# Beyond the Noise Reduction Rating: Advancing Hearing Protection Selecting Using HPOT and Electroacoustic Performance Metrics

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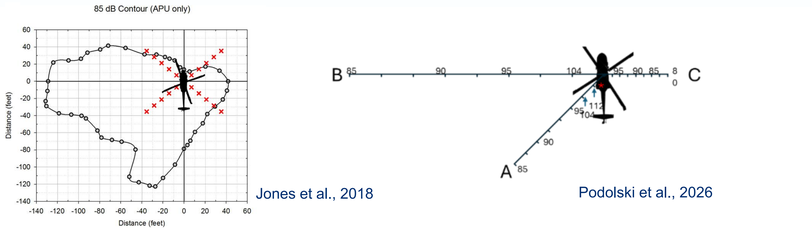
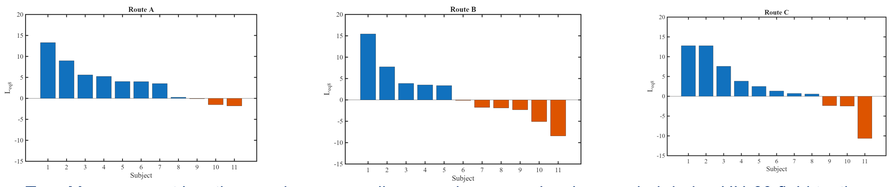
## Not All Hearing Protectors Are Created Equal

### Traditional Hearing Protector Selection

- Selects hearing protectors based primarily on attenuation requirements (NRR)
- Assumes devices with similar attenuation provide equivalent performance
- Does not account for mission-specific hearing performance requirements

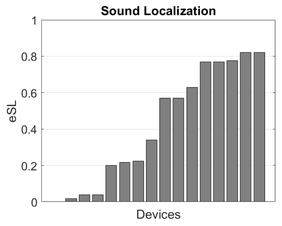
**Manufacturer-reported attenuation does not reliably predict real-world in-ear noise exposure.**



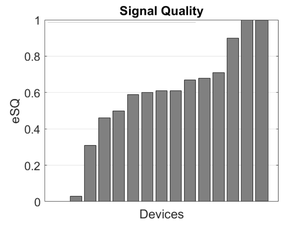




**Top:** Measurement locations and corresponding sound pressure levels recorded during UH-60 field testing.
**Bottom:** Measured insertion loss varied across routes, demonstrating that HPD attenuation significantly varies

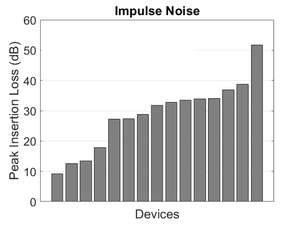
**HPDs with similar attenuation can exhibit dramatically different operational performance.**

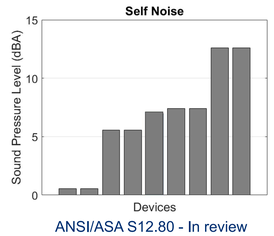

Audet et al., 2026

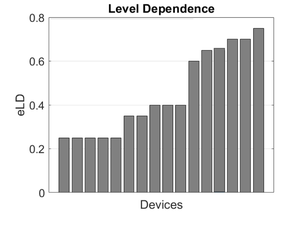



Butler et al., 2026




Greene et al., 2018
Anderson et al., 2023



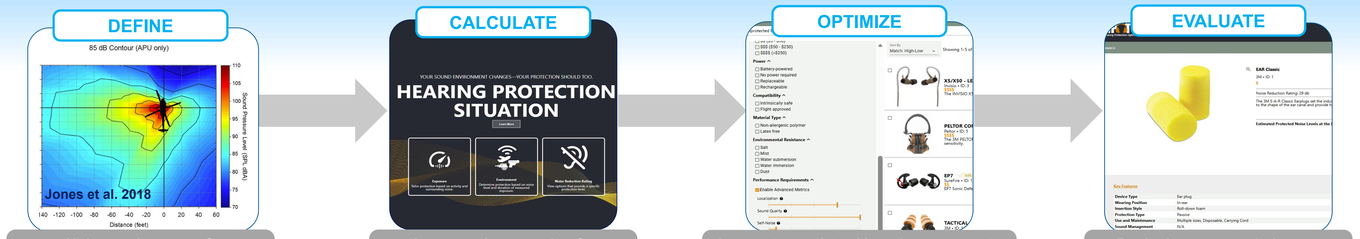

ANSI/ASA S12.80 - In review

Hearing protector performance metric scores were developed based on prior work from our group (Brown et al., 2015).

Devices with similar NRR can differ substantially in:

- sound localization
- speech quality
- self-noise,
- impulse protection
- level-dependent performance

## The Hearing Protection Optimization Tool: From Selection to Optimization



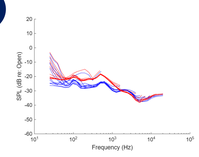

**Expands HPD selection beyond simple NRR-based methods by:**

**1**


Simultaneously considering:

- Required attenuation
- Performance metrics

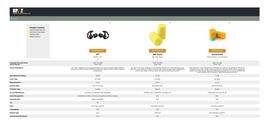
**2**




Automatically applying advanced analyses

- Octave band analysis
- Personal attenuation rating
- Double hearing protection
- Impulse noise evaluation

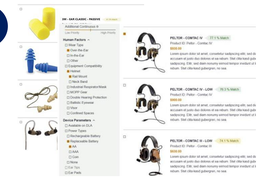
**3**



Considers and compares major device characteristics

- Device type
- Insertion style
- Wearing position
- Communication
- Cost
- Material type

**4**



Generates specific recommendations in a rank list by considering

- Noise environment
- Protection requirements
- User preferences

## Traditional Selection vs HPOT Optimization

- HPOT provides greater utility vs traditional HPD selection

| Traditional | HPOT |
|---|---|
| Attenuation only | Multiple metrics |
| Generic | Mission specific |
| Manual | Automated |
| Best available | Best performance |
| Selection | Optimization |

## Electroacoustic Standards Status

- Four performance standards approved for ASA/ANSI development.
  - Collaborating with ASA S12 Committee Working Group 11 to develop standardized evaluation methods.
  - Self-noise standard (ASA/ANSI S12.80) completed six draft revisions and addressed 250+ technical comments.
  - Publication of S12.80 is targeted by the end of the year, with development of the remaining standards to follow.
- Scientific validation against human performance
  - Sound Localization – eSL vs hSL (Audet et al., 2026)
  - Signal Quality – eSQ vs hSQ (Butler et al., 2026)


- ASA/ANSI S12.80: Self-Noise
- ASA/ANSI S12.81: Level-Dependent Performance
- ASA/ANSI S12.82: Speech Quality
- ASA/ANSI S12.83: Sound Localization

## Key Takeaways

- NRR alone does not provide enough information to effectively select adequate hearing protection
- Electroacoustic metrics quantify performance attributes previously unavailable for selection
- HPOT integrates these metrics into an automated decision support tool
- HPOT simplifies complex acoustic analyses into an intuitive workflow that supports informed, mission-specific hearing protector selection
- Emerging ASA/ANSI electroacoustic standards will enable consistent measurement and broader adoption of performance-based hearing protector selection

## Acknowledgements

**Additional ARA Contributors:** Dave Anderson, PhD*, Tyler Allen, Darrien Williamson, Elliot Fontenot, Kaleb Morgan, Curtis Laborde, Greg Rule, PE, Kiersten Reeser**
**University of Washington:** Andrew Brown, PhD
**Dr. Anderson is now with the University of Minnesota Duluth.*
***Kiersten Reeser is now with RbM Services*

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