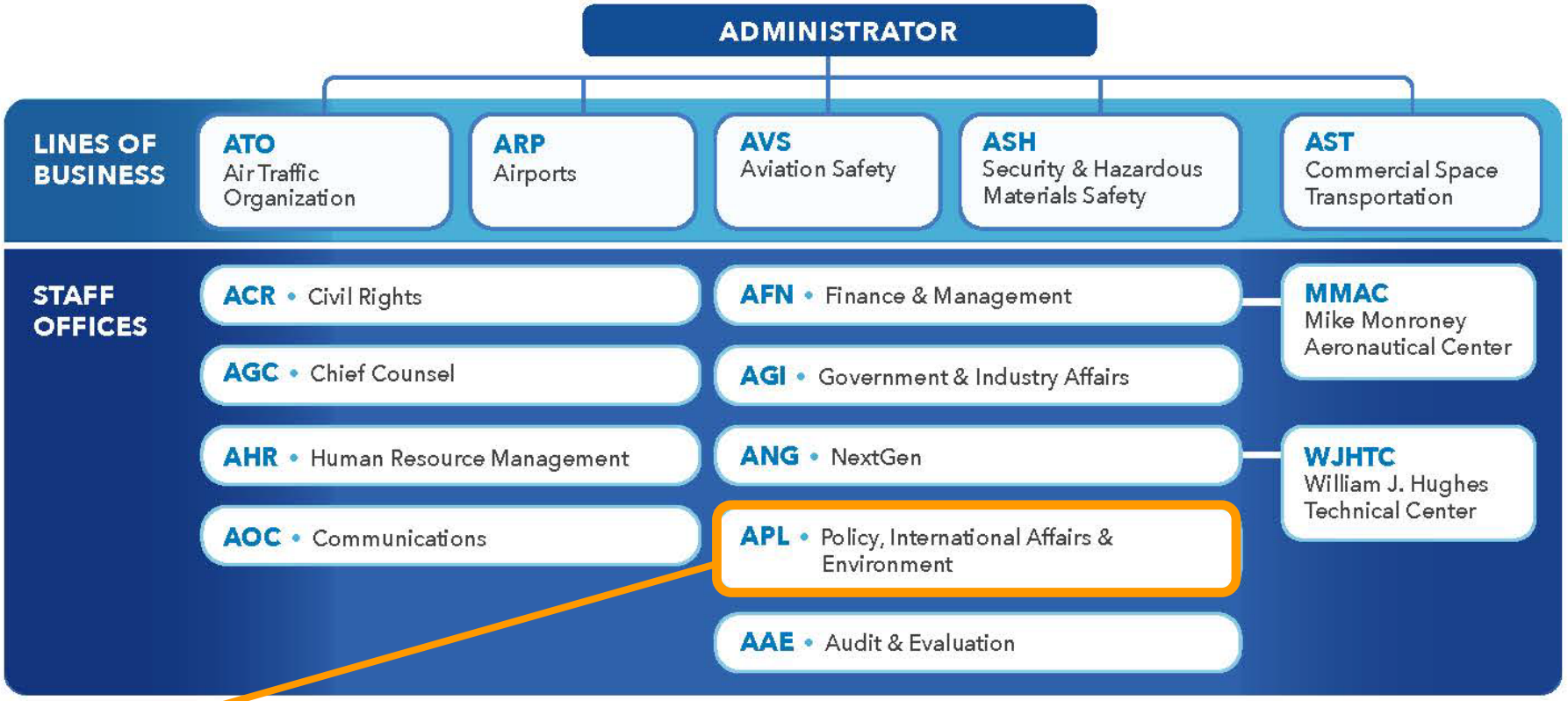
FAA Efforts to Understand and Address Aviation Noise and Emissions Challenges

Presented to: SEA-TAC Stakeholder Advisory Round Table Meeting

By: Kevin Welsh & Jim Hileman
Office of Environment and Energy
Federal Aviation Administration

Date: June 26, 2019

FAA Organizational Structure



Office of Environment and Energy (AEE)

Economic Benefits of Aviation

5.1% of U.S. GDP

10.6 Million
U.S. jobs

$1.6 Trillion
in U.S. economic activity annually

$59.9 Billion
of U.S. Trade Balance (exports-imports)

SOURCE: FAA Air Traffic Organization

Aviation equipment (aircraft, spacecraft, and related equipment) is largest export sector in U.S. economy accounting for over 8% of total exports.

SOURCE: U.S. International Trade Commission

AEE Mission and Vision

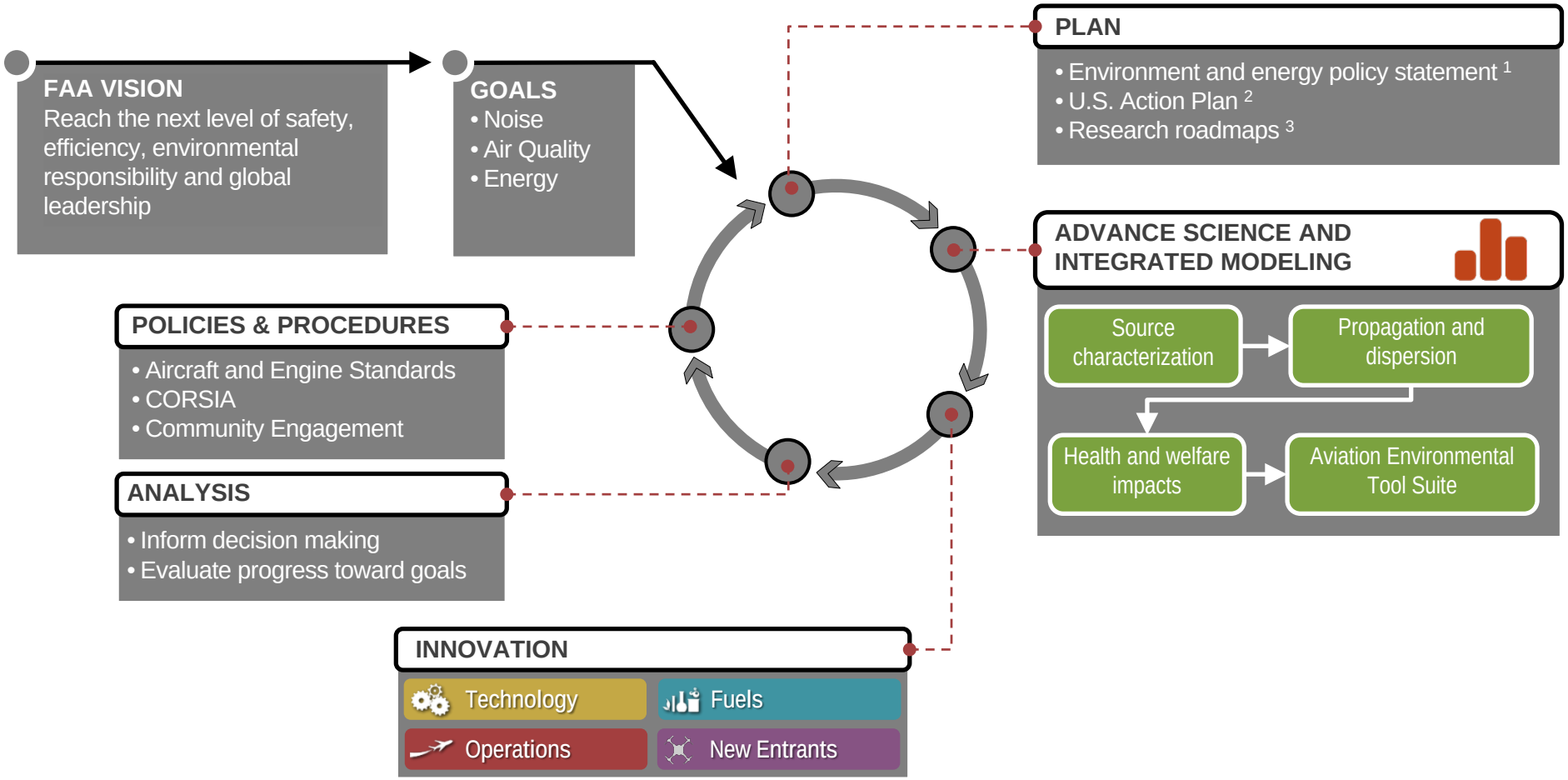
Mission:

To understand, manage, and reduce the environmental impacts of global aviation through research, technological innovation, policy, and outreach to benefit the public

Vision:

Remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation

Environmental & Energy Strategy



Notes:

1. Aviation E&E Policy Statement (Federal Register 77-141, 2012): http://www.faa.gov/about/office_org/headquarters_offices/apl/environ_policy_guidance/policy/media/FAA_EE_Policy_Statement.pdf
2. U.S. Aviation GHG Emissions Reduction Plan: http://www.icao.int/environmental-protection/Pages/ClimateChange_ActionPlan.aspx
3. Environment and Energy Website: http://www.faa.gov/go/environment

Environment and Energy (E&E) Research Programs

Continuous Lower Energy, Emissions and Noise (CLEEN)

- Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
- Cost share partnership with industry

ASCENT Center of Excellence (COE)

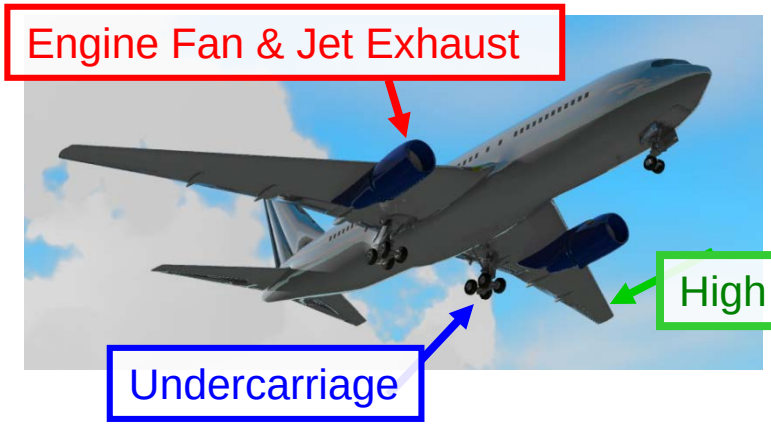
- COE for Alternative Jet Fuel and Environment
- Cost share research with universities

Additional Efforts

- Commercial Aviation Alternative Fuels Initiative (CAAFI)
- Contract mechanisms (e.g., SEMRS, PEARS-II)
- Volpe Transportation Center

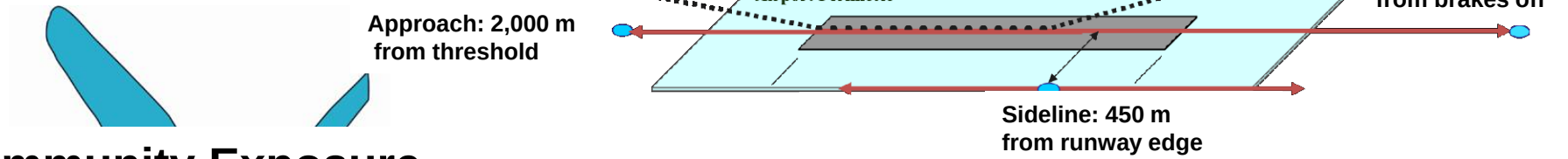
Community Noise from Aircraft

Aircraft Noise

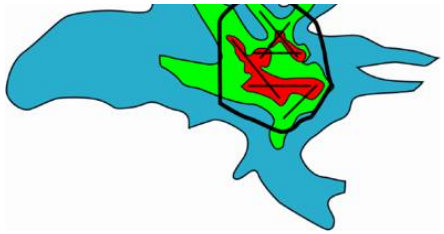


All noise sources contribute to acoustic signature – both at takeoff and during landing

Landing Takeoff Cycle

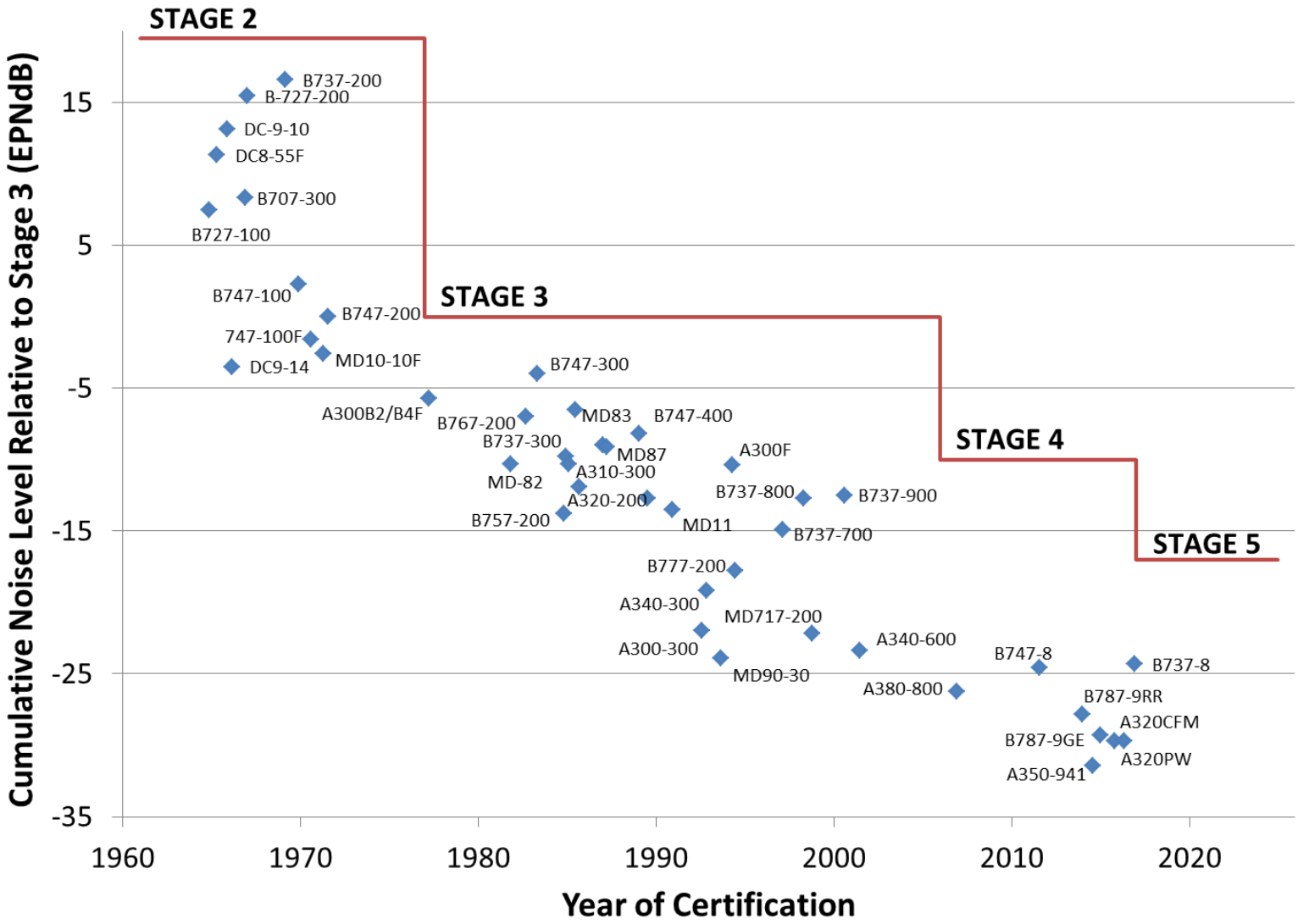


Community Exposure



Community exposure set by aircraft types and operational tempo over day and night

Commercial Aircraft Noise Evolution



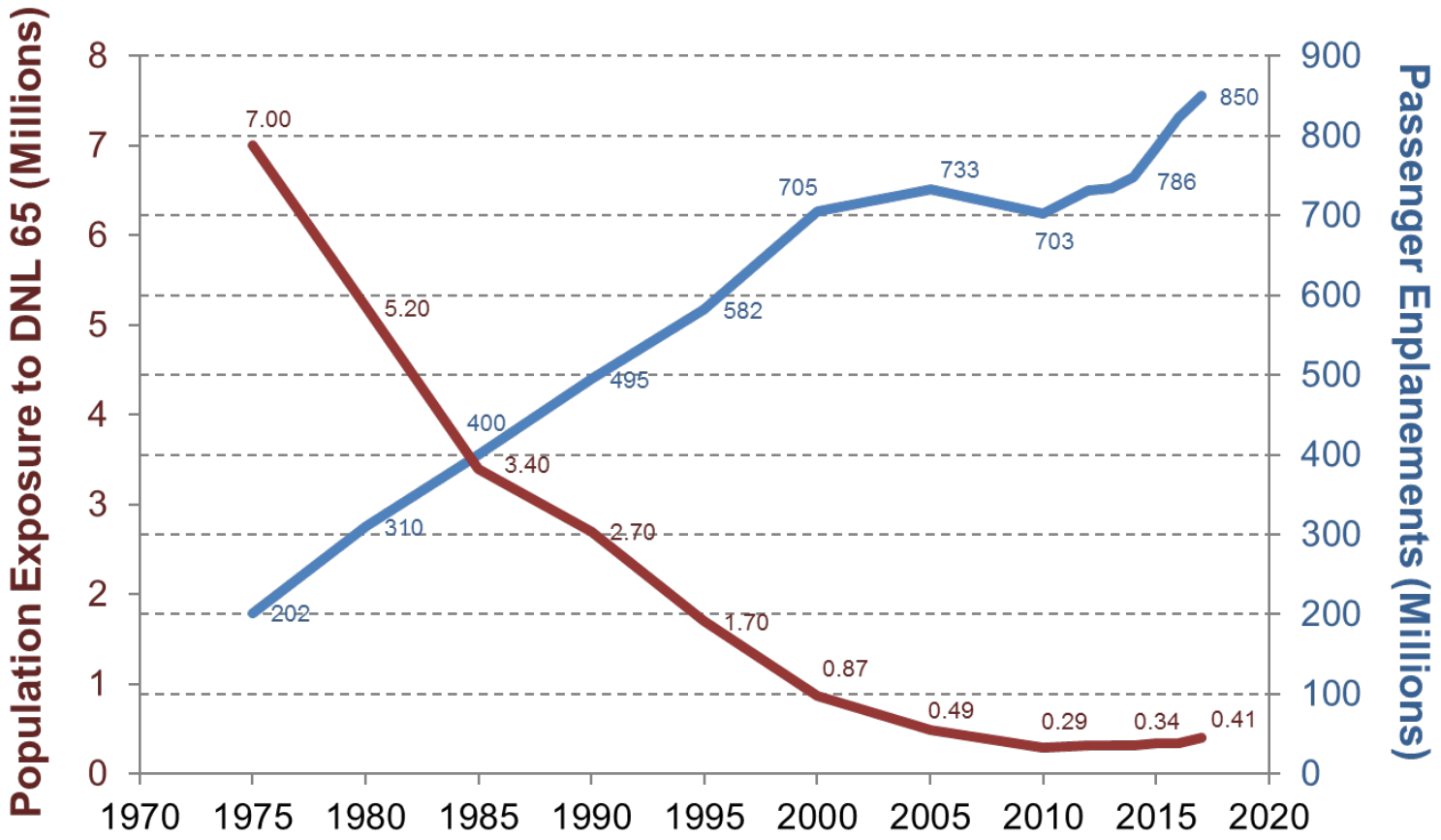
Noise Reduction through Technology

- Noise improvements have come with fuel efficiency gains
- Increased engine bypass ratio

- Simplified high lift systems

Images from airliners.net

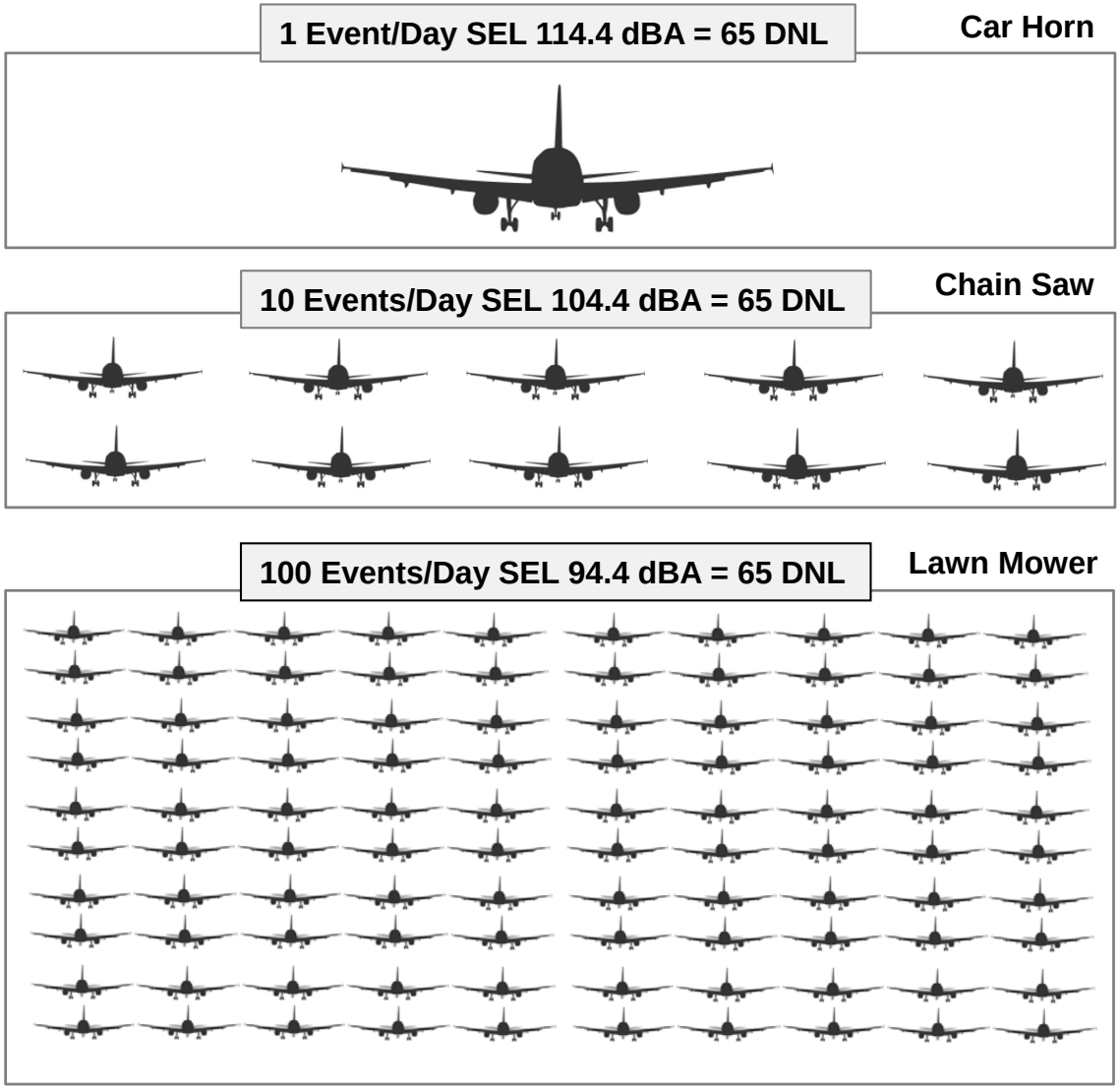
Historical Trends in Noise Exposure and Enplanements



A 93 percent decrease in community noise exposure while increasing enplanements by 340 percent – the noise experience is very different today then decades past and we expect it to continue to evolve

Today's Situation

- Aircraft noise from 1970s is different than aircraft noise today. Aircraft from 1970s produced the same acoustic energy as 10 to 30 aircraft operations today.
- A few, but relatively loud, events in 1970s would result in DNL 65 dB. Many, relatively quiet events today would also result in DNL 65 dB. However, noise experience would be very different.
- Precision navigation is being implemented to increase the safety and efficiency of the NAS. It also leads to a reduction in the overall number of people exposed to noise from aircraft operations.



Efforts Relating to Aircraft Noise

Understanding Noise

- Improving modeling capabilities
- Examining relationship between noise and annoyance, sleep, cardiovascular health and children's learning
- Evaluating current aircraft, helicopters, commercial supersonic aircraft, unmanned aerial systems, and commercial space vehicles

Outreach

- Enhanced community involvement
- Increase public understanding

Reducing Noise at the Source

- Aircraft technologies and architecture
- Noise standards

Mitigation

- Vehicle operations
- Sound insulation program

MITRE

ASCENT AVIATION SUSTAINABILITY CENTER

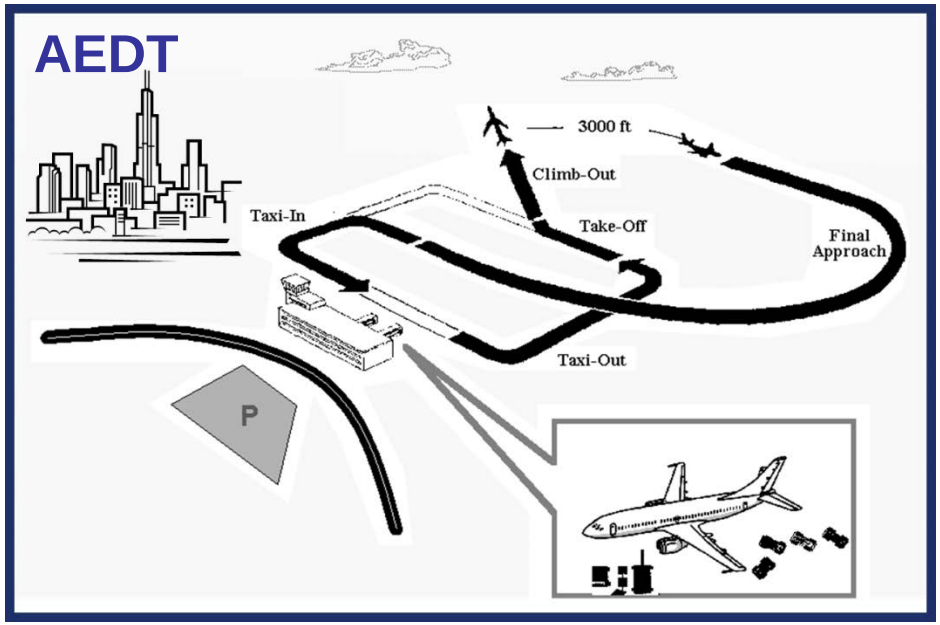
Continuous Lower Energy, Emissions & Noise CLEEN Federal Aviation Administration

the VOLPE center

NextGEN

Aviation Environmental Design Tool (AEDT)

- Computes noise, fuel burn and emissions simultaneously
- Can analyze airport, regional, national, and global scales
- Required for all regulatory actions
- Also in use by 428 international users from 36 countries



AEDT Development Plan

- Current version of tool, AEDT2d
- Developing AEDT3 with public release planned in 2019
  - Improved aircraft performance module
  - Improved takeoff weight and thrust modeling
  - Improved capabilities at lower noise levels
- Laying ground work to incorporate airframe noise more explicitly in AEDT4 with a planned 2022 release

Research Areas on Noise Impacts

- **Annoyance**
  - In 2014, FAA initiated a national survey to measure public annoyance to aircraft noise, as part of FAA's broader research portfolio related to aircraft noise
  - Responses from over 10,000 people living near 20 U.S. airports were collected
  - The survey results and a draft report are being reviewed by the FAA in coordination with the Department of Transportation and other federal agencies
- **Sleep Disturbance**
  - Conducted field studies to test different equipment viability
  - Have begun preparations for a national study
  - Determine what, if any, impact aviation noise has on sleep
- **Cardiovascular Health**
  - Associating historic, modeled noise levels with existing epidemiological studies
  - Determine what, if any, correlation exists between cardiovascular disease and aviation noise

For more information:
- PARTNER Project 44: http://partner.mit.edu/projects/aviation-related-noise-effects-elderly
- ASCNET Project 003: https://ascent.aero/project/noise-impact-health-research/
- ASCENT Project 017: https://ascent.aero/project/noise-exposure-response-sleep-disturbance/

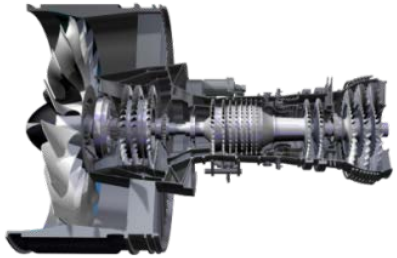
Efforts Relating to Aircraft Technology

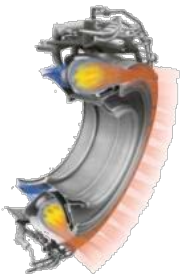
Continuous Lower Energy, Emissions & Noise (CLEEN)

- FAA led public-private partnership with 100% cost share from industry
- Reducing fuel burn, emissions and noise via aircraft and engine technologies and alternative jet fuels
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies

	Phase I	Phase II	Phase III*
Time Frame	2010-2015	2016-2020	2021-2025
FAA Budget	~$125M	~$100M	TBD
Noise Reduction Goal	25 dB cumulative noise reduction cumulative to Stage 5 ***and/or reduces community noise exposure (new goal for Phase III)***		
NO_X Emissions Reduction Goal	60% landing/take-off NO_X emissions	75% landing/take-off NO_X emissions (-70% re: CAEP/8)	
Fuel Burn Goal	33% reduction	40% reduction	-20% re: CAEP/10 Std.
Entry into Service	2018	2026	2031

***Notional**





Continuous Lower Energy, Emissions & Noise
CLEEN
Federal Aviation Administration

NextGEN

For more information on CLEEN program: http://www.faa.gov/go/cleen

CLEEN III Industry Day: https://faaco.faa.gov/index.cfm/announcement/view/32134

CLEEN III Solicitation: https://faaco.faa.gov/index.cfm/announcement/view/31885

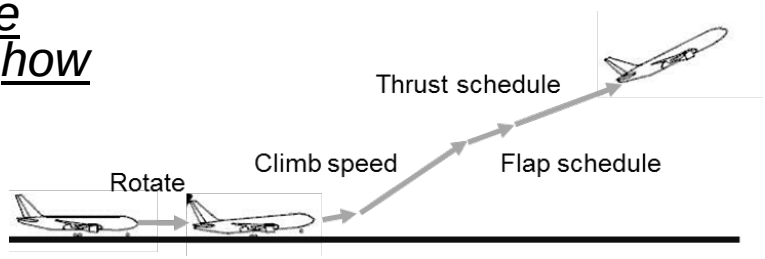
Efforts Relating to Aircraft Operations

Opportunities for noise reduction:

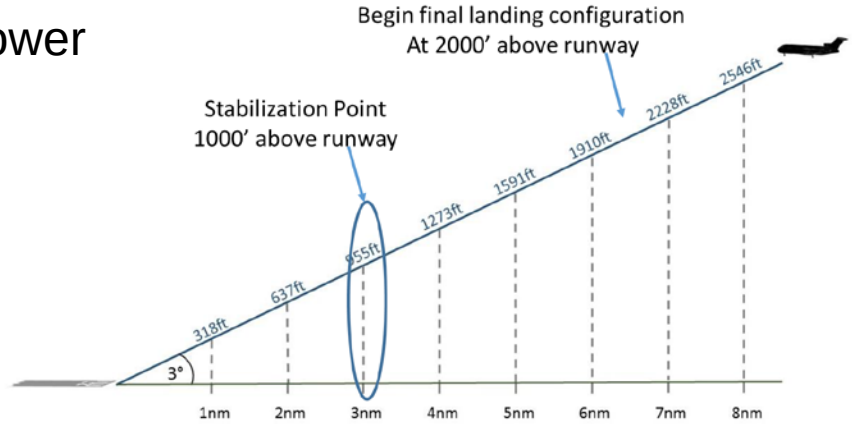
- Airlines determine *what* aircraft fly and *when*
- There might be opportunities to change *where* aircraft fly (through precision navigation) and *how* aircraft are flown

Concepts being evaluated:

- **Route changes**
- **Thrust / speed management**
  - Noise abatement procedures
  - Manage thrust and configuration to lower noise on takeoff and approach
- **Vertical profile**
  - Continuous climb operations
  - Continuous descent arrival
  - Modified approach angles
  - Staggered or displaced landing thresholds
- **Introduction of systematic dispersion**

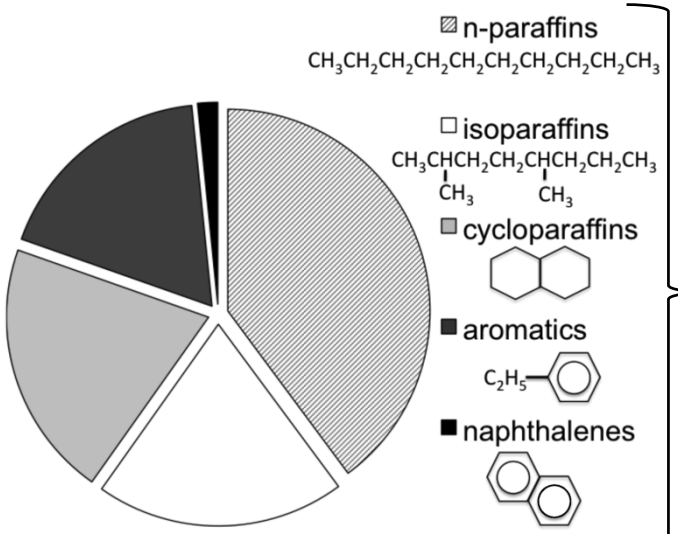


Takeoff Profile



Approach Profile

Aircraft Emissions and Air Quality

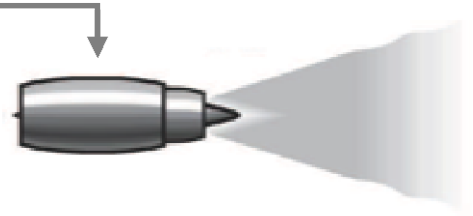


Weighted Mean Fuel Sulfur Content (PPM)		
	2006	2007
US East	446	321
US Gulf	858	800
US West	240	395
Nationwide	709	677

Fuel composition and engine design determine emissions

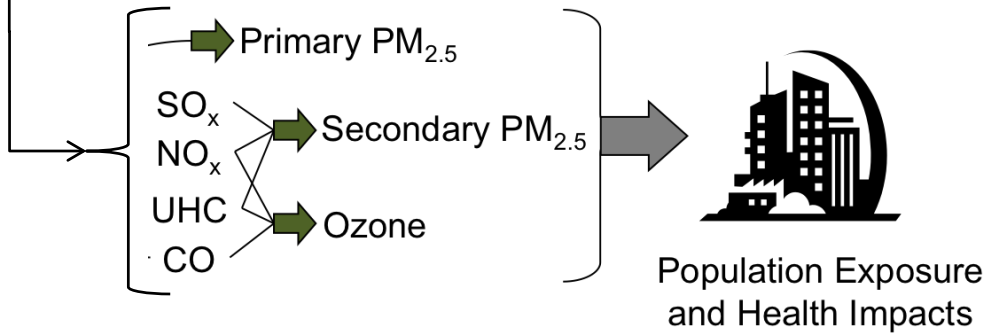
Fuel: $C_nH_m + S$

Air: $N_2 + O_2$



Tank-to-Wake Actual Combustion Emissions

$CO_2 + H_2O + NO_X + SO_X + soot + CO + HC + N_2 + O_2$



Atmospheric transformation, dispersion and removal determine pollutant concentration

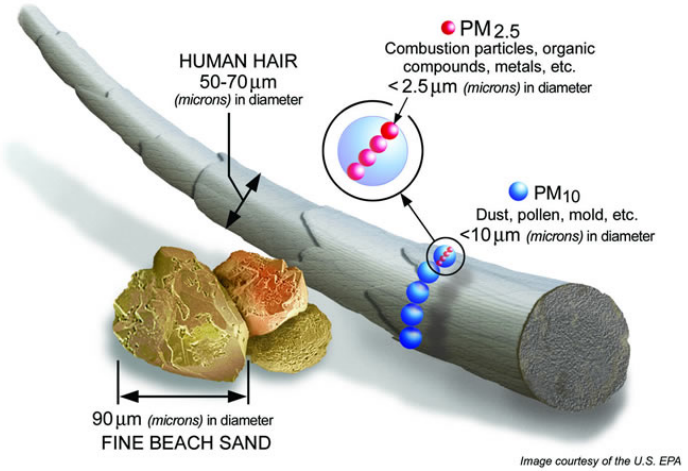
Particulate Matter

- Epidemiological studies link long-term exposure to fine Particulate Matter ($PM_{2.5}$) to increased risk of premature mortality

  Dockery et al. (1993); Pope et al. (2002); WHO (2008); Pope et al. (2009); USA EPA (2011)

- Particulate Matter consists of particles and liquid droplets
  - Particulate Matter = PM_{10} = diameter ≤ 10 μm (could enter lungs)
  - Fine Particulate Matter = $PM_{2.5}$ = diameter ≤ 2.5 μm (could enter blood)
  - Ultrafine Particulate Matter = $PM_{0.1}$ = diameter ≤ 0.1 μm (could enter systems)

- Particulate Matter from aircraft engines:
  - Soot (a.k.a., non-volatile PM, black carbon)
  - Volatile organic compounds from engine sulfate and nitrates & atmospheric ammonia
  - Aircraft engine PM is sufficiently small to qualify as ultrafine particulate matter



http://www3.epa.gov/airquality/particlepollution/basic.html

Aircraft Emissions in Perspective

- Based on analysis of top 66 airports in the U.S., aircraft operations contribute less than 1% of all ambient $PM_{2.5}$ in metropolitan areas.
  - UNC research - Boone, S. S. Penn, J. Levy and S. Arunachalam (2015). Calculation of sensitivity coefficients for individual airport emissions in the continental United States using CMAQ-DDM3D/PM, In Proceedings of the 34th International Technical Meeting on Air Pollution, Montpellier, France, May 2015.

- Aircraft activities contributes to 0.3% of the health impacts of combustion emissions in the U.S.
  - MIT research - Dedoussi and Barrett, “Air pollution and early deaths in the United States. Part II: Attribution of PM2.5 exposure to emissions species, time, location and sector,” Atmospheric Environment 99 (2014). http://dx.doi.org/10.1016/j.atmosenv.2014.10.033
  - MIT research - Yim et al., “Global, regional and local health impacts of civil aviation emissions,” Environ. Res. Lett. 10 (2015). doi:10.1088/1748-9326/10/3/034001

- Based on measurements in Seattle area, road traffic produces more PM, relative to aviation, at all sizes down to 20 nm. Aircraft produce more PM, relative to emissions, at sizes from 10 to 20 nm.
  - $PM_{0.1}$ is 100 nm and road traffic PM
  - U. Washington research - Preliminary findings presented by Prof. E. Austin of U.W. to 2019 Aviation Emissions Characterization Roadmap meeting available for download at https://deohs.washington.edu/mov-mobile-observations-ultrafine-particles-study

Efforts Relating to Jet Fuel and Emissions

Testing and Modeling

- Measure emissions from engines using conventional and alternative jet fuels
- Improve atmospheric impact modeling capabilities
- Support and improve Certification/Qualification testing to ensure alternative jet fuels are safe for use
- Analysis to understand environmental and economic sustainability of alt fuels

Reducing Emissions

- ICAO Carbon Offsetting and Reduction Scheme (CORSIA)
- Engine standard (NOx and PM standards)
- Modifications to fuel composition
- Aircraft technologies
- Vehicle operations

Coordinate Activities

- Public-private partnerships
- State, regional, interagency, and international

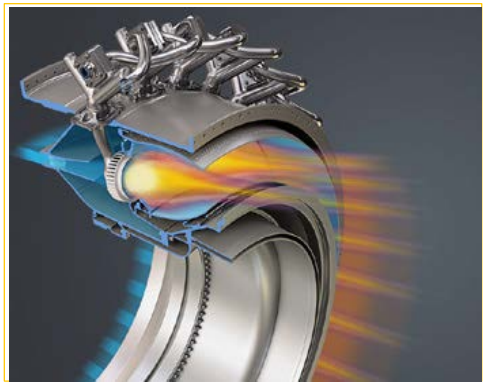
Technology & Emissions Reduction

- Visible smoke emissions have been eliminated

DC-8, 1958

Boeing 787, 2012

- 50% reduction in CAEP Nitrogen Oxides (NOx) emissions standard since 1995
- CAEP/11 agreement on a particulate matter standard for aircraft engines – limits on both particle number and mass
- CLEEN Program - Low Emissions Combustors
  - GE TAPS II Combustor,
    LTO Nox: 55% below most recent CAEP std
    PM: 90% below CAEP visibility smoke limit
  - CLEEN combustor development ongoing with GE, Honeywell, Rolls Royce



Our Direction

- Utilizing a comprehensive approach to address environmental challenges
- Working with a broad range of stakeholders to understand issues and develop solutions
- Placing more focus on innovation to overcome noise and emissions challenges
- Continue to seek partnerships for our R&D efforts
- Continue to be responsive to priorities outlined in the FAA Reauthorization Act of 2018