

# Aviation Noise Metrics Recommendations



## Hanscom Noise Workgroup

Presentation at *FICAN 2001 Airport Noise Forum*  
*University of California Tech Transfer Program*  
28 February 2001

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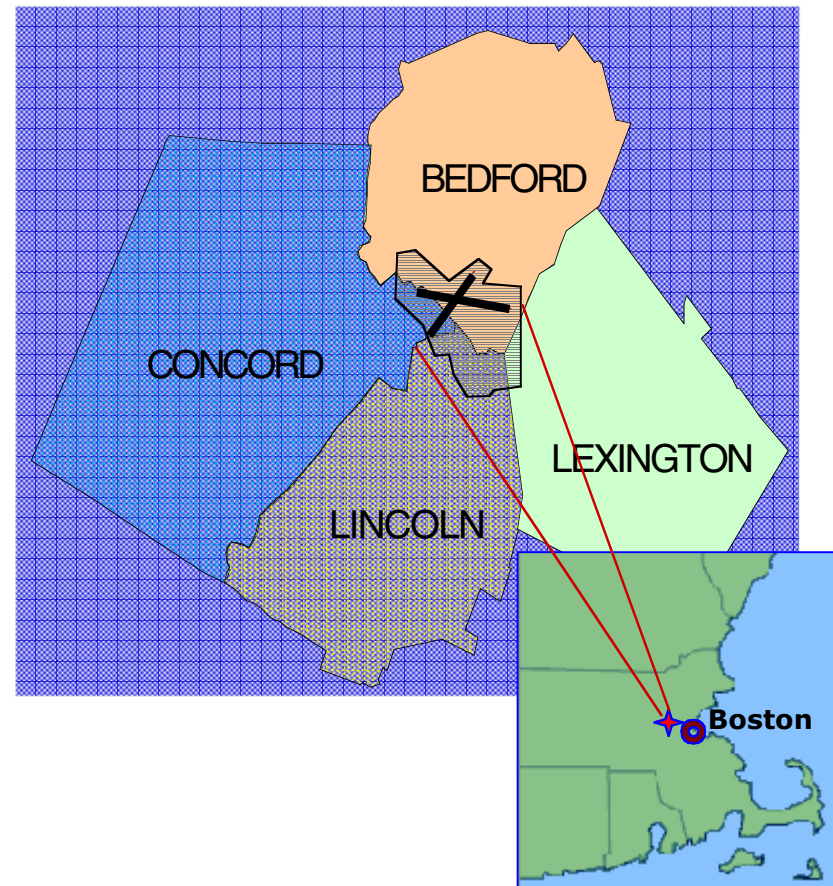
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# About Hanscom Field and the Hanscom Noise Workgroup (HNWG)

- General aviation airport in Bedford, Concord, Lexington, Lincoln MA
- Abuts Minuteman National Historical Park
- HNWG chartered by Massport to comply with Mass Secretary of Environmental Affairs mandate to address shortcomings of 1995 Generic Environmental Impact Report
- HNWG representation included representatives of abutting towns, aviation-related business owners, citizen groups, US Air Force, Nat'l Park

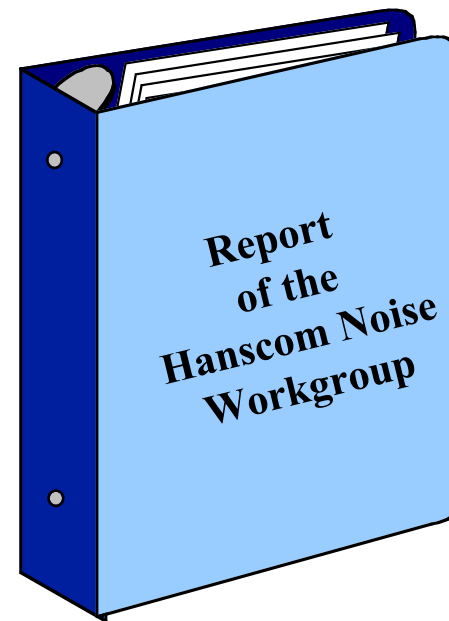


# About Hanscom Field and the Hanscom Noise Workgroup (HNWG)

- HNWG Report to Massport (1999):
  - 112 pages
  - 21 abatement recommendations
  - 14 metrics recommendations
- Report *unanimously* approved by members
- To obtain complete report:

<http://www.fican.org/pages/sympos03.html>

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# HNWG Criteria for 'Good' Noise Metrics

- An ideal noise metric, or set of metrics, should:
  - | Express the *sound level above ambient* noise level
  - | Take into account the *duration* of aircraft noise events
  - | Be affected by the *number of aircraft noise events*
  - | Express the *number of people affected*
  - | Express the *absolute sound level* of events

# Desired Attributes of Noise Metrics

- | **Assess current** aviation operations, **predict impacts** of future changes
  - e.g., changed number of operations, changed fleet mix
- | Reflect **"peaky"** nature of over-flight noise
  - I.e., **does not average excessively** over space or time
- | Readily express year-to-year and month-to-month **changes**
- | **Correlate to subjective perceptions** of the community affected
- | Provide **sufficient detail for analysis**
  - understand the root cause of noise and noise trends

## Desired Attributes of Noise Metrics (cont'd)

- | ***Complement, not replace, the Day-Night Noise Level***
- | **Can be *modeled by the Integrated Noise Model* (INM) program**
- | ***Permit a rerun* of INM data from previous years**
- | ***Be measurable* by the currently available noise monitoring system**
- | ***Show variations* of predicted noise levels expected from modeling assumptions and simplifications**

# HNWG Metrics Recommendations Overview

## 5 Major Categories:

- ① Greater use of *'Time Above'* (TA) noise metric
- ② *Statistical description* of aviation noise events –  
    ↪ *more information than just the average*
- ③ *Linear dimensionless metric* to complement  $L_{dn}$
- ④ *'Community Metrics'* easily understood by the general public
- ⑤ Assessment and discussion of *modeling limitations*

# 1

## Time Above (TA) Correlates with Flight Operations Better than $L_{dn}$

### # Aircraft operations Growth Scenarios

	# Operations			% Increase over Baseline
	Single	Jets	Total	Total
Baseline	447	30	521	-
2000/1%	451	41	548	5%
2000/3%	498	46	604	16%
2010/1%	459	67	605	16%
2010/3%	616	90	812	56%

### Time Above $L_{90}$ Ambient Growth Scenarios (2 example locations)

% Increase in Time Above over '95 baseline	Concord Localizer (location 35)				
	85 dBA	75dBA	65dBA	$L_{90}$ (=35dBA)	$\Delta L_{dn}$
2000 / 1%	0%	5%	4%	5%	0
2000 / 3%	0%	15%	14%	16%	0
2010 / 1%	50%	15%	13%	15%	-1
2010 / 3%	-100%	55%	52%	53%	0

% Increase in Time Above over '95 baseline	Concord Wastewater Plant (location 36)				
	85 dBA	75dBA	65dBA	$L_{90}$ (=50dBA)	$\Delta L_{dn}$
2000 / 1%	0%	0%	14%	5%	0
2000 / 3%	0%	0%	21%	15%	0
2010 / 1%	0%	0%	21%	13%	0
2010 / 3%	0%	0%	64%	50%	1

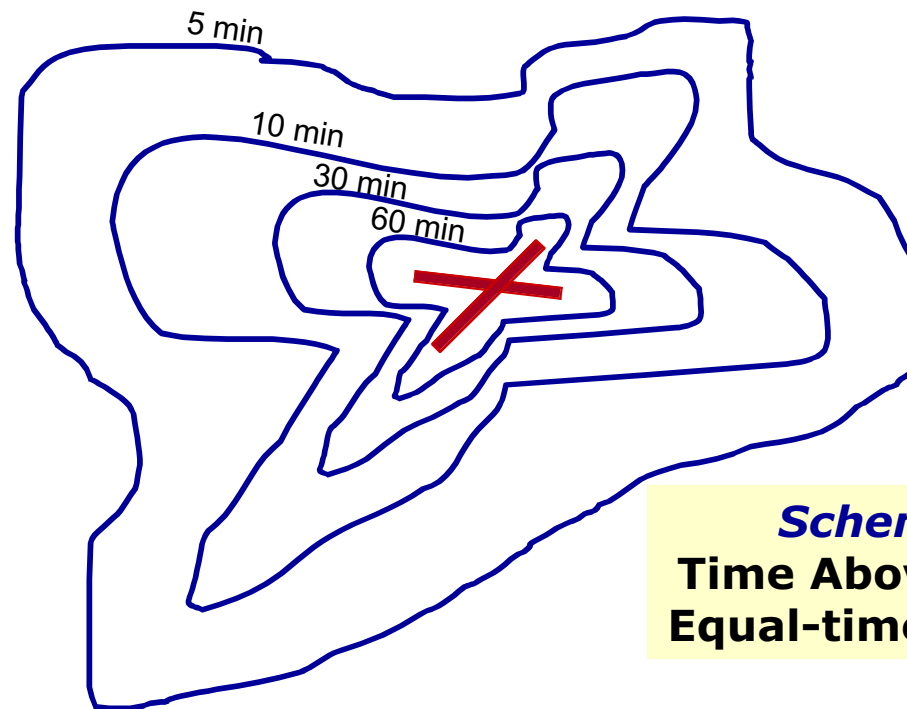
Data from Hanscom Field  
GEIR 1995

28 February 2001

Hanscom Noise Workgroup - Metrics Task Group

# Time Above Proposals

- Plot TA contours for 45, 55, and 65 dBA using INM
- Present *area* inside each contour – a *single number* expressing area affected



***Schematic:***  
**Time Above 65 dBA**  
**Equal-time contours**

# Benefits of Time Above



- Time and area both *readily understood* by general public
- *Calculated and plotted by INM*
- Time Above the  $L_{90}$  appears to *correlate approximately linearly* with changes in number of aircraft operations

## 2

# Single Event Level Distribution (SEL/D)

- **Average metrics are relatively insensitive** to changes in fleet mix, number of operations, and other changes
- Average metrics obscure **dynamic range** of acoustic events
  - ✦ *"How loud does it get?"*
- Proposed SEL/D uses **conventional statistical technique** to describe the **range of levels** due to aviation events
- SEL/D is a **histogram distribution of Sound Exposure Level (SEL) values** due to actual aircraft operations
  - SEL values from local database originating from the INM database
  - Operations data routinely collected monthly

# SEL/D Step 1 - group aircraft by database SEL value

**Example  
group:**

**Departure SEL  
= 95 ± 1 dBA**

Group #	Aircraft Type	Departure SEL (dBA)
12	C140 (MILITARY)	95.5
4A	DA20, N265-80	95.4
4B	HU25	95.4
14B	CS, T-43 (MILITARY)	94.8
14A	DC-9	94.8
18B	C130 - HVY TURBOS (MILITARY)	94.2
18A	G159, CV60 - HVY TURBOS	94.2
28	DC3, CV24 - HVY TWIN PISTON	94.2

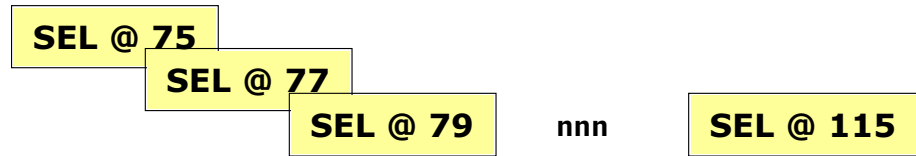
**All other aircraft types grouped by SEL level into  
2 dB wide bins**

# SEL/D Step 2 -

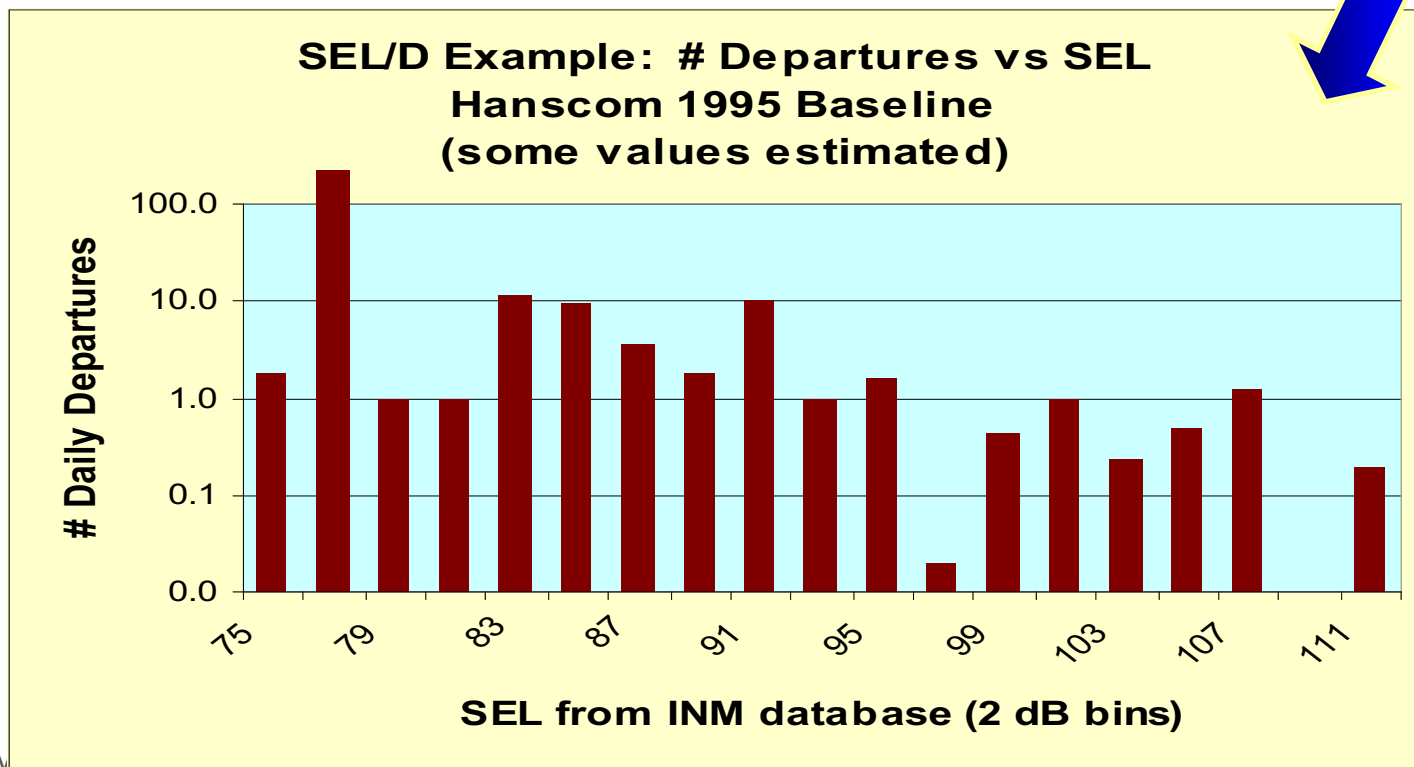
combine operations data with groups to create histogram

24	Dash 8 - 311
7	Beech King
57	Single engine
1	G-II
5	G-IV
...	

Operations Data

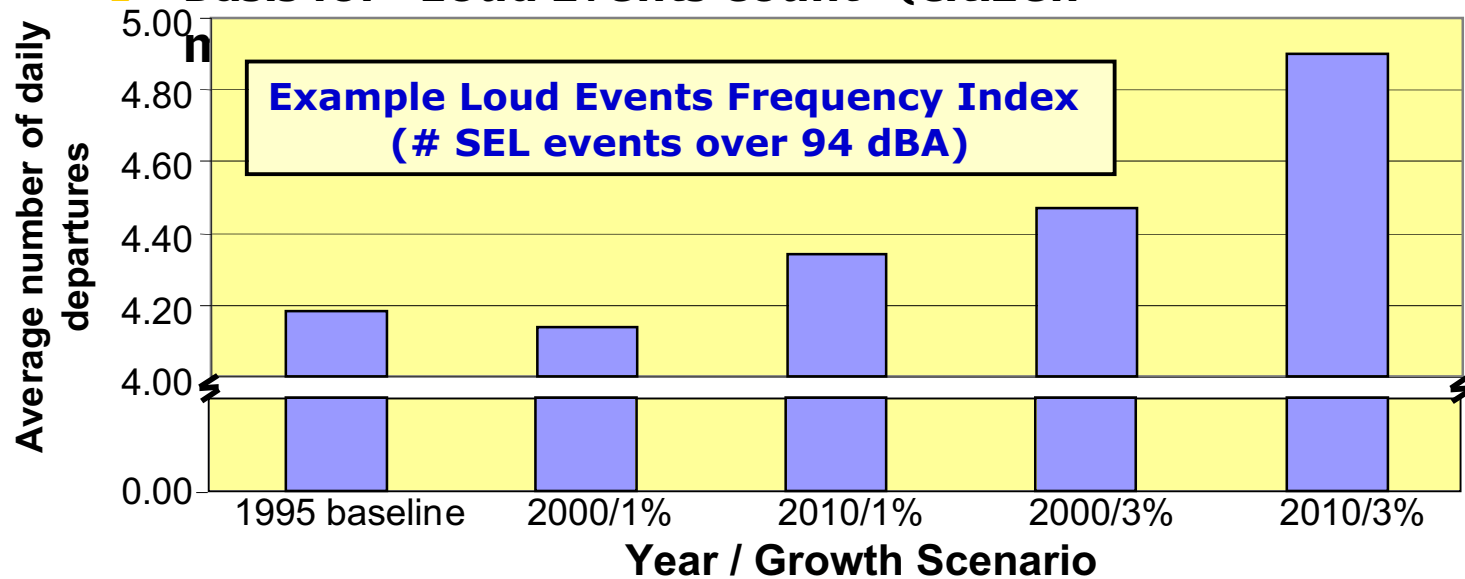


Database SEL Groups



# Benefits of SEL/D

- **Easy to implement** – simple to obtain data and create histogram with spreadsheet software
- **Trending**
- **Basis for "Loud Events Count" (Citizen**



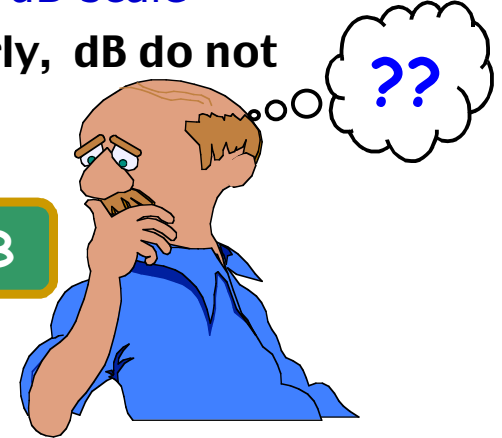
# 3

## Linear Dimensionless Metric

- Decibel measures not easily comprehended by general public
  - Large change in noise  $\leftrightarrow$  apparent **small change on dB scale**
  - Most measures (weight, length, etc) combine linearly, **dB do not**

$$\$50 + \$50 = \$100$$

$$50\text{dB} + 50\text{dB} = 53\text{dB}$$



- Proposed hypothetical linear metric is linear equivalent to  $L_{dn}$
- Desired linear ratio:

$$\frac{\text{Aviation noise}}{\text{Ambient sound}}$$

## Candidate Linear Metric

Aviation-to-Ambient Ratio:

$$\mathbf{AAR} = \frac{\langle p_{\text{dnAviation}}^2 \rangle_T}{\langle p_{\text{refAmbient}}^2 \rangle_T}$$

$p_{\text{dnAviation}}^2$  : day-night A-weighted sound pressure due to overflights

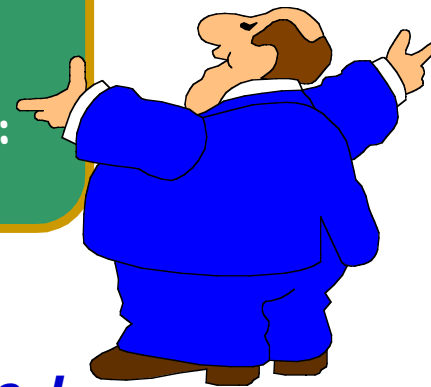
$p_{\text{refAmbient}}^2$  : representative  $L_{90}$  ambient pressure

# Benefits of Linear Dimensionless Metric

- ***Scales linearly*** with number of identical acoustical events

50 operations:  
 $AAR = x$

Double those operations:  
 $AAR = 2x$



- ***Complements, does not replace,  $L_{dn}$***
- **Linear equivalent to  $L_{dn}$**
- **Reference to Ambient Sound *allows scaling* from Urban to Suburban communities**

# 4

## Community Noise Metrics

- Objectives
  - *Facilitate communication with public*
  - *Improve credibility of airport authority, noise experts*
- Ideal attributes
  - *Zero value for zero impact*
  - *Scale linearity*
  - *Minimum metrics* – as few as possible
  - *Relation to experience*
  - *Explanatory title*
  - *Reference values*
    - e.g., 45 dB SPL is a whisper, 65 dB SPL leads to speech interference
  - *Simple numbers*

## Candidate Community Noise Metrics

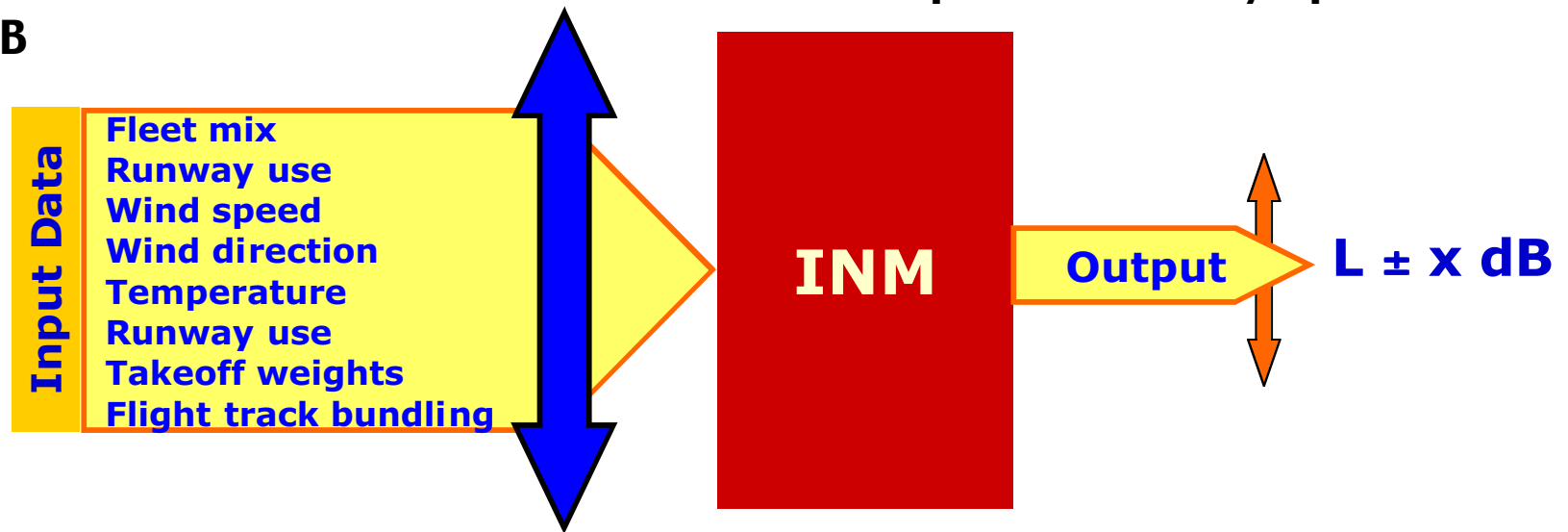


- ***Area*** Experiencing 30 or more minutes per day of 55 dBA Aircraft Noise (TA 30 min/day @ 55 dB)
- ***Area*** Impacted by Noise per EPA (55 dB DNL Contour Area)
- Monthly Loud Events ***Count*** (Events per month > 94 dB SEL)

# 5

## Range of Accuracy of the INM Analysis

- All mathematical models rely on assumptions, and produce results with some degree of error
- Actual measurements and model were reported to vary up to 10 dB

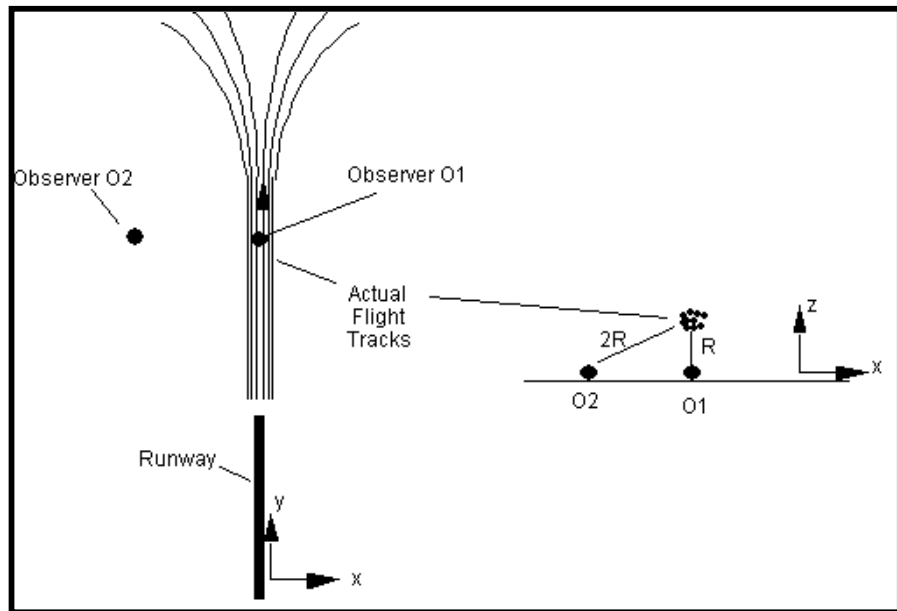


**Standard engineering practice:**

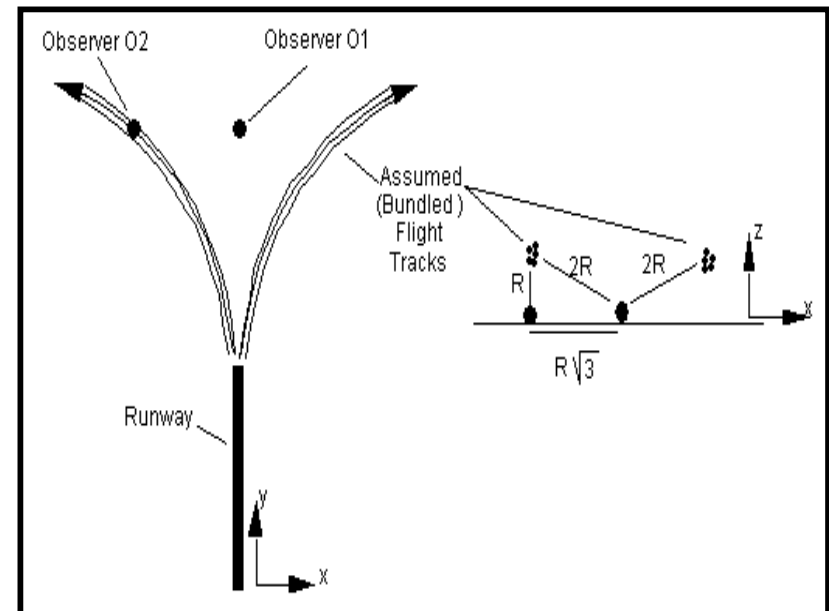
- list assumptions and constraints
- indicate expected error band of results

# Flight Track Bundling - potential variation due to different modeling assumptions

## Bundling scheme 1



## Bundling scheme 2



**Theoretical difference of two schemes at Observer 1 = 6 dB**  
**Theoretical difference of two schemes at Observer 2 = -3.3 dB**  
**The predicted result depends on selected bundling**

# **Benefits of Assumptions and Error Disclosures**



- **Assumptions scrutinized, understood, approved by other scientists and general public**
- **Predictions reproducible by any INM user**
- **Devote special attention to locations with large error bars**
- **Public trust in modeling enhanced**

# Conclusions



***Taken together, the HNWG recommended metrics would:***

- | Enhance understanding of acoustic impact of aviation operations**
- | Increase credibility of noise reports, EIR's, etc**
- | Increase trust and understanding of citizens**

# Call to Action

## *Research agencies & contractors*

- Fund studies to determine efficacy of HNWG recommended metrics
- Research other metrics meeting HNWG metrics criteria
- Research and define a Linear Dimensionless Metric
- Consider 'Model Airport' program for metrics study

## *FAA and other regulatory agencies*

- Require use of these metrics in noise reports, impact reports, etc.
- Specify and document INM modeling assumptions and output variability

## *Airport authorities*

- Implement these metrics

*Eve*

<http://www.fican.org/pages/sympos03.html>