

Military Noise Environments and Hearing Protection/Conservation

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Richard McKinley

Human Effectiveness Directorate



Briefing Overview



- **Defining the environment/problem**
 - F-22
 - JSF
 - Legacy aircraft - F-14, F-15, F-16, F-18, EA-6B
- **Personnel exposure requirements**
- **Integrated Solution**
 - Technology, training, education, and administrative controls



Boeing JSF





Lockheed JSF



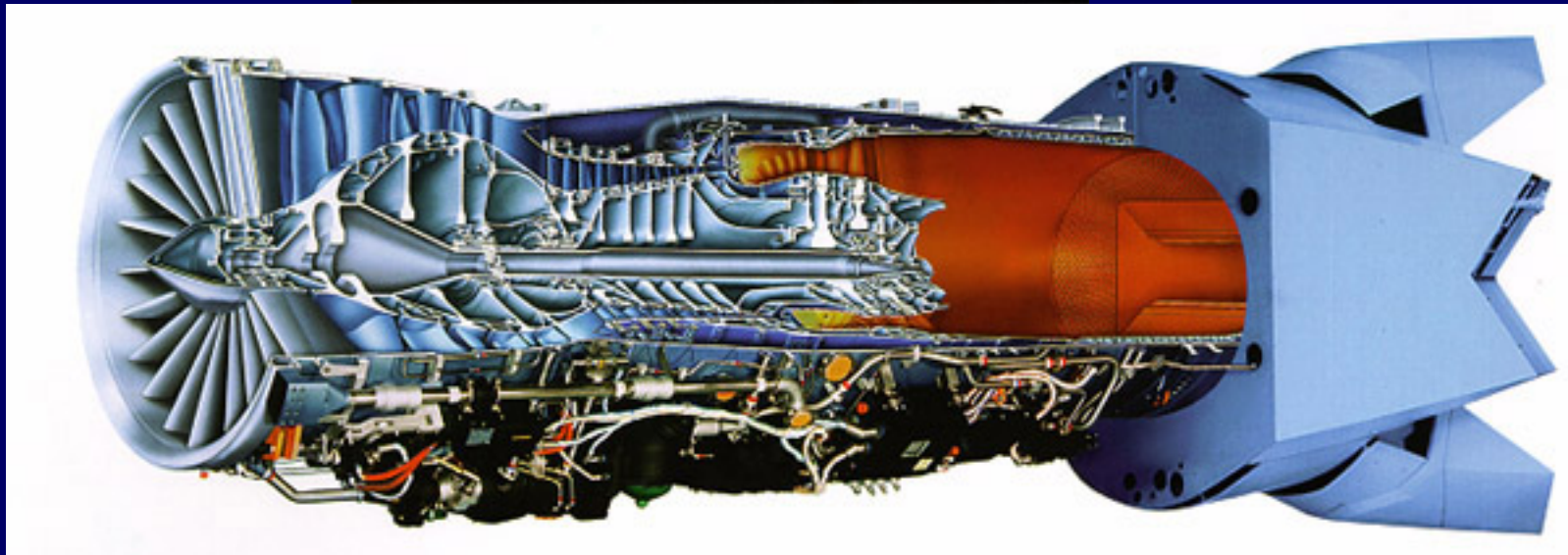


Lockheed/Boeing F-22





P&W F-119 Engine





Nimitz Class Nuclear Carrier





Crew Positioning





Crew Positioning





Crew Positioning





Carrier Crew Positioning





Navy/AF JSF VA Team





Carrier Crew Positioning





USAF Crew Positioning





USAF Crew Positioning





F-22 Acoustics



- **F-22 lessons learned**
 - Early measurements dispelled much of the concerns regarding intense low frequency noise
 - Cockpit noise became an issue during return to flight test
 - Probable non-linear propagation of noise - shock waves
 - Very intense acoustic levels aft of the tail



Military Noise Environments



- **Approach**
 - Define current Navy/Air Force noise and vibration exposure standards and requirements
 - Baseline current Air Force/Navy operational aircraft vibration and noise environments both cockpit and ground support/maintenance
 - Measure vibration and noise from F-119 engine in F-22
 - Initiate human exposure effects expansion of limits and/or mitigation studies if required
 - Measure vibration and noise on JSF CDA variants



F-22 Raptor Near Field Noise Crew Positioning



- Ground crew personnel locations

exhaust

Comm Line
50 ft Radius



Crew Chief position: 139 dBA



Engine Adjustment position: 150 dBA

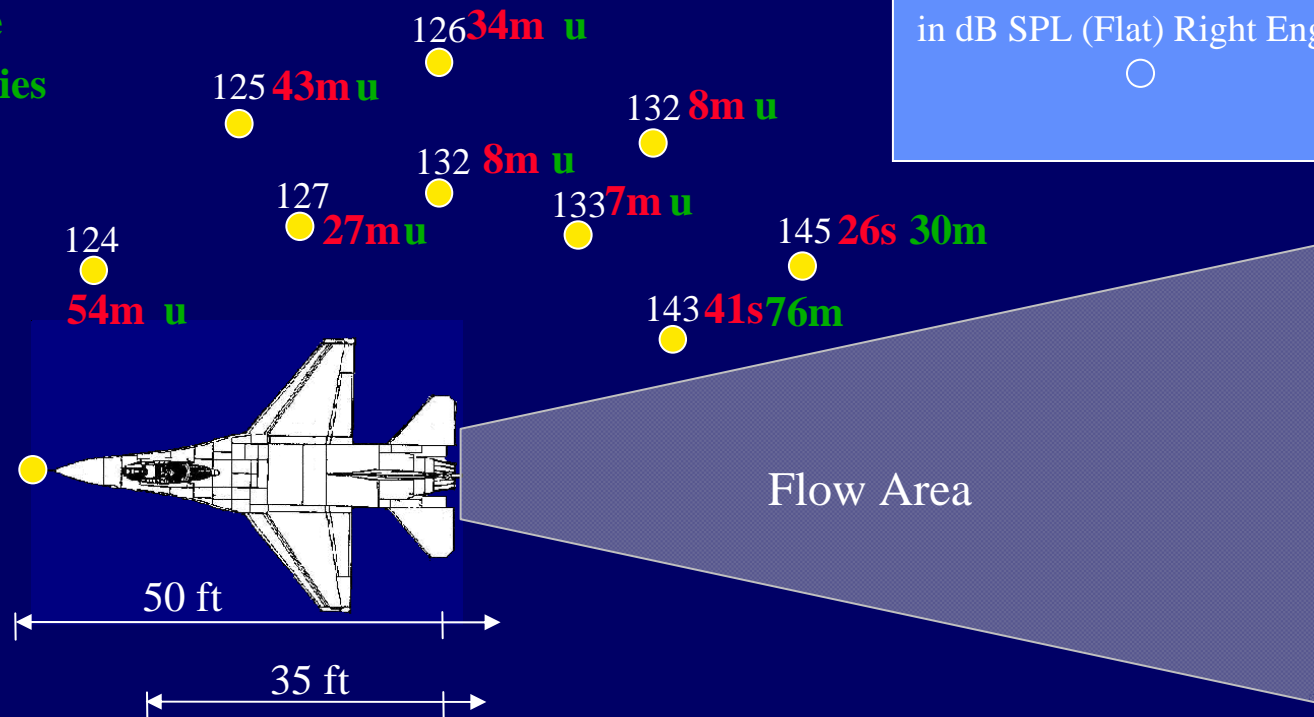


F-16C F100 – PW-229 Mil Power Near-Field Noise



Allowable exposure time
With current muff & plugs
Allowable exposure time
With new hpd technologies
U=unlimited

Legend
in dB SPL (Flat) Right Engine ○



Not to scale

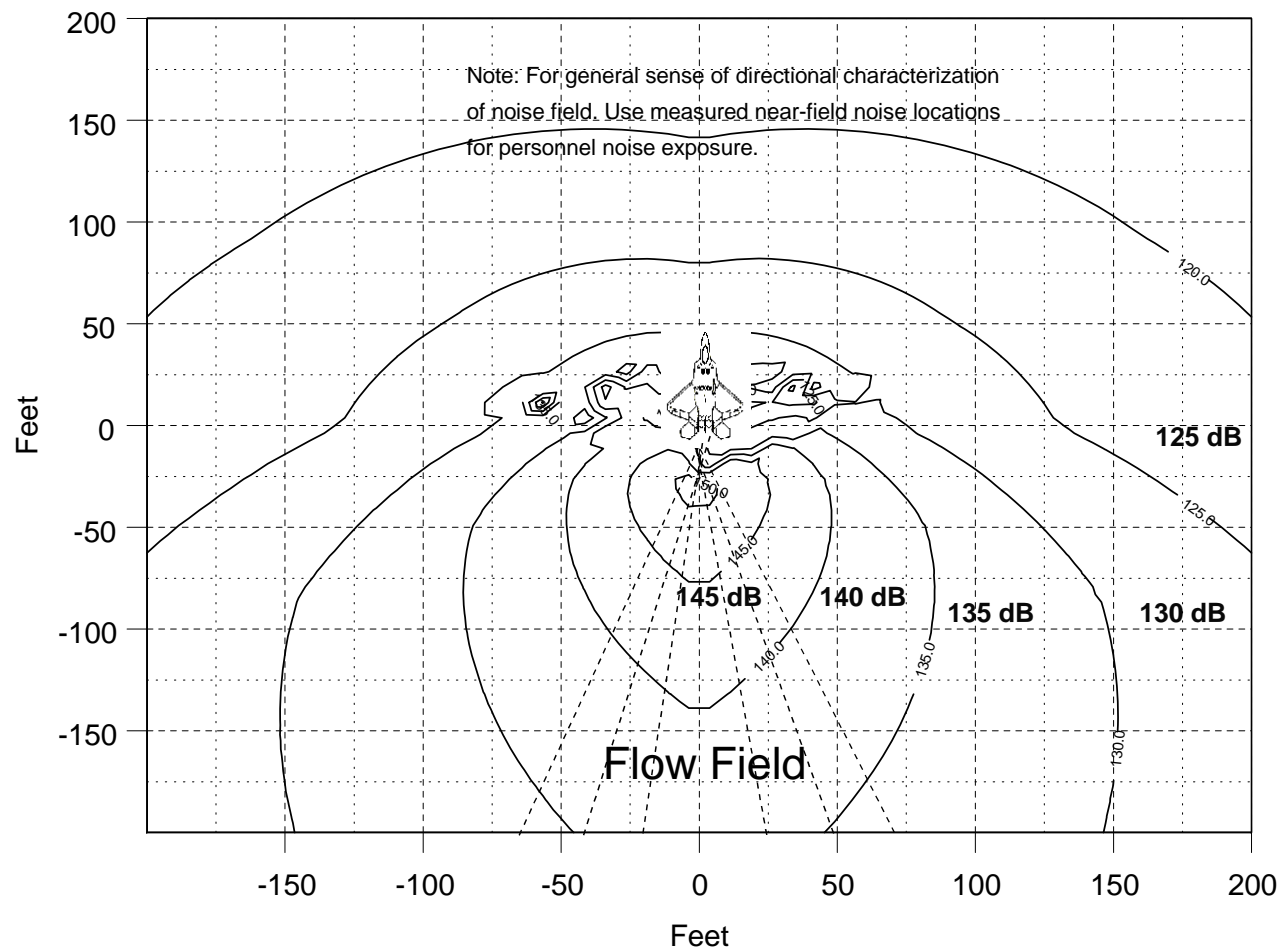


F-22 Near-field personnel noise



F-22 Right (Mil) 100% ETR - Left Engine 10% ETR

Near Field Noise Predictions (SPL in dB)



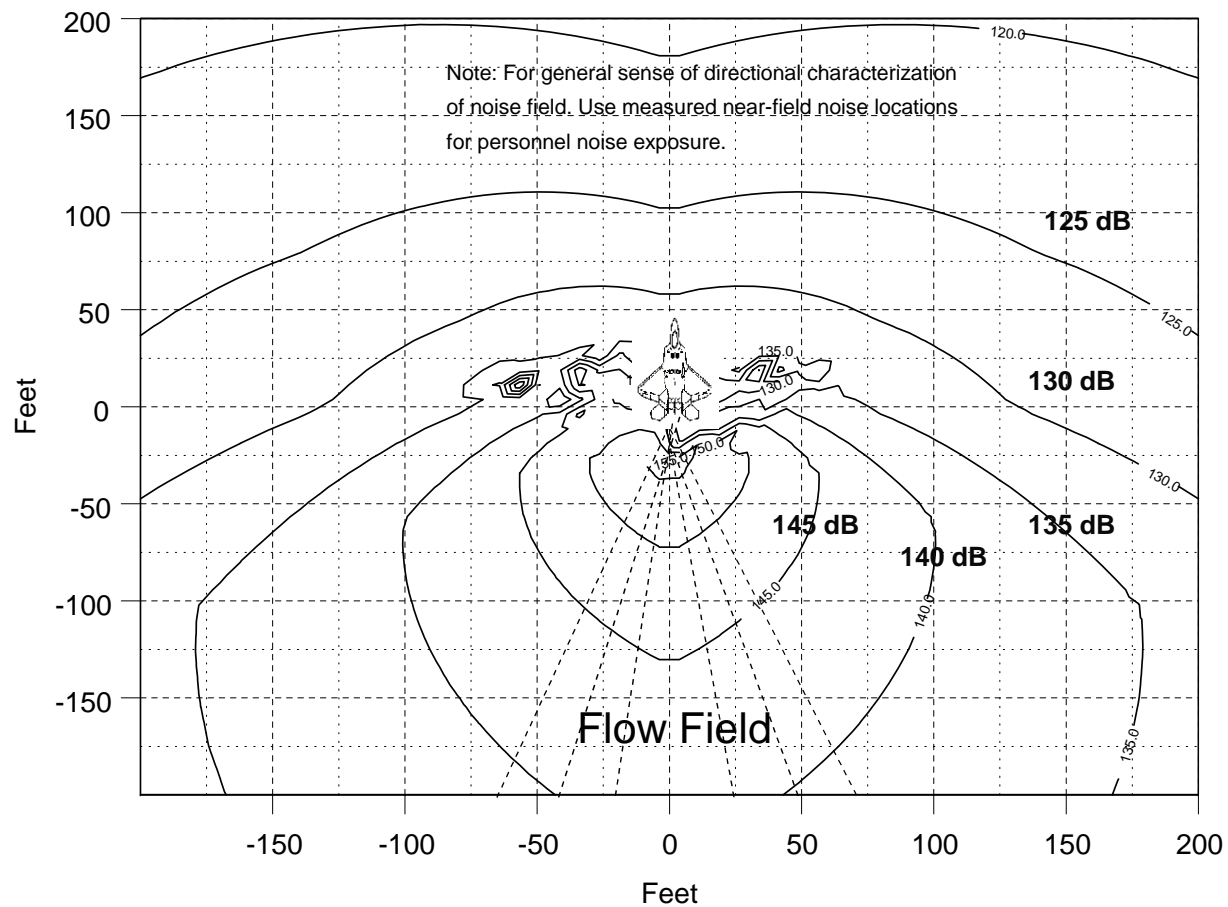


F-22 Near-field personnel noise



F-22 Right (A/B) 150% ETR - Left Engine 10% ETR

Near Field Noise Predictions (SPL in dB)





F-22 Near-Field Noise 35' & 50' A/B-150% ETR, Right Engine

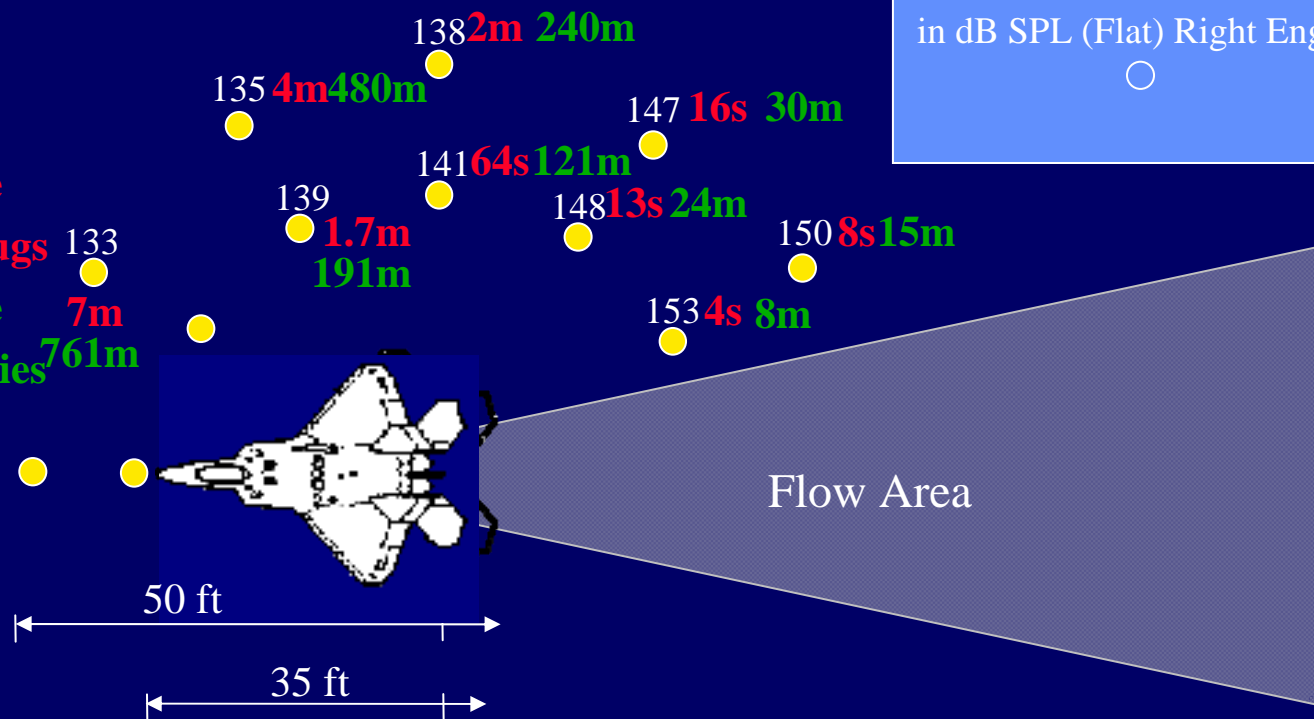


Allowable exposure time

With current muff & plugs

Allowable exposure time

With new hpd technologies



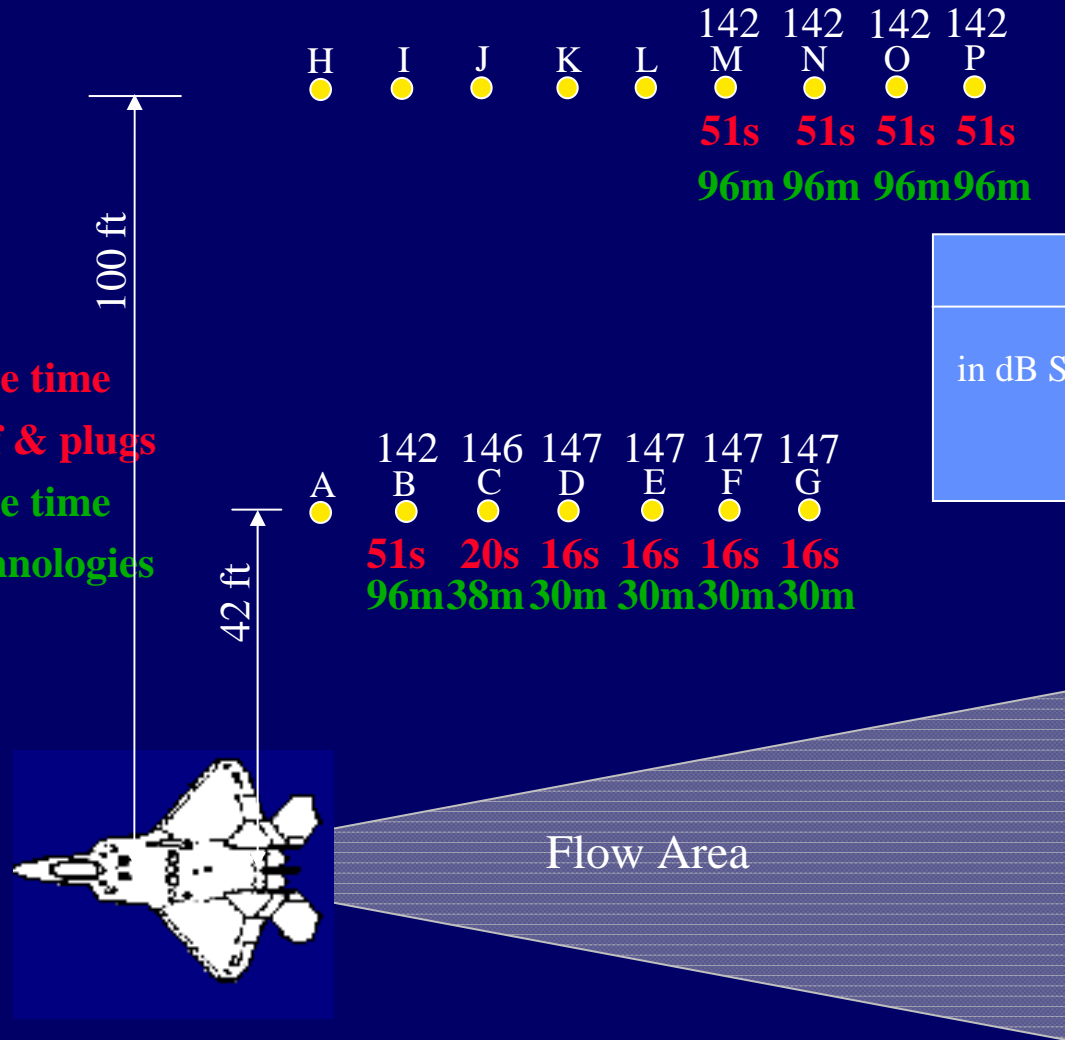
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F-22 Near-Field Noise 42' & 100' A/B-150% ETR, Right Engine



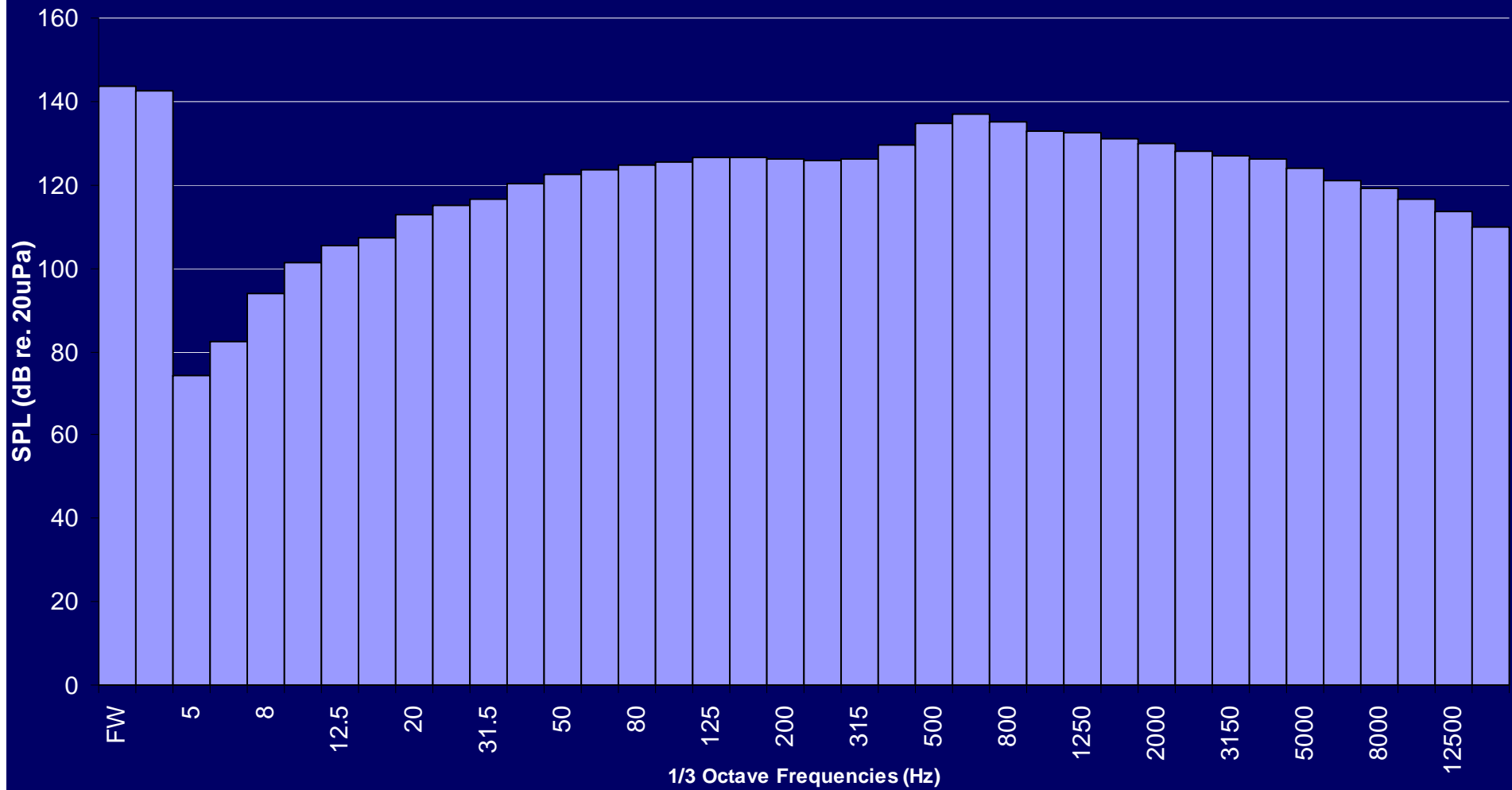
Allowable exposure time
With current muff & plugs
Allowable exposure time
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Legend
in dB SPL (Flat) Right Engine
○

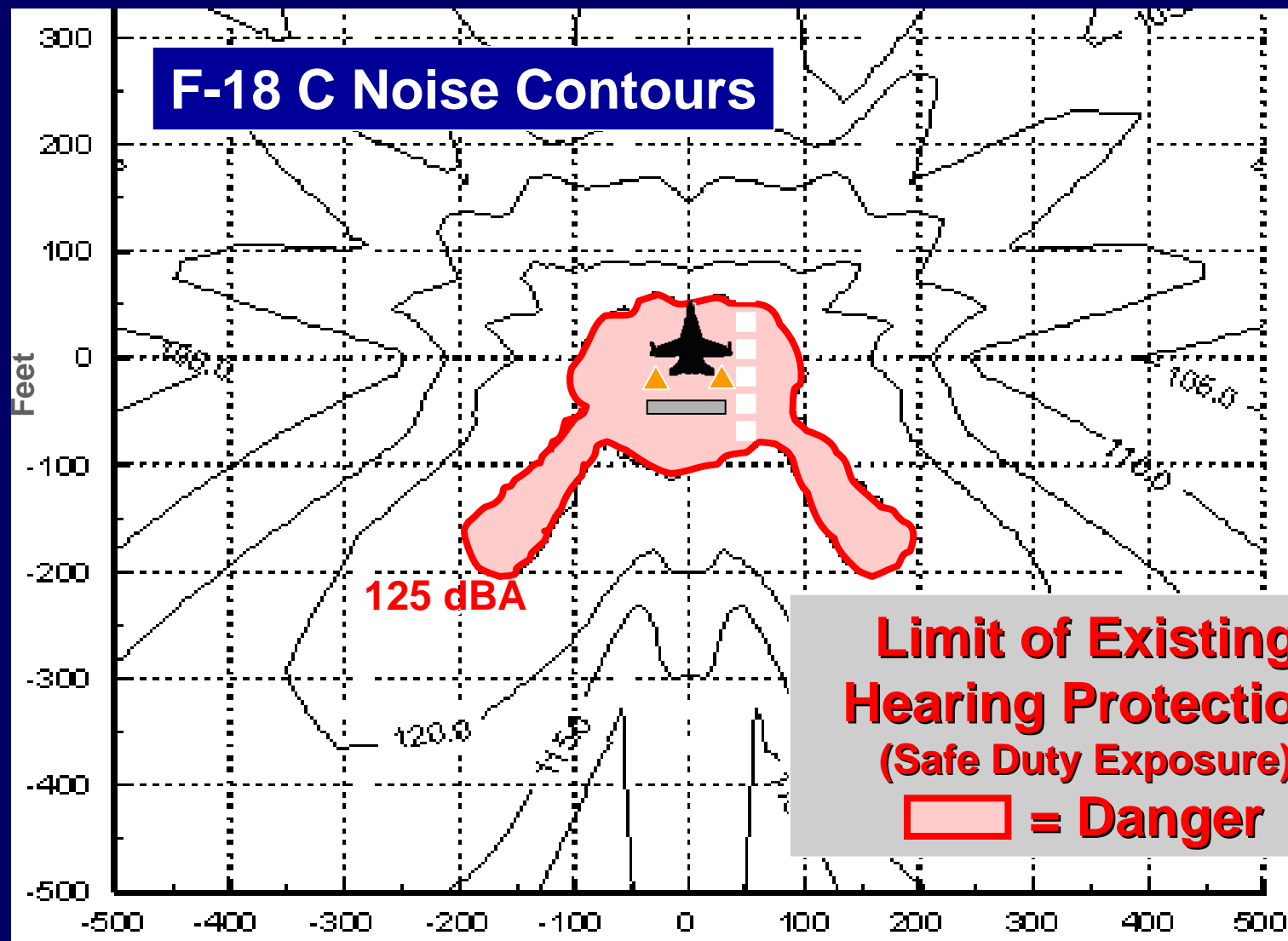


F-18F After-Burner Power - 42' Foul Line Microphone Position 4





JSF Personnel Noise Crew Positioning Challenges

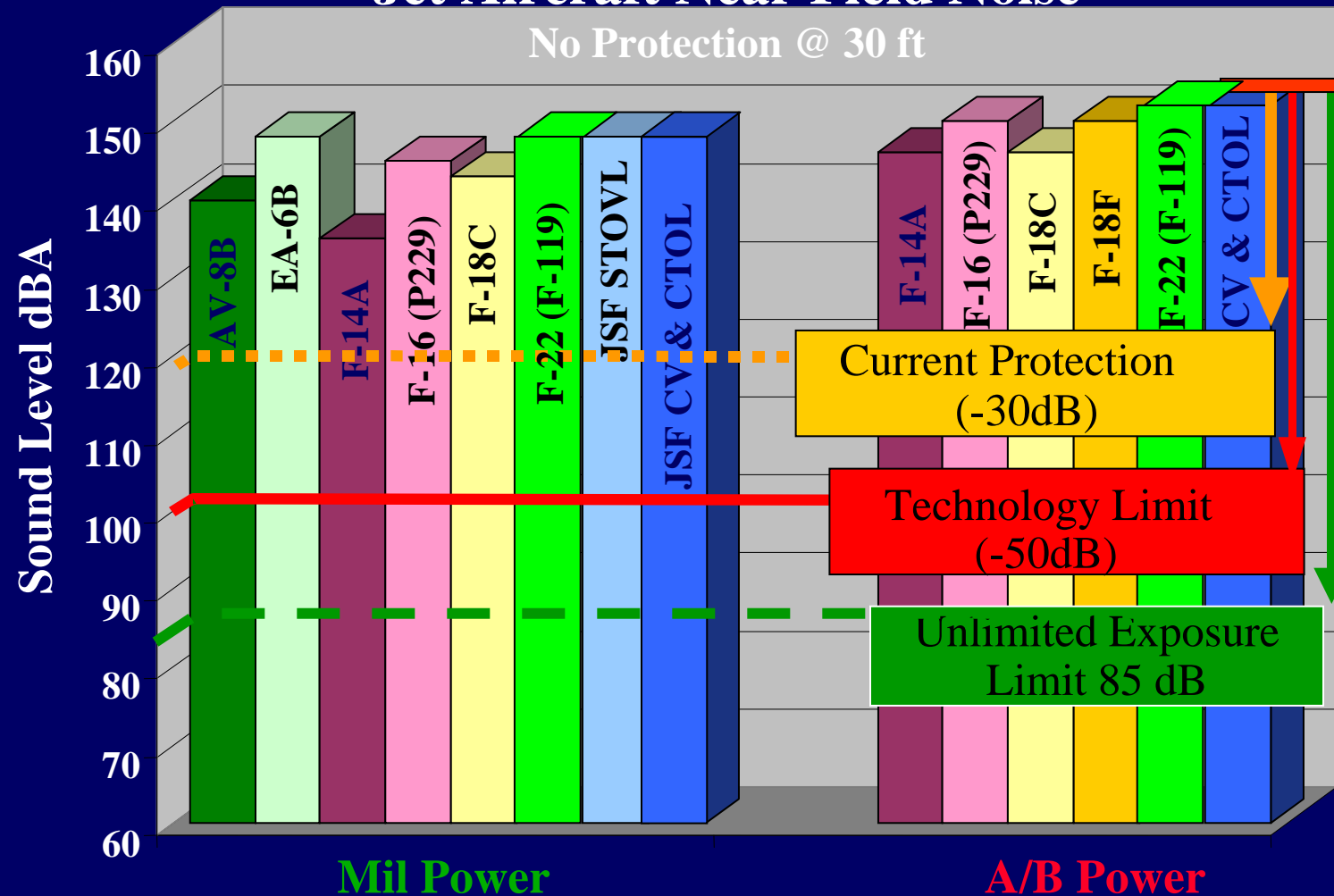




AF & Navy Personnel Noise



Jet Aircraft Near Field Noise





Personnel Noise Requirements



- **JSF JORD and Joint Model Spec**
 - Noise exposure for ground/flight deck crew shall not exceed a daily exposure equivalent to 85 dBA for 8 hrs with a 3 dB/doubling exchange rate
 - Normal operations defined as 60 launches and 60 recoveries within a 24 hr period
 - Assumes other exposures are less than 85 dBA
- **AFOSH 48-19 Hazardous noise exposure**
 - 85 dBA - 8 hrs - 3 dB/doubling
- **OPNAVINST 5001**
 - 80 dBA - 16 hrs - 4 dB/doubling
 - 85 dBA - 8 hrs - 3 dB/doubling



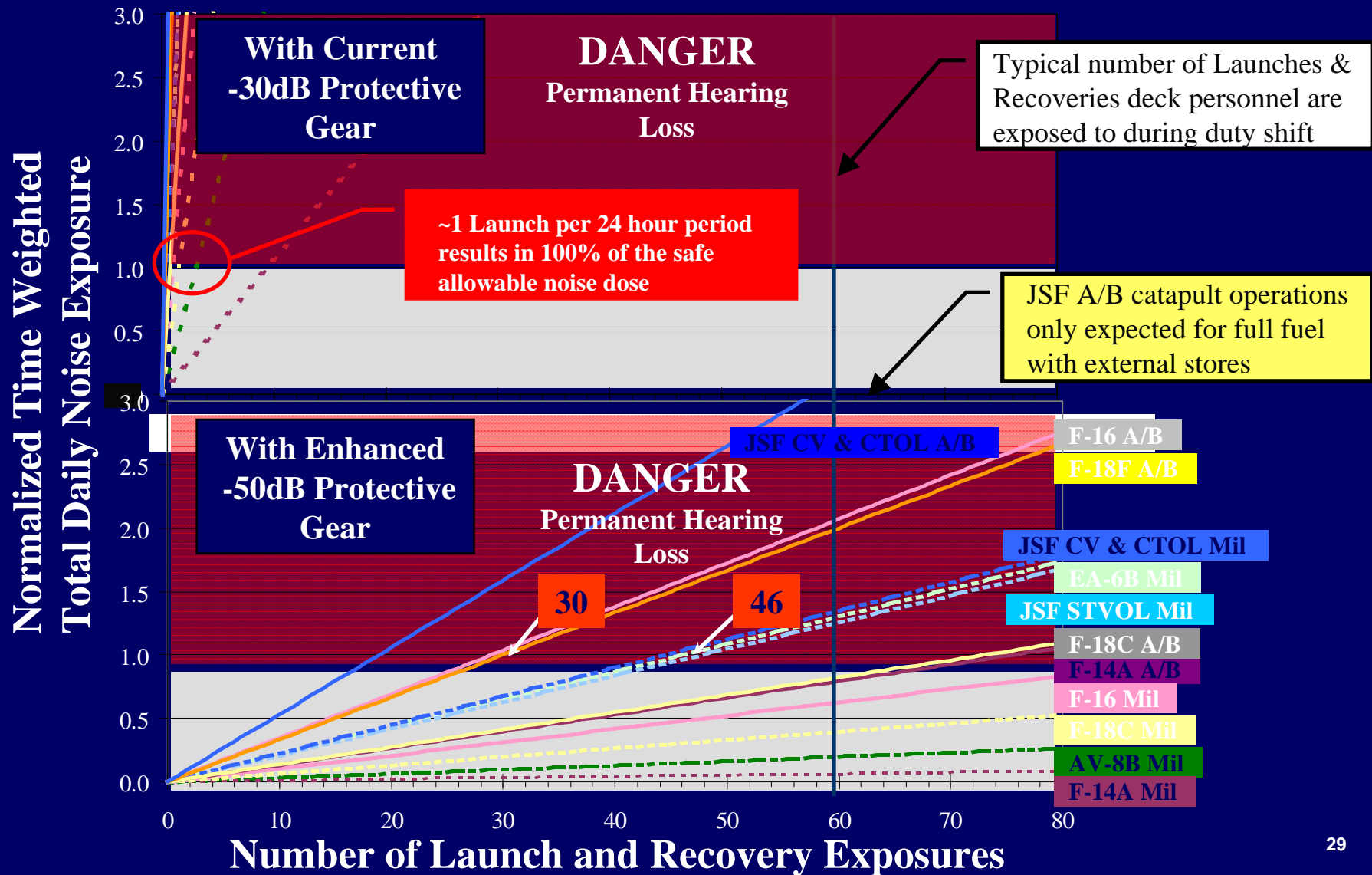
Whole Body Noise Exposure



- **Legacy aircraft - lessons learned**
 - Levels at personnel locations up to 150 dB
 - Intense acoustic field resonates chest - resonate frequency around 80 Hz
 - Other body systems resonate at other frequencies and can be a source of discomfort



Perspective on Material Solutions

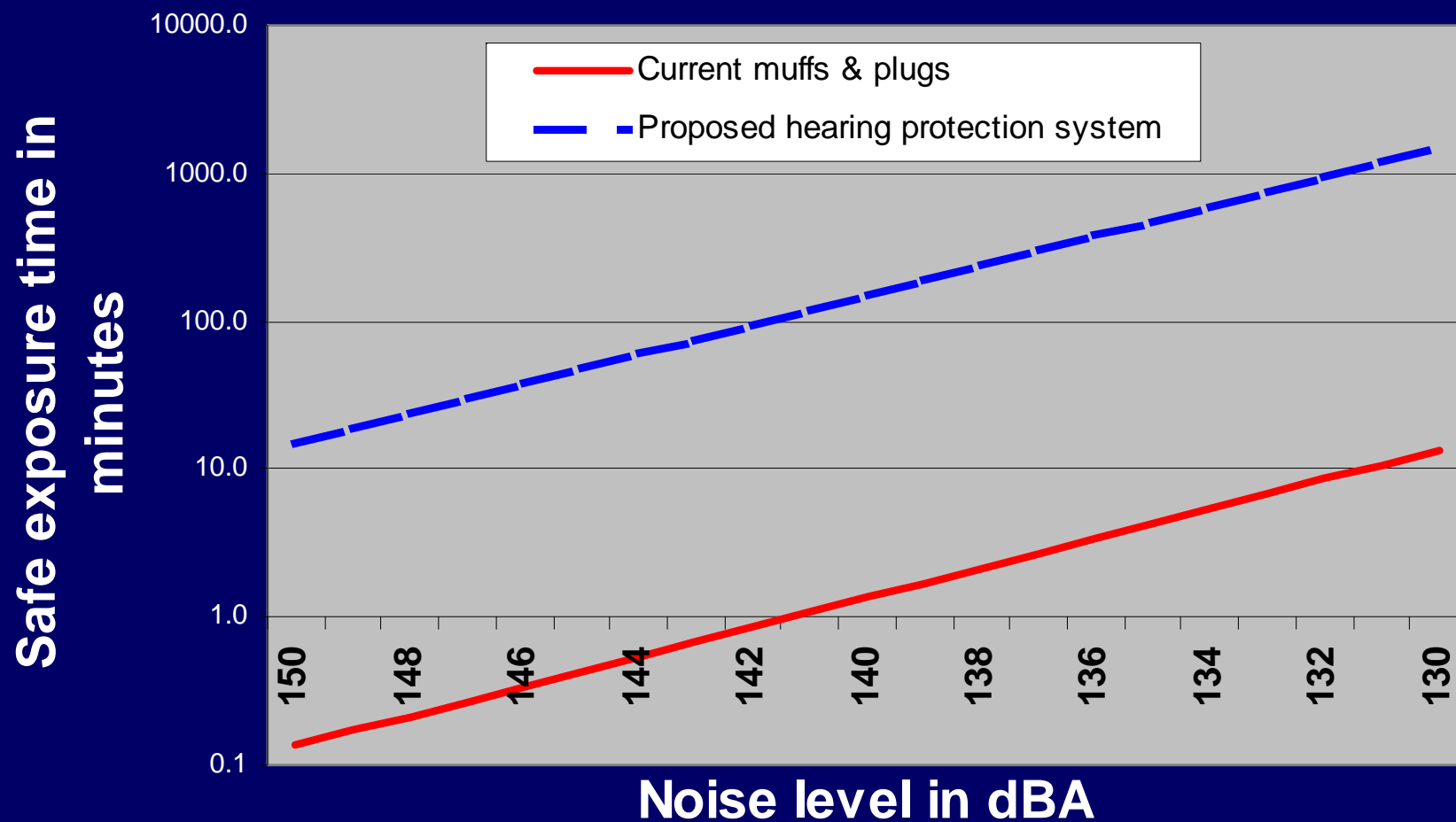




Personnel noise exposure



Noise level vs safe exposure time per AFOSH 48-19





Personnel Noise



- **Issue:**
 - Today's hearing protection is *not adequate* against current aircraft noise emissions - hearing loss is the #1 disability among retired US Military personnel
 - F-22 & JSF personnel noise similar to F-14, F-15, & F-18 (A/B takeoff)
 - No technology exists to quiet fighter engines without significant performance losses
- **Problem is multifold:**
 - Hearing protection- same technology past ~30years
 - Duty requires close proximity to noise source
 - Long duty shift, Cumulative exposure time



Non-Material Solutions



Policies & Procedures

- Crew rotation
- Crew relocation
- Operating procedures (e.g., run-up times, etc.)
- Flight deck/flight line improvements (e.g., robotics, telemetry, barriers)
- Training in equipment fit, use, & care
- Disciplined enforcement of protection use
- Personal issue engages a responsibility process





Near Term Solutions 2001-2002



- **Technology**
 - Optimized passive protection: Improved earplugs & earcups w/wo communication.
 - **Goal:** 35-40 dB of attenuation (includes non-material solutions previously noted, e.g. training)
- **Required S&T Investment**
 - Deep insert custom earplugs
 - Compliant: Marry benefits of custom fit & expandable materials
 - Improved noise attenuation earcups/cranial
 - Field performance metric
- **Enabling Research**
 - Materials
 - Optimal insertion depth (earplug)
 - Size, shape, seal, location, hygiene
 - Anthropometry: Identify fit issues and population norms
 - Field technology performance validation



Deep Insert Custom Plug Prototype Technology Demonstration





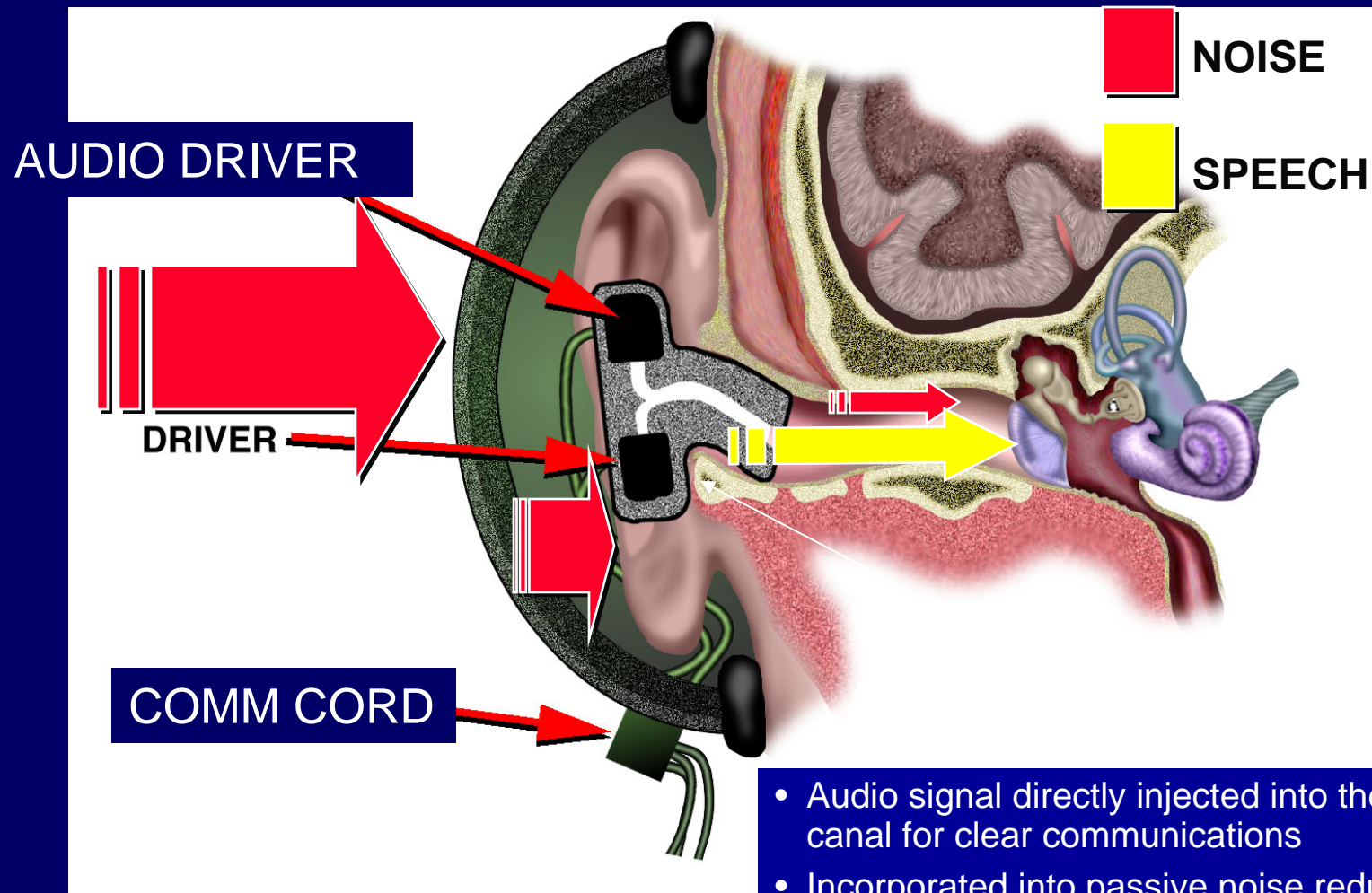
Mid Term Solutions 2002-2005



- **Technology Development**
 - Improved Passive Cranial
 - Active Noise Reduction (ANR) Earplug
 - **Goal:** 40 - 50 dB attenuation
- **Required S&T Investment**
 - High bandwidth, high intensity ANR techniques
 - Analog vs digital vs hybrid
 - Improve materials, sensors, drivers, anthropometry
 - Acoustic model of bone/tissue conduction
 - Airborne and structural pathways
 - Low vs. high frequency
 - Low vs. high intensity
 - Tympanic membrane, inner ear structures



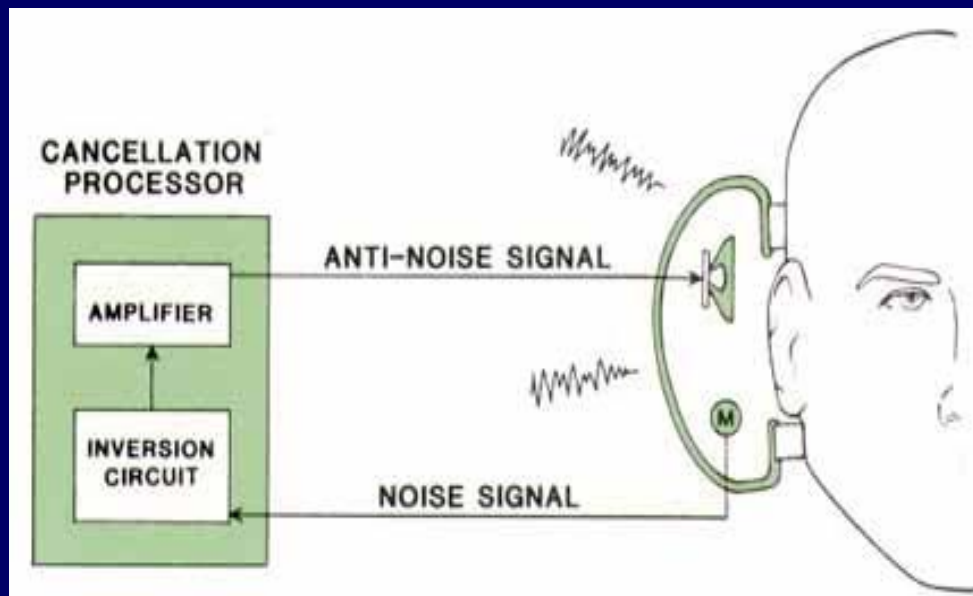
Active Noise Reduction Earplug



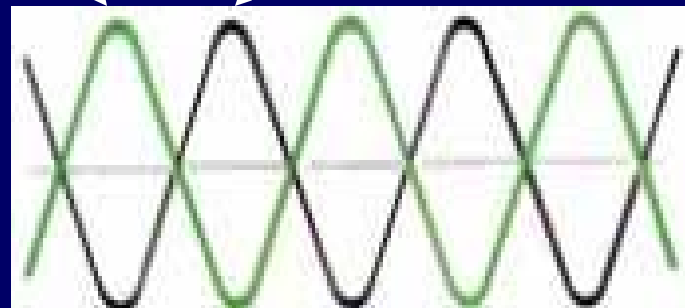
- Audio signal directly injected into the ear canal for clear communications
- Incorporated into passive noise reduction headset for maximum noise reduction



Active Noise Reduction (ANR) Communication Headsets



noise anti-noise



ANR uses Standing Waves principle



Far Term Solutions 2004-2007



- **Technology Development**
 - Active Vibration Control Cranial/Helmet
 - **Goal:** 50+ dB attenuation
- **Required S&T Investment**
 - Improve materials, sensors, drivers, anthropometry
 - Acoustic model of bone/tissue conduction
 - Airborne and structural pathways
 - Low vs. high frequency
 - Low vs. high intensity
 - Tympanic membrane interactions



Performance Metrics



Performance changes need to be measured and tracked as solutions are implemented

- **Databases mapping and tracking crew locations and crew performance versus hearing loss are poor and virtually non-existent**
 - Expand and maintain Air Force's computerized hearing repository data base
- **Mandate use of accepted national standards for characterization and testing**



Proposed Solution Recap



- Integrated solution of technology, training, education, and administrative controls
- R&D technologies for a dedicated hearing protection system improvement program
 - Custom Fit Deep Insert Earplugs
 - ANR Earplugs
 - Improved Passive Cranial
 - Active Vibration Control Cranial/Helmet
 - Enabling Research e.g., sensors, models
- Field performance verification/validation
- Crew rotation, administrative procedures





Personnel Noise Summary



- Personnel Noise
 - Current flight-line/deck hearing protection is **inadequate**
- improved hearing protection is needed **TODAY**
 - Some crew member locations should be moved and/or exposure time limited
 - Technology solutions to certain functions are being worked -
 - Work on engines continue projected effects are small 3-5 dB and very expensive
 - Flight deck/flight line noise levels are systemic
 - F-22, F-18E/F, & JSF in addition to numerous legacy aircraft have comparable personnel noise levels/exposures
 - Solutions must involve service headquarters, operators, acquisition, scientists/technologists, and service medical experts