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NIOSH Hearing Loss Research Program Response to the NAS Institute of Medicine Review through Strategic Planning

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1. Introduction

This document contains responses to recommendations from the 2006 National Academies Institute of Medicine (IOM) review of NIOSH hearing loss research (HLR) program and a strategic plan for future research. The IOM review evaluated the relevance and impact of NIOSH hearing loss research conducted during 1995-2006. In August, 2006 the IOM reported the results of its evaluation and recommendations for future NIOSH HLR research. The first part of the document will discuss the IOM review, its findings, its recommendations, and the NIOSH responses to these recommendations.

The second part of the document (beginning with section 6) describes the Hearing Loss Research strategic plan developed in response to the IOM recommendations. This plan consists of five strategic goals for the next decade (2007–2016). For each goal, intermediate goals are identified and project-related annual goals are listed. New intramural and extramural projects are identified to address research gaps that will remain after completing the current slate of hearing loss projects. The plan explains how the projects reflect research needs that flow from the overall strategic goals, and how the plan will be monitored and revised as the plan progresses during the next decade.

2. The NIOSH Hearing Loss Research Vision and Mission

Occupational hearing loss is a serious concern for many workers. Although precise numbers are difficult to come by, estimates indicate no fewer than four million Americans (and perhaps as many as 30 million Americans) are at risk of hearing loss from work place exposure to hazardous noise. Occupational hearing loss is not confined to a single work sector: It occurs among any work sector where hazardous noise levels or ototoxic agents are present. Therefore, NIOSH considers occupational hearing loss to be a cross-sector problem.

Since its establishment in 1970, the National Institute for Occupational Safety and Health has executed a planned program of research on occupational hearing loss. NIOSH is the sole federal agency with the primary responsibility for conducting research on occupational hearing loss, the factors which cause it, and methods of preventing it. As such, the NIOSH hearing loss research mission is to provide national and world leadership to reduce the prevalence of occupational hearing loss through a focused program of research and prevention. As NIOSH develops its strategic goals it has adopted the following vision:

In 10 years every occupational noise exposed worker in the US will be touched by NIOSH knowledge and technology.

Given the fact that the NIOSH hearing loss research teams have limited resources, NIOSH engaged its stakeholders in other government agencies, industry, labor and academia to help set research priorities. During this next decade, hearing loss research will be focused on solving problems in the mining, construction, and shipyard manufacturing sectors. However, given the cross-sector nature of occupational hearing loss, “lessons learned” from the planned research are

likely to apply to occupational hearing loss issues within other work sectors. Additionally, NIOSH hearing loss research teams will revisit their programs annually and revise them as necessary to be responsive to stakeholder input, emerging research findings, and guidance from senior NIOSH management.

NIOSH hearing loss research teams will endeavor to fulfill mission objectives and goals through:

High Quality Research: NIOSH will reduce of occupational hearing loss through dissemination of research results in significant high-impact journals and through the publication of prevention solutions that have demonstrated effectiveness.

Practical Solutions: The NIOSH cross-sector hearing loss prevention is committed to the development of practical solutions that are readily implemented by industry and are cost effective solutions for the complex causes of occupational hearing loss.

Partnerships: We recognize that collaborative efforts in partnership with labor, industry, government, and other stakeholders are usually the best means of achieving successful outcomes. Fostering these collaborations is a cornerstone of the NIOSH hearing loss prevention cross-sector research program.

Research to Practice (r2p): We believe that our research only realizes its true value when put into practice. Every research project within the NIOSH hearing loss prevention cross-sector program formulates a strategy to promote the transfer and translation of research findings into prevention practices and products that will be adopted in the workplace.

3. NIOSH Hearing Loss Research 1995-2006

Since the mid-1990s the National Occupational Research Agenda (NORA) has served as a framework to guide occupational safety and health research. Before NORA, no national research agenda existed in the field of occupational safety and health, and no research agenda in any field had captured such broad input and consensus. Approximately 500 participants outside NIOSH provided input into the development of the first agenda. The hearing loss research agenda was based on input from the NORA “noise team”, which consisted of internal and external researchers, occupational safety and health practitioners, manufacturers of protective devices, employers and worker groups. Based on the recommendations from the NORA Noise Team, a body of research needs was identified. These research needs fell into one of four broad research areas, and became the focus of NIOSH hearing loss research. These four research areas were:

Research Area 1: Contribute to the Development, Implementation, and Evaluation of Effective Hearing Loss Prevention Programs. The HLR program conducted three streams of research designed to improve hearing loss prevention programs (HLPPs). The first HLR program focus was on developing criteria for recommended standards (e.g. ANSI and ISO standards, standards of practice for hearing loss prevention professionals, and recommendations to regulatory agencies). Second, the HLR program investigated hearing

conservation program approaches, methods, and materials to develop and field-test best practices. The third HLR program focus applied principles from social psychology, persuasion science, social marketing, and health communication to create training and information programs that meet the needs of intended audiences and improve the motivation of employers and employees to protect hearing.

Research Area 2: Reduce Hearing Loss through Interventions Targeting Personal Protective Equipment. Even though the NIOSH hierarchy of controls orders engineering and administrative controls ahead of personal protective equipment (PPE), sometimes hearing protection devices (HPDs) are the only practical option for reducing hazardous noise exposures. For these reasons, one of the research goals has been to reduce hearing loss through interventions targeting personal protective equipment, which for noise is HPDs. The HPD research developed better methods for rating HPD effectiveness, including developing procedures to estimate the adequacy of a hearing protector as it would be worn on the job. In particular, NIOSH began working on a comprehensive solution that will integrate fit-testing and audiometric screening. Other HPD research included understanding the extent to which they protect against impulsive noise, and how HPDs can interfere with communication, especially among hearing impaired workers.

Research Area 3: Develop Engineering Controls to Reduce Noise Exposures. Application of engineering noise controls is the most desirable approach to reducing exposure to noise in the workplace and the noise induced hearing loss that often results. Engineering noise controls reduce or eliminate the noise at its source and insure that workers are not overexposed. Other approaches to reducing exposure, such as administrative controls and personal protection, are less effective because they rely on human actions. The HLR program began to focus some of its efforts on engineering controls of noise in the mining and construction industries in 2001. The program's approach has been to first gather and analyze information on noise emission levels to identify the highest noise producing equipment used in the mining and construction industries. Once the equipment was identified, existing engineering noise controls were investigated for their effectiveness and feasibility. Where controls did not exist, engineering controls were designed, developed, implemented, and tested for the noise producing equipment. The final stage of this approach was then to motivate the use of engineering noise controls through collaboration with other government agencies, unions, equipment manufacturers, and standard's setting bodies; and to develop necessary dissemination activities.

Research Area 4: Improve Understanding of Occupational Hearing Loss Through Surveillance and Investigation of Risk Factors. Understanding the fundamental mechanisms of hearing loss allowed the HLR program to improve prevention methods and technology. Many aspects of work-related hearing loss are not yet well-understood. Five lines of research were the focus of this research area. These included: (1) developing methods which could be applied to establish national occupational hearing loss surveillance methods; (2) identifying appropriate damage risk criteria associated with impulsive noise, and how best to measure impulsive events; (3) identifying the risk factors associated with ethnicity, race, and aging; (4) understanding the role of genetics

regarding individual susceptibility; and (5) understanding the hearing loss due to ototoxicants (such as solvents, heavy metals, and asphyxiates) alone or in combination with noise.

Detailed information on the NIOSH Hearing Loss Research activities, outputs, and intermediate outcomes from 1995-2006 for each of the above Research Areas may be found at www.cdc.gov/niosh/nas/hlr.

4. National Academy Assessment of Hearing Loss Research Program Relevance and Impact

To help promote the effectiveness of its mission, and in keeping with the Federal policy that all government agencies be periodically reviewed, NIOSH contacted the National Academies (NA) to request a review of NIOSH research programs. The NA Institute of Medicine (IOM) was tasked with reviewing the NIOSH Hearing Loss Research program. The IOM was asked to evaluate the relevance and impact of the HLR Program, as well as to comment on how NIOSH targets new research areas, and to identify emerging research issues. Finally, the IOM was asked to suggest ways in which the HLR Program could be strengthened.

The IOM elected to conduct its evaluation by individually reviewing each of the four areas described above. The review panel then assigned overall ratings for the HLR Program's relevance and impact over the past decade. In August, 2006, the IOM issued a report on the results of its review.

Overall, the IOM review committee concluded the HLR Program "...included strong, high-priority work, as well as projects that the committee viewed to be of lesser priority". To improve project prioritization, the committee recommended NIOSH give greater emphasis to surveillance research regarding occupational hearing loss and noise exposure. They recommended that NIOSH education and communication research should conduct more thorough evaluations of their effectiveness. It also recommended that the NIOSH noise control research that has concentrated on the mining and construction sectors should expand its expertise and scope to cover other high-risk sectors. For these reasons, NIOSH hearing loss research relevance was rated a 3 on a scale of 1 to 5. Using the same scale, the NIOSH HLR Program received a score of 4 for impact. The IOM committee found that each of the research areas has had outputs that have been put to use in meaningful workplace efforts to reduce occupational noise exposure and hearing loss. The IOM review committee was unable to assign a 5 for impact because they determined that effectiveness of hearing conservation intervention lacked documented results and that the engineering control program needed to be expanded into sectors other than mining. Additionally, IOM believes NIOSH should direct fewer resources to basic research. Details on the full IOM report may be found at: www.iom.edu/CMS/3740/31265/36811.aspx.

5. National Academy Recommendations and NIOSH's Response

In addition to providing overall ratings for relevance and impact, the IOM report also addressed areas for improvement. Fifteen areas for improvement were identified. Each of these will be discussed below along with the NIOSH response to each suggested area for improvement.

Recommendation 1: *Foster Effective Leadership.*

The IOM noted that the NIOSH HLR program operated in a matrix environment, referring to the NORA structure combined with the formal administrative structure. It did not discuss the fact that the NORA structure was in the process of transition from the original set of 21 priority areas to NORA II with 32 program areas dominated by industry sectors. During the NORA II transition, natural growing pains became evident which, understandably, were captured by the IOM review panel. As the IOM report went to press, the new program portfolio structure became fully operational. At this time, NIOSH has a single Program Manager to oversee all HLR efforts at the Hamilton and Taft Laboratories in Cincinnati, OH, as well as at the Pittsburgh Research Laboratory and the NIOSH research facilities in Morgantown, WV, and Spokane, WA. The Program Manager provides Institute-wide senior scientific and administrative leadership. The Program Manager also formulates strategic goals and implements research plans to ensure the hearing loss research program is responsive to input from external reviews, stakeholders, emerging research, and the NIOSH Director. This will improve NIOSH's ability to allocate program resources in accordance with Institute and national priorities. The matrix management structure will also enable the NIOSH Hearing Loss Research Program to be championed in an arena with significant competition for programmatic resources. NIOSH has also appointed a Research Coordinator and a Hearing Loss Steering Committee to assist the Program Manager. These actions respond to IOM recommendations to provide a more cohesive structure to program efforts that are both technically diverse and geographically separated. Increased internal collaboration better utilizes existing internal resources in surveillance and engineering controls.

Recommendation 2: *Recruit additional expert researchers to the NIOSH Hearing Loss Research Program staff.*

Reconciling NIOSH mission requirements with authorized staffing levels is a perennial challenge. However, following the IOM report, NIOSH has increased its HLR staff to include an additional senior research scientist, an additional research engineer, and an additional research audiologist. Also, NIOSH is actively recruiting three noise control engineers, an epidemiologist, and a laboratory technician to meet hearing loss research needs. Furthermore, the HLR strategic planning efforts are incorporating staffing review procedures to identify staffing needs associated with future new starts and retirements. These steps will help balance staffing needs with program requirements.

Recommendation 3: *Expand access to outside expertise.*

The HLR program has made significant headway in addressing this issue. For example, the IOM report specifically recommended NIOSH increase collaborative efforts with components of the National Institutes of Health, such as the National Institute on Deafness and Other Communication Disorders (NIDCD). In fact, NIOSH and NIDCD have an extensive collaborative relationship that was documented in the evidence package submitted to the IOM, but was not fully recognized in their report. Since the inception of NORA I in the mid-90s, NIDCD has been an active member of the NORA noise team, and thus, has helped shape the NIOSH hearing loss research agenda for the past decade. During this same period, NIOSH partnered with NIDCD to establish Wise

Ears – a national hearing health promotion outreach. More recently, NIOSH partnered with NIDCD, and the National Hearing Conservation Association (NHCA) to sponsor an international conference on hearing loss among children and young workers. Over the past decade, NIOSH has partnered with NIDCD to conduct audiometric testing as part of the National Health and Nutrition Examination Survey (NHANES) in order to collect extensive national data on hearing and related factors in adults. This effort has been extended and expanded to include a broader age range of subjects. The success of the NHANES collaboration has led to further collaborations with NIDCD on other large-scale epidemiologic studies of hearing loss. For example, the HLR program provided technical expertise and training for the Iceland Age Gene/Environment Susceptibility project (AGES), which collected audiometric and other health data from a cohort of individuals born between 1907 and 1934 and followed longitudinally since 1967. A second phase of audiometric testing in AGES is currently being planned. In addition, NIDCD has sought NIOSH input on the audiometric testing aspects of the Hispanic Community Health Study and the next Early Childhood Longitudinal Study–Kindergarten cohort, 2010.

Additionally, the IOM report identifies exploring collaborations with noise control engineers inside and outside the federal government. NIOSH has been and is continuing research collaborations with engineers from academia and private industry related to the noise control research efforts being initiated and conducted in reducing noise-induced hearing loss to workers.

The IOM report also recommended NIOSH “*draw upon a wider representation of the communities responsible for the prevention of occupational hearing loss as reviewers, conference participants, and collaborators.*” Again, NIOSH has taken important steps to be responsive to this recommendation. NIOSH is continuing and expanding sponsorship of a diverse array of national and international conferences. Since the IOM report was released, NIOSH sponsored the conference on hearing loss among children and young workers mentioned above and held a Mining Hearing Loss Prevention Workshop for the western region to augment the eastern workshop conducted in 2005. Prior to the IOM review, NIOSH organized and sponsored national conferences on ototoxicity, hearing protection, and impulsive noise. It has also sponsored a series of conferences on “best practices” for preventing occupational hearing loss. NIOSH recently has collaborated with the National Academy of Engineering on their effort to build a quieter America. NIOSH has collaborated with the Institute of Medicine to study hearing loss among military veterans, and NIOSH collaborated with the American Academy of Audiology to develop a position statement on preventing noise-induced hearing loss. Additionally, NIOSH currently has collaborative efforts with numerous academic institutions, with hearing protector manufacturers, with the American National Standards Institute, and other Federal agencies such as MSHA, OSHA, the U.S. EPA, the U.S. Army, U.S. Navy, and U.S. Air Force, among others. The National Hearing Conservation Association (NHCA) has endorsed the NIOSH guidelines for effective hearing loss prevention programs by incorporating them into their own recommendations. NIOSH and NHCA are working together closely to raise the quality of hearing loss prevention programs throughout the workforce. Finally, almost every national conference on occupational hearing loss now benefits from NIOSH sponsorship or participation. NIOSH staff serves

in both editorial and review capacity for numerous audiologic, acoustic, industrial hygiene and noise control engineering journals. The numerous collaborative efforts described above are expected to continue in future HLR efforts.

Recommendation 4: *Develop a strategic plan.*

Immediately upon publication of the IOM review report, NIOSH began efforts to develop a 10-year strategic plan. In addition to responding to the Institute's mission, this plan addresses many of the suggestions offered by the IOM review panel. The strategic plan is organized around five Strategic Goals:

1. Improve surveillance.
2. Reduce noise emission levels from equipment.
3. Develop hearing protector technology.
4. Develop evidence-based best practices for hearing loss prevention programs.
5. Identify hearing loss risk factors through epidemiologic research.

Each of these goals contains several intermediate goals. These intermediate goals describe the flow of current and planned research toward the achievement of specific outcomes. A separate section in this report (below) contains a detailed description of proposed research activities for Strategic Goals 1-5, respectively.

Recommendation 5: *Use surveillance data as well as stakeholder input to identify priorities.*

As was described above, in response to the IOM review, a new research area organized around surveillance is being proposed. See the detailed description of Strategic Goal 1, below. Selection of new projects and communication products will be guided by appropriate surveillance data whenever possible. In cases where surveillance data are not sufficient, new efforts to collect the data or assimilate outside datasets are being supported.

Throughout the past decade, the NORA noise team developed and maintained a hearing loss research agenda from which new research initiatives were drawn. Additionally, in 1997, NIOSH held public hearings regarding the revised noise criteria document. This included a listing of topics for future research. Thus, over the past 10 years, *all* newly initiated NIOSH hearing loss research was based on stakeholder input. NIOSH will maintain these types of efforts to obtain stakeholder input and will also expand its efforts by convening "town hall" discussions at national conferences. For example in 2007, NIOSH will have held "town hall" discussions on hearing loss prevention research needs at the annual conferences of the National Hearing Conservation Association, the American Academy of Audiology, and the Ohio Safety Council/Bureau of Worker Compensation.

Recommendation 6: *Use information from evaluation of hearing loss prevention measures to guide program planning.*

In 2004 OSHA implemented the NIOSH recommendation to record and track occupational hearing loss. Additionally, NIOSH has awarded a major contract to develop criteria for evaluating hearing loss prevention program effectiveness. NIOSH also has efforts well underway that will provide methods for assessing HLPP training effectiveness. Finally, all proposed research is now required to specify projected outputs and outcome measures. The enhanced surveillance capability described elsewhere will facilitate NIOSH's ability to evaluate program effectiveness and guide program planning. All new project proposals and plans will include appropriate evaluation metrics, and periodic reviews will assess implementation and performance according to the metrics. Each of these new tools will enhance our ability to respond affirmatively to this recommendation.

Recommendation 7: *Systematize collaboration with regulatory partners.*

NIOSH has had, and continues to have extensive systematic meetings with regulatory agencies for precisely those purposes which are identified in the IOM report. A recent internal NIOSH report regarding such activities is now (or shortly will be) posted on the NIOSH Hearing Loss web site www.cdc.gov/niosh/topics/noise. The information at this web site documents and describes the extensive systematic and ad hoc collaborations between NIOSH and regulatory agencies at both national and local levels. Such collaborations take place at all staff levels from the NIOSH Director to bench level scientists. Additionally, NIOSH has taken the lead in establishing a formal partnership with OSHA, MSHA and the National Hearing Conservation Association. This partnership is specifically focused on addressing mutual hearing loss prevention efforts and goals. For example, NIOSH and MSHA have been collaborating on hearing loss research since the year 2000 when MSHA promulgated a new noise standard. The new rule emphasizes the primacy of engineering controls as the strongest defense against excessive exposure to noise and the prevention of NIHL among miners and disallows reliance on HPDs as a means of compliance with the standard. A Coal Noise Partnership was then organized, where both NIOSH and MSHA played key roles in the collaborative effort.

In 2004, NIOSH presented research results to MSHA on two noise controls that were developed and tested by NIOSH (coated flight bars and a mist system for roof bolting) for two underground machines which contributed to the highest percentage of operators whose noise exposures exceeded the PEL. MSHA found the research to be significant and identified the controls as "promising" noise controls in the MSHA Program Information Bulletin P04-18, "Technologically Achievable, Administratively Achievable, and Promising Noise Controls (30 CFR Part 62)."

In 2005 and 2006, NIOSH, MSHA and the Coal Noise Partnership sponsored Mining Hearing Loss Prevention Workshops in Charleston, WV and Salt Lake City, UT. The workshops were conducted to present information related to practical tools and techniques that could be used to prevent noise-induced hearing loss to the mining

community. NIOSH and MSHA are still working together in resolving the excessive exposure to noise and the prevention of NIHL among miners.

NIOSH also has a long relationship with the Environmental Protection Agency (EPA) concerning ratings of hearing protection. For instance, NIOSH is working with EPA on revisions to existing ratings of hearing protection for continuous noise and is developing recommendations for rating protection from impulse noise.

Recommendation 8: Place greater emphasis on evaluation of the effectiveness of hearing loss prevention measures on the basis of outcomes that are as closely related as possible to reducing noise exposure and the incidence of occupational hearing loss.

This recommendation and the NIOSH response are closely tied to Recommendation #6 above. Additionally, NIOSH concurs with the IOM report that it is important to look at actual outcomes, and not just intended health and safety actions. For this reason, NIOSH is presently investigating how best to employ health communication models to influence work site hearing health behaviors. Also, NIOSH is evaluating methods which can determine “real world” (rather than predicted) attenuation values for hearing protectors. The proposed surveillance initiatives described herein will also provide effective baseline values against which the impacts of planned research outcomes can be compared.

Recommendation 9: Initiate national surveillance for occupational hearing loss and hazardous noise.

The hearing loss research staff concurs with this recommendation. A new strategic goal (SG 1) has been added to the proposed HLR agenda. The efforts associated with the Strategic Goal are singularly focused on hearing loss surveillance. See discussion of Strategic Goal 1, below.

Recommendations 10, 11, and 12.

10) Integrate the noise control engineering perspective into overall program efforts for all sectors.

11) Develop noise control engineering approaches for non-mining sectors.

12) Increase the visibility of noise control engineering as a component of the Hearing Loss Research Program.

NIOSH is increasing the visibility of its engineering efforts by increasing its noise engineering staff and by focusing a Strategic Goal (SG 2) specifically on control technologies. Given existing and projected resources, current plans will address noise control issues in the mining, construction and shipyard sectors. Resource limitations do not allow full noise control efforts across all industry sectors, but the previous efforts in construction can be substantially expanded into this high-risk industry. The HLR program will begin to address the manufacturing sector through shipyard operations in which the program has an established and willing stakeholder base. For other industry sectors that will not be directly addressed, NIOSH Research-to-Practice (r2p) models will be employed to optimize our ability to transfer control technology solutions to all work sectors. Control technology research efforts are described in detail below under the Strategic Goal 2 narrative.

Recommendation 13: *Accredit laboratories used to conduct studies for the Hearing Loss Research Program.*

The NIOSH hearing loss research program developed, maintains, and makes use of numerous laboratory facilities located on multiple research campuses. Some of these laboratory facilities have been and will continue to be accredited by appropriate independent accrediting bodies such as the National Institute of Standards and Technology (NIST), Standards Services Division, National Voluntary Laboratory Accreditation Program (NVLAP). There are two NVLAP accredited facilities at PRL. The Auditory Research Laboratory at PRL is NVLAP accredited for ANSI S12.6 “Methods for Measuring the Real-Ear Attenuation of Hearing Protectors.” The Acoustic Test Chamber at PRL is NVLAP accredited for ISO 3741 “Determination of Sound Power Levels of Noise Sources – Precision Methods for Broad-Band Sources in Reverberation Rooms” and ANSI S12.51 “Determination of Sound Power Levels of Noise Sources Using Sound Pressure – Precision Method for Reverberation Rooms.” In other cases, the functions performed in a given facility may not warrant the substantial expense associated with such accreditation. However, in such cases, the research conducted will employ instruments and methods which, when appropriate, conform to relevant national and/or international standards. Furthermore, in all cases, the methodologies and calibration procedures will be submitted to independent peer review to verify NIOSH research methods and facilities conforms to appropriate standards and procedures.

Recommendation 14: *Target more of the extramural research funding.*

NIOSH concurs with this recommendation. Currently, NIOSH is considering how best to sharpen its request for proposals to address HLR needs. One way would be to initiate an annual planning meeting designed to coordinate extramural and intramural planning efforts. This meeting would focus on ways in which extramural and intramural efforts can complement/augment each other. Together, they should fill gaps needed to reach the stated HLR Strategic Goals. For example, the HLR planned research program for FY 07 to FY 16 identifies both extramural and intramural research needs. A program planning chart for each Strategic Goal illustrates how extramural and intramural projects can be coordinated to meet the targeted outcomes for Strategic Goals 1-5.

Recommendation 15: *Increase collaboration and mutual awareness of ongoing work among intramural and extramural researchers.*

NIOSH concurs with this recommendation. The meetings and conferences mentioned above address this issue to some extent, and NIOSH is currently considering a more comprehensive strategy for implementing this recommendation. This will be of benefit not just to the Hearing Loss Research cross-sector, but to each of the NIOSH research sectors, cross-sectors, and coordinated emphasis areas.

6. NIOSH Hearing Loss Research Plan for 2007–2016

The research plan for fiscal years 2007-2016 has been developed from feedback provided by the IOM HLR program review committee as well as from feedback provided by stakeholders. Since September 2006 the HLR Program Manager has convened a series of meetings among HLR staff to develop responses to this input, and to develop a strategic plan for the next decade. This plan is one of 32 that NIOSH is developing for each of its program areas under the next decade of NORA. Specifically, it corresponds to the hearing loss prevention cross-sector program area in the NIOSH Program Portfolio.

The resulting plan follows a structural logic to make sure the overall vision can be attained through a systematic research portfolio that makes efficient use of human, financial, and material resources. The plan organizes research into five major areas that are interrelated and necessary to attain the overall vision. Each of the five areas has a Strategic Goal that is supported by several Intermediate Goals. The process of working toward the Intermediate Goals is indicated by Annual Goals that will be addressed by specific multi-year research projects. Current HLR projects are beginning to make progress on the Annual and Intermediate goals, but will not be sufficient to reach the overall strategic goal. Consequently, the plan identifies the gaps between what the current research projects can attain and the ultimate goals. These gaps are addressed through a proposed research portfolio of new projects. A resource analysis indicates what additional personnel and funding resources will be needed. The research plan will require more resources and expertise than can be completely supported through internal NIOSH capabilities, so a number of the planned research projects have been designated for funding through the extramural research program. These extramural projects remain part of the coordinated hearing loss research program, and their selection and oversight will necessarily be an integral part of the ongoing HLR management process.

A summary of the five Strategic Goals, their component Intermediate and Annual Goals, and the current and future projects needed to attain them are summarized below. Full details about each Strategic Goal have been prepared as a separate document that explains how the research gaps were identified and how they are being addressed with specific tasks within the planned research project portfolio.

Strategic Goal 1: Surveillance. *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.*

Plan components for reaching the five hearing loss strategic goals:

- Overall goal
- Background/importance
- Performance measure by 2016
- Intermediate goals with performance measures
- Annual goals
- Current projects
- Knowledge and technology gaps
- Future projects (intramural and extramural)
- Analysis of personnel and funding resources

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 Institute of Medicine. Little surveillance data on noise and occupational hearing loss has been published since the late 1980s. However, given that relatively few interventions have been adopted and the scarcity of regulatory changes, noise exposures and the prevalence of occupational hearing loss have likely 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 Institute of Medicine specifically recommended that such exposures be included in a surveillance initiative that examines hearing hazards.

Because occupational hearing loss 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 that a few industries would be given highest priority for surveillance projects. The high priority industrial sectors are mining, construction, and shipyard 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.

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 shipyard manufacturing.

Intermediate Goal 1.1: Hazard Surveillance.

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 one hearing hazard exposure surveillance upgrade. 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 shipyard manufacturing.

Intermediate Goal 1.2: Audiometric Surveillance.

Performance Measure: In 2008, 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 one audiometric surveillance upgrade. NIOSH 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 shipyard manufacturing.

Intermediate Goal 1.3: Disease Surveillance.

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 one hearing loss surveillance upgrade. NIOSH 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 shipyard manufacturing.

Strategic Goal 2: Develop engineering controls to reduce noise exposure. *Eliminate 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.*

Engineering noise controls are the preferred means of reducing noise exposure and noise-induced hearing loss. Developing engineering controls is a resource-intensive process, so the NIOSH HLR program relies heavily on surveillance data and stakeholder input to select the industry sectors, machinery, and work settings that will be addressed. Bureau of Labor Statistics (BLS) data shows that the goods-producing area, which includes the natural resources, mining, construction, and shipyard 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.

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.

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: Develop and maintain a noise source/worker exposure database for prioritizing noise control technologies for the construction and mining industries.

Performance measure: Develop 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.

Intermediate Goal 2.2: Identify existing engineering noise controls utilized in the construction and mining industries and evaluate their effectiveness and feasibility.

Performance measure: Complete a database that identifies existing noise controls and documents their effectiveness in the construction and mining industries.

Intermediate Goal 2.3: Develop feasible engineering noise controls applicable to the machines identified as the top source of noise overexposure in the construction, mining and shipyard 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).

Intermediate Goal 2.4: Motivate and educate the construction, mining and shipyard industries on the use of new and existing noise controls in the workplace.

Performance measure: This goal will be successful if workers and companies acquire, accept, and implement new and existing noise controls for their industries.

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

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-time 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.

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 and real-world research. The compendium will incorporate hearing protection training tools accessible to small businesses and the worker. 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, evaluate and disseminate effective fit-testing systems for use in occupational settings to determine performance of hearing protection devices.

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 American Academy of Audiology, or the National Hearing Conservation Association or by certifying organizations such as the Council for Accreditation in Occupational Hearing Conservation 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.

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.

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.

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

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 by 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 National Hearing Conservation Association or accrediting bodies such as the Council on Accreditation in Occupational Hearing Conservation.

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

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.

Intermediate Goal 3.5: Develop Tools to facilitate hearing protector selection.

Performance Measure: The completion of a revised online NIOSH Compendium of Hearing Protection Devices will be the first measure of success for this goal. The revised compendium will incorporate web-based training for the selection and fitting of protection.

Strategic Goal 4: Develop evidence-based best practices for hearing loss prevention programs.

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 when compared to non-exposed workers.¹ 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. Evidence-based 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. The elements of a successful hearing conservation program include training of hazards, verification of competence with safety procedures (how to select and fit hearing protection), annual monitoring, and evaluation of testing results. The current NIOSH Hearing Loss Research 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. Sound hearing loss prevention research has been shown to lead to improved regulations and standards. 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, the following performance measure has been established: 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 and accrediting organizations such as the American Academy of Audiology, the American College of

¹ Prince MM, Stayner LT, Smith RJ, Gilbert SJ [1997]. A re-examination of risk estimates from the NIOSH Occupational Noise and Hearing Survey (ONHS). *J Acous Soc Am* 101(2):950-963.

Occupational and Environmental Medicine, the National Hearing Conservation Association, the American Industrial Hygiene Association and the Council for Accreditation in Occupational Hearing Conservation. 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.

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.

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

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.

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

Performance measure: This effort will develop a method that 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.

Intermediate Goal 4.4: Revised NIOSH criteria.

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

Strategic Goal 5: Identify hearing loss risk factors through epidemiological research.

The primary focus for this Strategic Goal is to quantify and reduce risk factors other than continuous noise which act to produce hearing loss. 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 antioxidants, appear to have a protective effect against damage from noise. Findings from epidemiologic and population studies enable resources to be effectively targeted to reduce these risk factors for hearing loss. 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.

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 and accrediting 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.

Performance Measure: Development and commercial availability of an impulse meter. Publication of an initial database of impulse noise tasks/work environments. Initiation of ANSI working group for a new standard on impulsive noise measurement. Update NIOSH guidelines for measuring impulsive noise.

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

Performance Measure: Establish a Memorandum of understanding with the National Institutes of Health, National Institute on Deafness and Other Communication Disorders (NIDCD). Publish a peer-reviewed state-of-the-art review article. Prepare NIOSH guidelines dealing with individual susceptibility to noise-induced hearing loss.

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

Performance Measure: Publish a NIOSH “Best Practices” document.

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

Performance Measure: Publish a state-of-the-art literature review on effects of early life NIHL. Develop a study design and secure funding approval for a longitudinal study to determine the influence of early noise exposure on hearing levels in later years.

The HLR Steering Committee will conduct an annual progress review of the Hearing Loss Cross-Sector Research Program. This will also provide opportunities to adjust the Strategic and Intermediate goals to reflect changing or emerging mission needs. The annual review will also provide opportunities for continued stakeholder input.

7. List of Current Projects

Strategic Goal 1: Surveillance

Intermediate Goal 1.1: Hazard Surveillance.

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/nonmetal mining. These data can be used to guide the engineering control priorities as described in Strategic Goal #2, and to determine their effectiveness.

Intermediate Goal 1.2: Audiometric Surveillance

None.

Intermediate Goal 1.3: Disease Surveillance.

None.

Strategic Goal 2: Develop Engineering Controls to Reduce Noise Exposure

Intermediate Goal 2.1: Noise Source/Worker Exposure Database.

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 resulting 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.

Intermediate Goal 2.2: Existing Engineering Noise Controls.

None.

Intermediate Goal 2.3: Development of Engineering Controls.

Engineering Noise Controls for Roof Bolting Machines (10/2004 – 9/2007)

MSHA data indicates that the roof bolting machine ranks third among all mining equipment and second among underground coal equipment as a source of operator exposures exceeding 100% of the MSHA PEL. 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 pressure level measurements taken by the National Institute for Occupation Safety and Health (NIOSH) showed the A-weighted sound pressure 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 pressure level generated by horizontal vibrating screens used to process clean coal by 10 dB. This reduction would result in a 90% reduction in the sound power 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 pressure 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.

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.

None.

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

Intermediate Goal 3.1: Effective Fit-testing Systems.

Audiometry and Fit-Testing (10/2004-9/2008)

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.

Intermediate Goal 3.2: Performance and Utilization of Hearing Protection Devices.

None.

Intermediate Goal 3.3: Assessing Speech Intelligibility.

Hearing Protection for Hearing Impaired Workers (10/2006-9/2009)

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.

Intermediate Goal 3.4: New Technologies that Improve Hearing Protection Devices.

Comfort as a Predictor of Hearing Protectors Use (10/2004 – 9/2007)

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.

Intermediate Goal 3.5: Hearing Protector Selection.

Hearing Protector Testing Methods & Rating Schemes (10/96-9/2010)

This project has developed testing methods to assess non-linear passive hearing protection devices (HPDs), electronically augmented HPDs, as well as traditional passive HPDs. The project completed a six laboratory study of hearing protectors. The data analysis has resulted in a revision of an ANSI standard for measurement of hearing protectors and a draft standard for rating HPD attenuation. A "Noise Reduction Rating Calculator" has been developed to implement the proposed standard. All of the work of this project will underpin a revised

regulation for the labeling of HPDs to be promulgated by the EPA. The effort harmonizes with NIOSH's mandate to evaluate methods to prevent occupational disease through research in control technologies and personal protective equipment.

Hearing Protection and Audibility Considerations II (10/2006-9/2009)

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.

Strategic Goal 4: Develop Evidence-based Best Practices for Hearing Loss Prevention Programs

Intermediate Goal 4.1: Audiometric Test Protocols.

None.

Intermediate Goal 4.2: Training.

Remotely Accessible Audiometric Data (6/2005-9/2007)

This project will develop and pilot a model program in which carpenters will have their hearing tested, and records will be entered into a centralized data repository to enable follow-up actions.

Preventing Hearing Loss among Shipyard Workers (6/2006-9/2009)

The goal of this project is to reduce occupational hearing loss among shipyard workers. This will be accomplished by developing hearing protector fit-test hardware and methods that are practical for use in the field. Combining this fit-test capability with newly developed health communication based on training methods is expected to significantly improve the effectiveness of hearing protector devices. Additionally, this approach will give both workers and supervisory feedback on the amount of attenuation a worker's hearing protector actually provides as it is worn in the field.

Worker Empowerment Interventions for Hearing Loss Prevention (4/2006-9/2009)

This project is developing technologies and informational interventions that empower workers to preserve their hearing. The interventions help workers understand the causes and effects of noise-induced hearing loss, how they can reduce their exposure, and how they can make better use of noise controls and hearing protectors. The project is generating a continuing stream of communication products (training pages, interactive software, etc.) that can be distributed and used independently or as part of a conservation training 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.

Success in Hearing Loss Prevention (1/2007-9/2010)

This project involves a partnership between NIOSH and the National Hearing Conservation

Association (NHCA) to establish an award for “Success in Hearing Loss Prevention.” Successful real-world hearing loss prevention programs and public health practices are being documented and the information will be widely disseminated. The dissemination of evidence-based findings will enable other groups to effectively advance hearing loss prevention practice.

Intermediate Goal 4.3: Educating Managers.

None.

Intermediate Goal 4.4: Revised NIOSH Criteria.

None.

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

Intermediate Goal 5.1: Impulsive Noise.

New Methods for Evaluating Exposure to Impulsive Noise (10/2004-9/2007)

Considerable amounts of research have shown that impulsive noise is more likely to cause noise-induced hearing loss (NIHL) than continuous noise. Currently, no universally-accepted standard defines impulse noise adequately nor does a standard method exist to measure impulses. This project aims to develop, test, and validate methods and instrumentation that accurately capture and analyze impulsive noise in real-time in order to evaluate the effectiveness of various damage risk criteria for predicting hearing hazards of exposure to impulsive noise. In addition, current impulse damage risk criteria suffer from a lack of empirical data needed to quantify impulse noise exposures and assess potential damage to hearing. In 2003, NIOSH and the National Hearing Conservation Association (NHCA) co-sponsored the NORA Best Practices Workshop on impulsive noise. The working group on “measurements, methods, and instrumentation” recommended the need for research and development of standard methodology and instrumentation to capture and characterize impulsive noise.

Intermediate Goal 5.2: Individual susceptibility to noise.

None.

Intermediate Goal 5.3: Ototoxicants.

Preventing Hearing Loss from Chemical and Noise Exposures (10/2004-9/2008)

Occupational hearing loss prevention programs should not only monitor hazards, assess hearing, and control noise exposure. They should include assessing exposures to chemicals, such as solvents, metals, asphyxiants, and pesticides. Knowledge generated by this project has already impacted occupational health guidance and legislation. The results from NIOSH partners on this project will guide future occupational safety and health efforts in reducing the risks of work-related hearing loss and increase awareness of the ototoxic potential of chemicals. This ongoing project will make specific recommendations and disseminate information on an action level for

exposures to ototoxic chemicals and hearing loss prevention strategies, not limited to excessive noise exposures.

Hearing Loss in Boat Manufacturing (10/2004-9/2008)

In order to evaluate the effects of styrene on hearing, noise and styrene exposures will be measured along with biological markers of styrene exhaled air, and longitudinal audiometric databases from the boat workers will be analyzed. The results of exposed workers will be compared with the results of non-exposed workers, utilizing other available hearing databases from Poland, Sweden and Finland. Ultimately, the databases will be merged for a more comprehensive analysis to identify a dose-response relationship. This step of the project would be a continuation of collaboration with the European Community Project NoiseChem, which started with DART project 0020 Preventing Hearing Loss from Chemical and Noise Exposures.

Intermediate Goal 5.4: Long-term Noise Aftereffects.

None.

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

None.

8. List of Future Projects

Currently-funded HLR projects are already addressing the five strategic goals, but there are still significant gaps that need to be filled with new research projects to meet the ultimate 2016 targets. The plan identifies research gaps related to strategic, intermediate, and annual goals and proposes new projects that will fill these gaps. Additional analysis guided decisions about what projects should be done intramurally by the HLR staff or extramurally by non-NIOSH researchers. Where NIOSH already has the resources to perform a project, it was identified as intramural. In other cases, a project would require resources (expertise, laboratories, personnel, etc.) that NIOSH lacks but that exist in an outside research organization, and the project was identified as extramural. In between those two options are essential projects that would best be done by NIOSH with a moderate increase in staff and funding. Those projects are also identified as intramural, and the additional resources are accommodated in the overall resource analysis and plan.

Intramural Projects

Strategic Goal 1: Surveillance

See figure 1 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 1.

2008 Hearing hazard assessment in mining – Phase 1

2011 Hearing hazard assessment in mining – Phase 2

2014 Hearing hazard assessment in mining – Phase 3

2009-2016 Integrate hearing hazard surveillance into a comprehensive National Exposures at Work Survey (NEWS)

2008-2016 Identify existing databases that can be used for ongoing surveillance of occupational hearing loss

2008-2016 Use the Defense Occupational and Environmental Health Readiness System (DOEHRS) or some other commercially available Data Repository as a model to set up the infrastructure to handle and analyze data submitted to NIOSH by partners in other industrial sectors

2009-2011 Produce a guidance document on enterprise surveillance for hearing loss prevention

2009-2016 Use mining industry data to develop and maintain a national hearing loss prevention data repository including monitoring audiometry and individual hearing hazard exposure data

2008-2012 Support another occupational health supplement to the National Health Interview Survey (NHIS)

Strategic Goal 2: Develop Engineering Controls to Reduce Noise Exposure

See figure 2 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 2.

2010-2016 Cross-sectional mining survey

2014-2016 Noise reduction of underground coal equipment identified in Intermediate Goal 2.1.10 below 90 dB(A)

2010-2013 Reduction of front end loader noise below 90 dB(A)

2015-2016 Noise reduction of underground metal/nonmetal equipment identified in Intermediate Goal 2.1.11 below 90 dB(A)

2010-2013 Reduction of bulldozer noise below 90 dB(A)

2009-2016 Promote adoption of effective mining controls

2008-2011 Engineering noise control study – powered hand tools

2009-2011 Engineering noise control feasibility study – Puget Sound navy ship yard

2011-2014 Promote adoption of effective powered hand tool and shipyard noise controls

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

See figure 3 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 3.

2009-2012 Evaluation of objective fit-test systems in laboratory and real-world settings

2009-2012 Develop methods for the measurement of hearing protector attenuation in the presence of impulsive noise

2009-2012 Electronic NIOSH compendium of hearing protection devices

Strategic Goal 4: Develop Evidence-based Best Practices for Hearing Loss Prevention Programs

See figure 4 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 4.

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

2010-2012 Fit-test field study

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

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

See figure 5 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 5.

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

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

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

Extramural Projects

Strategic Goal 1: Surveillance

See figure 1 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 1.

2008 Develop a case definition and severity index for occupational hearing loss

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

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

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

2009 Develop a protocol and guidelines to collect, analyze and interpret quality noise exposure data

2009-2016 Initiate and support state-based surveillance programs that use data from audiometric providers to promote hearing loss prevention

2009-2016 Expand the Michigan SENSOR model for surveillance of occupational hearing loss to other states

2010 Develop a protocol and guidelines to collect, analyze and interpret quality non-noise hearing hazard exposure data

2009-2013 Hearing hazard survey in a high priority industry such as construction, or manufacturing.

Strategic Goal 2: Develop Engineering Controls to Reduce Noise Exposure

See figure 2 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 2.

2008-2009 Definition and assessment of engineering noise controls for coal mining

2009-2010 Definition and assessment of engineering noise controls for surface coal mining

2009-2010 Definition and assessment of engineering noise controls for bulldozer machines

2010-2012 Engineering noise controls for longwall mining system stageloaders

2012-2014 Definition and assessment of engineering noise controls for all underground mines

2014-2016 Definition and assessment of engineering noise controls for all surface mines

2010-2016 Cross-sectional construction survey

2011-2013 Engineering noise controls for large construction equipment

2009-2010 Definition and assessment of engineering noise controls for construction and shipyard industries

2013-2016 Promote adoption of effective large construction equipment noise controls

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

See figure 3 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 3.

2010-2013 Impulse test fixture Small Business Innovation Research grant

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

2012-2014 Develop and evaluate web-based training tools

Strategic Goal 4: Develop Evidence-based Best Practices for Hearing Loss Prevention Programs

See figure 4 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 4.

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

2010-2011 Determine the effectiveness of noise bands as audiometric monitoring test stimuli

2011-2014 Determine the principal economic factors associated with occupational hearing loss

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

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

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

See figure 5 for a timeline of all current and future intramural and extramural projects related to Strategic Goal 5. No extramural projects are planned for this Strategic Goal.

9. Analysis of Resources in Terms of FTEs and Discretionary Funds

At present, there are about 30 full-time equivalent (FTE) positions in the intramural portion of the NIOSH Hearing Loss Research program. This team includes 14 engineers, 5 audiologists, 4

psychologists, and single representatives of other professional disciplines, including physics, industrial hygiene, sociology, etc. This research staff is distributed among two research teams of approximately equal size in Cincinnati and Pittsburgh.

The current annual HLR program funding is about \$6 million with almost \$2 million allocated to extramural projects. The extramural funding could change each year in response to project cycles.

To be responsive to IOM recommendations, a number of new research projects have been proposed. Table 1 lists the new FTEs and discretionary funds that would be required if only intramural resources were used to achieve the NIOSH HLR strategic goal by 2016. The table shows that the intramural program would need a total of 23 new FTEs and about \$13 million additional discretionary funds. Some of the discretionary funding needs will be met through projected internal budget allocations, including NORA while \$9 million will be entirely new. As indicated previously, the current budget for the extramural program is about \$2 million. Some of the projects listed in the HLR strategic project portfolio can be performed by outside researchers using extramural funds. The suggested amount is approximately \$750,000 per year and this level of extramural funding will enable us to eliminate most of the \$9 million shortfall over the next ten years. It will also substantially address the need for new FTEs within the HLR intramural program.

Table 1. New employees and total discretionary funds needed to accomplish HLR strategic goals.

| | New FTE | Discretionary budget |
|---|----------------|-----------------------------|
| SG1 | 6 | 3,000,000 |
| SG2 | 7 (2)* | 4,896,000 |
| SG3 | 4 (1) | 1,555,000 |
| SG4 | 1 | 2,140,000 |
| SG5 | 4 | 1,000,000 |
| Total | 23(3) | 13,191,000 |
| <i>*Numbers in parentheses indicate technicians</i> | | |

10. Research to Practice (r2p) Plan

Research to Practice (r2p) is a NIOSH initiative focused on the transfer and translation of research findings, technologies, and information into highly effective prevention practices and products which are adopted in the workplace.

The goal of r2p is to reduce illness and injury by increasing workplace use of effective NIOSH and NIOSH-funded research findings. In order to achieve this, NIOSH is continuing to work with our partners to focus research on ways to develop effective products, translate research findings into practice, target dissemination efforts, and evaluate and demonstrate the effectiveness of these efforts in improving worker health and safety.

The HLR vision of “touching every noise-exposed worker” will only be possible through more comprehensive and effective r2p efforts. These efforts will start with techniques that have been successful for past HLR research, especially the close ties to influential stakeholders and high-quality information products, but will build on these successes with new initiatives. The objective will be to reach any worker currently at risk of noise exposure, as well as students and children who will become the future workforce. These new initiatives will require detailed

planning to target the recipients of the r2p efforts, identify the specific technical and human changes that need to occur, and specify appropriate r2p techniques that will bring about the desired changes.

NIOSH hearing loss prevention recommendations are provided to the mining community, Noise Partnership, to MSHA/OSHA, and the construction consortium of university, government, industry, and labor organizations. Introduction and implementation of these recommendations 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, along with support and buy-in from employees, will directly impact the consistent usage and acknowledgement of hearing loss prevention measures at the employee level.

Each of the Hearing Loss Prevention Program Strategic Goals incorporates a plan to transfer the research findings into the workplace. The methods for this translation of information into prevention practices include guidelines; computer programs; reference databases; and publications.

Examples of specific r2p plans include:

Strategic Goal 1: Surveillance

Surveillance can be a natural and effective r2p activity when the information is analyzed and shared in a meaningful way. Surveillance data will identify the workplaces, processes, and occupations at increased risk for hearing loss. It will also be an important tool to assess the effectiveness of interventions to prevent hearing loss. Surveillance data will be disseminated through the NIOSH Web site and through publication in scientific and trade journals.

NIOSH will also produce a guidance document on enterprise surveillance for hearing loss prevention which specifically disseminates information to end users so that they can be active participants in the surveillance goal.

Strategic Goal 2: Develop Engineering Controls to Reduce Noise Exposure

Noise control tools will be developed for end users, to include a computer program to guide identification of appropriate administrative controls; a collection of sound pressure profile plots and worker exposures will be distributed on the Internet, CD, and other media for use as a training aid for exposure awareness; Noise Control Guidelines related to specific commodities and specific pieces of equipment. Additionally, testimonies from the mine and construction workers will be one way of marketing the noise control technologies to the mining and construction communities. Furthermore, 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.

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: Reduce Hearing Loss through Interventions Targeting Personal Hearing Protection Devices

One of the outcomes of this goal will result in a revised hearing protection 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.

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.

Strategic Goal 4: Develop Evidence-based Best Practices for Hearing Loss Prevention Programs

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. By 2016 NIOSH will publish a comprehensive update of its 1998 “criteria document”: Occupational Noise Exposure – 1998 Revised Criteria for a Recommended Standard. Audiometric database management software will be placed into the public domain for use in developing an American National Standard. The fit-testing and training technologies will be “public domain” technologies. Education and training materials focused on making hearing loss prevention relevant to managers and supervisors will be added to the education/training chapter of the NIOSH noise criteria document. Training materials will be posted on the NIOSH web page to increase their dissemination.

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

An outcome of this goal is to develop instrumentation and standards to prevent NIHL from impulse noise. An impulsive noise monitor has been developed and the technology will be promoted for use in the workplace. As a part of this process, U.S. and International Patents are in their final phases.

The research conducted under this goal will also provide the scientific basis for new exposure guidelines. Following the established example of recommended exposure limits for continuous noise, guidelines on exposure limits for impulse noise and ototoxicants will be supplied to the team developing the 2016 Revised Criteria Document

The Strategic Plan as an r2p Mechanism

This strategic plan can also be used as a mechanism for translating research to practice. Aspects of NIOSH's response to the IOM review and nascent planning efforts have been used to brief two professional conferences in an effort to gain early buy-in from stakeholders.

Many of the major stakeholders were involved in the IOM review. The strategic plan will be used as a basis to keep the stakeholders informed of NIOSH's response to the review and the ways in which stakeholder interests will be addressed. The major stakeholders include:

- Occupational Safety and Health Administration
- Mine Safety and Health Administration
- National Institutes of Health (especially the National Institute on Deafness and Other Communication Disorders)
- Department of Veterans Affairs
- Environmental Protection Agency
- Department of Defense
- Labor Organizations (UMWA, CPWR, etc.)
- Mining Noise Partnership

NIOSH plans to brief each of these major stakeholders individually or in small informal meetings. All stakeholders will have access to the NIOSH HLR strategic plan and summaries via various media including:

- Internet publication through the NIOSH website and NIOSH eNews
- Peer-reviewed and lay documents
 - Acoustical Society of America's *Acoustics Today*
 - National Hearing Conservation Association's *Spectrum*
 - Industry-specific trade publications
 - Noise control and hearing conservation-related academic journals

Stakeholders will be invited to public meetings where information can be shared and partnerships and collaborations formed to move the HLP Plan forward. Specific invitations will go to professional organizations such as NHCA, AAA, NSC, ACGIH, AIHA, ASA, labor organizations (UMWA, UAW, USW, etc.), business organizations for the mining, construction, and shipyard industries (NMA, AGC, SCA, etc.), and other federal agencies and offices (MCOSH, ACOSH)

11. Summary and Conclusions

Since its establishment in 1970, the National Institute for Occupational Safety and Health (NIOSH) has conducted intramural and extramural research focused on reducing the incidence and prevention of occupational hearing loss. In 1996 NIOSH established the National Occupational Research Agenda (NORA) with hearing loss prevention as one of 21 priority areas. Over the next decade NIOSH research, including hearing loss prevention research, was

substantially driven by research needs identified by partners and stakeholders from labor, industry, academia, and other government agencies. In response to its NORA partners, NIOSH has pursued lines of research in four topic areas: (1) contribute to the development of effective hearing loss prevention programs, (2) reduce occupational hearing loss through interventions targeting hearing protection devices, (3) reduce occupational noise exposures through the development of effective control technologies, and (4) improve understanding of occupational hearing loss through surveillance and investigation of risk factors. Hearing loss prevention continues to be a NIOSH priority, and is one of 32 program areas in the next decade of NORA.

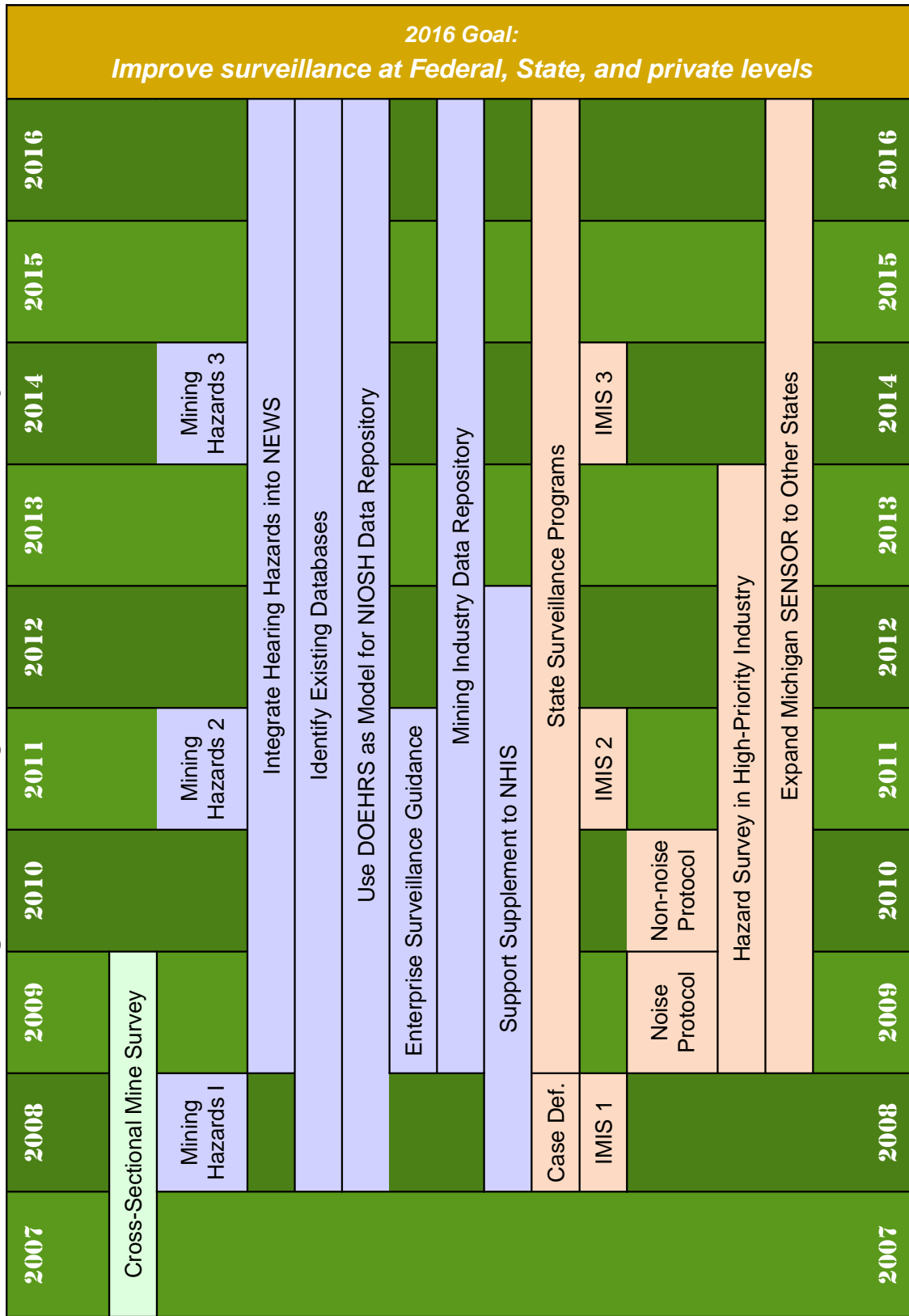
Upon the publication of the IOM findings, NIOSH established a Hearing Loss Research Steering Committee that is also a component of the new NORA program portfolio structure. This committee included a Hearing Loss Research Program Manager, a Program Coordinator, and an Assistant Coordinator. It also consisted of representatives from each NIOSH laboratory or division which had programs reviewed by the IOM. This report describes the Steering Committee's responses to each of the 15 IOM recommendations. These responses are embodied in lines of research which support one of five Strategic Goals for hearing loss research proposed for 2006-2016. The proposed lines of research represent efforts and projected outputs which are responsive to the IOM recommendations.

This plan is intended as a living document that will guide HLR program planning and execution during the next decade. New intramural projects will be selected for funding only if they are consistent with the overall strategic plan. This will preserve the HLR program's strategic focus and minimize the inefficient expenditure of scarce human and monetary resources on tangential issues.

The HLR Steering Committee will be reconvened at least annually for a formal review of the strategic plan. The committee will examine progress on attaining the annual, intermediate, and strategic goals to determine whether any tactical adjustments need to be made in order to reach the strategic goals. The committee will also review external factors to determine whether adjustments in the strategic goals are appropriate. For instance, stakeholder input or emerging research findings may lead to a change in relative priorities and a rearrangement of annual goals. The committee will also be responsive to solutions that arise from research or technologies developed outside of the HLR program and will use them wherever possible to accelerate progress toward the NIOSH objectives. Any revisions in the HLR strategic plan that result from these periodic reevaluations will be immediately reported to the NIOSH lead team.

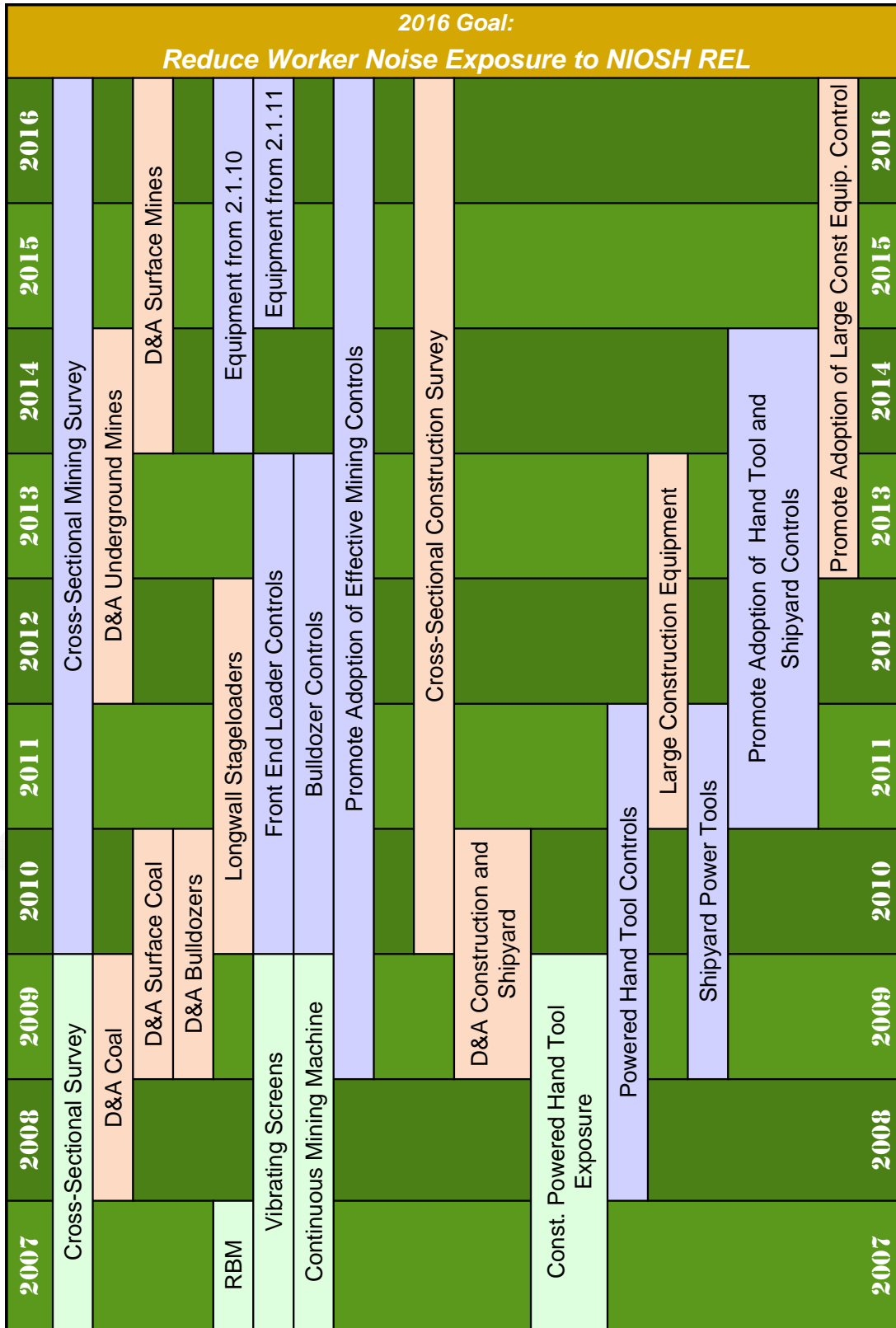
Enhancing the r2p component of the HLR strategic plan is an immediate priority for the Steering Committee and research teams. The plan's expected impact and vision of touching every noise-exposed worker will depend on a much more comprehensive and detailed assortment of r2p interventions. Within one year, the Steering Committee will prepare a detailed r2p plan that identifies the populations of current and future workers we will reach, how they will be reached, and what changes will be effected in the domains of technology, knowledge, skills, and work practices. The ultimate measure of this plan's success will be the degree to which worker's have been reached by NIOSH technologies and knowledge to preserve their hearing.

Figure 1: Strategic Goal 1: Surveillance Projects



Key: Current Project Future Intramural Future Extramural

Figure 2: Strategic Goal 2: Noise Control Projects



Key: Current Project Future Intramural Future Extramural

Figure 5: Strategic Goal 5: Hearing Loss Risk Factor Projects

