

# Noise Effects Research



Federal Aviation  
Administration

Presented to: FAA Noise Impacts Research Roadmap  
Workshop, San Diego, CA

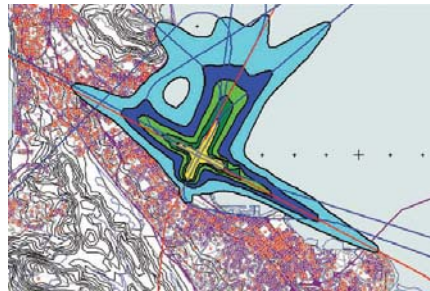
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Senior Vice-President  
HMMH

Background: Raquel Girvin, PhD  
Manager, Noise Division  
AEE-100

Date: 4 March 2010



# Welcome



# Objectives for the workshop

## 1. Provide FAA background

- Why do we need to research aircraft noise effects?
- What is a research roadmap?
  - Where are we going?
  - How do we get there?
- What will we do with the results?
- How did we get to today?



# Objectives for the workshop

## 2. Present and improve upon research roadmap

- What do we already know?
- What are the key outstanding issues?
  - Have we missed any?
- How do we plan to investigate them?
  - Are there better ways?



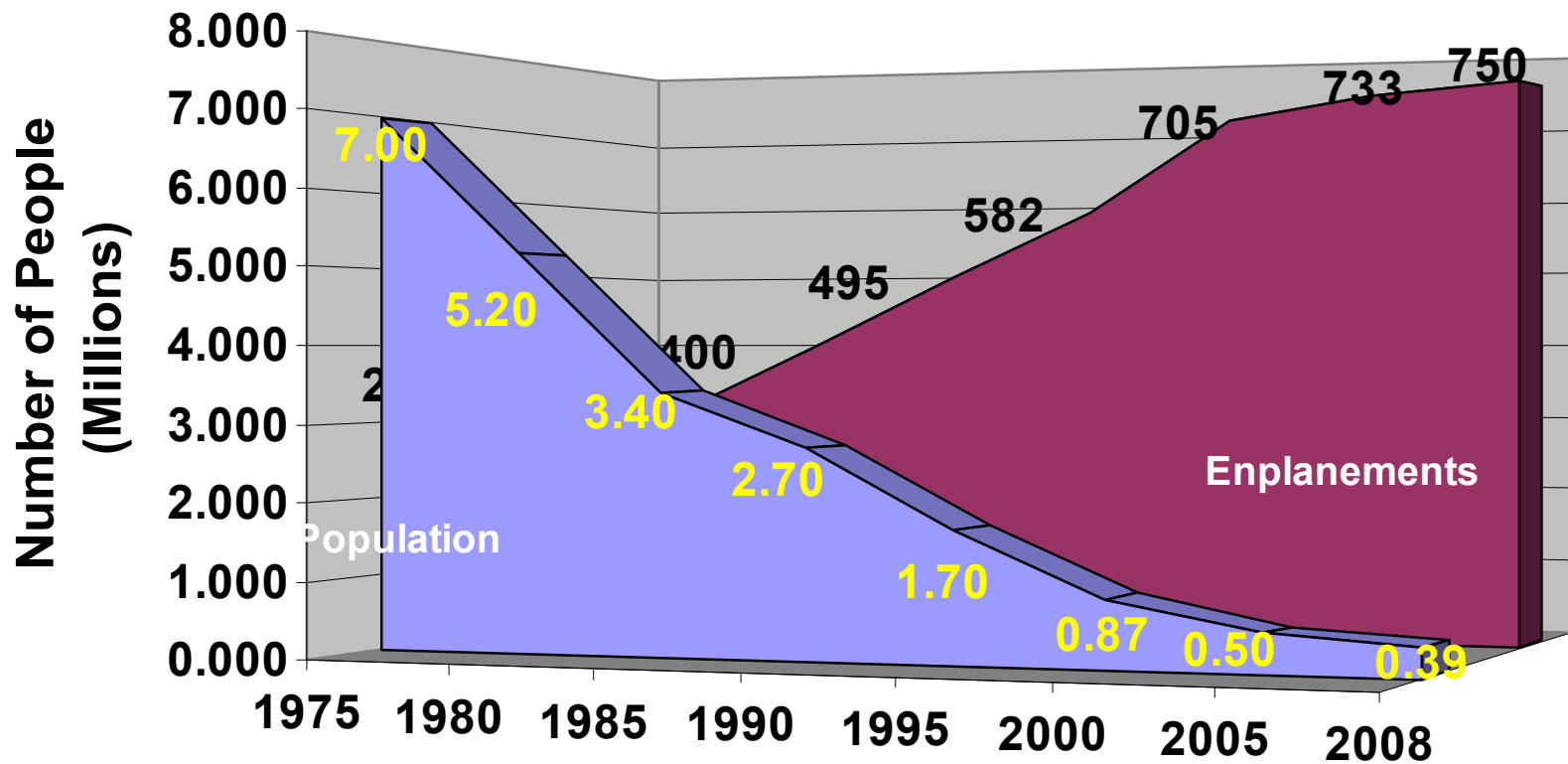
# Objectives for the workshop

## 3. Ask for support

- How can we work together?



# US trends: continuing decline in population exposed to $\geq$ DNL 65 dB



# So why pursue noise research?

## 1. FAA's capacity and efficiency projects have community noise effects

### – Examples

- One of NextGen solutions: “Increase Arrivals/Departures at High-Density Airports”
- Airspace redesign: in NY/NJ/PHL combines high and low altitude airspace to increase efficiency
- Airports: FAA study (FACT2) identifies airports needing to expand



# So why pursue noise research?

## 2. Recent research on noise effects mostly outside US

- Hypertension & Exposure to Noise Near Airports (HYENA study 2002-2006): *4861 persons at 7 European airports*
- Aircraft and road traffic noise and children's cognition and health (RANCH study 2002): *2844 children, 3 EU airports*
- WHO Europe issued “Night Noise Guidelines” based on EU research
- Since 1990, 95% of social surveys of residents' reaction to community/transportation noise have been overseas
  - Bulk of US data from 1970's
  - Example of most recent US airport community survey
    - 1999: 495 persons at MSP related to lawsuit



# So why pursue noise research?

## 3. We last reviewed the technical bases for our noise policies in 1992

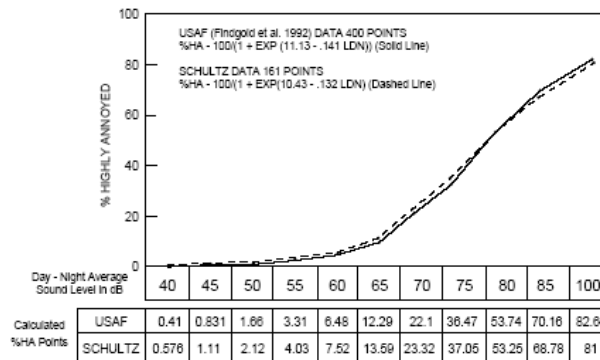
- Without actively engaging in research, from where do we derive the technical bases for updating our noise policies?



# Current noise policy

- **DNL 65 dB**

- Threshold\* of *significant impact* under National Environmental Policy Act (NEPA)
- Threshold\* below which all *land uses are deemed compatible*; deference to local authorities
- FICON (1992) re-affirmation of Schultz (1978) was last in-depth review for FAA



- **Case-by-case supplemental analysis**

**\*Use of these thresholds in no way suggests that there is no noise beyond it!**



# With a research roadmap - where do we want to go?

## Where

- Our policy (land use compatibility, noise impact/mitigation criteria) - is *based on best scientific evidence of effects of aircraft noise exposure*
- The public *trusts and understands* how we describe noise exposure and its effects
- We reduce the effects of noise efficiently: *where and when it matters*, balanced with other environmental considerations

So that we do our part to enable our agency's mission to deliver capacity and efficiency



# How do we get there?

- **Identify critical research areas based on gaps in current knowledge and capabilities**
  1. Noise effects on health and welfare
  2. Noise in National Parks and wilderness
  3. NextGen noise modeling enhancement operational regimes and unconventional aircraft
  4. Overall costs of aircraft noise on society
- **Map out and invest in research needed to bridge knowledge gaps and expand capabilities**

**Workshop Focus:**

- Annoyance
- Sleep Disturbance



# What will we do with research results?

**Recalling where we want to go -**

- **Update policy if research gives us technical evidence to do so**
  - Land use compatibility guidelines
  - NEPA significance threshold
  - Mitigation criteria
- **Use what we learn when we communicate with the public**
- **Develop more targeted solutions**



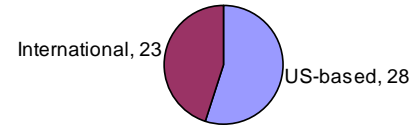
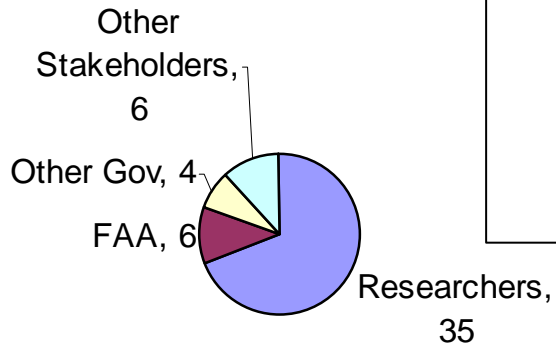
# How we got to today

- ✓ International forum - InterNoise Conference, Ottawa, Canada, 27 August 2009
- ✓ First research roadmapping workshop – Keck Center of the National Academies, Washington DC, 10-11 December 2009
- ✓ **Follow-on workshop, San Diego, CA, 4 March 2010**
- Annual meetings to track research progress

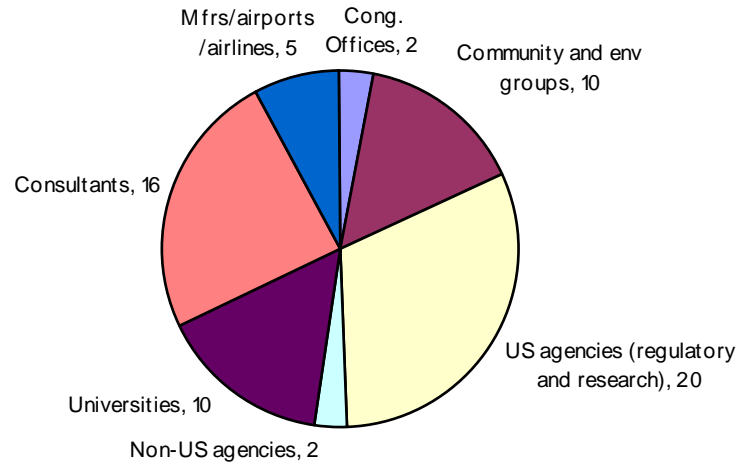


## International Forum Attendance

**51 attendees**



## Washington DC Workshop - 65 attendees



# Planning help we've received

## ❑ **Annoyance**

Kenneth Hume (UK researcher)

Sandy Lancaster (DFW airport)

Arlene Mulder (Mayor of Arlington Hts, IL; ONCC)

Paul Schomer (Consultant)

Kevin Shepherd (NASA)

Catherine Stewart (US Army)

## ❑ **Sleep Disturbance**

Mathias Basner (German researcher now US-based)

Patricia Davies (US PARTNER researcher)

Jim Fields (US researcher)

Barbara Griefahn (German researcher)

Sarah McGuire (US PARTNER researcher)

Nick Miller (Consultant)



# Online access to research roadmap material

For annoyance/sleep disturbance research roadmap at <http://www.fican.org/faaworkshop.html>

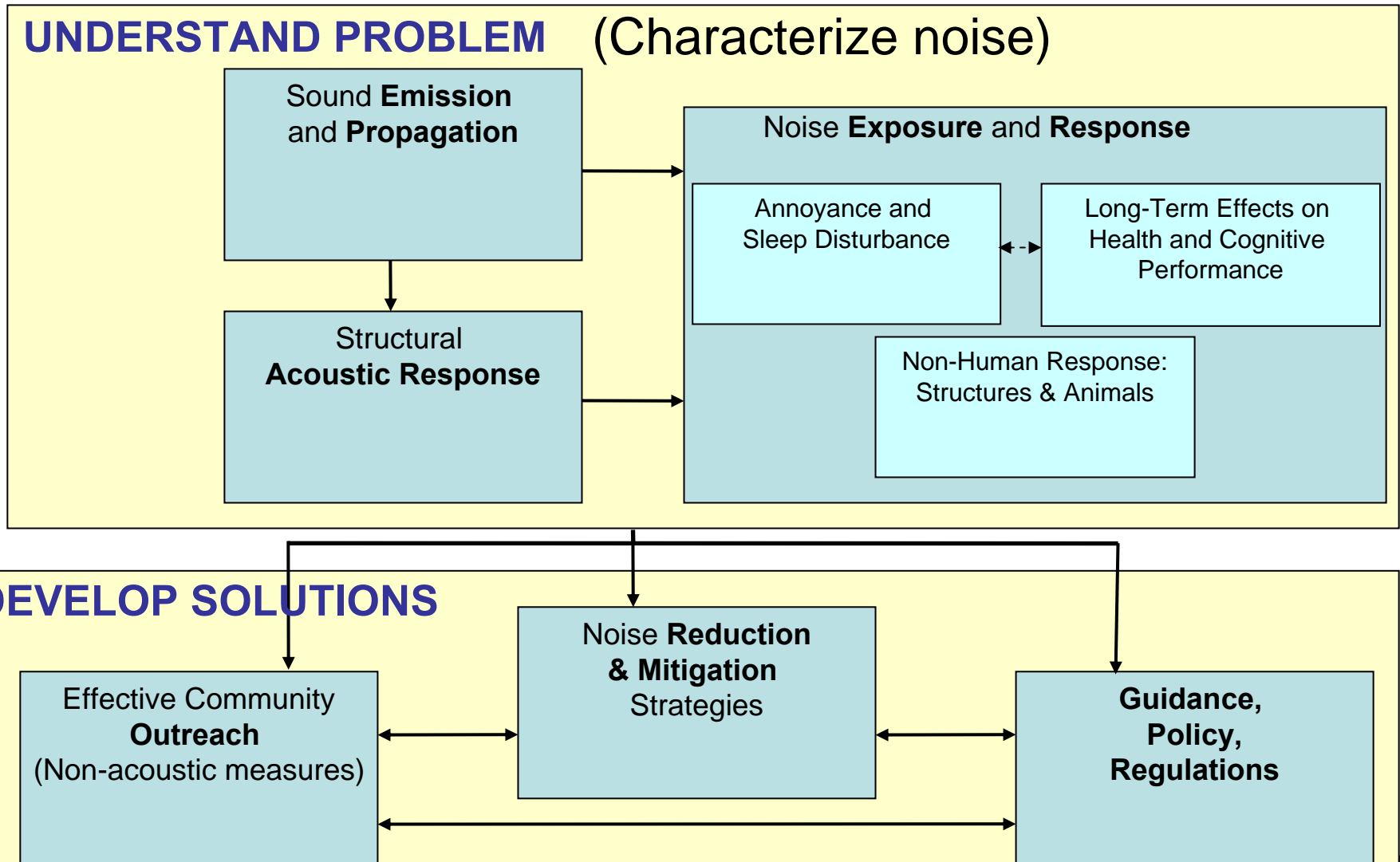
- Background and pre-work before meetings
- Summary report after meetings
- Information briefs from subject matter experts

Ongoing FAA Office of Environment and Energy research on noise impacts

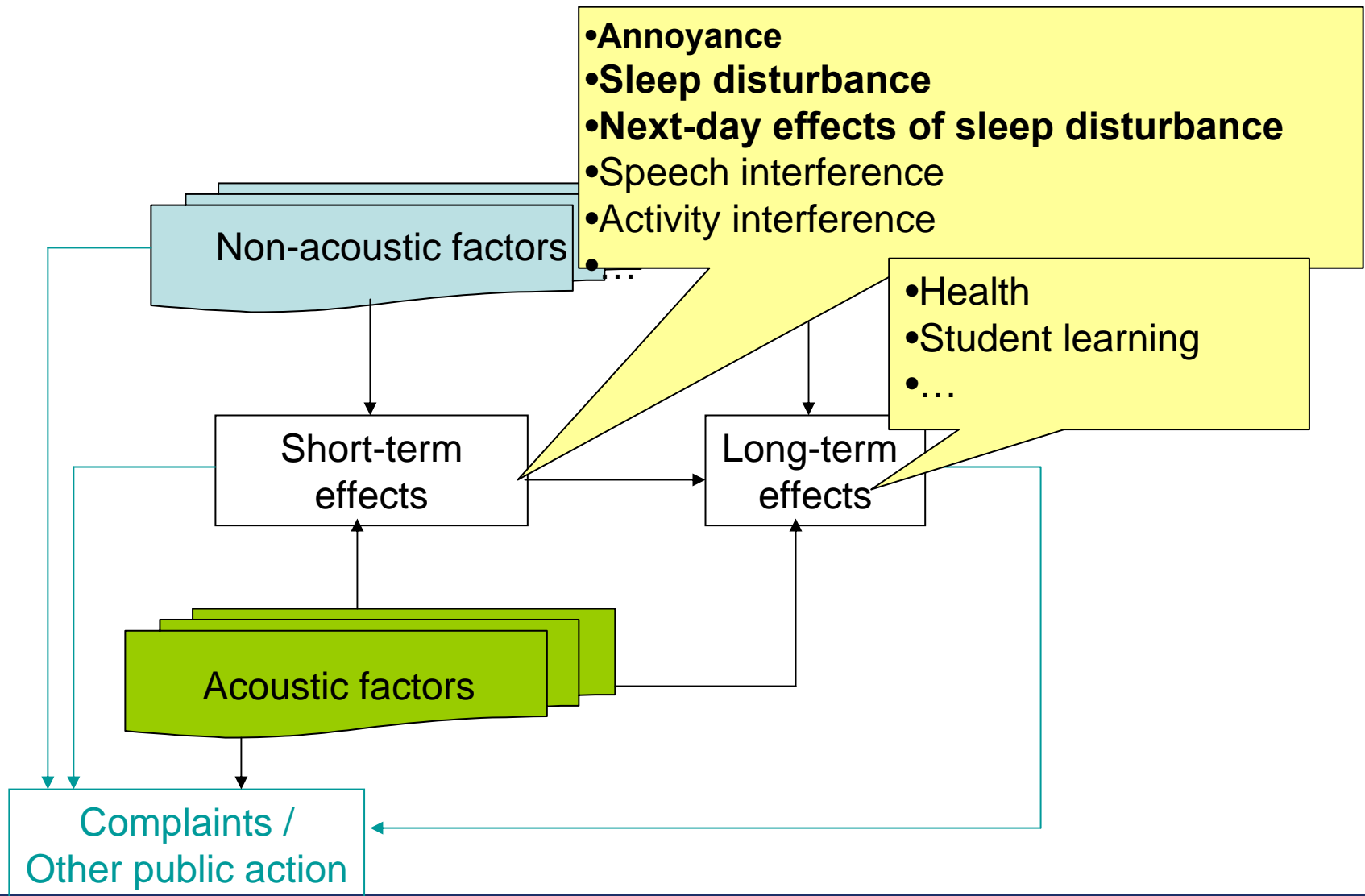
[http://www.faa.gov/about/office\\_org/headquarters\\_offices/aep/research/science\\_integrated\\_modeling/](http://www.faa.gov/about/office_org/headquarters_offices/aep/research/science_integrated_modeling/)



# FAA Noise Research Framework



# 1. Health and welfare – conceptual model of noise effects



# Overview of research roadmap

- **Focus research on two primary effects:**
  - Annoyance from two perspectives
    - **Private annoyance / reaction** – only from surveys
    - **Public action** – complaints, organized opposition, legal action
  - Nighttime sleep disturbance
- **Identify key issues for each effect**
- **Identify available existing relevant research**
- **Design and implement projects that use existing research**
- **Consider / design new studies to fill gaps**



# Private Annoyance – what we know

- **Traditionally determined by asking subject to rate annoyance on a scale – e.g., not at all to extremely**
- **Can be done without introducing significant bias**
- **Increases with increased noise**
- **May be no lower limit with no annoyance**
- **Influenced by multiple non-acoustic factors**
- **Different for different sources of noise**



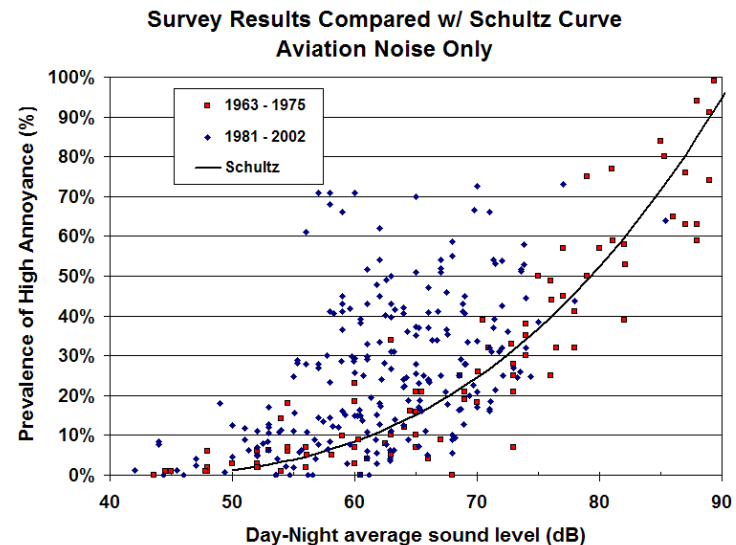
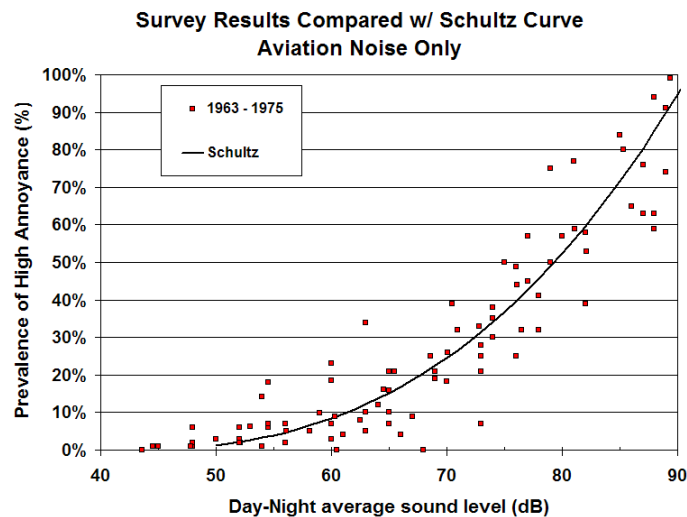
# Private Annoyance – what we know

- **Demographic factors – age, sex, social status, income, education, home ownership – have no reliable effect on reports of annoyance**
- **No clear “break point” in data – “significance” must be determined as policy decision**
- **Lack of recent data for U.S. populations**
- **ISO attempting to identify improved method for predicting aircraft annoyance**



# Key Issues—Annoyance - Private

- **What factors affect private annoyance?**
  - Has it increased with time? – some research evidence
    - Increased sensitivity / awareness?
    - More, quieter operations?



See also: Woodward & Mestre “Is the Schultz Curve Still a Useful Measure of Community Annoyance with Aircraft Noise?”



# Key Issues—Annoyance - Private

- **What factors affect private annoyance**
  - Is it different for different aircraft?
    - E.g., commercial jet airports v. GA propeller only
  - From experience that GA airports seem to have noise issues despite low levels of noise exposure



# Key Issues–Annoyance - Private

- **What factors affect private annoyance**
  - Is it location dependent – i.e., does low frequency content affect annoyance?
  - From experience of community concerns at lower A-weighted levels around runway end
  - Limited research suggesting annoyance ratings correlate better with C-weighted levels than with A-weighted levels



# Key Issues–Annoyance - Private

- **What factors affect private annoyance**
  - Is annoyance due to a step change in exposure the same as annoyance for more gradual changes?
  - Some research suggests that a step change:
    - Results in not only “movement” along the annoyance curve, but also
    - An “excess” annoyance response that may be of some (years) duration
  - If so, should it be considered for environmental analyses?
  - Does it alter interpretation of previous annoyance studies?



# Key Issues–Annoyance - Private

- **Project – Review available studies / data**
  - Available studies / data – some 628 surveys, all sources, to date
  - Determine whether some have addressed key issues
    - Look for similar / identical methodologies at different times
    - Similar methodologies at different airports
  - Determine if secondary analyses possible and conduct
  - Identify gaps and design additional studies



# Private Annoyance Research

- **Questions / comments?**



# Key Issues—Annoyance - Public

- **Can community / public actions be predicted?**
  - Should we have known what would happen?
  - Can proper use of the tools we have available give us clues as to probable public actions?
  - What additional tools could help?



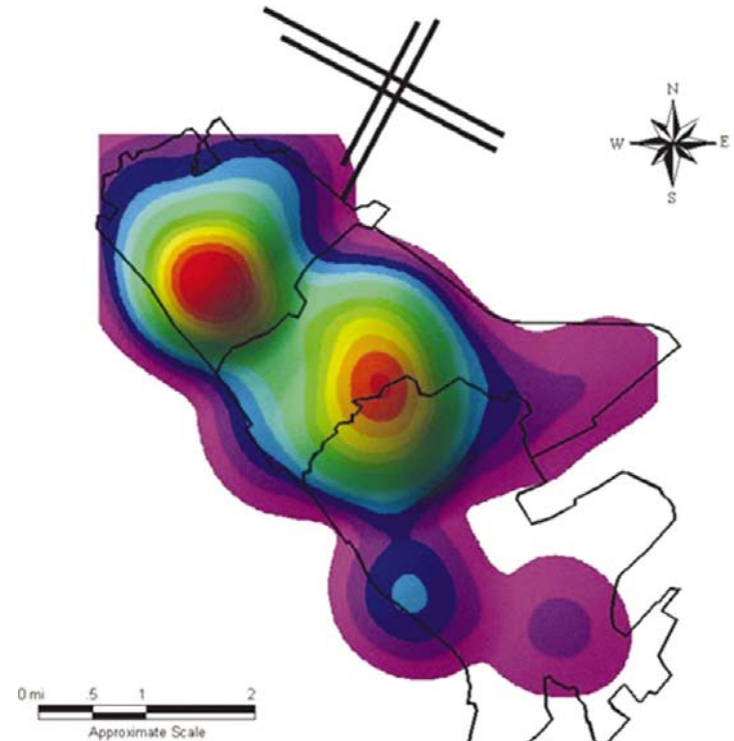
# Key Issues–Annoyance - Public

- **Project – Conduct retrospective examination**
  - Identify several past projects with significant changes in exposure – e.g., new runways
  - Determine before and after exposure
    - Changes in DNL?
    - Changes in Number Above a threshold?
    - Changes in SEL distributions?
    - Changes in % Highly Annoyed?
  - Review environmental process / community interactions
  - Review resulting community actions



# Key Issues–Annoyance - Public

- Can noise complaint data be used as an aid to airport management?
- Can we develop an easy to use tool for tracking?
- Can complaint data help estimate non-acoustic component of annoyance?
- Can complaint data help us quantify the rise and decay times of community actions related to operational changes?



Source, Fidell, 2003



# Key Issues–Annoyance - Public

- **Project – Collect / review complaint data**
  - Multiple airports with documented complaints, noise levels, aircraft flight tracking data
  - Can aircraft levels (single and cumulative) be associated with complaints?
  - Can geographic distributions be determined and tracked?
  - Is development of a standardized complaint handling system useful and feasible?



# Possible application of findings: Better communication w/ public

- **Test communication methods**
  - Based on factors that affect annoyance and / or complaints
  - Locations where noticeable changes will occur
  - Significant changes in terms of numbers of operations
  - Distributions of levels by location – research supports
- **Develop model(s) or standard(s) for communicating aircraft noise exposure and effects to the public**



# Annoyance Research Roadmap

- **Questions / comments?**



# Noise and sleep – what we know

- **Noises can awaken people**
- **People are awakened more readily in a laboratory setting than in their home**
- **There is considerable variation in awakening responses from person to person**
- **For most people, the chance of awakening from one event is quite small - <10% for events less than ~75 dB(A) at the ear**



# Noise and sleep – what we know

- **Subjective judgments of sleep quality are generally uncorrelated with objective measures**
- **Few people will awaken from events less than ~30 – 40 dB(A)**
- **People normally awaken “spontaneously” several times a night, depending on how “awakening” is determined**
- **There is no consensus on the “best” method for studying noise induced awakenings**



# Key Issues: Sleep disturbance

- **Is sleep disturbance due to noise different for different populations?**
  - Most studies are not of U.S. populations
  - May want justification for using other studies /results
- **Project – Compare U.S. and other results**
  - Use limited studies of behavioral awakenings
  - Are different airport results significantly different?



# Key Issues: Sleep disturbance

- **Is there a noise dose-sleep response relationship available for practical application?**
  - Mathias Basner has developed one
  - ANSI S12.9 Part 6
  - Needs to address entire night
  - Needs to address populations affected
  - Should include time of night
- **Project – Compare models and prediction results for realistic scenarios of entire night of operations**



# Key Issues: Sleep disturbance

- **What is the effect of noise-produced sleep disturbance on next-day effects?**
  - Is there a degree of noise-induced sleep disturbance that can affect next-day performance / sleepiness?
  - At what point does noise-induced sleep disturbance become significant compared to disturbances from other causes?
- **Project**
  - Review / examine available studies for sufficiency
  - What additional studies should be undertaken?



# Key Issues: Sleep disturbance

- **What are effects of variable night time exposures?**
  - Interventions – e.g. sound insulation can reduce night time exposures
  - Are there surveys with varying night time exposures for individual subjects?
- **Project**
  - Review / examine available studies for applicability
  - Try separation of effects by night time exposures



# Key Issues: Sleep disturbance

- **What is the relation between  $L_{\text{night,outside}}$  and sleep disturbance?**
  - WHO recommends use of  $L_{\text{night,outside}}$
  - Research on noise-induced sleep disturbance focuses on single events
- **Project**
  - Use available models of sleep disturbance to derive number / percent awakenings for each subject night
  - Compute  $L_{\text{night}}$  for each subject night and correlate  $L_{\text{night}}$  with number / percent of awakenings



# Key Issues: Sleep disturbance

- **Can non-noise sleep disturbance studies of health effects be useful for noise-induced sleep disturbance?**
  - Great amount of work has been done and will be done on sleep disturbance
- **Project – review available research with expert assistance**
- **Has any health research at NIH included noise or could up-coming research include noise?**
- **Project – liaison with NIH**



# Sleep Research Roadmap

- **Other sleep disturbance issues to consider:**
  - Effects of background noise
  - Existing data are very limited-
    - Only healthy adults
    - Relatively few in number of studies and subjects
  - Shortening of sleep period, not just disturbance
  - Annoyance and awakening likely to be related
  - Variability of outdoor-to-indoor reduction
  - Cultural differences (open or closed windows)
- **More studies required**



# Sleep Research Roadmap

- **Questions / comments?**



# Next

- **Identify Preliminary projects**
- **Schedule**
- **Budget**



# 1. Health and welfare - research status FY09-10

## Sleep disturbance

PARTNER CoE Proj 25 – Purdue U.

- **Developed preliminary sleep disturbance model – superposition of noise events on sleep structure model to predict awakenings**
- **Prepared report summarizing literature on sleep disturbance due to aircraft noise and potential related health effects**



## Other health effects

PARTNER CoE Proj 19 – Purdue U.

- **Completed health effects literature survey – report being edited “A Review of the Literature Related to Potential Health Effects of Aircraft Noise”**



## Student learning

ACRP 02-26 Assessing Aircraft Noise Conditions Affecting Student Learning - NEW

- **Based on current knowledge, will identify and evaluate conditions under which aircraft noise may affect student learning and**
- **Identify and evaluate one or more alternative noise metrics that best define those conditions**



# 1. Health and welfare - research status FY09-10

## Trends in response to noise exposure

Wyle / Jim Fields



- **Updated annoyance survey catalog identifying surveys that could be used to investigate trends – report available from AEE R&D website “An Updated Catalog of 628 Social Surveys of Residents' Reaction to Environmental Noise (1943-2008)”**
- **Identified surveys of high-interest for further study/re-analysis**

PARTNER CoE Proj 25 – Purdue U.



- **Documented status of public database of noise surveys/studies**
- **Identified challenges and potential solutions to building such a database**

New solicitation



- **Meta-analyses to update exposure-response curve for annoyance to aircraft noise**



# 1. Health and welfare - research status FY09-10

## Acoustic factors that contribute to annoyance

PARTNER CoE Proj 24 – Purdue U.

- **Investigated influence of sound characteristics other than loudness on annoyance**
  - Found that tonalness in addition to loudness had the strongest influence
  - Suggests that variability in annoyance at same DNL may be partially explained by tonal differences between aircraft

PARTNER CoE Proj 25 – Purdue U.

- **Investigated whether “meaning” of sound (i.e., identifying the source) influences response**
  - Neutralizing sound to remove meaning did not change annoyance ratings
  - Suggests that meaning doesn’t explain differences in degree of annoyance between modes



# Funding

- Modest for FY10 and FY11
- Currently planning for FY12
- Opportunities for Airport Cooperative Research Program (ACRP) FY11 and beyond



# Next steps

- **ACRP FY11 problem statements due April 15**
  - Annoyance knowledge gaps
    - Systematic re-analysis of existing data
    - Standardized US airport community surveys (broad array of airport types, geographic locations, ...)
  - Systematic review of complaint data; standardized complaint data collection
  - Retrospective study on public annoyance
  - Sleep disturbance knowledge gaps
    - Systematic re-analysis of existing data
    - Standardized US field studies
- **PARTNER**
- **Other FAA AEE-sponsored work**



# If you support this research initiative, how can you help?

## *All*

- Write ACRP problem statements related to annoyance and sleep disturbance research roadmap topics and/or express support for problem statements
- Suggest other funding avenues

## *Airports and communities*

- Agree to participate in field studies

## *Researchers*

- Establish/maintain contacts with international and interdisciplinary noise effects research community and let us know of collaborative opportunities



# Thank you !

