

# Hearing Protection: A Look at Some Tradeoffs

Protection

Detection

Localization

Speech Intelligibility

Mead Killion, John Casali, John Keady,  
Tim Monroe, Anjali Menon

**JDVAC**

San Diego, March 7-9, 2011

## Toward a Hearing Protection Device that Warfighters Will Wear



Models:

**EB1** Hearing protection for unexpected blasts  
+ Optional hearing enhancement

**EB15** Hearing protection for unexpected blasts  
+ Optional hearing enhancement  
+ Automatic 15 dB sound reduction  
for continuous loud noise

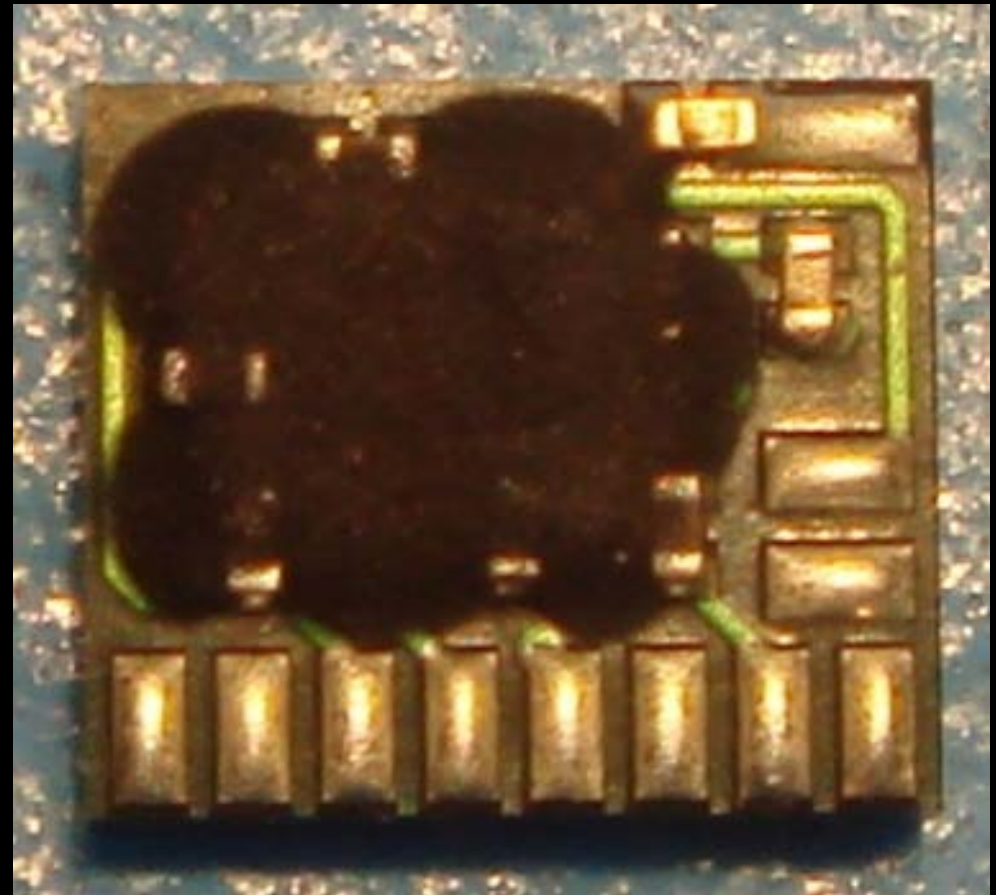
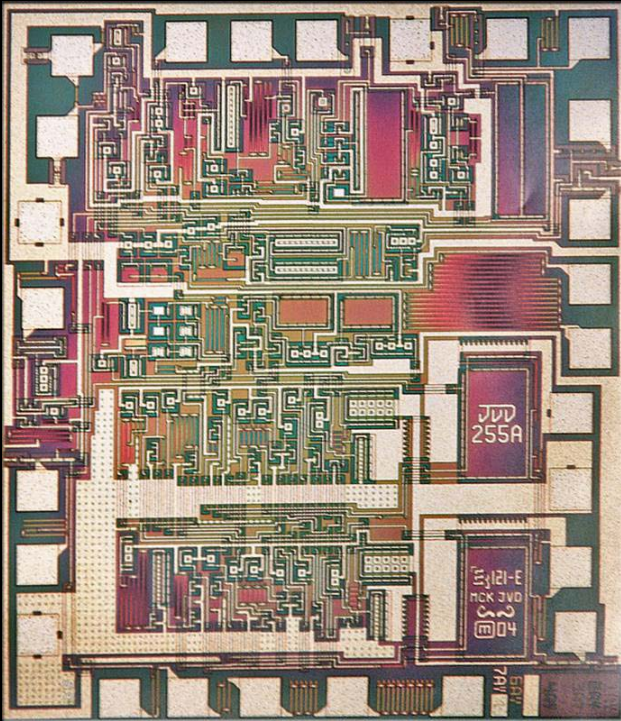
By some estimates, five to seven of these young warfighters may return with hearing damage

(Ahroon, 2007)



Photo used with permission 2

# Technology



A new ER-121 Bipolar Integrated Circuit chip  
(K-AMP engine w/ H-Bridge Class B output)

A new ER-43 Hybrid Circuit

# OUTLINE

## I. Tradeoffs

- Protection vs. Detection
- Protection vs. Localization
- Protection vs. Speech in Noise

## II. Electroacoustic Data on EB15 BlastPLG™ Earplugs

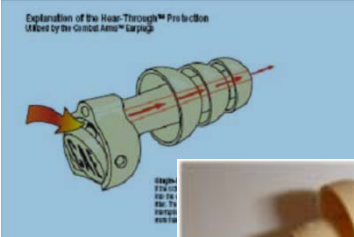
## III. Effect of Hearing Loss on Localization

- Loss of Speech cues  $\leftrightarrow$  Loss of Localization Cues
- Two 1-minute QuickSIN scores per ear predict localization scores

## IV. Conclusions

- Each of the tested HPDs appear to provide adequate protection for normal assignments
- There is evidence from hearing aid research that performance with a properly designed, wideband HPD device will equal that of the open ear after the 3-6 weeks wearing time typically required to accommodate to hearing aids. (Gatehouse and Killion (1993))
- Detection distance, on the other hand, is determined by microphone noise level and will not change with wearing time.
- The EB-series may provide better tradeoffs than presently exist

# Three devices that provide good hearing protection compared to the Open Ear



**Combat Arms**

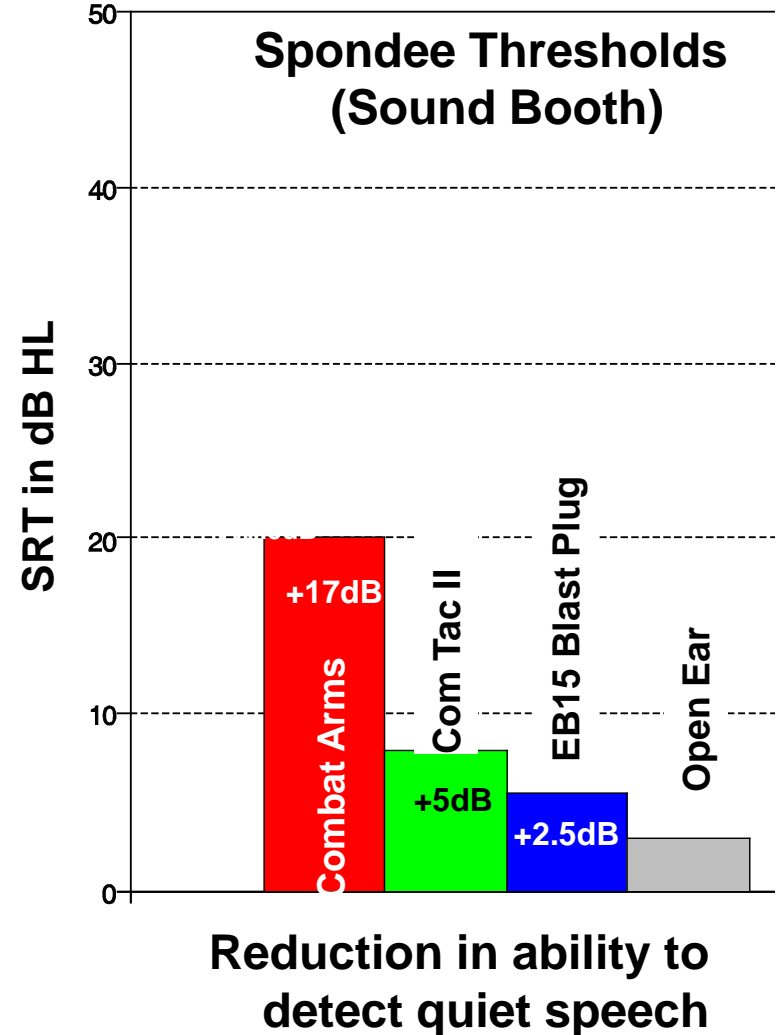
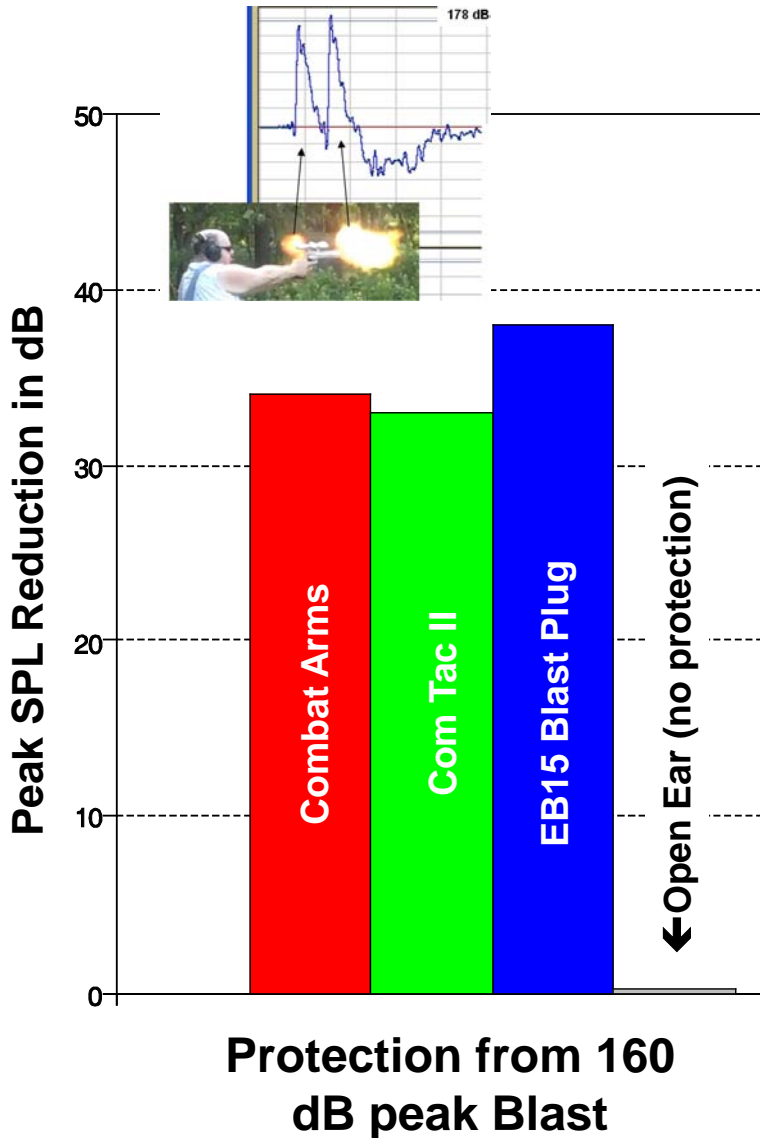
**ComTac II**



**EB series**



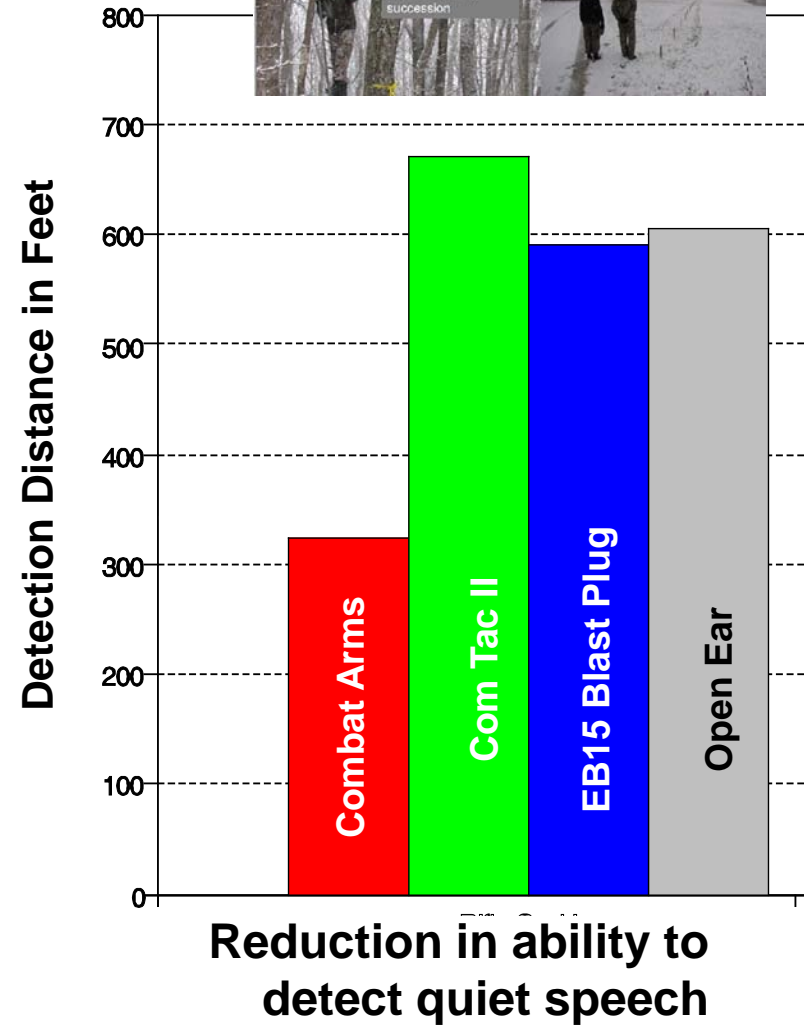
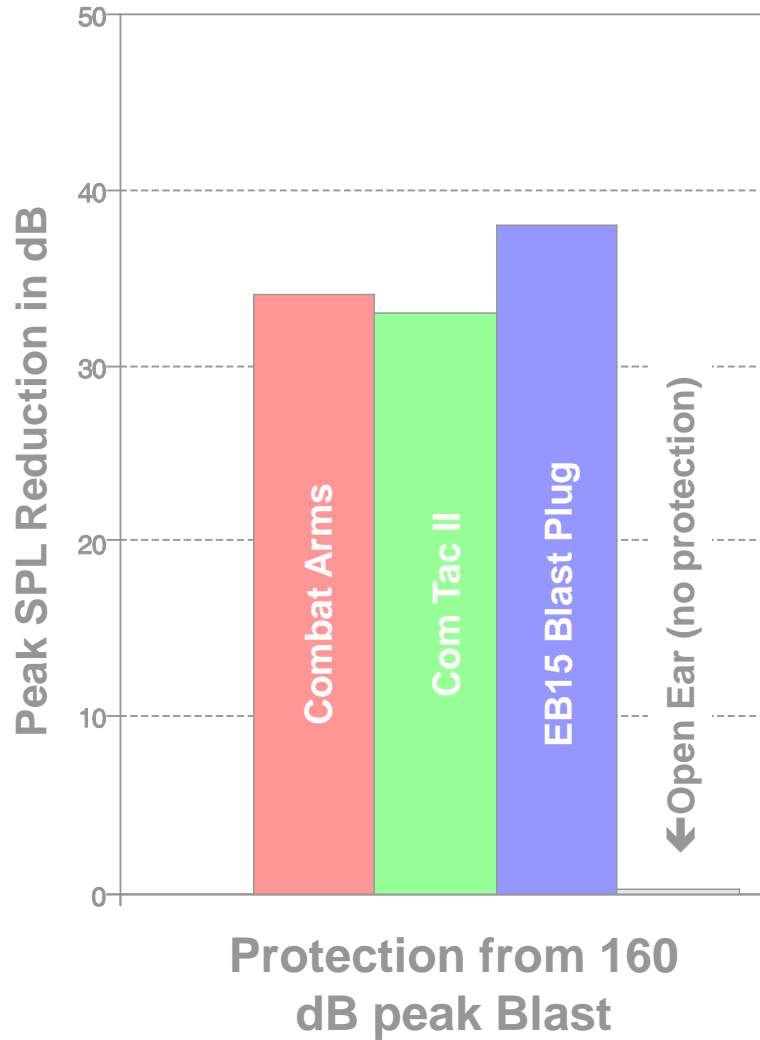
# Tradeoff: Protection vs. Detection



Average of 10 Normal Hearing Subjects  
Menon and Killion data (2011)

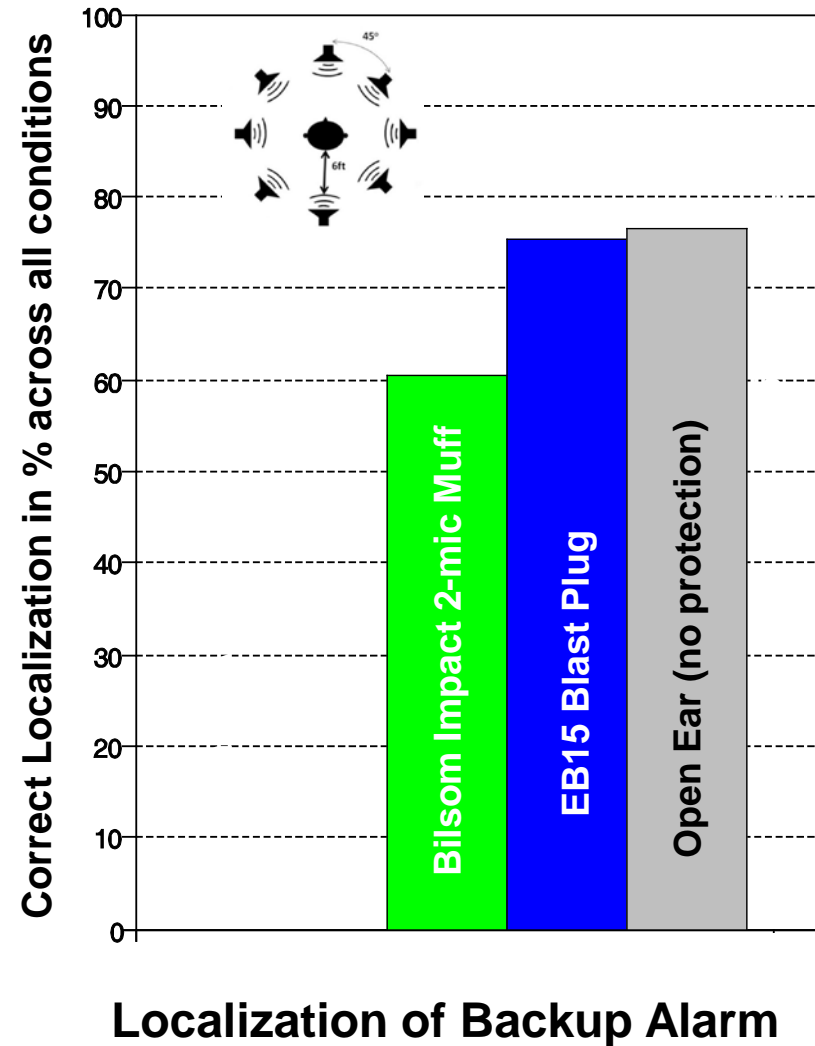
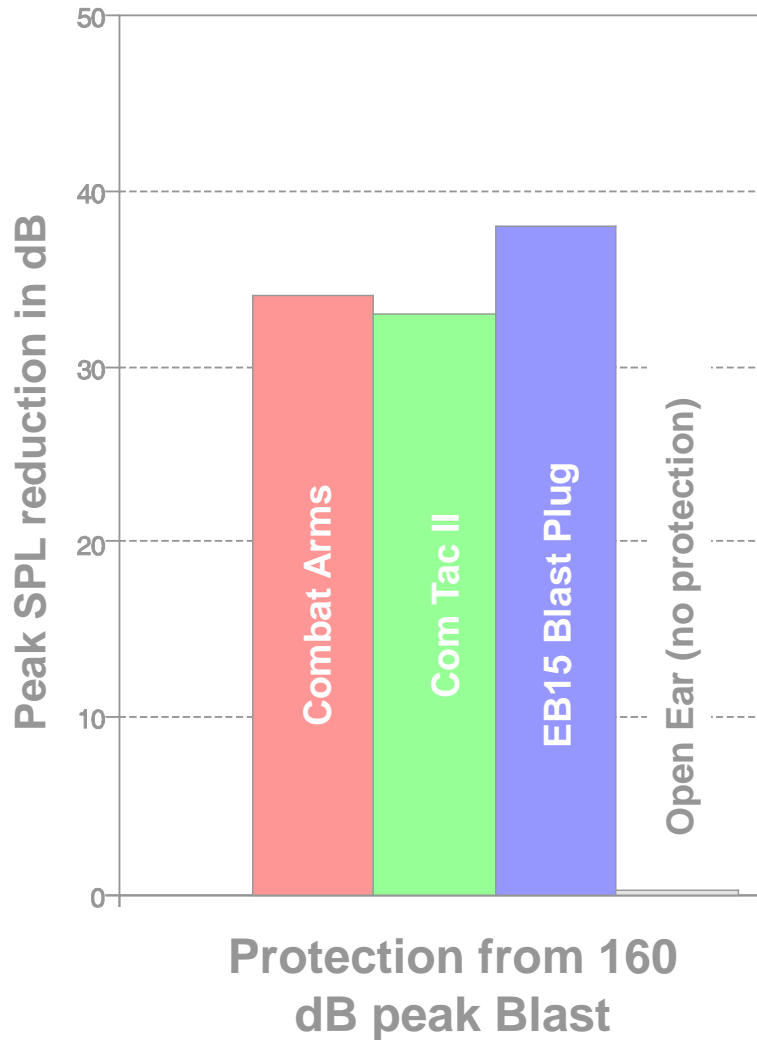
# Tradeoff: Protection vs. Detection Distance

## Rifle Cocking Sound (Open Field)



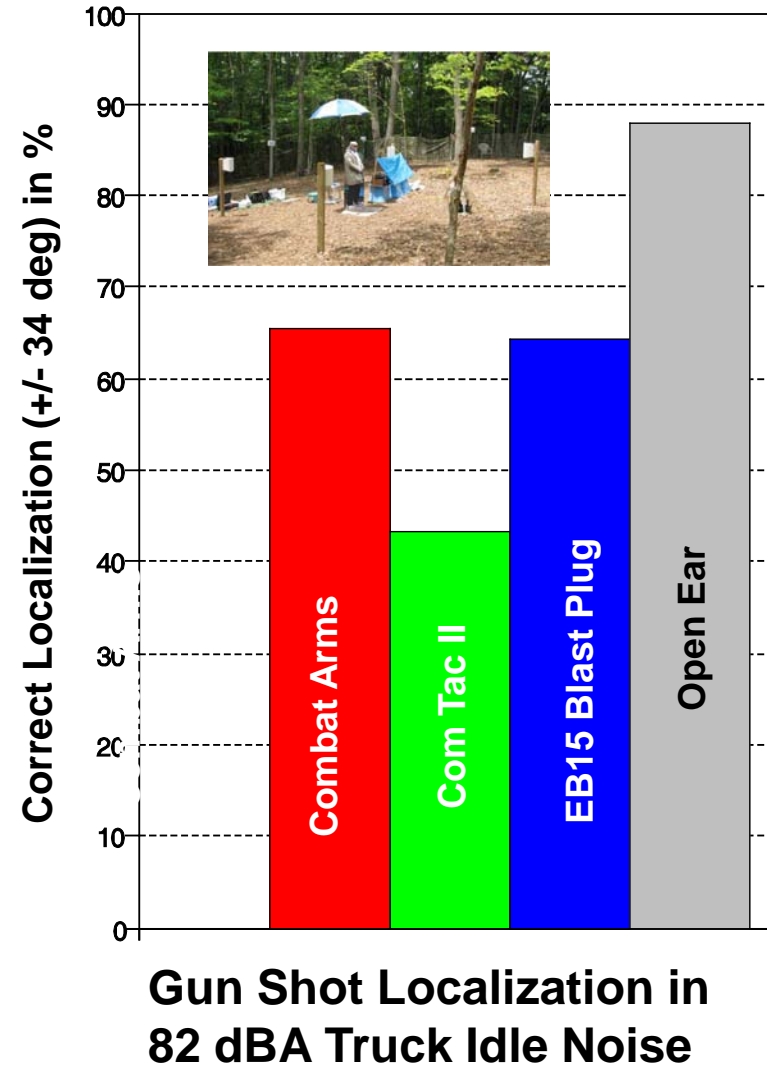
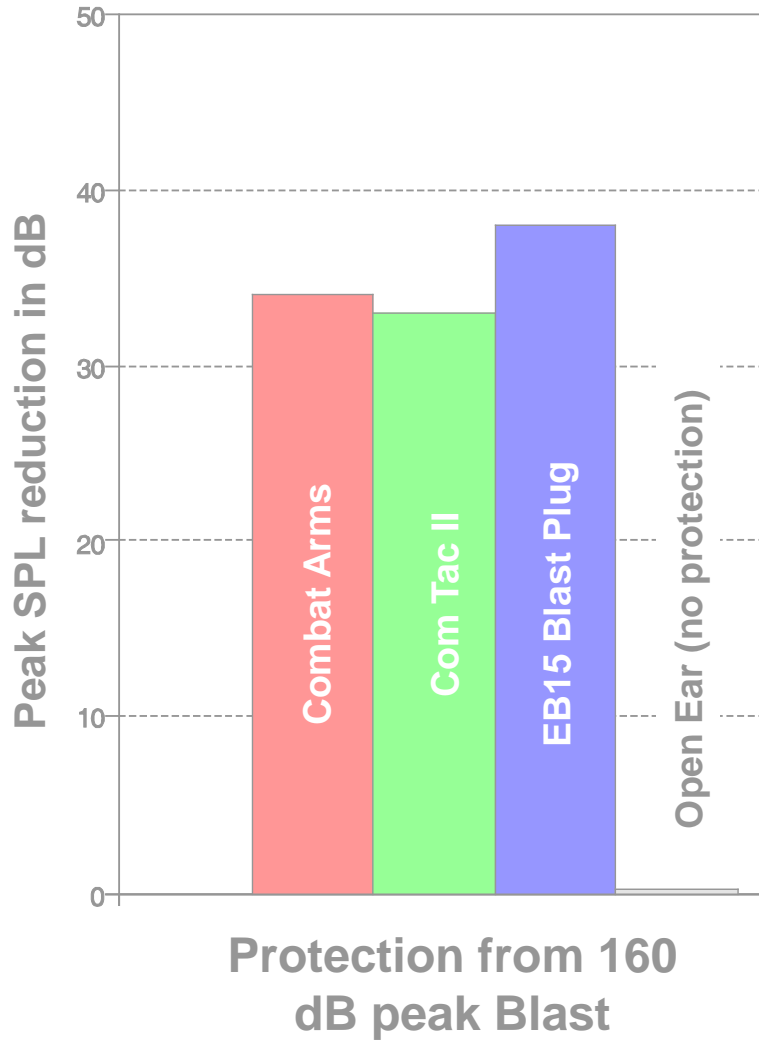
12 Subjects Casali and Keady data (2011)

# Tradeoff: Protection vs. Localization of Alarm



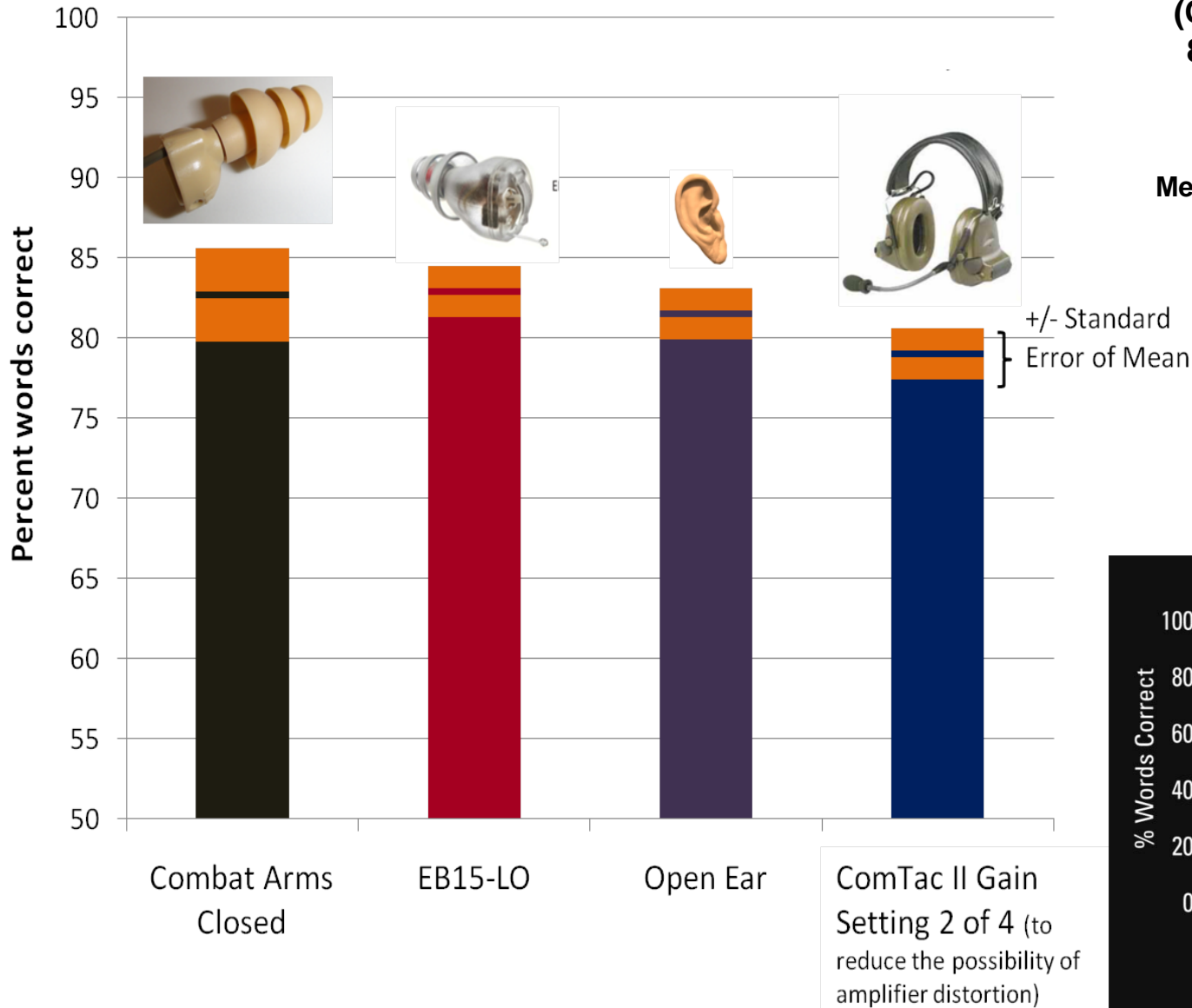
from Casali and Alali (2010), Average of 12 Normal Hearing Subjects, Bilsom data, from previous experiment, corrected 5% for better open ear average performance of the previous subjects

# Tradeoff: Protection vs. Localization of Gunshot



Average of 13 Subjects, from Casali and Keady (2010)

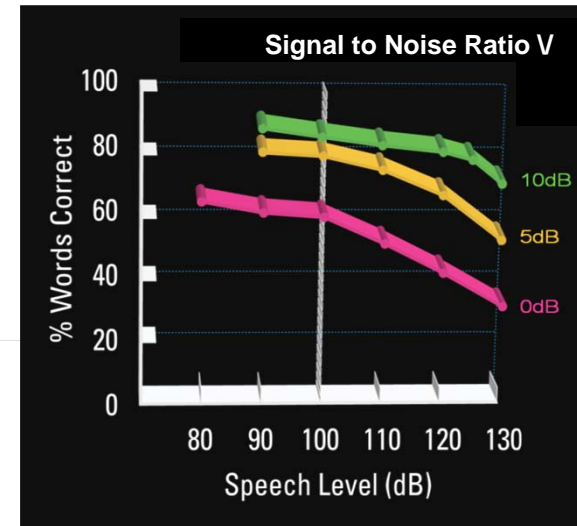
# Minimal Tradeoff: Protection vs. Speech in Noise



**Audiometric Booth Data**  
 (QuickSIN presented at  
 80 dB HL (93 dB SPL)  
 10 subjects)

**Menon and Killion data (2011)**

**Note:** The slightly poorer performance at 93 dBA SPL with the open ear compared to Combat Arms and EB15-LO is not statistically significant in this experiment, but is consistent with the report of Pollack & Pickett (1957)

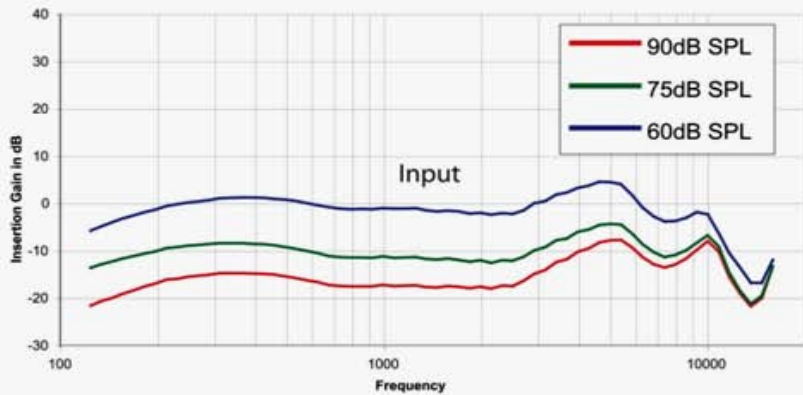


# 15 dB Protection from High-Level Noise

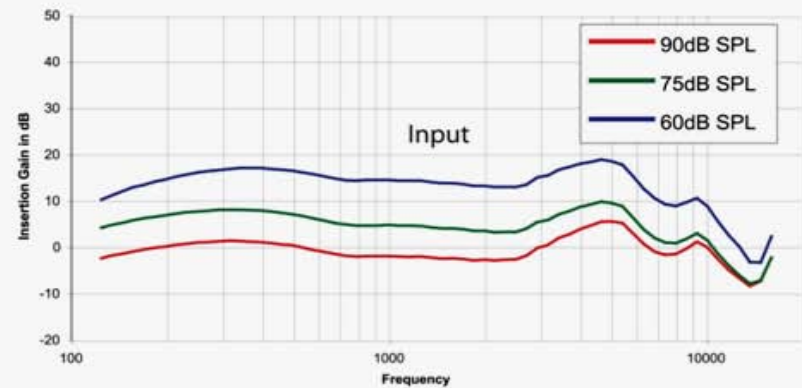
Measured Performance in Zwislocki-Coupler Ear Simulator, Referred to Diffuse Sound Field

In LO position, the EB15 acts as a high-fidelity 15 dB earplug between 90 and 115 dB SPL, but provides no attenuation for sounds below 60 dB. In the HI position, the EB 15 provides 15 dB of gain for sounds below 60 dB. Both provide good blast protection by the AHAAH analysis.

## EB15 Switch: LO



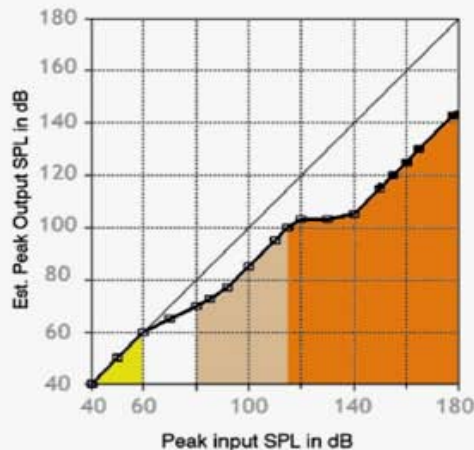
## EB15 Switch: HI



Switch: LO



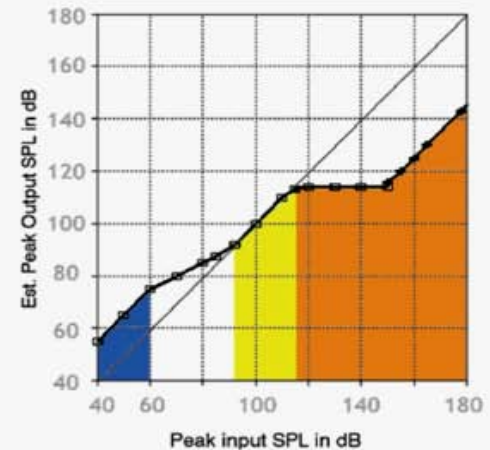
- Switch in the LO position:
- Natural hearing
- Protection from continuous loud noise
- Maximum blast protection



Switch: HI



- Switch in HI position:
- Boost for faint sounds
- Natural hearing
- Maximum blast protection

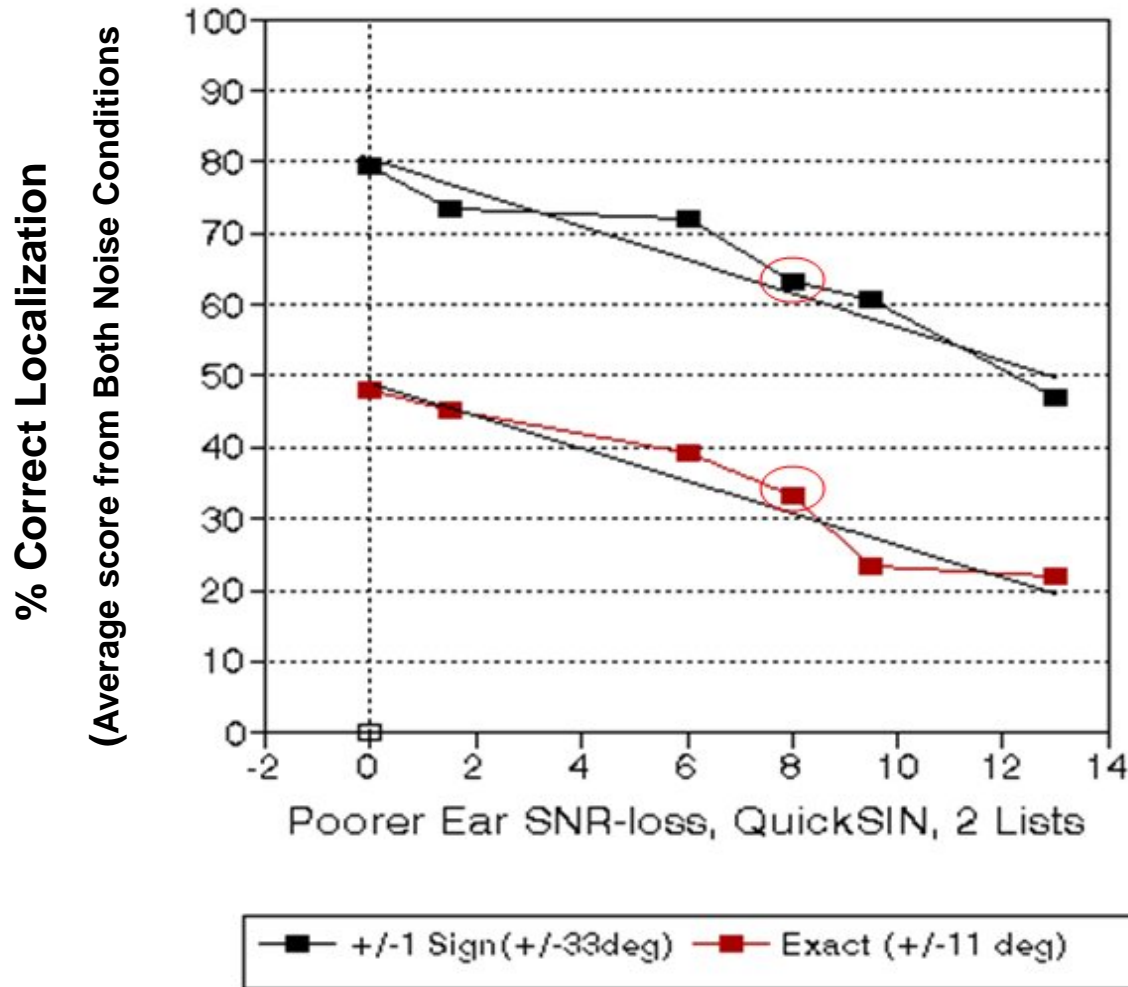


# An Unexpected Outcome of the Localization Research:

Loss of ability to localize gunshots was predicted by the loss of ability to understand speech in noise (QuickSIN™ test)

## % CORRECT LOCALIZATION VS. SNR LOSS

1 Army 1 Navy, 2 Hunters, 1 Student



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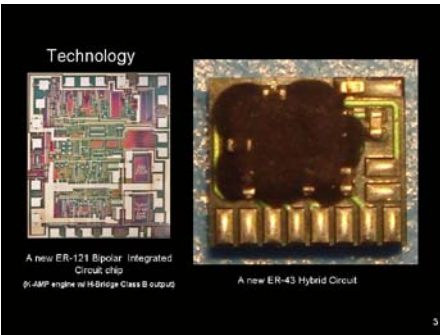
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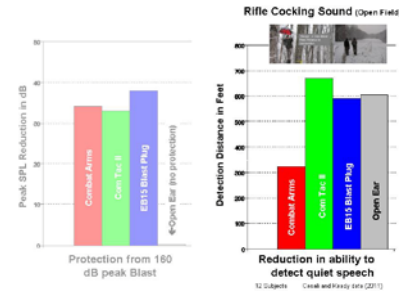
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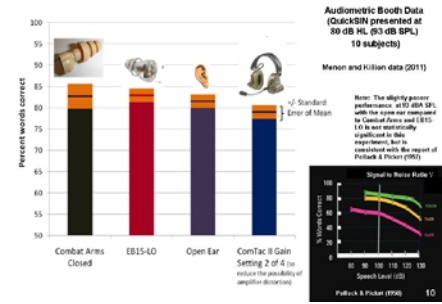
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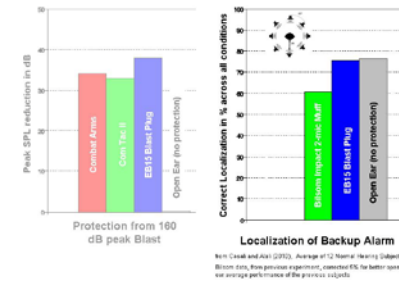
## Tradeoff: Protection vs. Detection Distance



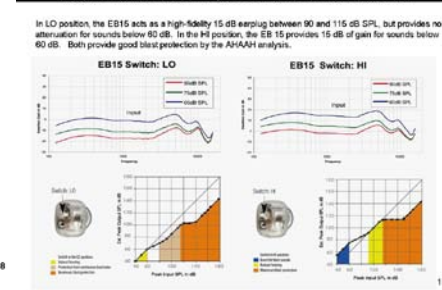
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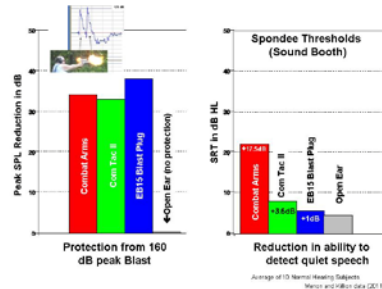
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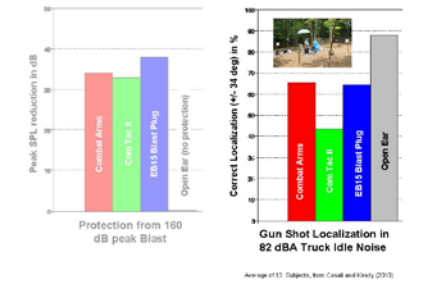
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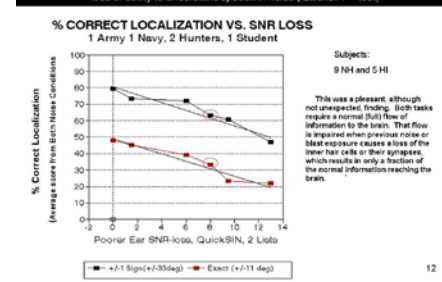
## Tradeoff: Protection vs. Detection



## Tradeoff: Protection vs. Localization of Gunshot



## An Unexpected Outcome of the Localization Research:



Poster is 72 wide by 42 " High