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Strategic Plan for the NIOSH Hearing Loss Research Program

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This document details the NIOSH hearing loss research strategic plan developed in response to a 2006 review by the Institute of Medicine (IOM) of the National Academy of Sciences (NAS). The full response to the IOM review is contained in a companion document, "NIOSH Hearing Loss Research Program Response to the NAS Institute of Medicine Review through Strategic Planning". The strategic plan is also a component of NIOSH's second decade of the National Occupational Research Agenda (NORA) in which hearing loss prevention is a key cross-sector program area in the overall program portfolio. The detailed plans for each of the five strategic goals contain descriptions of the overall goal, the intermediate goals necessary to attain the overall goal, and the annual goals that must be met in the process. Specific research projects are identified to accomplish the annual goals. Some of the goals will be met by existing projects, but a number of significant gaps are listed where new projects will be needed. The plans identify existing and new resources needed to undertake the new projects. The new projects are identified as intramural (if NIOSH resources are expected to be sufficient) or extramural (if intramural resources are not available or it is otherwise more appropriate to have the project performed externally to NIOSH).

Strategic Goal 1: Surveillance

Overall Goal: *Improve surveillance at the Federal, State, and private level to: determine the incidence and prevalence of occupational noise exposure and occupational hearing loss; support the identification of emerging technologies, and other noise hazards; evaluate intervention effectiveness; and identify future health and safety priorities in hearing and noise.*

Background

There are many reasons to conduct public health surveillance on hearing loss and noise exposure. Data from surveillance programs or longitudinal studies of selected populations are needed to: 1) identify industrial sectors or workforce populations with the highest levels of occupational hearing loss or noise exposure; 2) to set research priorities; 3) to evaluate the effectiveness of intervention activities; and 4) to identify trends in hearing loss and noise exposure. There are three broad types of public health surveillance: hazard surveillance; exposure surveillance; and, disease surveillance. Each of these types of surveillance can be used to generate data that is vital for targeting public health resources.

Lack of surveillance was one of the major shortcomings of the NIOSH Hearing Loss Research Program (HLRP) as determined by the National Academy of Sciences. Little surveillance data on noise and occupational hearing loss has been published since the late 1980s. However, given that relatively few interventions and regulatory changes have been adopted since then, we suspect that noise exposures and the prevalence of occupational hearing loss have changed little in the last two decades. Noise is considered the most pervasive hazardous agent in the workplace. Moreover, several chemical substances found in the workplace are ototoxic. In its review of the HLRP the National Academy specifically recommended that such exposures be included in a surveillance initiative that examines hearing hazards

Occupational hearing loss (OHL) is one of the most common occupational diseases and injuries. Because OHL is permanent and prevalent, prevention is of utmost importance. Surveillance is vital to prevention because it can identify the most problematic industries, occupations and work activities, and because it can be used to evaluate the effectiveness of intervention activities. At present NIOSH performs little noise or hearing loss surveillance.

Recognizing that there are limited resources available for this effort, it was decided to that a few industries would be given highest priority for surveillance projects. The high priority industrial sectors are mining, construction, and manufacturing. These industrial sectors were selected because they are all considered to have a high prevalence of occupational hearing loss and because they are recognized across NIOSH as having high priority.

Performance Measure: This goal will be successfully achieved if by 2016, current and new surveillance systems are adapted for use by NIOSH and stakeholders to track noise exposure and occupational hearing loss, to monitor and evaluate intervention effectiveness, and to identify future health and safety priorities in noise and occupational hearing loss. Although NIOSH would like to include all industrial sectors, emphasis will be placed on mining, construction, and manufacturing.

Intermediate Goal 1.1. Hazard Surveillance

Hazard surveillance is an assessment of the magnitude and trend in exposure to hazardous agents, including noise and other ototoxic exposures. Ideally, this surveillance can identify geographic areas, work settings, industries, and occupations with high exposures to the agent of interest. Workers in these settings may be exposed to high amounts of a hazardous agent and may be at risk for occupational disease (e.g. noise-induced hearing loss). Instituting early interventions to decrease hazardous exposures can reduce the burden of occupational disease. In addition to noise, a number of other agents are believed to function as ototoxicants, and thereby cause hearing loss. Ototoxic agents include organic solvents, metals, pesticides and carbon monoxide. Throughout this text we will use the term “hearing hazards” when referring to these hazardous noise and ototoxic agents. Note that Intermediate Goal 2.1 titled “Develop and maintain noise source/exposure database for construction and mining” relates to this Goal.

Performance Measure: In 2007, NIOSH will inventory existing hazard surveillance datasets to develop baseline goal metrics and to identify and prioritize upgrades needed to improve surveillance of hearing hazards. By 2012, NIOSH will implement 2 hearing hazard exposure surveillance upgrades. NIOSH will provide hearing hazard exposure status reports every third year, and in 2013 will prepare a report describing remaining national hearing hazard exposure surveillance needs. Although NIOSH would like to include all industrial sectors, emphasis will be placed on mining, construction, and manufacturing.

Current Projects:

Cross-sectional mine survey: noise exposure sources/patterns (10/2006 – 9/2009): Through measurement of equipment sound output levels, worker exposure and task observation, a database of mining noise exposures and sources is being created. Data have been collected on Coal; Stone; and Sand and Gravel mines. The next priority for this project is metal/non-metal mining. These data can be used to guide the engineering control priorities as described in Strategic Goal #2, and to determine their effectiveness.

Resources: 1.5 FTE; $32K intramural funding.

Gaps in Knowledge:

To our knowledge there is little or no hearing hazard surveillance data available.

New planned projects to fill the gaps

2008 Analyze data from the Integrated Management Information System (IMIS) -- Phase 1 (extramural)

2011 Analyze data from the Integrated Management Information System (IMIS) -- Phase 2 (extramural)

2014 Analyze data from the Integrated Management Information System (IMIS) -- Phase 3 (extramural)

IMIS is a database created and maintained by OSHA. It is a nationally representative source of occupational exposure measurements for industries other than mining. It consists of quantitative exposure measurements collected by compliance safety and health officers during enforcement investigations, and by representatives of state agencies administering the OSHA consultation program during onsite surveys. The initial assessment could be performed as a 1-year extramural effort, with reassessments every three years.

> **Major Achievement**: Peer-reviewed manuscript, which could provide important guidance to OSHA.

2009 Develop a protocol and guidelines to collect, analyze and interpret quality noise exposure data. (extramural) This protocol is needed to ensure that noise hazard surveillance is conducted using standardized, reliable, accurate, and reproducible procedures. To our knowledge, such a protocol does not exist.

> **Major Achievement**: Completed protocol and guidelines. A NIOSH-numbered publication may also be prepared.

2010 Develop a protocol and guidelines to collect, analyze and interpret quality non-noise hearing hazard exposure data. **(extramural)** Such a protocol is needed to ensure that surveillance for all non-noise hearing hazards are conducted using standardized, reliable, accurate, and reproducible procedures. To our knowledge, such a protocol dos not exist.

Major Achievement: Completed protocol and guidelines. A NIOSH-numbered publication may also be prepared.

2009-2013 Hearing hazard survey in a high priority industry such as construction, transportation, or public administration (including police and fire departments). (extramural) Given that a national noise survey of all industries may not be feasible in the short-term, it is recommended that a noise survey be conducted of at least one high-risk industry. This survey would identify high risk activities, tools and machinery in the high-risk industry. If possible, hazard surveillance for other ototoxic exposures will be undertaken. This information would be useful for identifying where the greatest good can be accomplished with the fewest resources. Note that this intermediate goal is similar to intermediate goal 2.1.

Major Achievement: Hearing hazard survey of a high-risk industry. Findings would be reported in a NIOSH-numbered publication, and in one or more peer-reviewed manuscripts. Data would also be available on the NIOSH Web site.

2008 Hearing hazard assessment in mining – Phase 1.
2011 Hearing hazard assessment in mining – Phase 2.
2014 Hearing hazard assessment in mining – Phase 3.
Mine operators are required to establish a system of noise monitoring that measures each miner's noise exposure to ensure compliance with MSHA's noise standard. These data will be analyzed using standardized, reliable, accurate, and reproducible procedures, and integrated with existing chemical exposure data. Note that this intermediate goal is similar to intermediate goal 2.1.

Resources needed: One FTE would be needed for each phase. This database will be continually maintained, and comprehensively analyzed at least every three years.

Major Achievement: Hearing hazard survey of the mine industry. Findings would be reported in a NIOSH-numbered publication, and in one or more peer-reviewed manuscripts. Data would also be available on the NIOSH Web site. The data would provide important guidance to MSHA.

2009-2016 Integrate hearing hazard surveillance into a comprehensive National Exposures at Work Survey (NEWS). Since NIOSH was created, it has conducted two national surveys to measure exposures in the workplace. The first was conducted in the 1970s and was called the National Occupational Hazard Survey (NOHS). The second was conducted in 1980-1983 and was called the National Occupational Exposure Survey (NOES). The NOES determined whether workers were exposed to continuous noise that exceeded 85 decibels using A frequency weighting (dB(A)), and to impact noise that involved noise-generating events spaced one or more seconds apart with an intensity of 130 decibels using C frequency weighting (dB(C)). This qualitative data was of limited usefulness with respect to information on noise hazard intensity. These surveys also estimated the number of workers exposed to various chemicals, some of which are thought to be ototoxic. Over two decades have passed since the last national noise exposure survey was undertaken.

Resources needed: This survey would cost several million dollars and would require a Congressional appropriation. In addition to information on hearing hazards, NEWS would collect exposure information on a wide range of occupational hazards. It is estimated that this project would require 7-10 years from planning to complete dissemination of information.

Major Achievement: Such a comprehensive NEWS survey would provide nationally representative data on the distribution and concentration of various occupational hazards including noise. Findings would be reported in NIOSH-numbered publications, peer-reviewed manuscripts, and on the NIOSH Web page. This project would provide immense visibility to NIOSH, and would provide extremely valuable information to researchers, labor and industry.

Intermediate Goal 1.2. Audiometric Surveillance (other relevant biomonitoring could also be included)

Exposure surveillance is used to assess the body burden of chemical and physical hazards, and their subclinical effects. Whereas hazard surveillance involves detecting the hazardous agent in the environment, exposure surveillance pertains to biomonitoring, and can include measurement of the toxic agent, its metabolite, or reaction products in urine or blood. It also involves measuring subclinical adverse effects (e.g. subclinical hearing loss on audiometric testing). Exposure surveillance doesn't include measuring clinically detectable health effects, as this is the purview of disease surveillance (discussed below). Ideally, this surveillance can identify individuals or populations in specific geographic areas or workplaces with elevated body burdens of a toxin or subclinical adverse effects, with the goal of taking preventive action before permanent adverse effects (e.g. hearing loss) become manifest. This information can be used to target preventive interventions to decrease toxic exposures and to ultimately reduce disease incidence. Note that data from these audiometric surveillance activities will help accomplish Intermediate Goal #4.1 titled "Determine the most effective audiometric test protocol for identifying noise-induced hearing loss."

Performance Measure: In 2007, NIOSH will inventory existing audiometric datasets to develop baseline goal metrics and to identify and prioritize upgrades needed to improve noise and occupational hearing loss surveillance. By 2012, NIOSH will have implemented 3 audiometric surveillance upgrades. NIOSH will provide audiometric surveillance status reports every third year, and will prepare a report describing remaining national audiometric surveillance needs in 2013. Although NIOSH would like to include all industrial sectors, emphasis will be placed on mining, construction, and manufacturing.

Current Projects: None

Gaps in Knowledge:

With the exception of the National Health and Nutrition Examination Survey and its limited occupational emphasis, little or no audiometric surveillance is being undertaken nationally.

New planned projects to fill the gaps:

2008-2016 Use the Defense Occupational and Environmental Health Readiness System (DOEHRS) Data Repository or some other commercially available data management system to set up the infrastructure to handle and analyze data submitted to NIOSH by partners in other industrial sectors. The Department of Defense (DoD) has an existing data repository called the Defense Occupational and Environmental Health Readiness System (DOEHRS). The DOEHRS data repository is the best practices model for the hearing loss prevention community. Partnering with an operational data management system such as DOEHRS would jump-start the development of a data repository for mining and other industrial sectors. NIOSH could add to the analytic capacity of DOEHRS but maintain segregated data (military and NIOSH) especially in the initial phases of development. This effort will result in a model system for conducting surveillance using audiometric data.

> **Resources needed**: PRL has an FTE who will work on this (audiologist with an epidemiology background). A memorandum of understanding to partner with DoD will be successfully completed by 2007. It is expected that this model will be developed in FY09.
>
> **Major Achievement**: This effort will result in a model system for conducting surveillance using audiometric data. This model will be applied to audiometric data from other industrial sectors.

2009-2011 Use mining industry data to develop and maintain a national hearing loss prevention data repository including monitoring audiometry and individual hearing hazard exposure data. This data repository will identify and quantify the magnitude and distribution of hearing loss in various mining environments and correlate these to workers' noise and other ototoxin exposures. The data will be collected from audiometry already conducted under MSHA requirements for underground and surface coal mines, coal preparation plants, and underground and surface metal and non-metal mining sites. The data repository of audiometry will be linked to noise exposure data and will be used by NIOSH and key stakeholders to develop and prioritize hearing loss prevention efforts. This effort will be guided by the model developed in the DOERS project. It will incorporate data from the high priority industry survey project. Note that this effort will provide the data needed to successfully accomplish Intermediate Goal 2.4 titled "Evaluate the effectiveness of newly developed noise controls for the construction and mining industries."

> **Resources needed**: Two FTEs will be needed. One new epidemiologist in addition to a current PRL employee (audiologist with an epidemiology background) will be needed.
>
> **Major Achievement**: It is expected that a national hearing loss prevention data repository including monitoring audiometry and individual noise exposure data for the mining industry will be developed in FY08. This mining data repository will identify types of mines, equipment, and activities most associated with subclinical hearing threshold shifts. This information will be useful for targeting public health resources and

can be used to evaluate the effectiveness of intervention activities. After FY08, similar efforts will be undertaken in other industrial sectors (e.g. manufacturing) based on resource availability.

2009-2016 Produce a guidance document on enterprise surveillance for hearing loss prevention. A NIOSH-numbered document will be created to provide stakeholders with instruction on how to establish and maintain a data repository and surveillance program that links audiometry and individual ototoxin exposure data at the company level. It will be based on the experiences and lessons learned through the data repository projects.

Resources needed: Shared FTEs involved with the data repository projects.

Major Achievement: A guidance document will be produced to provide information on how to develop and maintain surveillance programs for hearing loss prevention. The primary target will be industrial enterprises interested in using surveillance tools to protect their workers from noise hazards. Other target audiences include unions, non-governmental agencies, governmental agencies (e.g. State and local health agencies, other state and federal government agencies, and international agencies), and members of the public interested in hearing loss prevention. Guidelines for surveillance program development, case investigation, data collection, outreach, and education will be provided in the manual. The guidance document will promote effective surveillance activities to guide hearing loss prevention activities among companies and unions.

2009-2016 Initiate and support state-based surveillance programs that use data from audiometric providers to promote hearing loss. (extramural) A project will be undertaken to provide NIOSH funding to one or more states to develop surveillance programs for hearing loss prevention. The SENSOR model that already exists in Michigan will be one model that can be potentially expanded to other states. The state agencies will be encouraged to initiate and maintain collection of audiometric data from industrial enterprises or from contractors who provide industrial enterprises with audiometric services. It is anticipated that these data will be useful for measuring the statewide prevalence of subclinical hearing loss, and the severity of clinical hearing loss. Prevalence rates by industry and occupation will be calculated. This information can identify targets for public health resources and can be used to evaluate the effectiveness of intervention activities.

Resources needed: NIOSH funding of approximately $100,000 per year per state will be needed.

Major Achievement: This project will result in the development of federal-state partnerships to promote hearing loss prevention. It will strengthen to capacity of state health departments to conduct occupational health surveillance, especially with respect to hearing loss. The findings from state-level surveillance can be linked to effective intervention and prevention activities at the state and national level.

Intermediate Goal 1.3. Disease Surveillance

This pertains to surveillance of hearing loss. Hearing loss surveillance can serve many purposes. Surveillance data are useful for assessing both the magnitude and trend of occupational hearing loss. It can promptly identify emerging hearing loss problems, including those associated with a new industry, new work activity, or new piece of equipment. It can also identify hearing loss problems caused by noncompliance with noise regulations. Furthermore, risk factors identified through surveillance or follow-up investigations can be targets for effective interventions.

Performance Measure: In 2007, NIOSH will inventory existing datasets with information on hearing loss to develop baseline goal metrics and to identify and prioritize upgrades needed to improve noise and occupational hearing loss surveillance. By 2012, NIOSH will have implemented three hearing loss surveillance upgrades. NIOSH will provide hearing loss surveillance status reports every third year, and will prepare a report describing remaining national hearing loss surveillance needs in 2013. Although NIOSH would like to include all industrial sectors, emphasis will be placed on mining, construction, and manufacturing.

Current Projects:

None.

Gaps in Knowledge:

To our knowledge there is no hearing loss surveillance currently being undertaken.

New planned projects to fill the gaps

2008 Develop a case definition and severity index for occupational hearing loss. (extramural) NIOSH, working with relevant stakeholders, has created case definitions for many occupational diseases and injuries (e.g. acute occupational pesticide poisoning, occupational asthma, and carpal tunnel syndrome). These case definitions are used by organizations that conduct surveillance on these conditions. A standardized case definition would provide a consistent, objective approach for assessing the presence of occupational hearing loss. This standardization is important when aggregating across states and across time. Understanding severity is also important, so that the most severe hearing loss can be identified and targeted with interventions.

> **Major Achievement**: The case definition and severity index will be the subject of an MMWR article. The Council of State and Territorial Epidemiologists (CSTE) will be requested to add “occupational hearing loss” as a condition that should be reportable to state health departments. CSTE will be asked to define “occupational hearing loss” using the case definition developed by NIOSH and its partners.

2008-2016 Identify existing databases that can be used for ongoing surveillance of occupational hearing loss. NIOSH will analyze these databases in an ongoing manner to

estimates the magnitude and trend of occupational hearing loss. Databases that may be useful include:

- BLS Survey of Occupational Injuries and Illnesses (also known as the Annual Survey). This survey is based on the OSHA Log 300, which in 2004 added a specific column for capturing hearing loss.

- National Health Interview Survey. This survey is conducted annually by CDC's National Center on Health Statistics. This survey captures usual industry and occupation. Hearing difficulty is assessed by the question "Which statement best describes your hearing (without a hearing aid): good, a little trouble, a lot of trouble, deaf?"

- National Health and Nutrition Examination Survey (NHANES). Audiometric testing was conducted in NHANES I, which ran from 1971-1975, and reintroduced in 1999. Audiometric data are available on 6913 persons who participated in NHANES I, and on 5328 persons who participated in NHANES from 1999 to 2004.

- Medical claims data using two large health maintenance organizations operating in Pennsylvania (Highmark Blue Shield in Pittsburgh, and Independence Blue Cross in Philadelphia). This database may allow for an assessment of the prevalence of medical claims for hearing loss across various industries and occupations.

- Data on mine workers collected by PRL and mining companies. PRL has a mobile audiometric test facility which could provide audiometric data. Audiometric data may also be available from miners in some companies. This data could be included in the project described in goal 1.2.2.

- MSHA hearing loss prevalence data previously analyzed by John Franks. This data was never published. It will need to be located and perhaps could be updated by MSHA.

Resources needed: We will need a 1-2 NIOSH FTEs to analyze these databases in an ongoing manner. These FTEs would include epidemiological, statistical, and information technology (IT) support. If only 0.5 FTE were available, the databases described in 1.3.2 a, b, and c could be analyzed on a rotating basis, one per year.

Major Achievement: Currently, little information is available in the peer-reviewed literature on the prevalence of occupational hearing loss. The analytic findings from these databases would be published in peer-reviewed journals and would be placed on the NIOSH Web site. This information will be extremely valuable in identifying the industries and occupations with the highest prevalence of occupational hearing loss. The findings would aid OSHA, MSHA and NIOSH in prevention activities.

2009-2016 Expand the Michigan SENSOR model for surveillance of occupational hearing loss to other states. (extramural) State health departments will be encouraged to initiate and maintain surveillance of occupational hearing loss. This effort could be combined with the project on supporting state-based surveillance described in goal 1.2. It is anticipated that these

data will be useful for measuring the statewide prevalence and severity of occupational hearing loss. Prevalence rates by industry and occupation will be calculated. This information can identify targets for public health resources and can be used to evaluate the effectiveness of intervention activities.

Resources needed: NIOSH funding of approximately $100,000 per year per state. SENSOR projects are generally funded in 5 year cycles.

Major Achievement: This project will result in the development of federal-state partnerships to promote hearing loss prevention. It will strengthen the capacity of state health departments to conduct occupational health surveillance, especially with respect to hearing loss. The findings from state-level surveillance can be linked to effective intervention and prevention activities at the state and national level.

2008-2012 Support another occupational health supplement to the National Health Interview Survey (NHIS). Although the NHIS is conducted annually by CDC's National Center on Health Statistics (NCHS), an occupational health supplement was conducted in 1988 but has not been repeated since. The supplement provided useful information on a variety of occupational injuries and illnesses including: occupational hearing loss, back pain, carpal tunnel syndrome, tendonitis, occupational injuries, dermatitis, hepatitis, asthma, chronic bronchitis, emphysema, and pneumoconiosis.

Resources needed: The cost to repeat the 1988 supplement is estimated at $8 million. However, the cost could be reduced if fewer questions were asked. In addition, NIOSH and NCHS could try to identify other agencies and organizations to help support the funding. For example, BLS helped fund the 1988 supplement (which cost NIOSH approximately $500,000) and they may be interested in supporting a new supplement. Other organizations who may also be interested in supporting this supplement are MSHA, the National Institute on Deafness and Other Communication Disorders (NIDCD), and Liberty Mutual. It should be noted that there is precedence for private organizations providing funding support to NHIS. Given the high cost of the supplement, NIOSH likely would need to also request supplemental funding from Congress. The high cost may preclude using NIOSH NORA funds. If a supplement questionnaire could be provided to NCHS by July 2007, it could be included in the 2009 NHIS (a minimum of 18 months are required to prepare the survey instrument, including obtaining OMB approval before the instrument can be used in the field). The data would be available for analysis approximately 6 months after the conclusion of the calendar year when the survey was administered (i.e. 2009 data would be available in July 2010).

Major Achievement: The annual NHIS includes one hearing loss question. This supplement would allow for an increased number of hearing loss questions. It would provide more detailed information on occupational hearing loss across industries and occupations. Currently the best source of information on nonfatal occupational illnesses and injuries is the BLS Survey of Occupational Illness and Injury (SOII). However, this survey has many limitations which would be overcome by the NHIS occupational health supplement. These limitations include: approximately 22% of the US workforce is

excluded from SOII including self-employed workers (including contingent and possibly contract workers), public sector workers and individuals employed on farms with peak employment of 10 or fewer; SOII underestimates the true incidence of nonfatal occupational illnesses and injuries by 20-66%; because race and ethnicity data is an optional data element in SOII, this information in missing in a high proportion of cases, which means that little illness and injury information is available from SOII on Hispanic and other minority workers.

Intellectual Properties:

None.

R2P:

The projects included under this strategic goal may reduce occupational hearing loss in three ways: 1) trends in noise exposure and occupational hearing loss can be monitored; 2) workers in occupations with increased noise exposure and/or with increased risk of hearing loss can be targeted for intervention and prevention; 3) this information may be useful for adopting polices to reduce noise exposures across many industries. NIOSH researchers can work collaboratively with internal and external partners to pursue these and other preventive and protective interventions.

Current NIOSH resources available to work on the new planned projects

In addition to the resources earmarked for the current PRL surveillance project (0.5 FTEs, and $32,000 in discretionary funds), PRL has 0.5 FTEs to devote to the new planned surveillance projects. DSHEFS can provide 0.6 FTEs until June 30, 2007. Neither PRL nor DSHEFS currently have discretionary funds available for conducting new surveillance projects. It is estimated that 6 intramural FTEs and $300,000 annually in intramural discretionary funds would be required to complete all but the most ambitious projects (this estimate does not include projects 1.1.6 and 1.3.5 described in Intermediate Goal 1).

Strategic Goal 2: Develop Engineering Controls to Reduce Noise Exposure

Overall Goal

The elimination of new cases of occupationally related noise-induced hearing loss (NIHL) through a reduction of the noise emission levels of the machinery and equipment that produce hazardous noise levels.

Importance

The Bureau of Labor Statistics (BLS) measures the number of new work-related illness cases that are recognized, diagnosed, and reported during each year for each working sector. However, long term illnesses are difficult to relate to the workplace and are not adequately recognized and reported in the data.

The surveillance data shows that the goods-producing area, which includes the natural resources, mining, construction, and manufacturing sectors, accounted for 85% of all cases of hearing loss reported in 2004. A set of specific program research priorities needs to be focused on the goods-producing area relative to the data.

Performance Measure

Since the ultimate goal of the noise control technology program is the elimination of new cases of noise-induced hearing loss (NIHL) through a focused program of noise control research, the sectors mentioned above are the priority sector areas. However, the success of this overall goal will not be seen for 20 to 30 years. The short term goal of the noise control effort is to reduce machinery sound levels to bring the operator's noise exposure within the OSHA/MSHA Permissible Exposure Level (PEL) in five years. In the long term, the goal is to reduce machinery sound levels to bring the operator's noise exposure within the NIOSH Recommended Exposure Level (REL) in ten years.

Approach

For program success, it is imperative that each sector establish and collect critical stakeholder input and regulatory partner assistance in the identification of the research priorities with NIOSH researchers. In addition, universities, along with state and local government agencies need to provide input into the setting of priorities relative to the noise control program. This effort will contribute to new approaches and ideas across all sectors and provide dual-use applications.

Each of the targeted sectors will consist of a program relative to five program goals. In general, the program's approach is to: (1) gather and analyze information on noise emission from a variety of equipment used in each sector; (2) investigate available or existing engineering noise controls and their effectiveness and feasibility; (3) develop and test new engineering noise controls where controls do not exist; (4) establish partnerships with other government agencies, unions, equipment manufacturers, academia, and standard's setting bodies; and (5) implement

new noise controls and evaluate and measure their effectiveness and feasibility. Each sector will have the same goal or objective which is the reduction of NIHL through a focused program on engineering noise control.

Intermediate Goal 2.1: To develop and maintain a noise source/ worker exposure database for prioritizing noise control technologies for the construction and mining industries. *Although the work for this effort is essential for targeted noise control development, the project(s) associated with Intermediate Goal 2.1 will be conducted within Strategic Goal 1 of the Hearing Loss Strategic Plan.*

Performance measure: The development of a database of noise source/exposure relationships and equipment noise for the construction, mining and shipyard industries and use of the database by the targeted industry sector, government agencies, unions, equipment manufacturers, academia, and standard's setting bodies.

Annual Goal 2.1.1 (2007) - Define the relationship between noise source and worker exposure in all underground mines (coal, metal, non-metal, etc.).
Performance measure: This effort will be successfully achieved when the database for underground mining is completed.

Annual Goal 2.1.2 (2008) - Define the relationship between noise source and worker exposure in all surface mines (coal, metal, non-metal, etc.).
Performance measure: This effort will be successfully achieved when the database for surface mines is completed.

Annual Goal 2.1.3 (2009) - Build data acquisition hardware to include a geodesic microphone mounting system to validate impulsive and sound power level measurements in the field.
Performance measure: This effort will be achieved when the data acquisition system for field measurement of sound power levels and impulsive noise metrics from powered hand tools is developed and validation tests are completed.

Annual Goal 2.1.4 (2009) – Define the relationship between noise source and worker exposure related to the research gaps for the construction and shipyard industries.
Performance measure: This effort will be successfully achieved when the database for the construction and shipyard industries is completed.

Annual Goal 2.1.5 (2009) – Gather and publish impulsive noise data for a variety of impulse producing powered hand tools.
Performance measure: This effort will be successfully achieved when the impulsive noise data is posted on the existing NIOSH powered hand tool website database.

Annual Goal 2.1.6 (2010) – Identify, evaluate, and disseminate the findings on the relationship between noise source and worker exposure in the construction and shipyard industries.
Performance measure: This effort will be successful when the results are available to stakeholders via published handbooks, workshops, or industry briefings.

Annual Goal 2.1.7 (2010) – Identify, evaluate, and disseminate the findings on the relationship between noise source and worker exposure in underground mines.
Performance measure: This effort will be successful when the results are available to stakeholders via published handbooks, workshops, or industry briefings.

Annual Goal 2.1.8 (2011) – Identify, evaluate, and disseminate the findings on the relationship between noise source and worker exposure in surface mines.
Performance measure: This effort will be successful when the results are available to stakeholders via published handbooks, workshops, or industry briefings.

Annual Goal 2.1.9 (2012) – Define the relationship between sound power levels, impulsive sound levels, and noise exposure limits in conjunction with tool quality metrics, tool specifications, and information regarding other hazards (i.e. hand arm vibrations, dust, etc…).
Performance measure: This effort will be successfully achieved when an extensive database of sound power levels, impulsive noise metrics, noise exposure limits, and hand arm vibration data is made available through NIOSH's existing powered hand tool website database.

Annual Goal 2.1.10 (2013) – Define research gaps in the relationship between noise source and worker exposure for underground coal mining.
Performance measure: This effort will be successfully achieved when the research gaps are defined and the database for underground coal mining is updated.

Annual Goal 2.1.11 (2014) – Define research gaps in the relationship between noise source and worker exposure for underground metal/nonmetal mining.
Performance measure: This effort will be successfully achieved when the research gaps are defined and the database for underground metal/nonmetal mining is updated.

Annual Goal 2.1.12 (2015) – Define research gaps in the relationship between noise source and worker exposure for surface coal mining.
Performance measure: This effort will be successfully achieved when the research gaps are defined and the database for surface coal mining is updated.

Annual Goal 2.1.13 (2016) – Define research gaps in the relationship between noise source and worker exposure for surface metal/nonmetal mining.
Performance measure: This effort will be successfully achieved when the research gaps are defined and the database for surface metal/nonmetal mining is updated.

Current Projects

Cross-sectional mine survey: Noise exposure sources/patterns (10/2006 – 9/2009)
This is a comprehensive study combining the efforts of past research studies incorporating worker noise exposure characterization studies and equipment/activity related noise data. The resultant database will be an up-to-date comprehensive profile of the noise exposures of the mining population as a function of equipment and activity-specific measures. This study is a crucial component in NIOSH's effort to develop engineering noise controls because it will define the sources of miners' dosages and the characteristics of those sources. Once this crucial

information is available, efforts can be focused on the development and application of appropriate engineering control measures.

Construction workers' exposure to powered hand tool noise (10/2006 – 9/2009)
This project aims to reduce construction workers' noise exposure and noise induced hearing loss (NIHL) by providing quieter equipment and tools for use on construction sites. This project translates research on sound power level and noise into practical information for powered hand tool manufacturers, buyers, users, and occupational safety and health professionals. The project also partners power tool manufacturers with technical experts in noise control in order to develop and provide quieter tools in the marketplace.

Gaps in Knowledge and Technology

Continued collection of data is needed to monitor noise source/exposure relationships. The planned projects of SG #1.1 detail ways to obtain this data. There is currently little information provided to machinery and equipment users by manufacturers in the construction industry. Providing this information may motivate workers and tool buyers to request quieter tools from manufacturers and motivate the use of proper hearing protection equipment. Further, there is no single entity in the US to refer to when a question arises over excessive noise in the workplace or how noise levels may be mitigated in the workplace. Also, there is currently little information available to the tool purchasers and tool operators regarding noise levels and noise exposure limits for powered hand tools. Lastly, no hardware and software combination exists to accurately measure impulsive sound pressure peaks for the purpose of incorporating those measurements into sound power measurements. Sound power characterizes tools having continuous noise, while metrics to characterize impulsive sound peaks are still being developed.

Resources

A mining engineer and an engineering technician who can conduct field studies utilizing a noise dosimeter and sound level meter are needed. The engineer should have experience with mining and construction, conducting research projects and field studies, and performing noise and sound level measurements. The engineering technician should have experience with field studies, noise measurement techniques, and instrumentation. The engineer and engineering technician would be two new additional FTE's in 2007.

New Planned Projects to Fill Gaps

2010-2016 Cross-sectional mining survey
The current Cross-sectional survey project ends in 2009, but there will be a continuing need for the exposure surveillance and intervention effectiveness data it can provide.

2010-2016 Cross-sectional construction survey (extramural)

Major Planned Achievements

2008

Guidelines for Administrative Controls for Reducing Noise Exposures to Mine Workers

A software package developed from field study results of worker dosimetry measurements, task observations and sound pressure levels of mining equipment will provide the mining community with a user-friendly product for determining and administratively controlling mine workers' exposure to excessive noise levels. This effort will include a needs analysis involving key users and partners, promotion through websites, and demonstrations at conferences and workshops. The software is expected to see widespread use by the mining health and safety community and to be used as a viable, user-friendly tool in reducing workers' noise exposure.

2012

Development of Educational Materials Related to Impulsive Noise Metrics and Noise Exposure Limits of Powered Hand Tools

The addition of impulsive noise metrics and noise exposure limits will be included into the powered hand tools database. Upon completion, the development of educational materials detailing noise exposure limits and impulsive sound level metrics to tool purchasers, especially construction workers will be performed.

Intellectual Property and R2P

Intellectual properties developed through a consortium will be determined by initial cooperative research and development agreements (CRADA), memorandums of understanding (MOU), and other formal methods of cooperative collaboration based on prior research and input from stakeholders, NIOSH will develop the following technology transfer and R2P products: Administrative controls computer program for ease of entering of time study data, analysis of the data, and selection of appropriate administrative controls; CD of sound profile plots and worker exposures for use as a training aid for exposure awareness; Publications related to specific commodities.

Intermediate Goal 2.2: Identify existing engineering noise controls utilized in the construction mining and shipyard industries and evaluate their effectiveness and feasibility.
Performance measure: Completion of a database that identifies existing noise controls and documents their effectiveness in the construction and mining industries.

Annual Goal 2.2.1 (2007) – Identify existing engineering noise controls used in underground mines and evaluate their effectiveness.
Performance measure: This effort will be successful upon completion of a database identifying existing noise controls and their field effectiveness.

Annual Goal 2.2.2 (2008) – Identify existing engineering noise controls used in surface mines and evaluate their effectiveness.
Performance measure: This effort will be successful upon completion of a database identifying existing noise controls and their field effectiveness.

Annual Goal 2.2.3 (2008) – Disseminate the findings on the effectiveness of existing engineering noise controls used in construction and shipyard industries.

Performance measure: Success will be determined when the results are available to stakeholders via publications and as a functional, interactive technical website on noise control materials, techniques, and case studies.

Annual Goal 2.2.4 (2009) – Identify existing engineering noise controls used in preparation plants and evaluate their effectiveness.
Performance measure: This effort will be successful upon completion of a database identifying existing noise controls and their field effectiveness.

Annual Goal 2.2.5 (2010) – Disseminate the findings on the effectiveness of existing engineering noise controls used in construction and shipyard industries.
Performance measure: This effort will be successful when the results are available to stakeholders via NIOSH's web site as an interactive technical document/clearinghouse of existing noise control technologies for construction.

Annual Goal 2.2.6 (2010) – Disseminate the findings on the effectiveness of existing engineering noise controls used in underground mines.
Performance measure: Success will be determined when the results are available to stakeholders via published handbooks, workshops, industry briefings and selected into MSHA's Program Information Bulletin (PIB-04-18).

Annual Goal 2.2.7 (2011) – Disseminate the findings on the effectiveness of existing engineering noise controls used in surface mines.
Performance measure: Success will be determined when the results are available to stakeholders via published handbooks, workshops, industry briefings and selected into MSHA's Program Information Bulletin (PIB-04-18).

Annual Goal 2.2.8 (2012) – Disseminate the findings on the effectiveness of existing engineering noise controls used on bulldozers.
Performance measure: Success will be determined when the results are available to stakeholders via published handbooks, workshops, industry briefings and selected into MSHA's Program Information Bulletin (PIB-04-18).

Annual Goal 2.2.9 (2013) – Disseminate the findings on the effectiveness of existing engineering noise controls used on front end loaders.
Performance measure: Success will be determined when the results are available to stakeholders via published handbooks, workshops, industry briefings and selected into MSHA's Program Information Bulletin (PIB-04-18).

Annual Goal 2.2.10 (2014) – Identify existing engineering noise controls on equipment defined by Intermediate Goal 2.1.10 and 2.1.11 used in all underground mines and evaluate their effectiveness.
Performance measure: This effort will be successful upon completion of a database identifying existing noise controls and their field effectiveness for all underground mines.

Annual Goal 2.2.11 (2016) – Identify existing engineering noise controls on equipment defined by Intermediate Goal 2.1.12 and 2.1.13 used in all surface mines and evaluate their effectiveness. *Performance measure*: This effort will be successful upon completion of a database identifying existing noise controls and their field effectiveness for all surface mines.

Current Projects

None.

Gaps in Knowledge and Technology

Continued collection of data is needed to identify existing engineering noise controls utilized in the construction and mining industries and evaluate their effectiveness and feasibility. Additionally, there is currently little information provided to machinery and equipment users by manufacturers in the construction industry.

Resources

A noise control engineer and an engineering technician who can conduct noise measurements on mining equipment in the field utilizing sound intensity equipment, noise dosimeters and sound level meters is needed. The engineer should have experience with noise control technology, noise acquisition equipment and conducting research projects. The engineering technician should have experience with field studies, acquisition equipment, and with noise measurement techniques.

New Planned Projects to Fill Gaps

2008-2009 Definition and assessment of engineering noise controls for coal mining. (extramural)

2009-2010 Definition and assessment of engineering noise controls for surface coal mining. (extramural)

2009-2010 Definition and assessment of engineering noise controls for bulldozer machines. (extramural)

2009-2010 Definition and assessment of engineering noise controls for construction and shipyard industries. (extramural)

2012-2014 Definition and assessment of engineering noise controls for all underground mines. (extramural)

2014-2016 Definition and assessment of engineering noise controls for all surface mines. (extramural)

Major Planned Achievements

2008

Guidelines for Underground Metal Mine Noise Controls

This publication will provide clear practical guidance about selecting and applying noise control approaches. The document is intended for mine operational support personnel, and will increase the effective use of noise controls while helping to avoid the use of ineffective materials and techniques. Impact will occur through widespread use of the guidelines by the mining hearing loss prevention community.

2009

Guidelines for Underground Coal Mining Noise Controls

This publication will provide clear practical guidance about selecting and applying noise control approaches. The document is intended for mine operational support personnel, and will increase the effective use of noise controls while helping to avoid the use of ineffective materials and techniques.

2010

Guidelines for Surface Mines

This publication will show the relationship between noise source and worker exposure in all surface mines. The database is targeted for industry sector, government agencies, unions, equipment manufacturers, academia, and standard's setting bodies.

2011

Guidelines for all Coal Mining Noise Controls

This publication will provide clear practical guidance about selecting and applying noise control approaches. The document is intended for mine operational support personnel, and will increase the effective use of noise controls while helping to avoid the use of ineffective materials and techniques.

2014

Guidelines for all Mining Noise Controls

This publication will provide clear practical guidance about selecting and applying noise control approaches. The document is intended for mine operational support personnel, and will increase the effective use of noise controls while helping to avoid the use of ineffective materials and techniques.

2016

Guidelines for Construction and Shipyard Noise Controls

This publication will provide clear practical guidance about selecting and applying noise control approaches. The document is intended for mine operational support personnel, and will increase the effective use of noise controls while helping to avoid the use of ineffective materials and techniques.

Intellectual Property and R2P

Transfer recommendations to the mining community, Noise Partnership, to MSHA/OSHA, and

the construction consortium of university, government, industry, and labor organizations.

Intermediate Goal 2.3: Develop feasible engineering noise controls applicable to the machines identified as the top sources of noise overexposure in the construction and mining industries.
Performance measure: The goal will be successful if the sound levels at the operator's position of the targeted machines are reduced by a minimum of 3 dB(A).

Annual Goal 2.3.1 (2007) – Complete the field test (case study) on the cab in a mining/construction environment for insertion into the MSHA PIB.
Performance measure: The goal for the partial cab will be met when the control is listed in the MSHA PIB.

Annual Goal 2.3.2 (2007) - Develop engineering controls on roof bolting machines used in underground coal mines.
Performance measure: The goal related to the development of new engineering controls for roof bolting machines will be met when at least a 3-dB(A)-reduction in sound levels at the operator's position is achieved.

Annual Goal 2.3.3 (2008) – Develop engineering controls on vibrating screens used at coal preparation plants.
Performance measure: The goal related to the development of new engineering controls for vibrating screens will be met when at least a 3-dB(A)-reduction in the average sound level one meter from the screen is achieved.

Annual Goal 2.3.4 (2009) – Develop engineering controls on continuous mining machine cutting systems.
Performance measure: The goal will be met if there is at least a 3-dB(A)-reduction in sound levels at the operator's position of continuous mining machine cutting.

Annual Goal 2.3.5 (2010) – Demonstrate the practicality and applicability of the previously developed vibrating screen noise controls on similar vibrating screens.
Performance measure: Installation of the proven noise controls on various vibrating screens will be successful when at least a 3 dB(A) sound level reduction can be obtained at one meter from the screen.

Annual Goal 2.3.6 (2011) – Develop engineering controls on at least 6 powered hand tools used in the construction industry.
Performance measure: The goal will be met if there is at least a 3-dB(A)-reduction in sound levels at the operator's position of each construction power hand tool.

Annual Goal 2.3.7 (2011) – Prove the practicality and applicability of new noise controls developed on continuous mining machine cutting systems.
Performance measure: Installation of the proven noise control on a continuous mining machine cutting system will be successful when at least a 3 dB(A) sound level reduction can be obtained at the operator's position.

Annual Goal 2.3.8 (2011) – Prove the practicality and applicability of new noise controls developed for the shipyard industry.
Performance measure: Installation of the proven noise controls on at least six different tool/equipment types will be successful when at least a 3 dB(A) sound level reduction can be obtained at the operator's position.

Annual Goal 2.3.9 (2012) – Prove the practicality and applicability of previously developed noise controls on bulldozer machines.
Performance measure: Installation of the proven noise control on various bulldozers will be successful when at least a 3 dB(A) sound level reduction can be obtained at the operator positions.

Annual Goal 2.3.10 (2012) Develop engineering controls on large construction equipment determined by *Strategic Goal 1 of the Hearing Loss Strategic Plan (surveillance data).*
Performance measure: The goal will be met if there is at least a 3-dB(A)-reduction in sound levels at the operator's position of the large construction equipment determined by *Strategic Goal 1 of the Hearing Loss Strategic Plan.*

Annual Goal 2.3.11 (2013) – Prove the practicality and applicability of previously developed noise controls on front end loader machines.
Performance measure: Installation of the proven noise control on various bulldozers will be successful when at least a 3 dB(A) sound level reduction can be obtained at the operator positions.

Annual Goal 2.3.12 (2014) – Develop engineering controls for the equipment identify by Intermediate Goal 2.1.10.
Performance measure: The goal will be met if there is at least a 3-dB(A)-reduction in sound levels at the operator's position of the identified equipment determined by Intermediate Goal 2.1.10.

Annual Goal 2.3.13 (2015) – Prove the practicality and applicability of previously developed noise controls on the equipment identify by Intermediate Goal 2.1.10.
Performance measure: Installation of the proven noise control on various equipment identify by Intermediate Goal 2.1.10.will be successful when at least a 3 dB(A) sound level reduction can be obtained at the operator positions.

Annual Goal 2.3.14 (2016) – Develop engineering controls for the equipment identify by Intermediate Goal 2.1.11.
Performance measure: The goal will be met if there is at least a 3-dB(A)-reduction in sound levels at the operator's position of the identified equipment determined by Intermediate Goal 2.1.11.

Current Projects

Engineering noise controls for roof bolters (10/2004 – 9/2007) MSHA data indicates that the roof bolter is third among all the equipment and second among equipment in underground coal whose operators exceed 100% dosage. Roof bolter operators account for 17 % of the noise overexposures according to MSHA's data. The goal of this research is to reduce the roof bolter operator's noise exposure below the MSHA PEL. This goal will be accomplished by determining the major contributors to the operator's noise exposure during the drilling/bolting cycle and then developing noise controls to reduce the noise generated by these sources.

Engineering noise controls for horizontal vibrating screens (10/2005 – 9/2008)
Data from the Cross-sectional Survey Project indicates that 20 out of 46 surveyed coal preparation plant workers (43.5%) had noise exposures exceeding the MSHA PEL. Sound level measurements taken by the National Institute for Occupation Safety and Health (NIOSH) showed the A-weighted sound levels around a group of eight horizontal vibrating screens ranged from 94 to 98 dB. The goal of this project is to develop engineering noise controls that reduce the A-weighted sound power level generated by horizontal vibrating screens used to process and clean coal by 10 dB. This reduction would result in a 90% reduction in the sound energy generated by the screen and could lead to as much as a 90% reduction in the NIOSH REL noise dose and a 75% reduction in the MSHA PEL dose of a coal preparation plant employee.

Reduction of continuous mining machine noise below 90 dB(A) (10/2006 – 9/2009)
Continuous miner operators account for 35% of the noise overexposures according to MSHA's data. The goal of this study is to develop engineering noise controls for continuous mining machines that would reduce sound levels to below 90 dB(A). This would bring continuous miner operator's noise exposures below the MSHA PEL.

Construction workers' exposure to powered hand tool noise (10/2006 – 9/2009)
This project aims to reduce construction workers' noise exposure and noise induced hearing loss (NIHL) by providing quieter equipment and tools for use on construction sites. This project translates research on sound power level and noise into practical information for powered hand tool manufacturers, buyers, users, and occupational safety and health professionals. The project also partners power tool manufacturers with technical experts in noise control in order to develop and provide quieter tools in the marketplace.

Gaps in Knowledge and Technology

NIOSH has the capability of measuring machinery sound levels and worker noise dose, along with the ability to identify and locate noise sources on equipment. When equipment noise sources are identified, the task of developing noise controls can then be initiated. In order to eliminate trial and error approaches for developing the appropriate treatments, Finite Element Analysis (FEA) may be used to determine stresses and dynamic response. The engineering noise control program has knowledge and technological gaps in the area of FEA. The types of analyses required are linear and non-linear static, fatigue and force response.

Resources

The current resources for the mining sector consist of a total of 6 FTEs for the current three projects. They are three mechanical engineers, one general engineer with a background in electrical engineering, and two technicians. However, these projects and the future projects for the mining sectors still need 3 FTE, one with the experience in FEA and the other two with experience in development of noise controls for large construction and mining equipment. For each current project it requires one engineer to manage the project and one engineer and technician to conduct the lab/field tests and process and analyze the data. Having three additional FTE's, one experienced person in FEA and two experienced in noise control technology, would eliminate trial and error approaches for developing the new noise controls. As far as equipment and facilities the mining sector has the state of the art, except for FEA software.

The current resources for the construction and manufacturing sectors consist of 3 FTEs (both mechanical engineers with emphasis in noise control and vibrations and one engineering technician). Two additional staff with expertise in noise control, FEA and digital signal processing are needed to conduct combine laboratory and field assessment of noise controls for equipment in the construction and manufacturing sectors.

Also, 2 FTEs (one noise control engineer and one engineering technician) over a ten year period will be needed for the construction sector. This will be a combination field and lab based effort. Research gaps will be identified in field surveys while controls will be developed and evaluated in the lab followed by final field effectiveness assessments.

New Planned Projects to Fill Gaps

In the mining sector three new projects will be needed to fill the research gaps for surface and underground coal mines. These projects will involve development and implementation of engineering noise controls for bulldozers, longwall mining system stageloaders, and front end loaders. The operators of these machines account for 84% of the workers in the coal mining sector who are overexposed to noise related to the MSHA PEL. Since the bulldozer and front end loader projects would span across both the mining and construction sectors, personnel from PRL and DART would collaborate to address both sectors at one time. These projects would require three years to complete and the starting dates would be staggered over a three year period starting in 2009. In addition, two other new projects are needed. One focuses on noise reduction in shipyards while the other focuses on noise reduction on construction sites. These projects will demonstrate the feasibility of reducing noise emissions in a cost effective manner and seek "dual use" for noise control solutions developed in other sector's research such as mining.

2008-2011 Engineering noise control study – powered hand tools. This project aims to reduce construction workers' exposure to noise and the resulting NIHL by providing identifying, developing, and evaluating engineering noise controls for machinery, equipment, and power tools used in the construction industry. In addition to design and redesign for quiet, the project includes providing sound power level information to equipment and tool manufacturers, buyers, users, and occupational safety and health professionals. While hearing loss was the single largest category of recordable illness, the construction industry showed only a very modest 0.4 hearing

loss cases per 10,000 construction workers. However, there is no regulatory requirement in the construction industry to have a hearing conservation program (HCP) in place and therefore, the construction industry is the least likely across all industries to provide audiograms and monitoring of their employee's hearing. The low probability of HCP for the construction sector necessitates the development of quiet tools and equipment that reduce the risk of NIHL.

2009-2011 Engineering noise control feasibility study – Puget Sound navy ship yard. This project proposes an in-depth survey of pneumatic and electric power tool usage at the Puget Sound Navy Ship Yard (PSNS). The first phase identifies the tools/equipment to be evaluated or redesigned to lower noise emissions. The second phase develops noise control solution(s) and evaluates the control in the lab in partnership with the tool/equipment manufacturers. The third phase verifies the effectiveness of the noise control in the production environment at the PSNS. This implementation will be in partnership with particular tool, air compressor, and/or air handling equipment manufacturers and the US Navy. This project aims to reduce the shipyard workers' noise exposure and the resulting NIHL by providing quieter equipment and tools for their use. Over 6000 workers at PSNS are adversely affected by noise emissions from the operation of pneumatic and electric power tools. This includes background noise at PSNS from air compressors and other air handling equipment. Department of Defense figures for 2004 show that hearing loss accounts for 5.2% of all compensable claims by Navy civilians. This amounts to $12.7 million in 2004 alone. The PSNS has an annual incidence rate of significant hearing loss of 14%. Conservatively, at least 1 in 10 workers will experience a hearing loss principally due to noise exposure. This project leverages existing working relationships with the Branch Health Clinic at PSNS, and fosters new relationships with tool/equipment manufacturers and distributors.

2010-2013 Reduction of bulldozer noise below 90 dB(A). Bulldozer operators account for 24% of the noise overexposures according to MSHA's data. The goal of this study is to develop engineering noise controls for bulldozers that would reduce sound levels to below 90 dB(A). This would bring bulldozer operator's noise exposures below the MSHA PEL.

2010-2012 Engineering noise controls for longwall mining system stageloaders. (extramural) NIOSH studies have shown that nearly 50% of the full-shift dose measurements of longwall mining system face workers exceeded the MSHA PEL of 100%, or a TWA_8 of 90 dB(A). As a result, an engineering approach to reducing noise exposure to the mine workers on the longwall mining systems is needed. This goal will be accomplished by determining the major contributors to the stageloader operator's noise exposure and then developing noise controls to reduce the noise generated by these sources.

2010-2013 Reduction of front end loader noise below 90 dB(A). Front end loader operators account for 8% of the noise overexposures according to MSHA's data. The goal of this study is to develop engineering noise controls for front end loaders that would reduce sound levels to below 90 dB(A). This would bring bulldozer operator's noise exposures below the MSHA PEL.

2011-2013 Engineering noise controls for large construction equipment. (extramural) The specifics of this project will be determined by *Strategic Goal 1 of the Hearing Loss Strategic Plan.* This project would be needed to fill the research gaps related to the development of noise controls for large construction equipment.

2014-2016 Noise reduction of underground coal equipment identified in Intermediate Goal 2.1.10 below 90 dB(A). The goal of this study is to develop engineering noise controls for the identified equipment by Intermediate Goal 2.1.10 that would reduce sound levels to below 90 dB(A). This would bring operator's noise exposures below the MSHA PEL.

2015-2016 Noise reduction of underground metal/nonmetal equipment identified in Intermediate Goal 2.1.11 below 90 dB(A). The goal of this study is to develop engineering noise controls for the identified equipment by Intermediate Goal 2.1.11 that would reduce sound levels to below 90 dB(A). This would bring operator's noise exposures below the MSHA PEL.

Contracts Needed

In addition to our intramural and extramural engineering controls research efforts, the application of noise control technology to reduce noise in a variety of occupational settings will be evaluated by from universities and noise control experts through contract efforts. At this time the need is in the construction and mining sectors. For the construction sector, a research effort based on the results from the pilot study entitled "Construction Workers' Exposure to Powered Hand Tool Noise" is needed for the development of noise controls for powered hand tools by 2008. For the mining sector, small contracts would be required in the areas of FEA and manufacturing of new noise controls. These projects could start as early as 2008 and continue thru 2012. While expanding our research portfolio, these extramural projects and contracts would provide a mechanism to identify and employ additional engineering noise control researchers.

Major Planned Achievements

2008

Reduce Roof Bolting Machine Noise by 10 dB(A)
Noise treatments on a roof bolting machine will be developed and shown in laboratory evaluations to reduce sound levels at the operator position by 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and show that the controls have sufficient durability to survive in a working underground mine environment.

2009

Reduce Continuous Mining Machine Noise to 90 dB(A)
Noise treatments on a continuous mining machine will be developed and shown in laboratory evaluations to reduce sound levels to at least 90 dB(A). Field tests will be used to confirm the 90 dB(A) reduction and show that the controls have sufficient durability to survive in a working underground mine environment.

Reduce Noise on Vibrating Screens, Utilized in Coal Preparation Plants, by 10 dB(A)
Noise treatments on a vibrating screen will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and

show that the controls have sufficient durability to survive in a working underground mine environment.

2010

Bulldozer Machine Noise Controls
Noise treatments on a bulldozer will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and show that the controls have sufficient durability to survive in a working mine environment.

Engineering Noise Control Workshop
This workshop will be organized together with the Noise Partnership and will give a practical, hands-on to all the effective noise control techniques developed by NIOSH from 2005 to 2009 on prep plants, surface and underground coal mines.

2011

Longwall Mining System Stageloader Noise Controls
Noise treatments on a longwall mining system will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and show that the controls have sufficient durability to survive in a working mine environment.

2012

Front End Loader Noise Controls
Noise treatments on a front end loader will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and show that the controls have sufficient durability to survive in a working mine environment.

Targeted Heavy Equipment Noise Control for Construction
Noise treatments on the targeted heavy equipment will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and show that the controls have sufficient durability to survive in a working environment.
Revision of at least 3 existing standards

Workshops to Promote Noise Reduction in Machinery and Equipment in Construction
Workshops will be conducted which promote the reduction of noise emissions from machinery and equipment through relevant measurements, data reporting, and labeling. Attendance at national and international conferences to share information on reduced noise emitting machinery and equipment. Publication of research articles in peer reviewed journals, of informal articles in trade magazines, and of updated technology breakthroughs on the NIOSH live document web site Noise Control Compendium.

2014

Engineering Noise Control Workshop

This workshop will be organized together with the Noise Partnership and will give a practical, hands-on to all the effective noise control techniques developed by NIOSH from 2010 to 2014 on prep plants, surface and underground coal mines.

2015

Reduce Equipment Noise by 10 dB(A) (Identified by Intermediate Goal 2.1.10)

Noise treatments on the identified equipment by Intermediate Goal 2.1.10 will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A). Field tests will be used to confirm the 10 dB(A) reduction and show that the controls have sufficient durability to survive in a working mine environment.

2016

Reduce Equipment Noise by 10 dB(A) (Identified by Intermediate Goal 2.1.11)

Noise treatments on the identified equipment by Intermediate Goal 2.1.11 will be developed and shown in laboratory evaluations to reduce sound levels 10 dB(A).

Intellectual Property and R2P

Introduction and implementation of engineering noise controls in the workplace is an organizational issue that intersects across management, safety, training, and maintenance departments in an organization. Successful acceptance and implementation at the higher levels of an organization will directly impact the consistent usage and acknowledgement of engineering controls at the employee level.

A successful research to practice effort must have three key components: (1) involvement of stakeholders, (2) a technology transfer plan, and (3) a marketing/dissemination plan. The involvement of stakeholders and a marketing/dissemination plan are imperative to raise industry awareness related to the noise control technologies developed by NIOSH. A “good” technology transfer plan is needed to establish scientific credibility of the research performed. This effort will contribute to new approaches and ideas across all sectors and provide dual-use applications.

Having testimonies from the mine and construction workers will be one way of marketing the technologies to the mining and construction communities. A marketing video on DVD or CD media and a marketing brochure will be developed for distribution to interested parties and made available through the NIOSH website.

Published journal articles and DVD/CD at conferences where NIOSH has a booth will be a way to transfer technology. In addition, publications will be made available on the NIOSH website in downloadable PDF format.

Intermediate Goal 2.4: Motivate and educate the construction and mining industries on the use of new and existing engineering noise controls in the workplace. Activities in Intermediate Goal 4.4 should focus on ways to get management and workers to use effective noise controls.
Performance measure: This goal will be successful if workers and companies acquire, accept, and implement new and existing noise controls for their industries.

Annual Goal 2.4.1 (2007) – Assess the coated flight bars for continuous mining machines.
Performance measure: This effort will be successful when the mining and any other applicable sector is using the coated flight bars and cases of Temporary Threshold Shift (TTS) are decreased by 2%.

Annual Goal 2.4.2 (2008) – Assess the partial cab.
Performance measure: This effort will be successful when mining and any other applicable sector is using the partial cab and cases of TTS are decreased by 2%.

Annual Goal 2.4.3 (2008) - Develop NIOSH Hazard Alert on Noise Emissions from Powered Hand Tools.
Performance measure: Publication of the hazard alert.

Annual Goal 2.4.4 (2009) – Assess the drill steel and mist system for roof bolting machines.
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the mist system and drill steel noise controls and cases of TTS are decreased by 2%.

Annual Goal 2.4.5 (2010) – Assess noise controls for vibrating screens
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the noise controls developed for vibrating screens and cases of TTS are decreased by 2%.

Annual Goal 2.4.6 (2010) – Develop a consortium with leading universities and major manufacturers of machinery and equipment used in the construction and manufacturing industries conducting work in the area of the engineering control of noise. NIOSH will facilitate the activities of the consortium and work to promote the development of a noise control engineering infrastructure within the US. Establish a research consortium of university, government, industry, and labor organizations to examine the application of existing noise controls, identify research gaps, and develop new noise controls where none currently exist.
Performance measure: This effort will be successfully achieved when the consortium has accomplished significant noise reductions (> 3 dB(A)sound power level) on at least 10 different types of machinery and equipment targeted for noise reduction.

Annual Goal 2.4.7 (2010) - NIOSH is represented on at least 2 national or international committees dedicated to the promotion and creation of an independent organization focusing on design and implementation of engineering noise controls.
Performance measure: Committee/partnership is formed and meeting periodically.

Annual Goal 2.4.8 (2010) - Noise Control Compendium – Contract a revision, final review and formatting of NIOSH's revised Noise Control Compendium for publication as a functional, interactive technical website on noise control materials, techniques, and case studies.
Performance measure: Compendium is posted on NIOSH's web site as a live interactive technical document/clearinghouse of existing noise control technology.

Annual Goal 2.4.9 (2011) – Assess noise controls for continuous mining machine cutting systems.
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the noise controls developed for the continuous mining machine cutting systems and cases of TTS are decreased by 2%.

Annual Goal 2.4.10 (2012) – Assess noise controls for the bulldozer machine.
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the noise controls developed for the bulldozer machine and cases of TTS are decreased by 2%.

Annual Goal 2.4.11 (2013) – Assess noise controls for the front end loader machine.
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the noise controls developed for the front end loader machine and cases of TTS are decreased by 2%.

Annual Goal 2.4.12 (2015) – Assess noise controls for the equipment identify by Intermediate Goal 2.1.10.
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the noise controls developed for the equipment identify by Intermediate Goal 2.1.10.and cases of TTS are decreased by 2%.

Annual Goal 2.4.13 (2017) – Assess noise controls for the equipment identify by Intermediate Goal 2.1.11.
Performance measure: This effort will be successful when the mining and any other applicable sectors is using the noise controls developed for the equipment identify by Intermediate Goal 2.1.11.and cases of TTS are decreased by 2%.

Current Projects

None.

Gaps in Knowledge and Technology

Continued and effective use of noise controls requires support from every level from owners and management to workers and maintenance personnel. Methods to communicate and document the value of noise controls must be developed

Resources

None.

New Planned Projects to Fill Gaps

2009-2016 Promote adoption of effective mining noise controls. This project is needed to develop and evaluate guidelines and other resources that will promote adoption of effective mining noise controls identified in intermediate goals 2.2 and 2.3.

2011-2014 Promote adoption of effective powered hand tool and shipyard noise controls. This project is needed to develop and evaluate guidelines and other resources that will promote adoption of effective powered hand tool noise controls identified in intermediate goals 2.2 and 2.3.

2013-2016 Promote adoption of effective large construction equipment noise controls. (extramural) This project is needed to develop and evaluate guidelines and other resources that will promote adoption of effective large construction equipment noise controls identified in intermediate goals 2.2 and 2.3.

Major Planned Achievements

Documentation of the effectiveness and use of noise controls will require success in several other intermediate goals of this strategic plan. Intermediate Goals 1.1, 2.1, 2.2, 2.3 and 4.4 are all integral to achieving and documenting reduced exposures to noise hazards. Once successful noise controls are developed, implemented, tested and gain acceptance, the incidence of new cases of noise-induced hearing loss should decrease as documented by surveillance efforts.

Strategic Goal 3: To Reduce Hearing Loss through Interventions Targeting Hearing Protection Devices

Background

Although the use of personal protective equipment ranks third behind engineering and administrative controls in the hierarchy of solutions for reducing occupational noise exposure, hearing protection devices have been increasingly relied upon as the primary means to reduce the noise exposures for workers. Based on data from several decades of research, the performance of hearing protection as measured in the laboratory environment differs considerably from the performance measured in real-world settings. The methods used to assess real-world performance have advanced to allow objective measurement of insertion loss of hearing protection performance. Because attenuation is closely related to insertion loss, the real-time performance of an HPD can be measured and (with careful analysis) should be correlated with traditional dosimetry. The differential risk for impulsive versus continuous noise has brought to the forefront the need to understand the performance of HPDs in moderate to high level impulsive environments. Currently, methods to assess the effectiveness of HPDs for impulsive noise are limited to mannequin or acoustic test fixture measurements. Finally the effect of hearing protection on the ability to communicate in noise has not been an area of focused research within the Hearing Loss Research Program. Specific guidelines for the selection of HPDs for use in noise must be supplemented with recommendations for different types/styles of hearing protectors.

Performance Measures: The successful outcome of this strategic goal will be measured through the development of documents, adoption of recommendations by industry and the development of consensus standards that influence the practice of hearing loss prevention. NIOSH has provided guidance through its Hearing Protection Device Compendium (www.cdc.gov/niosh/topics/noise/hpcomp.html), which has largely focused on passive devices and includes little information about the aforementioned research areas. One of the outcomes of this goal will result in a revised compendium with areas focused on research to practice (r2p), communicating the latest results of laboratory research. The compendium will incorporate hearing protection training tools accessible to small businesses and the consumer. Second, NIOSH's involvement with consensus standards setting bodies provides a unique opportunity to have NIOSH recommendations accepted as the "best practices" for industrial hygiene and safety within the workplace. Standardized methods for fit-testing, determining speech intelligibility and assessing the acoustic impulse performance of HPDs will be developed and validated. Just as fit-testing is required in any OSHA or MSHA respiratory protection program, NIOSH recommendations for fit-testing of hearing protection will be adopted OSHA and MSHA in future rules for hearing conservation and guidelines in non-mandatory appendices. NIOSH will partner with audiometer manufacturers to integrate fit-testing with new models of audiometers. Methods for assessing acoustic impulse performance will be included as a part of EPA regulations to label the performance of hearing protection devices. The adoption of NIOSH recommendations for hearing protection devices will provide a third method of assessing the importance of our recommendations.

Intermediate Goal 3.1: Develop and evaluate and disseminate effective fit-testing systems for use in occupational settings to determine performance of hearing protection devices

Hearing protection devices are only as effective as the person's ability to properly fit the protector. Franks et al. (2003) demonstrated that subjective fit-test methods exist which provide reasonable approximations to the standard laboratory methods for testing hearing protector attenuation. However, the current subjective laboratory procedure is time consuming when estimating hearing protector attenuation at several frequencies. Research in this area will test existing fit-test methods to determine accuracy, efficiency and cost-effectiveness. Before industrial partners will accept fit-testing, the testing time must be reduced and it must also be demonstrated that fit-testing improves the match of workers to hearing protection. Specifically, subjective methods require more robust software and efficient algorithms with appropriate correction factors when using large volume circumaural headphones. As well, newly-developed objective methods require verification of performance which accurately compensates for known differences between real ear attenuation at threshold (REAT) and insertion loss measurements.

Performance Measure: This goal will be successfully achieved if by 2016, fit-testing methods have been evaluated and NIOSH recommendations for implementation of hearing protection fit-testing are adopted by professional organizations such as the American Speech-Language Hearing Association, the Council for Accreditation in Occupational Hearing Conservation, or the National Hearing Conservation Association for inclusion in hearing loss prevention programs. Further evidence of success under this intermediate goal is the inclusion of a fit-testing element in the OSHA and MSHA regulations for hearing conservation programs to document the ability of a worker to properly fit hearing protection.

Annual Goal 3.1.1: (2008) Develop a multi-subject fit-test system for use in a hearing loss prevention program

This goal is the subject of an existing project (CAN 92700AE) designed to evaluate the psychometric methods which will permit fast and efficient assessment of an individual's hearing threshold. Coupled with this effort, a multi-subject prototypical fit-test system has been developed. This effort will leverage resources for hearing protector testing and rating research as well as work to implement a single-subject fit-test system in an existing hearing loss prevention program. One approach to implementing the fit-test would be to couple the annual audiometric test with the fit-test. To accomplish this, research is needed to develop a large-volume audiometric headphone which will not interfere with insert earplugs. The test system must also be capable of generating sufficiently high sound pressures to permit testing of persons with moderate levels of hearing loss when their ears are occluded by the protector.

Current Projects:

Audiometry and fit-testing (10/2004 – 9/2007).

Gaps in Knowledge and Technology:
For this goal, the knowledge already exists to develop testing and to implement such a system. The technology has not been applied to developing a multi-subject fit-testing system. Reliable

algorithms for assessing threshold exist, but must be coupled with audiometric pure-tones tests to reduce the test burden. Finally a gap in knowledge for transfer functions of the pure-tone to unoccluded noise band threshold needs to be validated.

New Projects:

None are needed.

Extramural Effort:
A contract to complete a series of measurements is needed to have several laboratories carefully quantify the pure tone threshold under headphones to noise-band unoccluded diffuse field threshold.

Resources needed: The effort currently has 0.7 FTEs and $10000 discretionary funding assigned to it, but realistically needs 2 or 3 FTEs to complete the goals of the project and $50,000-$100,000 funding to permit the development of the multi-subject fit-test system into a commercially viable program as well as to fund the development of the audiometric headphone.

Major outcome: Provide industry with test methods that accurately and efficiently assess real-world noise attenuation (i.e. assess how a particular hearing protector is worn in the workplace). Recommendations will be produced based upon NIOSH research and integrated into revised versions of the NIOSH Hearing Protection Device Compendium.

Intellectual Property and r2p:
The knowledge of how to create such tests already is available in the published literature and the fit-test technique has been described in public domain NIOSH publications. The development of a new large-volume circumaural audiometric headphone represents an opportunity for research to practice. Another possible r2P effort would be sharing our development of the multi-subject fit test system with the manufacturers of audiometry testing equipment.

Annual Goal 3.1.2: (2012) Evaluate the performance of objective fit-test systems in laboratory and real-world settings

Recently, two companies (Custom Protect Ear and Sonomax Hearing Healthcare) have developed objective fit-test systems using a transmission loss measurement to assess the quality of the seal of a subject's hearing protection device. Both of these systems have been designed for use with a vented custom hearing protection device. The Sonomax system is being modified for use with traditional earplugs through an exclusive licensing arrangement with Aearo/E•A•R Inc. Such a system presents the potential for a quick evaluation of earplug seal and could be integrated into existing hearing loss prevention programs. The objective method is attractive due to the lack of reliance upon the worker's state of hearing. That is, even workers with significant hearing loss could be evaluated.

Current Projects:

None.

Gaps in Knowledge and Technology:

For this effort, the gap in knowledge is primarily in the area of understanding the relationship between transmission loss and real ear attenuation at threshold measurements. Sonomax and Aearo Technologies have begun to develop this foundational set of measurements, but it may be useful for the product manufactured by Aearo/EAR. Similar measurements can be collected for earmuffs for the purpose of objective fit-testing.

New Projects:

2009-2012 Evaluation of objective fit-test systems in laboratory and real-world settings. The development of objective insertion loss or transmission loss methods to assess the performance of HPDs will require a focused effort to validate the system against the traditional Real Ear Attenuation at Threshold technique. This project could be proposed for an FY2009 small NORA effort. While existing staff have the expertise to conduct this research, an additional staff member would be needed to accomplish this effort.

Extramural Efforts:

None.

Resources needed: Currently, no projects exist in this new area of investigation. Since the technology has already been developed, it would be of interest to perform a head-to head comparison of the objective system with a subjective system in an existing hearing loss prevention program. One to two FTEs would be appropriate to complete the research over a 5-year period and could be drawn from existing DART or PRL staff. A project for NORA funding will be proposed for fiscal year 2009. The effort will require approximately $50,000-$75,000/year during the project to fund the equipment purchases and travel to the study site.

Major outcome: This project will evaluate the time required to collect these results on workers as a part of the hearing loss prevention efforts and it will assess the incidence rate of significant threshold shifts correlated with implementing the objective and subjective fit-test systems. From these data, recommendations for the integration of objective and/or subjective fit-test systems into HLP programs will be developed.

Intellectual Property and r2p:

The research developed as a result of this effort would not be patentable. The results of this research would be useful in designing recommendations for the implementation of objective fit-testing as a section of the Practical Guide to Hearing Loss Prevention Programs as well as a revised NIOSH Criteria Document on Occupational Noise Exposure.

Intermediate Goal 3.2: Develop Methods for assessing acoustic performance and utilization of hearing protection devices in the presence of impulsive noise between 120 and 170 dB peak SPL

Hearing protection devices have been used as a means to protect workers exposed to high-intensity, short duration sounds produced typically by objects colliding (impact noise) or by an explosive release of energy (impulse noise). While the fundamental physics of the impact and impulse waveforms are different, both are characterized by a rapid increase in pressure with a slower decay of sound energy as the event dissipates. Peak sound pressure levels in excess of 120 decibels (dB) are generally classified as impulsive noise. OSHA regulations prohibit exposure to peak levels in excess of 140 dB; immediate damage to a person's hearing can result from single exposure in excess of this level.

Earplugs and/or earmuffs are often the only protection for exposures above 140 decibels. Because peak levels at or above 140 dB are no longer governed by linear assumptions of acoustics for lower levels, the attenuation of a protector must be determined as a function of level. To accomplish such measurements, appropriate testing methods must be developed for both acoustic test fixtures and for human subjects when assessing the performance of hearing protection devices in the presence of impulsive noise. The methods must be tested with several types of protectors so that recommendations can be produced. As well, electronically enhanced hearing protectors present a unique challenge to understanding the performance of transducers and associated circuitry when used in extreme acoustic environments. Consequently, the stability of the entire protector circuitry will need to be tested in a standardized manner.

Performance Measure: This goal will be successfully achieved if recommended testing standards for the performance of hearing protection devices in the presence of impulsive noise are adopted by NIOSH and consensus standard setting organizations. NIOSH will incorporate these testing methods either into a revision of the Recommended Criteria for Exposure to Occupational Noise or as a part of the NIOSH Hearing Protection Device Compendium. The recommendations will be submitted to consensus standard setting organizations such as the American National Standards Institute and the International Standards Organization for consideration. Adoption of these testing standards by federal or state agencies, other governments or consensus standard setting will be considered successful completion of this goal.

Annual Goal 3.2.1: (2012) Develop methods for the measurement of hearing protector attenuation in the presence of impulsive noise.

Hearing protection devices are currently not evaluated for response to high-level impulsive noise at levels exceeding 120 dB peak sound pressure level. The US Army, Air Force and NIOSH have been interested in the potential for damage to hearing due to impulsive noise exposure. Accordingly, some measurements have been conducted using mannequins and even fewer measurements have been made with actual subjects where free-field peak levels exceed 140 dB. NIOSH researchers have renewed an interest in this area due to the increasing numbers of industrial exposures which approach the 140 dB peak limit mandated by OSHA and MSHA. NIOSH will propose measurement methods for use with an acoustic test fixture to assess the transfer function of a hearing protector while mounted on the test fixture. These

recommendations will be provided to the American National Standards Institute and the International Standards Organization for the basis of a related measurement technical specification or standard.

Current Projects:

None

Gaps in Knowledge and Technology:
The development of models for the performance of HPDs in impulsive noise is a major missing component for the knowledge of this research. Suitable microphones for use underneath all types of hearing protectors present a gap in technology that must be overcome. Due to the lack of attenuation at high frequencies, probe tube microphones are inadequate for this type of measurement at high intensities.

New Projects:

2009-2012 Develop methods for the measurement of hearing protector attenuation in the presence of impulsive noise. This project will conduct a series of laboratory and field studies to verify the methods which have been studied under current interagency research effort for the US EPA. The project will need to work closely with external partners to collect in-situ protected and unprotected data from real world occupations.

2010-2013 Impulse test fixture Small Business Innovation Research grant (extramural) This project could potentially be accomplished with an RFA in coordination with the Dept. of Defense.

Resources needed: No existing internally funded research projects are devoted to this goal. DART has one project (CAN 92700AF) devoted to the effects of impulsive noise on hearing. This project is focused on developing measurement equipment for use in free-field conditions. DART also has an interagency agreement which is closely related to methods development. The US EPA has provided funding for NIOSH to conduct research in testing and rating methods for hearing protection devices. A portion of this effort has been devoted to assessing the performance of protectors in the presence of impulsive noise. Approximately 3 FTEs are devoted to the EPA and Impulsive Noise effort. To complete this effort, one FTE will be needed to develop standards for impulsive noise measurement for hearing protection devices. Funding over the course of 4 years will require initially $40,000 and decreasing to $25,000 per year to provide measurement instrumentation, transducers appropriate for high-level measurement.

Major outcome: The development of standards would constitute the outcome for this goal. Practical guidelines exist for measuring impulsive noise, but no standards exist for the assessment of the performance of hearing protectors in impulsive noise.

Intellectual Property and r2p:
The results of this effort would be recommendations for the Criteria Document and Compendium of Hearing Protection Devices. If a sufficiently large population of protectors were surveyed, then the results could be incorporated into Army's damage risk criteria.

Intermediate Goal 3.3: Develop methods for assessing the speech intelligibility for hearing protection devices when worn in noise.

Current hearing conservation regulations and hearing protector fitting procedures do not address the issue of decreased speech intelligibility when hearing protection is worn. The inability to understand speech is a commonly cited reason for misuse of hearing protection in noisy environments. When workers are unable to communicate effectively, they commonly remove the protection in an effort to boost the level of the speech. The development of electronically enhanced or uniformly attenuating hearing protectors offers some hope for improving communication in noisy settings. NIOSH has identified speech intelligibility as a research need in the 1998 Criteria for a Recommended Standard for Occupational Noise Exposure.

Several laboratory tests have been developed over the years to attempt to assess speech intelligibility. NIOSH will evaluate the acoustical characteristics of various hearing protective devices, with an emphasis on optimizing the balance between under-/over-protection, effectiveness, and communication ability. From the results of these evaluations, and a comprehensive review of the scientific literature, recommendations for the best practices to assess speech intelligibility from physical acoustic measurements will be developed. Methods to improve the audibility of important sounds while wearing hearing protectors will be identified. Without the benefit of knowing to what extent each hearing protector affects speech intelligibility for a given acoustic environment (and employee's hearing status), the best device may not always be selected.

Performance Measure: NIOSH will develop a set of recommendations for the acoustic evaluation of hearing protection devices useful for the prediction of speech intelligibility in noisy environments. A guidance document for how to select hearing protection based upon the acoustic attenuation and speech intelligibility will be developed. As a corollary to this research, these recommendations may have application to the integration, protection and rehabilitation of hearing impaired workers into the occupational setting when noise is prevalent. NIOSH recommendations will be proposed for adoption OSHA and MSHA in the non-mandatory appendices. Further evidence of successful completion of this goal will be the approval of a consensus standard by the American National Standards Institute and the inclusion of NIOSH recommendations in policies of professional organizations such as the American Academy of Audiology or the Council on Accreditation in Occupational Hearing Conservation.

Annual Goal 3.3.1: (2008) Develop a standard assessment protocol that will allow hearing conservation professionals to recommend appropriate accommodations for noise-exposed, hearing-impaired workers.

The large NORA noise program initiated in 2000 contained a project entitled "Accommodation of Noise-Exposed, Hearing-Impaired Workers." The goal of this project was to develop a simple

assessment and intervention protocol that will allow hearing conservation professionals to recommend appropriate accommodations for noise-exposed, hearing-impaired workers. The final year of this project will be used to fully analyze laboratory data collected in an earlier phase of the project, and produce two or more scientific journal articles describing the laboratory results.

Current Projects:

None. This goal is meant to complete the research proposed in the previous large NORA program for noise.

Gaps in Knowledge and Technology:

The technology and knowledge exist, what this represents is a validation of a method for use in a hearing loss prevention program.

New Projects:

None.

Extramural Efforts:

None.

Resources needed: We will be working with Babette L. Verbsky, PhD who returned to NIOSH as a visiting scientist, and who personally conducted most of the earlier laboratory research. Completion of this analysis will require minimal funding.

Major outcome: The assessment protocol includes: (a) a questionnaire to gather information from the individual worker regarding the unique difficulties caused by the working in a noisy environment with a hearing loss; (b) an evaluation of the worker's particular noise exposure; (c) audiometric testing, with an emphasis on evaluating the worker's ability to hear speech; and (d) the worker's performance with different hearing protection options.

Intellectual Property and r2p:

This project will produce a set of recommendations appropriate for inclusion in a revised Criteria Document on Occupational Noise Exposure.

Annual Goal 3.3.2: (2009) Evaluate various styles/types of hearing Protection devices for effects (either advantageous or detrimental) on speech intelligibility in industrial noise environments.

Statistics show that workers in service and "blue-collar" occupations are over-represented among those individuals reporting hearing difficulty. Therefore, several million hearing-impaired workers in manufacturing, construction, and other occupational sectors are required to wear hearing protection, yet the combined effect of their hearing loss and the type of hearing protector

worn may interact to provide a less-than-optimal listening condition. This problem can have serious consequences, considering that a study of older workers with disabilities indicated hearing loss as a risk factor for occupational injury (Zwerling et al, 1998). Current hearing conservation standards, regulations, and practices do not address the problem that a hearing loss could be both a health and a safety issue in the workplace.

Current Projects:

Hearing protection of hearing impaired workers (10/2006 – 9/2009).

Gaps in Knowledge and Technology:

For this goal the technology exists, but the knowledge is lacking about how different types of protectors are best used for continuous or intermittent noise. Specifically, electronically enhanced protectors (i.e. sound restoration or active noise cancellation) may be better suited for specific noise environments.

New Projects:

None.

Extramural Efforts:

None.

Resources needed: A currently funded project (CAN 921Z6KN) is designing a method to collect data regarding the effects of hearing protectors on speech intelligibility. This project will generate the necessary but currently unavailable data through controlled laboratory studies, and will integrate speech intelligibility information obtained from the scientific literature and other hearing loss prevention professionals.

Major outcome: The overall objective of this project is to identify and/or predict when the audibility of important sounds can be improved while wearing hearing protectors. The final product from this research would be the compilation of enough data to support the development of a new national standard for evaluating the ability to communicate while wearing hearing protection.

Intellectual Property and r2p:

One potential tool that could be developed from this effort is a computer-based speech intelligibility test that would aid the worker or hearing conservationist to select appropriate protection for use in different environments. The principal result will be recommendations for the Compendium of hearing protection devices and the revision of the Criteria Document on Occupational Noise Exposure.

Intermediate Goal 3.4: Develop, evaluate and promote new technologies that improve hearing protection devices for acceptability and usability.

Hearing protection devices largely come in three flavors, muffs, plugs or canal-caps. Many workers are unaware of hearing protectors that utilize active noise reduction, sound-restoration or communication systems. Workers commonly complain of the inability to hear warning signals or identify problems with equipment due to the attenuation of the protector. This goal would examine methods for incorporating proximity warning signals into a hearing protection device that don't rely on the airborne transmission of warning signals. The development of technologies which improve the communication between workers would be examined within this goal. Methods for assessing the acceptance of a hearing protection device have not been researched. Obvious methods include focus group testing, market surveys and attitude and belief surveys. Through the fostering of partnerships with manufacturers and end-users of HPDs, assessment methods can be validated.

Performance Measure: The performance measure for this goal is based on two elements. The first is the creation of a set of metrics for evaluating the comfort of hearing protection. Informative guidance will be developed to aid potential purchasers in the evaluation of the comfort of hearing protection. The second project will develop a new patentable technology for hearing protection. Neither of the annual goals under this intermediate goal will result in changes to OSHA, MSHA or EPA regulations.

Annual Goal 3.4.1.: (2008) Development of Assessment metrics for usability and acceptability.

Currently one project (CAN 927006D) has been focused on investigating the role of comfort in hearing protection selection. The project has conducted a large real-world study which tested the acceptability of a semi-custom molded protector with a population of about 100 workers. At the same time, the project field tested the NIOSH Attitudes and Belief Survey for hearing protection. The survey did not yield conclusive results demonstrating any particular pattern of response and the choice of hearing protector. The project is continuing to research issues related to the extraction force of an earplug, earmuff clamping force, heat and humidity underneath an earmuff.

Current Projects:

Comfort as a Predictor of hearing protectors use (10/2004 – 9/2007)

Gaps in Knowledge and Technology:

This project represents more gaps in knowledge about what physically measurable features constitute a comfortable hearing protector. The trade off between clamping or expansion force and attenuation need to be measured to allow for the knowledge gap can be closed.

New Projects:

None

Extramural Efforts

None

Resources Needed: Currently one FTE is assigned to this project effort, but the project has no discretionary funds to conduct further research. Additional funds are needed to advance the work beyond the data which has already been gathered.

Major outcome: This goal will validate methods for measuring the acceptability of HPDs and for assessing the comfort of hearing protectors.

Intellectual Property and r2p: The project will not result in patentable technology, but the information developed from this research could provide recommendations for the design of earplugs and muffs.

Annual Goal 3.4.2.: (2014) Development of non-auditory Proximity warning systems for hearing protection devices.

Hearing protection devices are designed to attenuate sound levels to safe limits of exposure. Warning signals are typically provided in an auditory format as a pulsed alarm with a high volume. To ensure that warning signals are provided directly to the worker, the warning signal could be provided via local proximity broadcast. These warning signals would be broadcast within the user's hearing protection to provide an increased signal to noise ratio.

Current Projects:

None

Gaps in Knowledge and Technology:

To date radio-frequency or local broadcast warning signals have not been implemented for backup alarms or proximity warning devices. The technologic gap is one which an experienced electronics device manufacturer would need to partner with a protector manufacturer to develop such a system.

New Projects:

2012-2015 Development of non-auditory proximity warning systems for hearing protection devices (extramural)

Resources needed: DART and PRL currently have no projects in this area. New project funding would need to be pursued either through intramural or NORA funding mechanisms. The development of enhanced electronic protectors would require the development of both the transmission and reception technology which would be incorporated with proximity warning systems and hearing protection. A significant amount of funding will be required to design and develop circuitry in conjunction with industry manufacturers.

Major outcome: The creation of a new style of proximity warning system would be the principal product from this portion of the strategic goal. This system could potentially be licensed to PPE manufacturers.

Intellectual Property and r2p: This goal could result in a patentable product that would have commercial potential.

Intermediate Goal 3.4: Develop Tools to facilitate hearing protector selection for protector use.

To increase hearing protector use among worker resistant to using HPDs, workers must be educated to the hazards noise exposure and informed about the wide range of protectors that are available. As well, hearing loss education efforts in primary and secondary school will raise the awareness of persons entering the workforce. NIOSH currently has a limited scope of tools available on the CDC internet. While the information is current, it suffers from a poorly designed interface and from a confusing array of information. The goal of this effort will be to design better selection tools that focus more upon the job and potential environment where the protection will be used. From studies conducted with naïve users, group and one-on-one training improved the attenuation that users were able to achieve.

Performance Measure: The completion of a revised on-line NIOSH Compendium of Hearing Protection Devices will be the first measure of success for this goal. The revised compendium should incorporate web-based training for the selection and fitting of protection.
These studies demonstrate the point that testing with naïve subjects will yield lower estimated ratings than if the subjects were trained or instructed. What has not been demonstrated is whether subjects with limited experience and focused training achieve comparable attenuation to similarly trained persons in real-world occupational settings where hearing protection is typically required.

Annual Goal 3.5.1: (2012) Redesign the NIOSH Compendium of Hearing Protection Devices

The project will determine the shortcomings of the current Compendium, analyze of the needs of users of the Compendium; redesign the underlying data structures, access methods and interface; and test the new Compendium. During the first and second years of this goal, the project protocol will be developed and Office of Management and Budget approval package will be obtained. Once approval has been obtained, usability testing of the current Compendium can be conducted. The second and third years of the project will be devoted to collecting data on methods to present information effectively to the end-user. The development of database structures necessary to

code the interface of the Compendium will be completed in the beginning of the second year. Preliminary versions of the interface will be developed at the end of the second year and the beginning of the third year. The redesigned Compendium will be completed and usability testing will be conducted in the third year. The completed Compendium will be submitted for NIOSH OD approval, and ITSO certification and verification at the end of the third year and will be posted on the CDC web site during the fourth year.

Current Projects:

None

Gaps in Knowledge and Technology:

This goal addresses a shortcoming in the current NIOSH Compendium of Hearing Protection Devices. Changes in the manner in which information is presented to the user are being addressed. In order to accomplish this, knowledge about how people need to access hearing protector information.

New Projects:

2009-2012 Electronic NIOSH compendium of hearing protection devices. Preliminary development of the revised Compendium interface has been conducted through the EPA interagency agreement. The project will seek to accomplish many of the goals proposed in the intermediate goal 3.5: Develop tools to facilitate hearing protector selection and use. The primary effort will be the redesign of the current HPD compendium. Focus group testing designed to assess the usability of the current compendium will be conducted. Suggestions for the redesign will be incorporated and will work to develop a selection matrix based upon occupations and jobs that workers engage in rather than focusing upon the noise level about which most workers are ignorant.

Resources needed: At least one FTE will be needed to guide the research related to this goal. Additional funds will be required for hiring a programmer that can develop web-based applications within the framework of the CDC specifications.

Major outcome: The redesigned web page will be the most significant outcome for the first year's effort on this strategic goal.

Intellectual Property and r2p: No intellectual property rights are anticipated. The r2p for the project will be the development of a different method of identifying hearing protection based around the type of job rather than being focused on the noise levels of the task. The evidence-based recommendations developed from Intermediate Goals 3.1, 3.2, 3.3, and 3.4 will be incorporated into the narrative sections which accompany the Compendium.

Annual Goal 3.5.2: (2014) Develop and evaluate web-based training tools

The creation of a range of on-line training tools will be provided to internet user to assist them in learning proper techniques for fitting and choosing hearing protection devices. The redesigned Compendium will provide a means of matching the job with certain types of protection, but the specific protector which is chosen will still require a level of training to achieve a good fit. In this annual goal, the development of materials which facilitate this training will be accomplished. The training will primarily be video based. With some advances in technology, other training modes might be employed such as interactive test and measurement.

Current Projects:

None

Gaps in Knowledge and Technology: In some respects there is not a gap in technology in the sense that we have the capability to produce training videos and web-based materials appropriate for this goal. However, determining how to develop materials which are effective and whether the training is applicable to a broad range of industries represents the knowledge gap.

New Projects:

2012-2014 Develop and evaluate web-based training tools. (extramural) The work could be conducted through contracts with web-designers and video production companies. It could also be accomplished through contracting with universities for development and focus group testing.

Major outcome: The web-based tools will be the primary outcome from this annual goal. The tools will be available to users for download or accessible through the CDC/NIOSH website.

Intellectual Property and r2p: The web-based training tools might have some element of intellectual property. The tools would fall within r2p since they would be available to industries and hearing protector manufacturers for use within their hearing loss prevention programs.

Current Projects

Schemes and methods for testing and rating hearing protection devices (2007-2010)
Schemes and methods for testing and rating hearing protection devices (2007-2010)
These two projects represent the direct and reimbursable funds for the work being completed for the Environmental Protection Agency related to the revision of the Hearing Protection Labeling Regulation 40 CFR 211 Subpart B. The effort has included completion of interlaboratory studies and investigation of performance of HPDs in impulsive noise. The project is scheduled to end in 2010 when the latest interagency agreement expires.

Audiometry and fit-testing (2004-2007) The focus of the project has been the development of integrated fit-testing and audiometric methods for hearing protection devices. Part of the effort has been to develop more efficient test protocols and another portion has been the development of a multi-subject fit-test system. A third effort which has suffered due to a lack of funding is the

development of a large-volume audiometric headphone suitable for both audiometry and fit-testing.

Comfort as a predictor of effective hearing protector use (2005-2008) This project expires in 2008. The project has completed a large real-world study of hearing protector use and a survey of related comfort. The project is also going to examine the effects of force necessary to extract a protector as well as the headband clamping force and heat and humidity underneath the protector.

Hearing protection for hearing impaired workers (2007-2009) The overall objective of this project is to identify methods to improve the audibility of important sounds while wearing hearing protectors. Currently, no standard test method exists for the evaluation of a hearing protector's effect on speech intelligibility. Therefore, data regarding the effects of a particular protector on speech intelligibility are not readily available from the manufacturer. Without the benefit of knowing to what extent each hearing protector affects speech intelligibility for a given acoustic environment (and employee's hearing status), the best device may not always be selected. This project will generate the necessary but currently unavailable data through controlled laboratory studies, and will integrate pertinent information obtained from the scientific literature and other hearing loss prevention professionals.

Worker empowerment interventions for hearing loss prevention (2006-2009) This project can be spread between strategic goals 3 and 4. The main output of the project will be a web-based and printed implementation guide to assist other operations in creating more effective hearing loss prevention programs. These communication products will provide easy access to the "best practices" tools and show, by example, how these can be adapted to a specific work setting through participatory teams. In addition, the project will generate a continuing stream of communication products (training pages, interactive software, etc.) that can be distributed and used independently from the entire conservation program. The project has some overlap with the development of tools for assisting in the selection of hearing protection devices and has conducted research on simplified training techniques to facilitate better use of hearing protection.

Hearing protection and audibility considerations II (2007-2009) The long term objective of this project is to identify methods to improve the audibility of important sounds while wearing hearing protectors. The availability of optimally selected hearing protectors will provide a degree of protection and safety beyond what is currently attained in most mining environments. A primary outcome of this investigation is to develop a detailed knowledge base regarding the ability to communicate and hearing warnings while using different types of hearing protection devices.

Knowledge and Technological Gaps

Within the intermediate goals listed above, several areas require further research to complete the goals. Particularly, the assessment of HPDs for use in impulsive noise, development of proximity warning systems that don't rely solely on acoustic transmission, the development of better methods for speech intelligibility and the development of web-based tools for hearing protector selection are areas which require greater infusion of knowledge both in the body of literature and

in the areas of researchers within NIOSH with the ability to achieve these goals. While we have personnel that are expert in the measurement of impulse noise or in designing electrical circuitry, they are not currently focused on the problems proposed in the intermediate goals. NIOSH has access to computer programmers, but the hearing loss research program does not have personnel directly within the respective sections at PRL or DART that are dedicated to software development. Speech intelligibility and the selection of devices for hearing impaired workers will require research that is currently underway to develop evidence-based recommendations for hearing loss prevention.

Research 2 Practice

Within each of the annual goals, the r2p products are described. The principal elements will be the revision of the NIOSH hearing protection device compendium; the development of a warning device that would integrate non-acoustic transmission methods with hearing protection devices; and recommendations for uses, applications and ratings for HPDs that can be incorporated into the revision of the NIOSH Criteria Document for Exposure to Occupational Noise.

Intellectual Property

The only item which might present intellectual property would be the development of a non-acoustic transmission of warning signals.

Personnel assigned to Strategic Goal 3:
(6.25 FTEs assigned to this)

CAN 9278344: (0.85 FTE) Hearing Protector Testing Methods and Rating Schemes

William J. Murphy, Ph.D.	0.25 FTE
David C. Byrne, M.S. CCC-A	0.20 FTE
Pamela S. Graydon	0.20 FTE
Mark R. Stephenson	0.20 FTE

CAN 92100AE: (0.55 FTE) Audiometry and Fit-Testing

William J. Murphy, Ph.D.	0.25 FTE
Pamela S. Graydon	0.20 FTE
David C. Byrne, M.S. CCC-A	0.10 FTE

CAN 9217451: (0.1 FTE) Accommodation of Noise-exposed, Hearing Impaired Workers

David C. Byrne, M.S. CCC-A	0.10 FTE

CAN 921Z6KN: (0.5 FTE) Hearing Protection for Hearing Impaired Workers

David C. Byrne, M.S. CCC-A	0.50 FTE

CAN 927006D: (1.1 FTE) Comfort as a Predictor of Effective Hearing Protector Use

Rickie R. Davis, Ph.D	0.90 FTE
Pamela S. Graydon	0.20 FTE

CAN 927Z6NN: (0.8 FTE) Hearing Protection and Audibility Considerations II

Theresa Schulz, Ph.D.	0.30 FTE
Roberta Hudak, R.N.	0.20 FTE
Arthur J. Hudson	0.30 FTE

CAN 927Z4QT: (2.35 FTE) Worker Empowerment Interventions for Hearing Loss Prevention

Roberta Hudak, R.N.	0.70 FTE
August Kwitowski	0.30 FTE
Robert Randolph, M.S.	0.65 FTE
Theresa Schulz, Ph.D.	0.25 FTE
Ellsworth Spencer	0.45 FTE

Discretionary Funding for Projects currently within Strategic Goal 3:

9278344/921Z0HF	$0 DART / $72,830 EPA interagency agreement
92700AE	$10,000 DART
921Z6KN	$10,000 DART
927Z4QT	$42,000 PRL
927Z6NN	$25,000 PRL

Strategic Goal 4: Develop evidence-based best practices for Hearing Loss Prevention Programs

Background

Each year the Bureau of Labor Statistics (BLS) lists occupational hearing loss as among the most common occupational illnesses. BLS statistics corroborate NIOSH studies which have demonstrated that complying with existing OSHA and MSHA hearing conservation standards will not eliminate occupational hearing loss. Specifically, workers exposed to the current OSHA and MSHA PEL (90 dB(A) TWA) have a 25% excess risk of material hearing impairment. Such data clearly demonstrate that existing hearing loss prevention programs are failing to protect workers' hearing. Thus, until control technologies can eliminate hazardous noise exposures, hearing loss prevention programs must not only be put into place but must also be improved in order to prevent occupational hearing loss. Such recommendations for improving existing standards of practice and regulations would constitute the best practices for preventing occupational hearing loss.

Simply monitoring the progression of occupational hearing loss, or passing out hearing protectors hardly constitutes a hearing loss prevention program. Yet, data have demonstrated this is what many programs consist of. Effective hearing loss prevention programs are composed of several elements. The current NIOSH Hearing Loss Research (HLR) portfolio includes efforts responsive to strategic goals which address research needs associated with exposure measurement and monitoring, control technology, and hearing protector devices (HPDs). To ensure the NIOSH HLR portfolio is comprehensive in its approach to preventing occupational hearing loss, this strategic goal is focused on the other elements of an effective HLPP: audiometric monitoring, training/motivation, and data management. By implementing a focused program of hearing loss prevention research, and by integrating the results from each strategic research area, NIOSH can develop recommendations which function as best practices guidelines.

Performance Measure

Sound hearing loss prevention research has been shown to lead to improved regulations and standards. Historically, however, in the United States as well as in other industrial nations the time between the publication of research results and the promulgation of improved regulations and standards has taken many years – in some cases, decades. During this interim it is important to have "best practices" recommendations to facilitate the dissemination of research and to update standards of practice. Research efforts conducted in support of this strategic goal will focus on the audiometric monitoring, education/training, and record keeping/data management elements of an HLPP. Knowledge gained from these efforts will subsequently be integrated with knowledge gained from other projects in the NIOSH Hearing Loss Research Portfolio. This will take the form of a revised noise criteria document. Thus, we have established the following performance measure: By 2016 NIOSH will publish a comprehensive update of its 1998 "criteria document": *Occupational Noise Exposure – 1998 Revised Criteria for a Recommended Standard*. This new criteria document will function as a "best practices" recommendation. Success will be measured by the adoption or endorsement of NIOSH recommendations by professional organizations such as the American Academy of Audiology, the American College

of Occupational and Environmental Medicine, the Council for Accreditation in Occupational Hearing Conservation, the National Hearing Conservation Association, and the American Industrial Hygiene Association. Adoption of NIOSH recommendations will ultimately lead to improved standards of practice and hearing loss prevention regulations.

Intermediate Goal 4.1 Determine the most effective audiometric test protocol for identifying noise-induced hearing loss and determining work-relatedness.

A combination of laboratory and field studies will evaluate different auditory stimuli with respect to their ability to identify work-related hearing loss, and to improve our ability to measure hearing levels among workers who already have noise-induced hearing loss. Current hearing loss prevention program (HLPP) protocols for conducting baseline and periodic monitoring hearing tests do not efficiently or effectively identify occupational hearing loss. For example, current protocols do not enable audiometric monitoring supervisors (i.e., audiologists and physicians) to efficiently identify early stages of occupational hearing loss. Likewise, current protocols do not enable audiometric monitoring supervisors to effectively determine the work-relatedness of hearing loss as is required by newly enacted OSHA legislation (29 CFR 1904.10). Additionally, tinnitus can substantially interfere with the ability to measure hearing threshold levels. Exact numbers of persons suffering from tinnitus are not known. However, the American Tinnitus Association estimates that "most" persons with noise-induced hearing loss also suffer from tinnitus. Additionally, it is known that tinnitus is presently the most common disability among military veterans, and that this is almost exclusively a consequence of noise exposure. It has recently become technically feasible to replace pure tone stimuli with narrow bands of noise. This effort will determine the extent to which modified audiometric test protocols (i.e., use of 8 kHz and narrow band noise stimuli) improve our ability to accurately obtain hearing thresholds among workers at risk of occupational hearing loss.

Performance Measure. This goal will be successfully achieved if revised audiometric test protocols are adopted by NIOSH and stakeholders as the standard of practice for the audiometric monitoring element of an HLPP.

Gaps in Knowledge and Technology

Because of insufficient knowledge about the reliability of 8 kHz as a test frequency, neither OSHA, MSHA, nor the DoD require its use in HLPP audiometric monitoring. Consequently, it is not possible to detect 6 kHz notches. Continued reliance on pure tone test stimuli compromises the ability to obtain accurate hearing thresholds among workers with tinnitus. These problems make it difficult or impossible to accurately identify noise-induced hearing loss and determine the work-relatedness of such hearing loss.

Current Projects:

None

New Planned Projects to Fill Gaps

2008-2011 Determine the viability of 8 kHz as an audiometric test frequency

2011-2012 Determine the need for audiometric monitoring to be performed at 500 Hz

2010-2011 Determine the effectiveness of noise bands as audiometric monitoring test stimuli. (extramural)

Resources needed: Efforts pursued under this intermediate goal will not require any new FTEs. Continuing the staffing currently requested to MNF AO16 (preventing hearing loss among shipyard workers) would also be adequate for the 500 Hz project.

Major Achievement: This effort will provide authoritative data to support NIOSH policy recommendations regarding the type(s) of auditory stimuli which should be used to establish hearing threshold levels for HLPP audiometric monitoring, and to determine the work-relatedness of an observed hearing loss.

Intellectual Property and R2P
Research outcomes will be incorporated into a revision of the NIOSH noise exposure criteria document per IG 4.5.

Audiometric database management software will be placed into the public domain for use in developing an American National Standard.

Intermediate Goal 4.2 Develop practical training that will improve the performance of hearing protectors.

Until engineering controls eliminate hazardous noise, hearing protector devices (HPDs) are the only way to reduced noise levels at the workers ear. It is well documented that hearing protectors provide only a fraction of their potential attenuation. Worse yet, there is literally no relationship between a hearing protector's rated attenuation (i.e., the Noise Reduction Rating or NRR) and the attenuation a worker actually obtains. Finally, there currently is no way for workers to know if they are properly wearing an earplug or how much protection they are actually getting. Unlike respirators, fit-testing procedures available for earplugs are either proprietary technology or cumbersome psychophysical methods.

Performance measure. This goal will have been deemed successful if, by 2012 NIOSH has developed an integrated practical HPD training program and earplug fit-testing system.

4.2.1 Conduct a feasibility pilot study to demonstrate it is possible to integrate HPD fit-testing protocols into an existing HLPP.
(2006-2007, Intramural; joint NIOSH - U.S. Navy)

4.2.2 Develop HPD fit-testing methods which are practical for use by industry.
(2007-2010, Intramural)

4.2.2 Field test an integrated HPD training/practical fit-test system. (2011-2012, Intramural; Joint NIOSH - U.S. Navy)

Gaps in Knowledge and Technology

Neither workers nor their supervisors know how much protection a given worker is getting from a hearing protector as it is actually being worn. Current HPD fit-testing methods can accurately determine how much attenuation workers are actually getting from their earplugs. However, current fit-testing methods are not practical for use in most workplaces because it requires 30 minutes per worker to conduct a fit-test. This effort will develop a fit-test system that can measure HPD performance in two minutes or less. Furthermore, the training methods paired with current fit-test procedures are impractical for use in many environments because they require the use of a computer and monitor. This effort will develop methods in which an iPod (or equivalent) can be used to display 2-minute training videos which are customized for each specific earplug.

Current Projects:

Conduct a feasibility pilot study to demonstrate it is possible to integrate HPD fit-testing protocols into an existing HLPP. (2006-2007)

Develop HPD fit-testing methods which are practical for use by industry (2007-2010)

New planned projects to fill gaps

2010-2012 Fit-test field study. This is a new start which would be designed to capitalize on the current collaborative relationship between NIOSH and the U.S. Navy regarding preventing hearing loss among shipyard workers.

Resources needed: No new intramural resources are necessary.

Major Achievement: This effort will have been deemed successful if by 2013 it has developed and field-tested in a U.S. Navy shipyard an “iPod”-type training program integrated with a practical fit-test method. “Practical” is defined as a method/system in which the combined time to train a worker how to use a specific earplug followed by fit-testing will be less than 5 minutes. By 2015 the U.S. Navy will have adopted this approach in each of its four shipyard hearing conservation programs.

Intellectual Property and R2P
The fit-testing and training technologies will be “public domain” technologies. In addition to these technologies being transferred to the U.S. Navy, they will be transferred to the other military services via the DoD Hearing Conservation Working Group. They will be transferred to the general hearing loss prevention community via an updated NIOSH noise criteria document.

Intermediate Goal 4.3 Develop education and training materials focused on issues relevant to managers and supervisors.

Hearing loss prevention training has traditionally been focused on workers. There is a paucity of data regarding training and motivation of management and supervisors. Without management and supervisory support, hearing loss prevention efforts are unlikely to be successful. This effort will develop a model the hearing loss prevention community can used to create education/motivational training focused on management and supervisors. It is hypothesized that economic factors will be significantly associated with management/supervisor attitudes, beliefs, and behavioral intentions to promote hearing loss prevention activities. Thus, this effort will develop models which industry can use to assess economic factors such as the relationship between hearing loss and job-related injuries, and the impact of hearing loss prevention activities on productivity. This represents a new initiative projected to begin in FY 09. Although it may be that DSHEFS will be able to provide an FTE to support this, it may also be that this will require a new FTE.

Performance measure. This effort will develop a method industry can use to perform economic analyses of hearing loss prevention programs. It will also develop a model for assessing management and supervisor attitudes, beliefs, and behavioral intentions towards hearing loss prevention. Integrating the economic analyses methods with the behavioral assessment model will subsequently lead to the development of a model training program which can motivate managers and supervisors to support hearing loss prevention programs for their workers.

This effort will have been deemed successful if it can be demonstrated that NIOSH training and materials result in management decisions to initiate hearing loss prevention programs where none are currently provided or to improve a marginal HLPP by establishing a program which addresses all major elements of an HLPP.

Gaps in Knowledge and Technology

There are no data to quantify what percentages of companies provide comprehensive or partial HLPP services when their workers are exposed to hazardous noise. The last study to provide these data was conducted in 1988 by NIOSH. This study demonstrated only the largest companies were likely to provide a hearing loss prevention program, and even then only a minority of these companies did so. A more recent survey (1999) of Michigan companies looked at the percentage of companies who simply monitored workers' hearing. These data also found discouragingly small percentages. In order to develop educational materials which can positively influence decision makers to implement/support HLPP efforts, it is critical that we know what HLPP services are currently being provided. Additionally, there are virtually no data regarding the effects of noise exposure or occupational hearing loss on such important factors as productivity or job-site accidents. Such information would also be of vital importance in developing education and motivational training focused on managers and decision makers

Current Projects

None.

New Planned Projects to Fill Gaps

2009-2010 Determine the percentage of small, medium, and large companies which currently measure noise exposures, provide worker training, provide HPDs, and conduct audiometric monitoring. (extramural)

2011-2014 Determine the principal economic factors associated with occupational hearing loss. (extramural)

2013-2016 Develop and field test hearing loss prevention education and motivation materials designed for managers and decision makers. (extramural)

Resources Needed:

All three projects will be supported through the extramural research program.

Major Outcome.

a. This effort will provide current baseline data on the percentage of companies which provide hearing loss prevention programs. This is a very important effort which will bridge a 22 year gap in our knowledge regarding industry's provision of hearing loss prevention programs. It will provide data that will be used to develop motivational training materials focused on decision makers.

b. By 2014 this effort will provide the first-ever large-scale analysis of the economic impact of occupational hearing loss on productivity and job-site accidents.

c. By 2016 this effort will develop HLPP education/motivation materials for managers and decision makers, and demonstrate their effectiveness at influencing positive hearing loss prevention behaviors.

Intellectual Property and R2P

Results will be published in peer-reviewed journals and used to revise the education/training chapter of the NIOSH noise criteria document. Training materials will be posted on the NIOSH web page to increase their dissemination.

Intermediate goal 4.4. Produce an updated (3rd edition) NIOSH noise exposure criteria document.

By 2016, the NIOSH noise criteria document (NIOSH 98-126) will be 18 years old. By then, NIOSH noise criteria will represent research that is 20-30 years old. It is important for NIOSH to continue its standard of representing best practices for occupational safety and health. This will be accomplished by a careful review and analysis of hearing loss prevention research conducted in the interim since the 1998 noise criteria document was published. This will take approximately three years. Beginning in 2014 a review of hearing loss prevention research will

be conducted. In 2015, a draft of an updated noise criteria document will be produced. In 2016 public hearings will be conducted and a final version of an updated noise criteria document will be produced. This can be conducted with existing staff resources.

Performance measure. Publication of an updated (3rd edition) NIOSH noise criteria document.

Gaps in Knowledge and Technology.

In the 1960s the U.S. Public Health Service published a report on the hearing of American Adults. Given current knowledge, this report has very serious limitations. Unfortunately, the Department of Labor and most hearing conservation professional organizations use these tables to compute age correction values when determining if a worker's hearing has significantly changed from baseline hearing levels. New age correction methods and data must be developed in order to more properly apply aggregate data to individual workers, and to represent both older workers as well as workers who are black or Hispanic. Results would be incorporated into the revised criteria document.

Current Projects
None.

New Planned Projects to Fill Gaps

2012-2014 Develop age-correction tables for use when calculating the presence or absence of significant hearing changes. (extramural)

2014-2016 Produce an updated (3rd edition) NIOSH noise exposure criteria document

Resources Needed:
The extramural age correction project is expected to be funded at $100K for three years. The criteria document project can be performed with existing personnel.

Major Outcome

Publication of new NIOSH age tables for males and females from 18-69 years and for Caucasians, Blacks, and Hispanics. The age tables will include distribution data. Publication of an updated NIOSH noise criteria document (3rd edition). This is expected to be adopted as the authoritative reference for best practices in preventing occupational hearing loss. It is expected to provide the scientific justification for updated federal and state regulations dealing with occupational noise exposure.

Research to Practice

The research-to-practice (R2P) model will be used so that the "best practices" methods developed by this research can be transferred from the laboratory to the hearing loss prevention community, and lead to several outcomes. Specifically, by completing the supporting intermediate goals listed above, NIOSH will be able to update its 1998 "criteria document":

Occupational Noise Exposure – 1998 Revised Criteria for a Recommended Standard. Because stakeholders will have been involved in all phases of these efforts, an expected outcome of an updated criteria document would include the adoption of NIOSH recommendations by professional organizations such as, the American Academy of Audiology, the National Hearing Conservation Association, the Council for Accreditation in Occupational Hearing Conservation, the American Industrial Hygiene Association, and the American College of Occupational and Environmental Medicine, among others. It is our vision that by improving hearing loss prevention programs, occupational hearing loss will cease to be among the most common occupational illnesses cited in the Bureau of Labor Statistics annual report.

Strategic Goal 5: Identify Hearing Loss Risk Factors through Epidemiologic Research

Overall Goal for SG5: The ultimate goal of this Strategic Goal is to quantify and reduce risk factors other than continuous noise which act to produce hearing loss.

Background: Occupational hearing loss has long been recognized as a consequence of workers' exposure to loud noise. While there is much that is understood about how excessive noise causes hearing loss, there are many other aspects that are not understood, such as the effects of impulsivity, intermittency, and spectra. Furthermore, it is recognized now that many different factors can cause or potentiate occupational hearing loss: noise, pharmaceuticals, aging, genes and ototoxic chemicals. Other compounds, such as anti-oxidants, appear to have a protective effect against damage from noise. Epidemiologic and population studies identify research issues that enable resources to be effectively targeted to understand the effect of these factors on hearing. This research is important because even when noise is reduced to levels that are considered safe, some workers will continue to suffer noise-induced hearing loss.

Performance Measure: Methods developed by this research will be transferred from the laboratory to the hearing loss prevention community and lead to several outcomes. Specifically, information from these goals will allow NIOSH to update its 1998 "criteria document": *Occupational Noise Exposure – 1998 Revised Criteria for a Recommended Standard*. Because stakeholders will have been involved in all phases of these efforts, an expected outcome of an updated criteria document would include the adoption of NIOSH recommendations by professional organizations such as the American Academy of Audiology, the National Hearing Conservation Association, and the Council for Accreditation in Occupational Hearing Conservation. It is our vision that by better understanding basic mechanisms of hearing loss, noise-induced hearing loss reports on OSHA Form 300 will drop from 30,000+ in 2004 to less than 22,000 in 2016.

Intermediate Goal 5.1. Develop instrumentation and standards for preventing hearing loss from impulsive noise.

Background: Impulsive noise has been identified in animal models as more damaging to hearing than continuous noise of equal energy. A number of hearing loss standards (e.g. ISO1999) includes a factor for impulsive noise by adding a few decibels to the noise exposure. Instrumentation and measurement standards such as ANSI S1.25, ANSI 12.19, or IEC 61672 are not appropriate or incomplete for impulsive noise measurement or characterizing exposures. Until the 1980s, digital technology and digital signal analysis techniques were not sophisticated enough to collect impact and impulsive noises in real time. Current technology, however, has addressed these limitations, and there are now instruments and standards which allow adequate characterization of impulsive noise exposures. By correctly characterizing and quantifying impulsive noise, damage risk criteria can be developed to better protect workers' hearing.

5.1.1. By 2007, partner with an instrument manufacturer to develop a field instrument for measurement of exposure to impulse noise

5.1.2. By 2009, conduct real time risk assessment of impulsive noise in the field

5.1.3. By 2010, identify the best metric associated with measurement of impulse noise
5.1.4. By 2011, publish NIOSH technical documents and recommendations.
5.1.5 By 2012 propose standards to ANSI and ISO for impulse noise measurement and analysis

Current Projects.

New methods for evaluating exposure to impulsive noise (10/2004-9/2007)

Gaps in Knowledge and Technology

Lack of an instrument such as sound level meter (SLM) or dosimeter which can calculate the candidate impulse noise metrics (kurtosis, analytical wavelet function and/or AAHAH units.) Until such a SLM and/or dosimeter exists, surveillance research cannot progress.

Resources: An intramural scientist who can conduct a field study utilizing the impulsive noise dosimeter is needed. This scientist should have experience with field studies and with noise measurement techniques. This scientist could be an existing member of the NIOSH staff or could be a new FTE. In addition, a significant expenditure for the new technology needs to be made (~$200,000).

New Planned Projects to Fill Gaps

2009-2012 A field study of an impulsive noise dosimeter and sound level meter

Major Planned Achievements

Technical documents and publications describing damage risk criteria for impulsive noise, the introduction of a new impulsive noise instrument, and recommendations to standard committees for new standards.

Provide evidence to the new NIOSH Noise Criteria Document.

Performance measure

- Impulse meter available for sale to U.S. industry.
- A number of impulsive environments sampled.
- Results of sampling published in the peer-reviewed literature.
- ANSI and ISO standards written for measuring impulsive noise. \
- Section in updated criteria document specific to damage risk criteria for impulsive noise.

Intellectual Property and R2P.
U.S. and international Patents in final stages for approval for an impulsive noise monitor.

Intermediate Goal 5.2. Prevent hearing loss by understanding individual susceptibility to noise.

It has been demonstrated both in human epidemiological studies and numerous animal experiments that two individuals exposed to the same level of noise do not incur the same level of hearing loss. Some individuals are resistant to noise-induced hearing loss while others appear to be susceptible. These differences are important for setting regulatory limits for hearing conservation programs. Setting the exposure limit high is economically advantageous for the regulated industry but a higher percentage of workers will incur a material hearing impairment. Setting the exposure limit low will result in fewer workers harmed by noise, but it will impose a significant economic burden on employers. By understanding the genetic factors which enter into the susceptibility to noise, more rational noise limits can be promulgated and most workers can be protected. Recently two candidate genes have been identified. Van Laer et al. (2006) demonstrated a noise susceptibility phenotype in Swedish steel and pulp mill workers with a mutation of a potassium recycling enzyme. Yang et al. (2006) showed a correlation between noise susceptible Chinese autoworkers and a unique isoform of heat shock protein. The National Academies review clearly did not support NIOSH research into genetics.

5.2.1. By 2008 partner with NIH to stimulate research relevant to variation in audiological response to noise exposure through a "memorandum of understanding" and a "request for proposals."

5.2.2. By 2009 research and write a state of the art review on worker susceptibility to NIHL.

Current Projects.

None.

Gaps in Knowledge and Technology.

Candidate genes need to be identified. This could be done by academic or Federal scientists.

Resources: This effort would not require additional resources at this time. High level meetings between NIOSH and NIDCD would be of value. This will be an extramural effort.

New Projects. None at this time.

Major Planned Achievements. Literature review of susceptibility to NIHL.

Performance Measures.

- Memorandum of understanding signed with National Institute of Health, National Institute on Deafness and Other Communication Disorders (NIDCD).
- State-of-the-art review article published in the peer-reviewed literature.
- Section in updated criteria document concerned with individual susceptibility to noise-induced hearing loss.

Intellectual Property and R2P.

None at this time.

Intermediate Goal 5.3. Prevent hearing loss from exposure to ototoxicants alone or in combination with noise.

Many chemicals commonly found in industry, mining, construction, and agriculture can cause or exacerbate hearing loss. Yet we do not understand the mechanism by which these ototoxic chemicals cause damage, and the characterization of dose-response and levels of exposure in the workplace are inadequate to develop specific recommendations for exposure limits that would prevent occupational hearing loss. The magnitude of ototoxic chemical exposures is lacking and a surveillance effort to quantify exposure and disease is needed. It is planned and the details can be found in the Strategic Goal 1 section.

Currently in the US, standard hearing conservation practices focus entirely on noise and do not take into account the potential risk to hearing posed by chemical exposures. Only workers who are exposed to noise levels above 85 dB(A) are required to have their hearing tested. The detection of chemical effects on hearing requires meticulous analysis of audiometric and exposure history data.

5.3.1. In a planned surveillance effort, estimate the number of U.S. workers exposed to ototoxic chemicals, the level of their exposures, and the associated risk of hearing loss (linked to Strategic Goal 1).

5.3.2. By 2008, prepare a Best Practices document with practical guidelines for the prevention of hearing disorders from ototoxic exposures. Make specific guidelines and tools available for managing workers exposed to chemicals. Develop an ototoxin adjustment factor to modify noise exposure levels to redefine a safe level of noise. Propose new inclusion criteria for Hearing Loss Prevention Programs that take into consideration chemical exposures alone or in combination with noise. By 2010 track distribution and solicit feedback on the document.

5.3.3. Promote extramural research on the ototoxicity of industrial chemicals by preparing Requests for Applications and focused Program Announcements.

Current Projects.

Preventing hearing loss from chemical and noise exposures (11/2002-11/2008)

Hearing loss in boat manufacturing (10/2004-9/2008)

Gaps in Knowledge and Technology.

The list of ototoxicants is currently incomplete. This list can be completed by contract to academia or a contractor. Development of an ototoxin adjustment factor is in its early stages.

Resources: There is currently one FTE associated with this effort. Some additional money should be allocated for extramural contracts to develop an ototoxicant list.

New projects.

2009-2010 Applied studies of ototoxic chemicals in industry: Best practices manual development

Major Planned Achievement. List of ototoxicants. Best Practices Document on Chemical Ototoxicants.

Provide evidence for new NIOSH Noise Criteria Document.

Performance Measures.

- Best Practices Technical Document issued and placed on NIOSH website.
- Request for proposals issued for external research.

Intellectual Property and R2P.

None at this time.

Intermediate Goal 5.4. Examine the long term hearing effects of occupational noise exposure after the exposure ends.

This question is similar to the aging question. Will a noise-induced hearing loss in a worker removed from a noisy situation continue to increase in severity? Or will the hearing loss cease with exposure? This is an important question both for the worker and for the responsible employer. It could be possible for a worker to be removed from the noise prior to suffering a Standard Threshold Shift, yet convert within a short time to demonstrate an STS. There is currently no clear epidemiological research which addresses this possibility.

There are new experimental animal data which indicate that one-time noise exposures early in life can evolve over a lifetime to be greater than the same noise exposure received when older (Kujawa and Liberman, 2006). This would seem to indicate that younger workers should be targeted to protect their hearing. This model needs to be explored in greater detail in humans.

5.4.1. By 2008, in collaboration with an epidemiological group in government or academia, design a study to specifically examine the effects of a noise exposure early in a career and then followed for a reasonable time to detect increased hearing loss. Possible subjects might include young soldiers who received rifle training but went on to other careers not in the infantry, fire fighters who received exposure to a single, hearing-damaging blast, and other short duration, high energy discrete exposures.

5.4.2. By 2010, identify a population that would be appropriate to study this question. This will require partnering with unions, the Department of Defense, the Veteran's Administration and companies where infrequent, short duration discrete exposures happen.

Current Projects.

None.

Gaps in Knowledge and Technology.

There are currently no human data documenting the progression of early hearing loss across the working lifetime. Development of a longitudinal audiometric and otoacoustic emissions database of (for example) soldiers who received noise exposure early in their work-life then went on to non-noisy careers is fundamental. Non-human primate research would also be able to provide insight into these processes.

Resources: This effort would require an intramural FTE epidemiologist. An alternative would be to contract this effort out to extramural academia or a federal contractor.

Future projects.

2008-2012 Lifetime effects of a noise-induced hearing loss incurred at a young age

Major Planned Achievement.
Study design, literature review, NIOSH Noise Criteria Document.

Performance Measures.
- Issue study design for comment on NIOSH website.
- Publish state-of-the-art literature review on effects of early life NIHL.
- Evidence for new NIOSH Noise Criteria Document.

Intellectual Property and R2P.

None at this time.

Intermediate Goal 5.5. Prevent noise-induced hearing loss through research on otoprotectants.

There is recent animal research indicating that certain compounds taken prior to noise exposure protect the ear. The Department of Defense has been actively studying these compounds when given to soldiers prior to firearms training and pilots prior to flying very noisy jet aircraft. If these compounds are found to be safe and effective, they may be valuable for use in situations where noise control and hearing protection are inadequate to reduce noise exposure to a safe level.

5.5.1 Continue monitoring Department of Defense research.

5.5.2 In 2010 re-evaluate NIOSH role in otoprotectant research. At that time, evidence might be available to suggest strategies for using chemicals or nutrients to protect hearing against noise. Research, write and publish state-of-the-art review of otoprotectant viability in occupational settings.

Current Projects.

None.

Knowledge and Technology Gaps: Although there are a number of promising compounds which may provide useful for protecting worker hearing, whether an affordable, effective protectant can be found is questionable. While the Department of Defense is interested in otoprotectants which can protect against short term exposures (hours) it is not clear that workers could safely take these compounds for their thirty year career.

New Planned Projects to Fill Gaps. None at this time.

Analysis of Resources. Maintain and monitor Department of Defense and academic contacts for any new developments. In 2010, re-examine research for a NIOSH role. No additional resources needed beyond intramural permanent staff at this time.

Major Planned Achievements. Research review article.

Performance Measures.

- Publication of State-of-the-art review on otoprotectants and long term use by workers in a peer reviewed journal.
- Presentation at international meeting (e.g. Association for Research in Otolaryngology.)
- Memorandum of understanding with NIH.

Intellectual Property and R2P.

None at this time.

Summary of Strategic Goal 5.

This strategic goal identifies six factors which interact with noise, modify the effects of noise or act alone to lead to noise-induced hearing loss. These six intermediate goals when implemented over the next ten years will reduce the occupational hearing loss burden to American workers.

Once impulsive noise can be better monitored (intermediate goal 5.1) effectively a damage risk criterion can be developed. A better damage risk criterion will lead to more effective regulation and better hearing protectors. This effort currently has a portion of an electronic engineer's time associated with it. We are requesting an additional intramural FTE to develop and run the associated worker study.

Intermediate goal 5.2 would establish a closer partnership between NIOSH and NIH to encourage extramural researchers to study individual susceptibility to noise-induced hearing loss. These genetic studies have been conducted in animal models for about 15 years and are just now making the leap to the workplace. No additional resources are being requested at this time for this effort.

Intermediate goal 5.3 calls for quantification of workers exposed to ototoxins and noise. This IG also promises a Best Practices paper for workers and managers to reduce the effects of ototoxins in conjunction with noise. This effort currently has a permanent existing intramural FTE associated with it.

Intermediate goal 5.4 involves examining the effect on hearing late in life to a hearing loss incurred early in a worker's career. There is new animal evidence which seems to indicate that an early hearing loss does not remain stable as the animal ages. The hearing loss tends to get worse even without further noise exposure. This IG proposes to follow a population of workers receiving early, limited noise exposures for a period of time to see if the same phenomenon happens in humans. We are requesting an additional intramural FTE for this effort.

Intermediate goal 5.5 involves monitoring the current research being conducted by the Department of Defense in otoprotectants. These compounds are given to protect the ear from noise damage prior to or soon after noise exposure. This could be a very important tool in the hearing conservationist's toolkit if these compounds could be shown to be safe and effective over the course of a worker's career. We are not requesting any additional resources at this time.