REVIEW OF USAF STUDIES OF MILITARY TRAINING ROUTE (MTR) NOISE

Robert C. McKinley, C. Stanley Harris, Eric Stusnick, John Molino and Kenneth J. Plotkin

Presented by Robert C. McKinley
Research Psychologist
USAF AL/OEBN
2610 Seventh St
Wright-Patterson AFB OH 45433-7901

Phone (513) 255-3664
FAX (513) 476-7680

The USAF routinely conducts low-altitude, high-speed training missions on Military Training Routes (MTR)s and within Military Operating Areas (MOA)s. The noise produced by these missions can be characterized as sporadic, with short durations, rapid onsets and higher levels compared to noise generated around airbases. The $L_{chmn}$ noise metric has been used by the USAF as an interim metric to assess the impact of noise generated by MTR and MOA missions on the civilian population. The USAF conducted a series of acoustic and psychoacoustic studies to measure the noise levels and validate the $L_{chmn}$ metric. The acoustic studies measured the flight track dispersion across several MTRs and noise signatures from low-altitude, high-speed flyovers. The psychoacoustic studies primarily examined the contribution of sound exposure level, onset rate, and the sporadic nature of flyovers to the development of annoyance. From these acoustic and psychoacoustic studies a revised noise metric has been recommended. This validated noise metric and tract dispersion model are used in ROUTEMAP II and MOAMAP, which are the USAF programs for predicting the impact of noise generated by MTR and MOA operations, respectively.

Mr. Robert C. McKinley is a research psychologist for the Noise Effects Branch of Armstrong Laboratory of the United States Air Force. His primary research has been human response to noise. He is also interested in developing educational tools for addressing noise concerns. Bob started working for the Noise Effects Branch in December 1989. He has recently completed his masters degree from Wright State University in Human Factors Psychology.
Review of USAF studies of Military Training Route (MTR) noise.

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Introduction

- U.S. Air Force has a training requirement to fly low altitude, high speed aircraft operations.
- Noise characterized as:
  - sporadic
  - short durations
  - rapid onsets
  - higher levels compared to noise generated around airbases
- Interim $L_{dnmr}$ metric used in ROUTEMAP.
- Wyle Laboratories has worked for Armstrong Laboratories to assess impact.
Interim $L_{dnmr}$

- Modification of the $L_{dn}$ metric.
- Integration period equal to the calendar month with the highest number of operations.
- Up to 5 dB onset rate penalty added to the Sound Exposure Level.
- Penalty applied only to events with max A-weighted sound level exceeding ambient by 15 dB.
Interim Onset Rate Penalty

- No onset rate penalty for onset rates < 15 dB/s.
- For onset rates between 15 and 30 dB/s penalty equals $16.6 \log_{10}(\text{onset rate}) - 19.5$.
- For onset rates > 30 dB/s penalty is 5 dB.
Noise Exposure Validation
In-house acoustic studies

- Measured noise signatures from low-altitude, high-speed flyovers.

- Onset rate predicted from measured data.

\[
\text{ONSET} = 10.0^{**}(0.002247 \times \text{Speed} - 0.0003228 \times \text{Altitude} \\
- 0.00014 \times \text{Lateral Offset} + 0.008987 \times \text{SEL} \\
- 0.434)
\]

- Measured excess attenuation for low-altitude flights at large lateral distances.
Noise Exposure Validation
Wyle acoustic studies

- Flight track dispersion across several MTRs.
  - Distribution from “center-line” (IR) and “dispersed” (VR) flight operations
  - Dispersed (VR) distribution (SD = 0.17 Route width)
- Validated noise levels across several MTRs.
ARMSTRONG LABORATORIES
NOISE EFFECTS BRANCH

$L_{dnmr}$ Validation
Sequence of psychoacoustic studies

<table>
<thead>
<tr>
<th>Study Setting</th>
<th>Noise Source</th>
<th>Exposure Time</th>
<th># of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-house Studies</td>
<td>Simulated</td>
<td>5 x 30 min</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Simulated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyle Studies</td>
<td>Simulated</td>
<td>2 x 2 hr</td>
<td>76</td>
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<tr>
<td>Laboratory</td>
<td>Simulated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rented Home</td>
<td>Simulated</td>
<td>2 x 6 hr</td>
<td>60</td>
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<tr>
<td>Hybrid Own Home</td>
<td>Simulated &amp; Real</td>
<td>1 month</td>
<td>63</td>
</tr>
<tr>
<td>*Own Home</td>
<td>Real</td>
<td>3 months</td>
<td>30</td>
</tr>
<tr>
<td>* Planned</td>
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</tbody>
</table>
Examined the contribution to human annoyance of the following:

- sound exposure level
- onset rate
- number of events
- sporadic nature
- background noise level
- subject’s task
- setting
- event duration
Psychoacoustic studies

Results

- Significant
  - sound exposure level
  - onset rate
  - setting
  - event duration
  - background noise level

- Not significant
  - sporadic nature
  - subject’s task
  - number of events independent of Leq
Effect of Onset Rate on Annoyance
Laboratory Studies

- ● 115 dB SEL
- ▲ 105 dB SEL
- ■ 95 dB SEL
- ◆ 85 dB SEL

Wyle outdoor lab study

In-house study

Mean Annoyance Rating vs. Onset Rate (dB/s)
Effect of Onset Rate on Annoyance
Rented Home Study

Mean Annoyance Rating

Onset Rate (dB/s)

- 110 dB SEL
- 95 dB SEL
Onset Rate Penalty
New Recommended Penalty

- No onset rate penalty for onset rates <15 dB/s.
- For onset rates between 15 and 150 dB/s penalty equals $11 \log_{10}(\text{onset rate}) - 12.9$.
- For onset rates > 150 dB/s penalty is 11 dB.
Leq vs Leq

Percentage of subjects highly annoyed for one-hour session

AF Schultz Curve

$R^2 = 0.62$

AF Schultz Curve

$R^2 = 0.24$
Onset Rate Penalty Comparison

Penalty to SEL (dB)

Onset rate (dB/s)
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Onset Rate Penalty
ROUTEMAP Comparision

F-4C under VR dispersed operations at Altitude 125 ft, 550 kts, 98% RPM, 2 flights/day