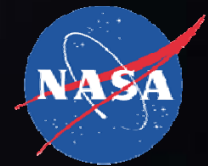


“Buy-Quiet” and “Quiet-by-Design”

***Beth Cooper, PE INCE.Bd.Cert.
NASA Glenn Research Center***



Buy/Design-Quiet Program goals

- ≡ Establish a low-noise workplace
 - ≡ Reduce noise-induced hearing loss
 - ≡ Improve safety and productivity
- ≡ Influence NASA workforce to be proactive
 - ≡ Find, evaluate and select low-noise products
 - ≡ Design low-noise equipment and systems
- ≡ Harmonize with infrastructure and culture
 - ≡ Procurement mechanisms
 - ≡ Site-specific operations and culture

Proactive and innovative approach

- ≡ More than policy and directives
- ≡ Provide education, guidance and tools
 - ≡ Applicable beyond NASA and contractor programs
- ≡ Assume National leadership role for NASA
 - ≡ Join NIOSH, Federal agencies, Armed Services
 - ≡ Early member of NIOSH PtD planning team (2006)
 - ≡ Set example for corporate programs
- ≡ Contribute to the state of the art
 - ≡ Equipment noise emission measurements
 - ≡ Voluntary product noise labeling effort (INCE)

Buy/Design Quiet concept

- ≡ Control the noise, not the exposure
- ≡ Controlling the noise controls the exposure
- ≡ Buy-Quiet
 - ≡ Buy new equipment that is “quiet”
 - ≡ Manufacturer assumes financial and design risk
- ≡ Quiet-by-Design
 - ≡ Design new systems that are “quiet”
 - ≡ NASA is the “manufacturer” for in-house designs

Why create a low-noise workplace?

- ⌘ Lower risk of noise-induced hearing loss
- ⌘ Better speech intelligibility
 - ⌘ Between employees, w/ or w/o hearing protection
 - ⌘ Announcements from PA systems
 - ⌘ When using radios
- ⌘ Increased safety
 - ⌘ Increased alarm audibility
 - ⌘ Increased concentration
 - ⌘ Reduced fatigue
- ⌘ More productive, comfortable environment

Why can't we just wear earplugs?

(if we cared only about preventing hearing loss)

- ⌘ Hearing protection isn't worn consistently
- ⌘ HPD performance is difficult to quantify
 - ⌘ Far less than the package label (NRR)
 - ⌘ Highly dependent on individual fit
- ⌘ Sometimes, no HPD offers enough protection
- ⌘ Some employees will still incur hearing loss
- ⌘ Hearing protectors can hinder communication
- ⌘ **Engineered controls are legally required**
 - ⌘ **Designed-in quiet is an *engineering* strategy**

Classical Hearing Conservation Program Model

- ≡ Noise exposure monitoring
- ≡ Audiometric monitoring
- ≡ Audiogram review and follow-up
- ≡ Hearing conservation training
- ≡ Personal hearing protective devices
- ≡ Recordkeeping
- ≡ Program management
- ≡ Engineered controls
 - ≡ Retrofit noise control solutions
 - ≡ **Acquisition of low-noise equipment**

Buy-quiet approach

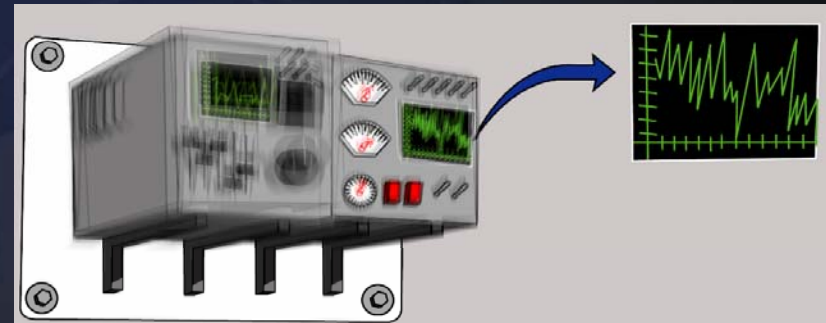
- ≡ Requestor specifies achievable noise *emission* limit that supports noise *exposure* limit
- ≡ Vendor assumes burden of meeting spec
- ≡ Noise emission criterion (limit) language included in specification
 - ≡ Submittal data required prior to purchase
 - ≡ Shop verification before shipment
 - ≡ Field verification after installation
- ≡ Noise considered during “research” if no formal specification is issued
 - ≡ Applies to bank-card and GSA Schedule purchases

Why is it so important to
buy (design) quiet equipment

instead of
buying/designing a “loud” thing and
then trying to make it quiet?

1. Low-noise designs usually reflect better engineering

- ≡ Noise is usually a waste byproduct
- ≡ Noise indicates an inefficient process
- ≡ Noise induces harmful vibration
 - ≡ Human exposure
 - ≡ Equipment damage
 - ≡ Data interference



2. Manufacturer-supplied controls always beat retrofit



because they work properly and are maintainable

3. It's bad economics



to buy more noise if you are (and you should be)
investing in retrofit controls

4. Retrofit control is often impossible



if there are multiple, unique or expensive sources

“Low-noise” is good in every respect

- ☰ Environmentally friendly
- ☰ Ergonomically superior
- ☰ Energy efficient
- ☰ Maintainable
- ☰ Sustainable
- ☰ “Green”

Yes, but . . .

Won't it cost more to Buy Quiet?

- ≡ . . . maybe, but less than the long-term cost of a hearing conservation program
 - ≡ Noise exposure monitoring
 - ≡ Audiometric monitoring
 - ≡ Audiogram review and follow-up
 - ≡ Hearing conservation training
 - ≡ Personal hearing protective devices
 - ≡ Recordkeeping
 - ≡ Program management
 - ≡ **Required retrofit noise control solutions**

Won't it cost more to Buy Quiet?

- ⌘ . . . plus the costs of inevitable hearing loss
 - ⌘ Hearing loss claims (Workers' Compensation cost)
 - ⌘ Lifetime medical follow-up
 - ⌘ Hearing aids and batteries
- ⌘ **Quantifying these costs is essential for effective advocacy**

Is “low-noise” equipment available?

- ☒ Most manufacturers can offer manufacturer-supplied controls for nominal product
- ☒ Demand increases supply (think IT and consumer product industries)



Getting there . . .

- ≡ Low-noise product design is possible
- ≡ Corporate consumers must be proactive
- ≡ Demand will increase supply
- ≡ Successful corporate programs do exist
- ≡ Resources, models and help are available!

NASA Buy-Quiet Program

- ≡ Buy-Quiet and Quiet-by-Design requirements added to Agency-wide policy in 2006
 - ≡ NPR 1800.1C Chapter 4.8
- ≡ Precursor work at Glenn Research Center
 - ≡ Mid 1990s effort motivated by surge in installation of new high-noise equipment and systems
- ≡ My role is to assist Field Centers:
 - ≡ Agency-level program planning and direction
 - ≡ Technical expertise
 - ≡ Development of technical resources and tools
 - ≡ Oversight and evaluation assistance for HQ

NASA Agency-wide requirements

- ≡ Each field center must develop and implement a center-specific program to:
 - ≡ ***“Include noise emissions with technical and performance criteria*** when purchasing or designing new equipment that is expected to generate noise emission levels of concern for hearing conservation (80 dBA and above).”
- ≡ Noise emissions shall be considered equally with all other requirements.
- ≡ Language left vague intentionally to allow Centers to develop site-specific programs

NASA Buy-Quiet Vision:

Everyone thinks like a hearing conservationist

- ☰ Noise emissions *Intentionally* considered
- ☰ Noise-related consequences of purchase decisions routinely anticipated and evaluated
- ☰ Long-term cost of each option quantified
- ☰ *Informed* purchase decisions are made
- ☰ Noise-related impact properly accommodated
- ☰ Best practices approach promoted for “non-hazardous” equipment noise emissions

Benefits of *structured* BQ process

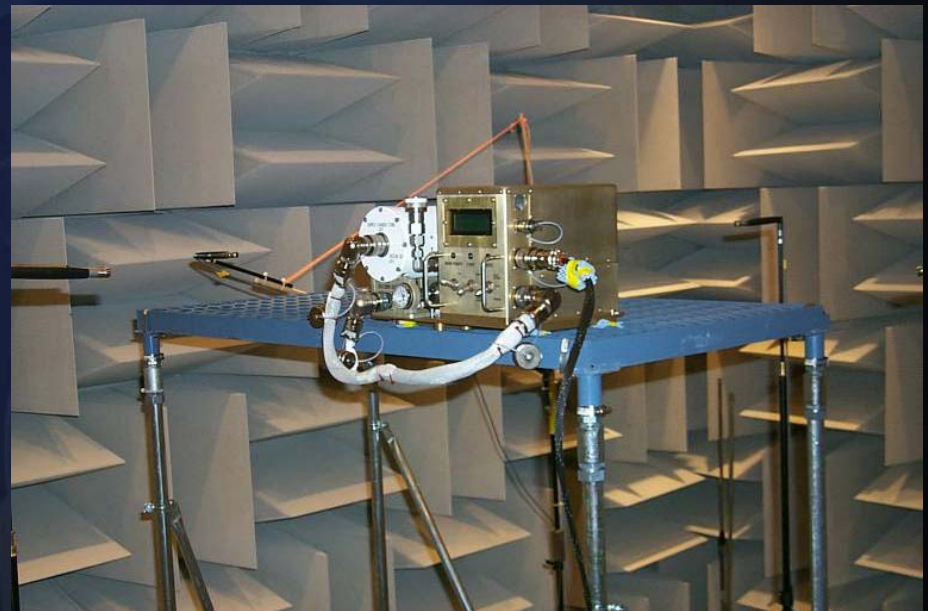
- ≡ An official corporate position sends a message
 - ≡ NASA's program has been widely noted
 - ≡ NIOSH is incorporating our *Roadmap*
- ≡ Publicly visible programs create a precedent
 - ≡ The existence of one program helps launch others
 - ≡ One company's program fuels another's advocacy
 - ≡ Our *Roadmap* incorporates parts of other programs
- ≡ Some vendors won't quote low-noise products unless formally requested
- ≡ Formal specifications level the field
- ≡ **Voluntary product noise labeling is crucial!**

NASA Precedent: ISS Acoustics

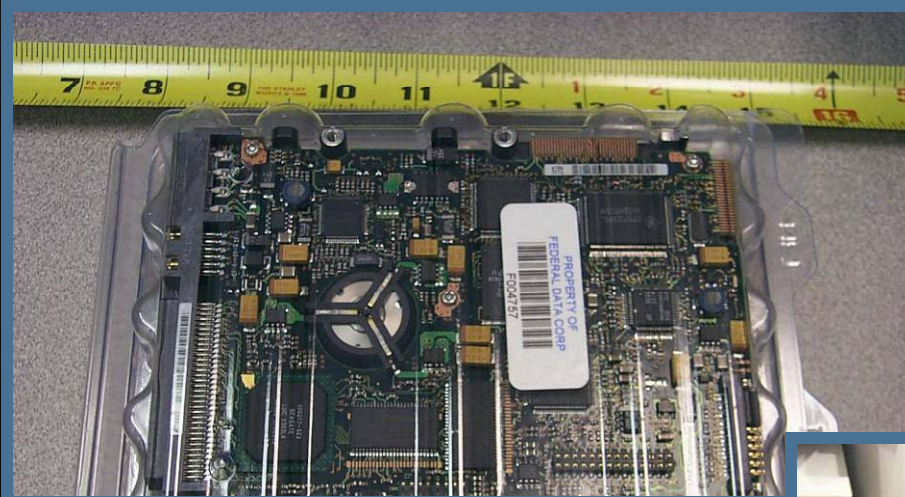
- ≡ Motivated by Shuttle noise problems
- ≡ Environmental noise level targets established
 - ≡ Focus is on *communication* goals
- ≡ Noise emission allocations for flight hardware
 - ≡ Systems and racks sub-allocate to payloads
 - ≡ Payload developers expected to comply
- ≡ Verification by test required prior to launch
- ≡ GRC Acoustical Testing Laboratory
 - ≡ Full-service support for payload developers
 - ≡ \$1.5M/yr budget 2000 - 2005

Noise emission budget sub-allocation

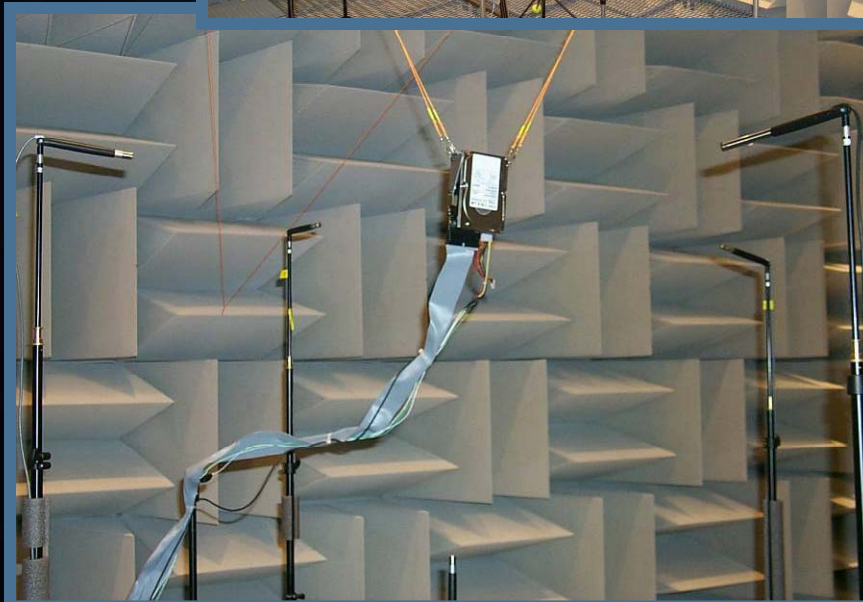
Rack  subsystem  source



“Buy-Quiet” in ISS payload context



Sound source testing



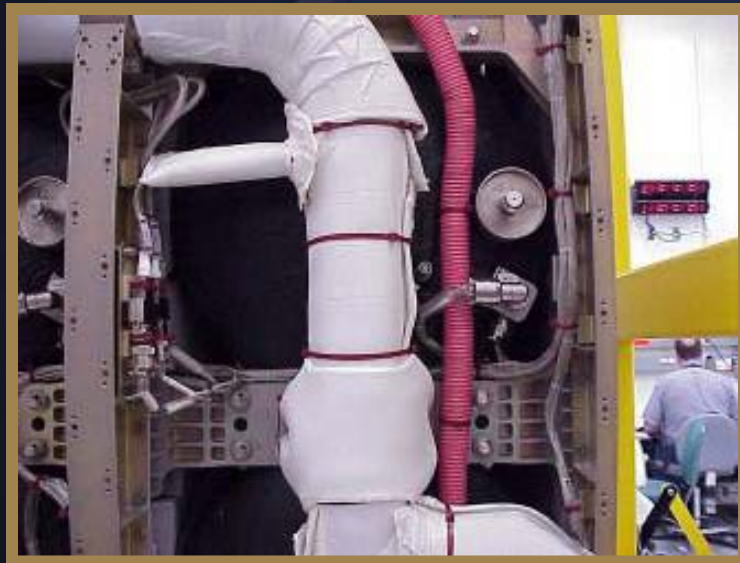
System-level subassemblies



Rack-level verification test



Retrofit noise control, ISS-style



It's not rocket science, but . . .

☰ Rocket scientists need help, too

- ☰ Methodology and process guidance

- ☰ Design tools

- ☰ Training courses

- ☰ Technical expertise and support

- ☰ Coaching and oversight

☰ ISS acoustics experience provides a model

- ☰ Technology and process can be adapted

- ☰ Lessons learned provide valuable advocacy

Implementation challenges for Buy/Design Quiet Program

- ≡ Diversity in operations, culture across Centers
- ≡ Responsibility distributed throughout Center
- ≡ Advocacy and training are major tasks
 - ≡ Technical content outside EH&S scope of practice
 - ≡ Program “users” (requestors) are outside EH&S
 - ≡ Centers have multiple contractors and tenants
 - ≡ Stakeholders are unfamiliar or skeptical (or both)
- ≡ Contractor compliance must be monitored
 - ≡ Can only “suggest” without a contract requirement
- ≡ Senior management enforcement is critical

Meeting the BQ requirement

- ≡ Interpretation of “include noise emissions” intentionally left to each site
- ≡ Implementation must be site-specific
 - ≡ Organization, communications, and procedures
- ≡ Responsible POC in each EH&S organization
- ≡ Series of six-month steps established by HQ
- ≡ Periodic (~6 mo) status review telecons
- ≡ Video and conference training sessions
- ≡ Enforcement via HQ audit team site visits
 - ≡ Checklists mirror goals discussed in status reviews

Field Centers want to know . . .

- ⚙️ What are other companies, government agencies, and the military doing about this?
- ⚙️ Do manufacturers make low-noise equipment, and how much more does it cost?
- ⚙️ How to navigate the process of locating, evaluating, purchasing, and verifying the performance of low-noise equipment?


Best-practices case studies

- ≡ Solicited 60 individual (corporate, military, federal) contacts plus
 - ≡ ANSI S Committees
 - ≡ AIHA Noise Committee
 - ≡ Institute of Noise Control Engineering members
 - ≡ ORC Occupational Health and Safety Network
 - ≡ NIOSH 'Prevention through Design' project
- ≡ Compiled detailed data on 10 non-NASA Buy-Quiet programs
 - ≡ **Most successful programs use 80 dBA noise emission limit**

Manufacturer interviews

- ≡ Solicited 60 individual manufacturer contacts plus these lists:
 - ≡ INCE Product Noise Technical Committee
 - ≡ ANSI S Committees
 - ≡ National Academy of Engineering “Technology for Quieter America” project
- ≡ Compiled detailed data from 11 manufacturers re: design/marketing
 - ≡ **Most estimate 10% - 20% markup for “quiet” equipment**

NASA Buy-Quiet Process Roadmap

- Web-based tool 
- Provides stepwise process guidance
- Developed for NASA but applicable externally
- Technical content by Nelson Acoustics; web design and content editing by Gelfand Design
- Incorporates best practices from corporate, military, government programs
- Incorporates manufacturer–provided data on availability and cost of low-noise equipment
- Contributions from 20+ external organizations

NASA Buy-Quiet Process Roadmap



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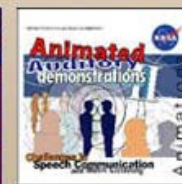
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EARLAB provides **activities, services, and products** that support the practice of hearing conservation at NASA field centers. Our **educational resources and training tools** are also freely available to hearing conservationists, acoustical engineers, and educators worldwide.

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Buy-Quiet Process Roadmap

Key external contributors

- ☰ Baltimore Aircoil
- ☰ United Technologies
- ☰ Caterpillar
- ☰ Cisco
- ☰ Honeywell
- ☰ Hewlett Packard
- ☰ Ingersoll Rand
- ☰ Toro
- ☰ Carrier
- ☰ ExxonMobil
- ☰ Colgate Palmolive
- ☰ Trane
- ☰ 3M
- ☰ Becton Dickinson
- ☰ General Motors
- ☰ Air Force
- ☰ Navy
- ☰ National Park Service
- ☰ NIOSH

NASA Buy-Quiet Process Roadmap


Key features

- ☰ Relevant to hearing-conservation scenarios
 - ☰ Considers community noise impact
- ☰ Leads user through step-wise process
- ☰ Includes customizable specification template
- ☰ Authorization forms promote *responsible* departures from process
- ☰ “Cost of noise” calculation calculates net present value of long-term exposure
 - ☰ Can compare equipment differing in noise and cost
 - ☰ Total cost = purchase + long-term noise exposure




NASA Buy-Quiet Process Roadmap

Key features

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Buy-Quiet Purchasing

NASA field centers and facilities are required to maintain site-specific "Buy-Quiet" programs that guide the identification, evaluation, and procurement of low-noise products in a manner that is both consistent with NASA procurement policies and compliant with Agency-mandated hearing conservation directives.

The NASA Buy-Quiet Process Roadmap

A Web-based *Buy-Quiet Process Roadmap* provides purchasers with a guided path through the procurement process and provides flexibility for field centers to customize the resources for site-specific application. The *Roadmap* incorporates elements of several successful best-practices programs, based on a survey of industrial, government, and military organizations in the United States. A common factor in these programs, which has been adopted in the NASA *Roadmap*, is a maximum equipment noise emission specification of 80 dBA. In addition to a stringent noise specification, the *Buy-Quiet Process Roadmap* incorporates field verification requirements as well as a means for estimating the cost of relevant noise exposure over a career, and it provides links to extensive online databases documenting typical noise emission for a wide variety of equipment types.

The *Buy-Quiet Process Roadmap* is intended primarily for use by NASA field centers and facilities. It is intended to be generic and flexible enough to apply to a broad range of industries and equipment classes, but it must be customized to meet the site-specific needs of each audience. Non-NASA organizations are invited to adapt the *Roadmap* to their operations but are cautioned that NASA does not provide technical support for the *Roadmap* or for any auxiliary resources associated with it.



Technical content for the Roadmap was developed for NASA by David Nelson of [Nelson Acoustics](#). Amy Gelfand of [Gelfand Design](#) provided content editing and Web site design.


[Go to the Buy-Quiet Process Roadmap »](#)

RELATED RESOURCES

- NASA Buy-Quiet Program Advocacy PowerPoint® slideshow presentation
- A Buy-Quiet Program Incorporating Career-Cycle Noise Costs
- Development and implementation of policy-compliant site-specific Buy-Quiet programs at NASA

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Responsible NASA Official: Beth Cooper
Curator: Beth Cooper
Site design by [Gelfand Design](#)

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Buy-Quiet Program status

- ≡ Beta **Roadmap** version launched summer 2009
- ≡ **Roadmap** incorporated into new Auditory Demonstration Laboratory website February 2010
- ≡ HQ procurement review identified needed **Roadmap** language and process changes
- ≡ Currently adapting to NASA procurement structures
- ≡ NF 1707 form being modified to include noise
- ≡ Introducing occupational health language into NPR 8715.1 and NPR 8715.3 to facilitate contractor programs

Next up: Quiet-by-Design!

- ≡ NASA assumes technical burden “in-house”
- ≡ Applies to engineering of gas flow systems
 - ≡ Advanced engineering (gas dynamics, aeroacoustics)
 - ≡ Buy-Quiet program output provides criterion
- ≡ Applies to engineering of inhabited spaces
 - ≡ “Best-practices” architectural and engineering design
 - ≡ Requires understanding hearing conservation goals
- ≡ “Ground” equivalent of ISS Acoustics Program
 - ≡ Existing program materials provide starting point
 - ≡ A successful program model is already developed!



Next up: Quiet-by-Design!



Vision for a NASA Quiet-by-Design Program

- ≡ Agency-wide program development
- ≡ Guidance and oversight for center programs
 - ≡ Use “Buy-Quiet” agency-wide program model
- ≡ Technical tools and resources
 - ≡ Updated web-based implementation of *Reduced-Noise Gas Flow Design Guide (1997)*
- ≡ Technical training
 - ≡ 3-5 day classroom low-noise design course
 - ≡ ViTS, webinar and other e-training vehicles

NASA hearing conservation resources

☰ Demonstrations, trainers, and games

☰ *Auditory Demonstrations in Acoustics and Hearing Conservation*

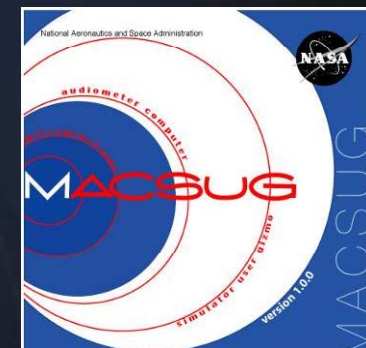
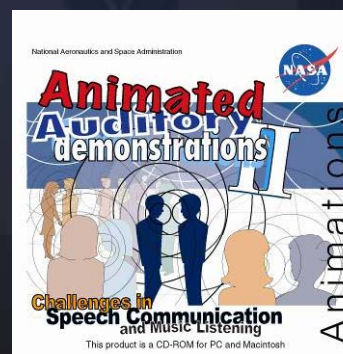
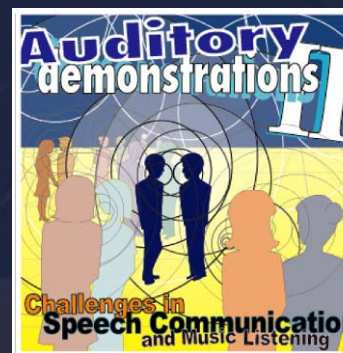
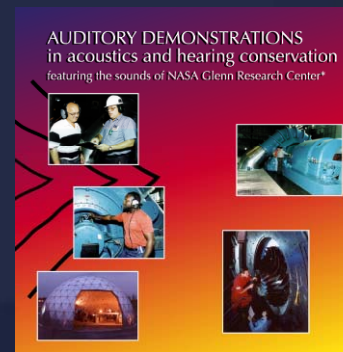
☰ *Auditory Demonstrations II*

☰ *ANIMATED Auditory Demonstrations II*

☰ *JeopEARdy*

☰ *MACSUG audiometry and audiogram review software*

☰ *TWA Calculator Noise Exposure Dose Trainer*



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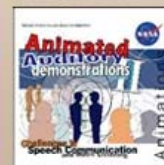
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