Reduction of Preventable Noise Exposure

Language for Acquisition Documents

What acquisition language pertaining to noise is there?

And…

What is Noise?

What are noise sources, types, and environments?

What are some ways to effect noise reduction?

Created by SURVIAC in conjunction with DSOC
Current as of 30 Sept 2011
Cleared for public release, Case # 88ABW-2011-5245

Noise: Please Consider Your System & Make a Selection

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What is Noise

“Noise is a sound that is loud or unpleasant or that causes disturbance”
(Oxford Dictionaries, 2011)

When analyzing noise, it is important to consider the types of noise, levels and pattern of noise, noise sources, noise transmitters, and environmental acoustics.

***Types of noise**:*

Airborne - noise travels through the air from the source to the receiver

Ambient - the amalgamation of all the sounds within an environment, including sounds made by natural sources such as water or wind

Flow - that is created by air flowing through ducts

Impulse - a short, intense burst of energy that is emitted as a loud sound or shockwave

Mechanical - that is created by machinery or tools

Steady-state - a continuous noise emitted from a source

Structure-borne - noise is transmitted through the structure of the environment, such as metal beams, wood support, or other materials, to the receiver

Engineering for Noise Reduction/Prevention

Examples of engineering noise controls include:

Passive:

Sound absorbent materials

Noise barriers or enclosures

Vibration damping

Mufflers

Active:

Friction reduction/elimination

Turbulence reduction/elimination

Examples of noise reduction practices include:

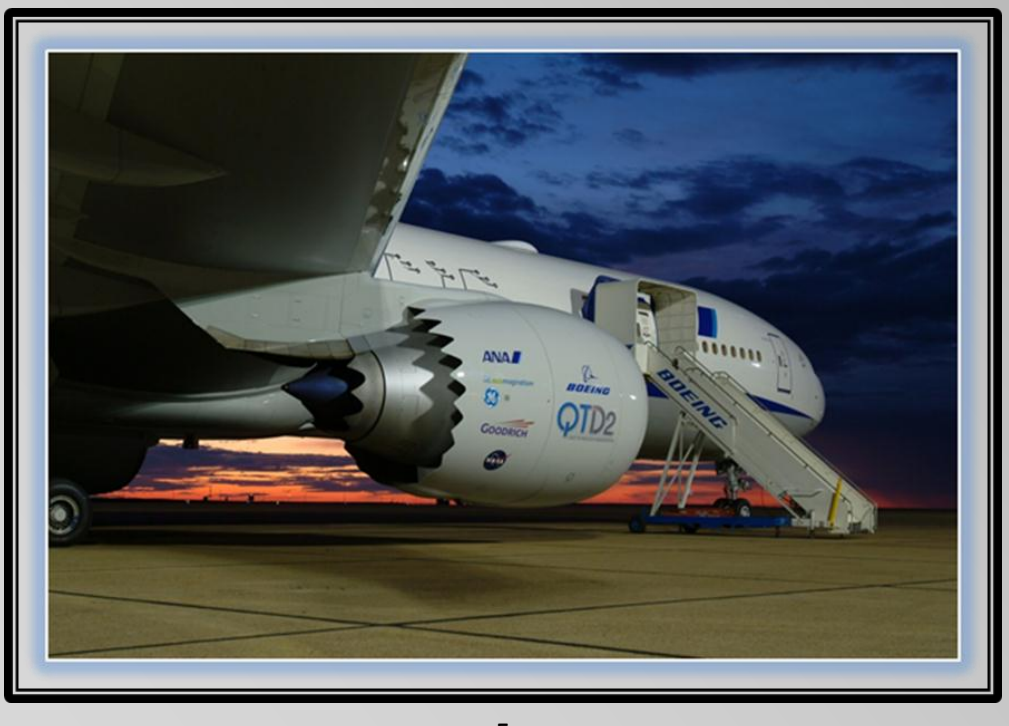
Replacing worn parts

Reducing mechanical shock between parts

Reducing friction between metal parts

Reducing fluid flow noise

Reducing noise from imbalanced or malfunctioning parts and equipment



Analysis of Alternatives (AoA)

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Sample Noise Prevention Language for an AoA

Document Section	Example Language
Objectives	Specific objectives to be fulfilled by this AoA include ***<insert objectives>***.
Objectives: Objective	Analyze to extent ***<system name>*** solution can satisfactorily fulfill the program requirements. These requirements include improvements in the characteristic acoustic attenuation.
Objectives: Performance Standards	For Passive Noise Reduction: The ***<system name>*** shall provide **<XX>** dB Passive Noise Reduction (PNR).
Objectives	For Active Noise Reduction: The ***<system name>*** shall allow the incorporation of Active Noise Reduction (ANR) technologies.
Objectives: Sympathetic Harmonic	The ***<system name>*** shall not demonstrate a detrimental sympathetic harmonic vibration regardless of system speed or maneuver.
Objectives: Mechanical Noise	The ***<system name>*** shall withstand mechanical vibration regardless of system speed or maneuver.
Objectives: Performance Features Comparison Analysis	A good and reliable fit under system speeds and maneuvers was critical to effective sound attenuation with little of the effective noise protection attributed to a specific technical design characteristic. ***<System name>*** was as capable as the ***<enter competitor name>*** under ideal fit conditions. Noise protection will favor those ***<system name>*** technologies that can achieve and maintain this ideal fit.
Objectives: Requirement Example	Noise control alternatives must be considered and presented according to the following categories: 1. Noise reduction/prevention alternatives for which the operator has adequate implementation authority. 2. Noise reduction/prevention alternatives for which the requisite implementation authority is vested in a local agency or political subdivision governing body, or a state agency or political subdivision governing body. 3. Noise reduction/prevention alternatives for which the contractor has the ability to utilize construction of barriers and acoustical shielding, including the soundproofing of buildings.

Request for Information (RFI)

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Sample Noise Prevention Language for a RFI

Document Section	Example Language
RFI: General	Respondents to this RFI shall provide sufficient representative examples to demonstrate their experience in applying noise reduction/prevention to system design. Describe your company's past experience on previous projects in which noise reduction/prevention was a critical factor or was a significant issue.
RFI: General	Describe your company's experience and specific noise mitigation techniques applied when conducting noise reduction/prevention activities and provide sufficient representative examples of how the noise reduction/prevention was integrated with activities associated with program management, systems engineering, and logistics.
RFI: General	Describe your company's experience by providing sufficient representative examples in executing noise reduction/prevention plans.
RFI: General	The ***<system name>*** shall be capable of providing noise dampening technology to allow for normal voice conversation ability. **For example:** Noise generated by low bypass turbine engines represents one of the most acute noise sources for military aircraft. Passive approaches for noise reduction, such as mechanical chevrons and fluidic mixing at the nozzle exit aperture, increase jet mixing in the exhaust plume shear layer downstream of the nozzle exit thus breaking up shock cells in the over-expanded nozzle flow. Known passive methods are prone to impacting engine performance, weight and potentially other aspects. More aggressive and costly system-level noise reduction approaches for military aircraft such as noise-optimized exhaust nozzle re-designs and variable cycle engines are being considered but involve major impacts to the overall system. Noise reduction concepts having high potential for reducing noise without significantly impacting the overall system are needed for low bypass tactical aircraft. Active approaches related to the jet shear layer instability waves that generate large-scale coherent structures are of interest. There is a correlation between flow interactions and noise radiation. Supersonic jets contain complex flow fields having unsteady flow velocities, sharp temperature and density gradients, and can include mixed gas species and shock waves. Little focused work has been done on supersonic jets as a noise energy source.

Document Section	Example Language
RFI: How To Respond	Respondents to this RFI should provide information on training and logistics support experience pertaining to noise reduction/prevention to include, but not be limited to, training development plans and logistics plans.
RFI: How To Respond	Provide sufficient representative examples for risk mitigation associated with environment, safety, and occupational health hazards and how identified risks were incorporated into the program's overall risk management program.

Request for Proposal (RFP)

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Sample Noise Prevention Language for a RFP

Document Section	Example Language
RFP: General	Describe your company's experience in conducting noise reduction/prevention activities and provide representative examples of how the reductions were integrated with activities associated with program management, systems engineering, and logistics.
RFP: General	Describe your company's experience by providing representative examples in executing noise reduction/prevention in programs and plans.
RFP: SOO (HFE Language)	HFE design efforts shall focus on minimizing or eliminating system characteristics that result in mission-critical errors or produce safety or health hazards due to noise.
RFP: SOO (ESOH Language)	ESOH Risks - Identified environmental, safety, and health risks caused by noise shall be eliminated, minimized or controlled to acceptable levels within cost, schedule, and performance constraints. All health risks associated with operation, maintenance and support caused by noise shall be identified during development and design, and shall be eliminated or mitigated to an acceptable level as agreed by a government HSI team.
RFP: SOO (ESOH Language)	Program ESOH Protection Goal - The fielded system shall 1) be compliant with applicable ESOH laws and regulations concerning noise, 2) minimize ESOH noise hazards, 3) reduce/prevent noise pollution at the source, 4) minimize ESOH impacts to program cost, schedule and performance through the system life cycle, 5) generate a lesser mishap rate, and 6) produce lower noise levels than its equivalent systems without adverse impact to cost, performance or schedule.* (* The terms "lower", "fewer" and "lesser" should be replaced with quantitative objectives, specifically developed for the system. Also the types of mishaps to be reduced should be qualified.)
RFP: SOO (ESOH Language)	ESOH Hazard Goal - Identify and eliminate, reduce or control ESOH hazards and the associated risks caused by noise within the constraints of program cost, schedule and performance throughout the life cycle of the system.

Document Section	Example Language
RFP: PWS/SOW (ESOH Language)	The contractor shall ensure that all identified environment, safety and occupational health risks caused by noise are eliminated, minimized, or controlled to acceptable levels within cost, schedule, and performance. The contractor shall design the ***<system name>*** to assure health and safety risks due to noise are kept to an acceptable level as determined by the Human Systems Integration Working Group. The contractor shall ensure the ***<system name>*** and its support do not present any uncontrolled safety, health or environmental hazards due to noise throughout its life cycle.
RFP: PWS/SOW (Survivability Language)	For systems with missions that might be exposed to combat threats, the contractor shall ensure survivability issues are mitigated through noise reduction/prevention methods such as dampening or re-engineering of noise producing equipment.
RFP: PWS/SOW (Habitability)	The contractor shall ensure habitability requirements that are necessary for meeting and sustaining system performance and maintaining quality of life have been incorporated into the ***<system name>*** program.
RFP: Section L (HFE Language)	The offeror shall describe in detail the proposed design approach incorporating noise reduction/prevention procedures in accordance with (IAW) applicable directives, to ensure that the system can be operated and maintained in an effective, efficient, and safe manner by appropriately trained personnel throughout the range of its intended operating environments. The offeror shall specifically explain how their design will meet the Key Performance Parameters (KPP) thresholds of the performance specification requirements, and as many of the Key System Attributes (KSA) and Other System Attributes (OSA) thresholds as possible pertaining to noise reduction/prevention. The offeror shall describe how their proposal incorporates trade-offs in an effort to maximize performance, minimize risk, and/or reduce life cycle costs, while meeting overall schedule length.
RFP: Section L (ESOH Language)	The offeror shall explain how they will integrate ESOH criteria and requirements into the system design and demonstrate how ESOH criteria and requirements will be defined, allocated, baselined and traceable to system level requirements. Areas of consideration will be to minimize ESOH noise hazards and manage ESOH risk throughout the life cycle of the system, manage hazardous material and control system-related noise emissions to reduce/prevent noise pollution at its source at the lowest possible cost, schedule, and performance risk, and ensure the system generates fewer mishaps, lower noise levels and uses a lesser quantity of hazardous materials than the equivalent systems.
RFP: Section M (HFE Language)	Does the design approach demonstrate the potential to meet the thresholds for all Key Performance Parameters (KPPs), and as many of the Key System Attributes (KSAs) and Other System Attributes (OSAs) thresholds in the Prioritized Requirements Matrix pertaining to noise reduction/prevention? Rationale for trade-offs will be evaluated based on risk, schedule implications, lifecycle cost savings, and performance gains. In general, obtaining an objective over a threshold is desired.
RFP: Section M (ESOH Language)	The subfactor is met when the offeror's proposal demonstrates how they will minimize ESOH hazards and manage ESOH risk, and develop a system with fewer mishaps and lower noise levels.

Capability Development Document (CDD)

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Note: Consider role of noise in system performance: Is communication essential to performance? If so, include communication/intelligibility in Section 6, Performance Parameters.

Sample Noise Prevention Language for the CDD

Document Section	Example Language
Maintainability, Usability, Performance: KSAs Speech Intelligibility	The ***<system name>*** will enable crew to score greater than ***<XX>*** percent on the Modified Rhyme Test (MRT) in the laboratory with talker and listener under simulated noise conditions.
	<System name> shall not subject any personnel to acoustic noise levels that result in a Total Daily Exposure (TDE) greater than **<C>.**
	Acoustic noise within **<X>** feet each pilot shall be within **<Y>** dBA throughout <**Z>** hours of operation.
Safety and Occupational Health	The system must be designed to eliminate or mitigate safety, health or physical risks pertaining to noise. Where hazards/risks exist, health and safety equipment and/or procedures must be identified. Health and Safety procedures and engineering design considerations must conform to all pertinent standards. Crew task load, fatigue factors, broad range of operation environments, and data assimilation must be considered.
	Identified safety and health risks pertaining to noise will be eliminated, minimized, or controlled to acceptable levels within cost, schedule, and performance constraints and shall be accomplished for the life of the system.
Environment	The system design shall reduce or eliminate noise during the manufacture, operation, maintenance, and disposal of the system.
Maintainability	The system design shall take advantage of advances in technology to improve total system performance inclusive of the human, hardware, and software pertaining to noise. This includes but is not limited to usability, effectiveness, decision support/aiding, information management/fusion, component reliability, embracing concept of “maintenance by exception”, and reducing time required to remove, repair, and replace components.
Maintainability: Key Boundary Conditions and Material Approaches	A comprehensive plan for training and noise reduction will be developed by the PM during the acquisition process. The plan will state that noise thresholds will not exceed **<XX>** levels.

Document Section	Example Language
Maintainability: HSI Considerations	The ***<system name>*** design will address applicable HSI domains (Manpower, Personnel, Training, HFE, ESOH, Personnel Survivability, and Habitability) with relation to noise reduction/prevention to optimize total system performance, minimize total operational cost, and ensure the system is designed to accommodate the characteristics of the user population that will operate, maintain, and support the system.
Maintainability: ESOH	ESOH issues will be eliminated, minimized, or controlled to acceptable levels within cost, schedule, and performance constraints. Implement noise reduction/prevention to ensure crews and passengers are only exposed to acceptable noise levels for the duration of all mission profiles.
	FAA Noise Restriction (Stage IV) Compliance: The ***<system name>*** shall be fully compliant with Stage IV noise restrictions standards.
	The system must be designed to eliminate or control to an acceptable level the environmental, safety, health, or physical risks within cost, schedule, and performance constraints in relation to noise reduction/prevention throughout the system life cycle. Where hazards or risks exist, health and safety equipment and/or procedures must be identified. ESOH residual exposures and risks must be identified, acknowledged by the appropriate authority, and controlled by the order of precedence to satisfy applicable requirements. Crew task load, fatigue factors, broad range of operating environments, and data assimilation must be considered.
	Digital High Frequency (HF) Radio: Upgrade of current analog HF radios to digital is required to allow crews to make optimal use of HF capabilities (i.e., increased radio coverage and reliability, secure communications, Simultaneous Operation (SIMOP), and elimination of HF “noise”).
	For systems operating in foreign and international environments the **<system name>** will maintain full compliance with applicable federal, state, local, foreign and international pollution control laws and regulations to include “noise pollution”.
Maintainability: HSI	The ***<system name>*** will address applicable HSI domains (Manpower, Personnel, Training, HFE, ESOH, Personnel Survivability, and Habitability) to optimize total system performance, minimize total operational cost, and ensure the system is built to accommodate the characteristics of the user population in relation to noise reduction/prevention that will operate, maintain, and s9upport the system.
Maintainability: Executive Summary, Capabilities Shortfall	Current ***<system name>*** does not provide adequate noise, impact, and ballistic protection.
Maintainability: Capabilities Gap Overview	Current ***<existing system names>*** do not provide adequate noise and impact protection.
Maintainability: Analysis Summary	The levels of impact and acoustic protection available in modern commercial and military ***<system names>*** exceed the protection available in the current design. Poor integration of unique ***<system name>*** mission capabilities (examples) with the ***<system name>*** has resulted in effectiveness and safety issues that need to be addressed by the execution of a replacement ***<system name>*** program.

Document Section	Example Language
Maintainability: KSAs Acoustic Dose	The ***<system name>*** will ensure operators experience acceptable noise levels, technically defined as 100% Acoustic Dose (1.0 Total Daily Exposure (TDE) @ mean -2 Standard Deviations (SD) performance for fit) for crew positions in ***<XX>*** percent of the system. For systems that do not meet the ***<XX>*** percent Acoustic Dose requirement, the ***<system name>*** will provide the best available solution within the limits of the design technology.
Maintainability: ESOH Requirements	The ***<system name>*** shall comply with all applicable laws, regulations, and standards on air/water pollution, waste/hazardous waste disposal, sewage disposal, radiation, noise, and reporting. Identified environmental, safety, and health risks, will be eliminated, minimized, or controlled to acceptable levels within cost, schedule and performance constraints. ESOH concerns are important to the user community.

System Engineering Plan (SEP) / System Engineering Management Plan (SEMP)

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Sample Noise Prevention Language for the SEP / SEMP

Document Section	Example Language
SEP/SEMP: Technical Performance Measurement	At a minimum, Technical Performance Measurements (TPMs) for the ***<system name>*** effort will include noise prevention criteria. Noise reduction/prevention criteria will be derived from key Operational, Safety, Suitability, and Effectiveness (OSS&E) attributes and will include OSS&E baseline parameters at a minimum.
SEP: System Overview	Add Noise reduction/prevention and applicable designation as a KPP, KSA or OSA and priority (if KSA or OSA) to the list of requirements.
SEMP: Capabilities To Achieve	Ensure that noise reduction/prevention is included and denotes noise limits suitable to your program/system.
SEMP: Constraints	Ensure that noise reduction/prevention applicable to your program/system is included and denotes noise limits that are not to be exceeded.
SEP/SEMP: Environmental, Safety and Occupational Health	Ensure that noise reduction/prevention is cited as part of relevant safety requirements.
SEP/SEMP: HSI	Ensure that noise reduction/prevention is mentioned as a factor in ensuring that human engineering operator/maintainer requirements are optimized within the overall system design and integration and is a critical part of the physical interface between human and system.
SEP	The ***<system name>*** shall be designed to minimize exposure of personnel to noise hazards generated by the ***<system name>*** or its equipment/components.
SEP	The ***<system name>*** shall ensure compatibility with the environment to provide safe levels of noise during operations/maintenance.

System Performance Specification (SPS)

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Sample Noise Prevention Language for the SPS

Document Section	Example Language
Program Unique Requirements	Noise reduction/prevention shall be considered in system design to ensure that ***<system name>*** systems employ optimal productivity while striving toward the goal of minimizing noise that may be detrimental to operators/maintainers and/or the environment.
	Unit shall operate at full load and part load conditions without exceeding the 90 dBA sound level in the equipment room. If unit does not meet the 90 dBA requirement, as measured in accordance with Air-Conditioning and Refrigeration Institute (ARI) Standard 57-587, provide all attenuation devices necessary to meet this requirement.
	Human performance shall be demonstrated and measured through HSI simulation and testing using representative operator and maintainer personnel and representative operational scenarios.
	The ***<system name>*** shall be designed such that it does not subject personnel to noise levels in excess of the limits specified in DoD, Federal, or State standards applicable to military equipment, systems, facilities or the environment.
	The ***<system name>*** shall contribute to a safe operating environment for all personnel by incorporating design features that eliminate, reduce, or mitigate the potential for injury, illness, or disability of all assigned operators and maintainers from noise exposure.
	The noise levels generated by the ***<system name>*** and associated equipment shall meet applicable federal, state and local laws and regulations and be no greater than ***<set an appropriate standard for the program>***.
	The ***<system name>*** shall be designed to minimize exposure of personnel to noise hazards generated by the ***<system name>*** or its equipment/components.
	The ***<system name>*** shall ensure compatibility with the environment to provide safe levels of noise during operations/maintenance.

Programmatic Environmental, Safety, and Health Evaluation (PESHE)

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Sample Noise Prevention Language for the PESHE

Document Section	Example Language
Strategy for ESOH Considerations	It is not the government's intent to require the System Development and Demonstration (SDD) contractors to use any specific Military Standard (MIL-STD) or Technical Order (TO) for PESHE guidance as long as the SDD contractors: 1) abide by their local, state, and federal regulations; 2) use environmentally friendly processes; and 3) meet the SDD cost, performance, and schedule commitments. The government is committed to lessening the amount of toxic and noise exposure incurred by operators/maintainers and the environment. The PESHE documents the ***<system name>*** efforts to emphasize elimination or reduction to safe levels of the amount of Hazardous Materials (HAZMAT), Ozone Depleting Substances (ODSs), and noise involved with development, use, and disposal of the ***<system name>***. It also seeks to ensure a safe ***<system name>*** design and reduce occupational hazards.
Environmental Compliance	The ***<system name>*** program office will include clauses in the program agreements to ensure the contractors will restrict the use of Ozone Depleting Substances (ODSs) and reduce, minimize, or eliminate noise and the use of hazardous materials.
Noise Reduction/Prevention	The ***<system name>*** will employ noise reduction/prevention measures in order to comply with local, state, and DoD standards in relation to noise exposure to both operators/maintainers and the environment.
Pollution Prevention	The contractor will identify sources of noise pollution associated with the ***<system name>*** and take measures, where possible, to eliminate or minimize the noise pollution.
System Safety and Health	The ***<system name>*** shall contribute to a safe operating environment for all personnel by incorporating design features that eliminate, reduce, or mitigate the potential for injury, illness, or disability of all assigned operators and maintainers from noise exposure.
	The noise levels generated by the system and associated equipment shall meet applicable federal, state and local laws and regulations and be no greater than ***<set an appropriate standard for your program>.***
	(If applicable) Evaluate the ***<system name>*** for effects of system components and the entire system on Whole Body Vibration (WBV).

Contract Incentives for Noise

Below are questions for PMs to consider when including incentives related to noise reduction/prevention contracts.

- Will enhanced performance of noise reduction/prevention provide additional value to the mission?
  - Yes: Noise Induced Hearing Loss (NIHL) reduces the ability of warfighters to communicate in the field and critical mishaps and mistakes increase when warfighters cannot communicate effectively.
  - Yes: Temporary Threshold Shift (TTS) causes degraded communications in a battlefield environment. Hearing could take days to recover to baseline level of normal hearing after instant or prolonged exposure to excessive noise.
- Which subsystems of the requirement would benefit most from enhanced performance of noise reduction/prevention?
  - Example: Propellers on the Navy's aircraft carrier fleet have a new, improved design that reduces the propeller excitation of the ship structure. IMPACT: Results in less turbulence, less vibration and less noise.
- Which areas do not need added incentives (or which areas can do without)?
  - None: Military services are acquiring systems that produce a level of excessive noise that virtually guarantees hearing loss. The only question is when and to what extent operators/maintainers will suffer permanent hearing damage (McCleary, 2008).
- How much is the agency willing to pay to achieve a level of performance beyond the performance standard? Do contractors within a particular industry prefer additional performance periods (award terms) in lieu of monetary incentives (award fees)?
  - This must be determined on a case-by-case basis and will depend on system complexity, contractor familiarity with the system type, technology maturity, and contractor solvency among many other factors.
- Is the incentive affordable? Will it affect timelines or affect schedules in a positive way? Adversely?
  - Take into consideration: Hearing loss is expensive. In an article by the Columbia Broadcasting System (CBS), the Department of Veteran Affairs (DVA) states that of 1.3 million troops who have served in Operation Iraqi Freedom and/or Operation Enduring Freedom (Afghanistan) nearly 70,000 are collecting disability for tinnitus, more than 58,000 are on disability for hearing loss. These instances of hearing damage will result in payments totaling $1.1 billion annually by 2011.
  - This must be determined on a case-by-case basis; however, if the incentive ultimately will reduce or prevent excessive or damaging noise related to the system/acquisition and, consequently, decrease subsequent medical and disability ramifications which could total millions of dollars per year in total ownership costs then all options should be considered.

TIP: Make sure incentives are realistic and attainable—in other words, understand that a contractor will not spend a dime to earn a nickel. To achieve the desired outcome, incentives should be consistent with the effort and the contract value. They must also be carefully structured to consider their overall impact and to avoid any unintended consequences while providing value for achieving the mission. (Performance-Based Services Acquisition in the Department of Defense (Dec 2000)).

TIP: Make sure that incentives are built upon performance objectives and performance standards, and ensure that they are measurable and attainable. If they do not clearly communicate the agency's desires and expectations, they will have—at best—only a random chance of achieving the desired outcome. An "I'll know it when I see it" approach is neither an incentive nor a performance standard. (Performance-Based Services Acquisition in the Department of Defense (Dec 2000)).

Cost-Plus Incentive Fee Contracts

The cost-plus incentive fee contract is a contract in which the contractor is offered a negotiated incentive fee which is based on the actual total cost being less than the contracted total cost. This increase or decrease is intended to provide an incentive for the contractor to manage the contract effectively (FAR Subpart 16.4).

Example Usage:

For services such as maintenance of equipment, typical measures would be Mean Time Between Failures (MTBF), Mean Time To Repair (MTTR) or system availability rates (incommission rates). Regardless of the measure, performance incentives must be quantified and within a reasonable range (high-target-low). This could be applied to equipment that has a complex system that requires noise reduction/prevention equipment or engineering. This will encourage the contractor to take time when engineering in order to ensure a quality product.

Cost-Plus Award Fee Contracts

The cost-plus award fee is a type of contract with special fee provisions. It provides a means of applying incentives to contracts which are not susceptible to finite measurements of performance necessary for structuring incentive contracts. The fee is provided in two parts: a fixed amount unrelated to performance, and an award amount related to a subjective judgment of the quality of the contractor's performance (FAR Subpart 16.4).

Example Usage:

The cost-plus award fee provides a means of applying incentives in contracts which are not susceptible to finite measurements of performance during research and development for example, the development of new noise reduction/prevention technologies or processes.

Fixed Price Incentive Contracts

A fixed price incentive contract is a fixed price contract that provides for adjusting profit and establishing the final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost. The final price is subject to a price ceiling, negotiated at the outset.

Example Usage:

The contractor assumes a degree of responsibility for cost control, and this provides a positive profit incentive for effective cost control and performance. Examples of when to use fixed price incentives are: when modifying the noise output on a piece of equipment, and when the contract includes incentives on technical performance and/or delivery of noise reduction/prevention prototypes, etc. The performance requirements will provide a reasonable opportunity for the incentives to have a meaningful impact on the contractor's management of the work.

Fixed Price Incentive (Firm Target) Contracts

A fixed price incentive (firm target) contract can be utilized when the parties can negotiate at the outset a firm target cost, target profit, and profit adjustment formula that will provide a fair and reasonable incentive and a ceiling that allows the contractor to share the risk. The target profit should reflect the contractor’s acceptance of the risk (FAR Subpart 16.4).

Example Usage:

A fixed price incentive (firm target) contract can be utilized when modifications to existing equipment are needed to incorporate noise requirements. The contractor can utilize known technologies to reduce/prevent noise. By using the known technologies, the pricing for the parts is established and eliminates the unknown factors surrounding new technology development.

Fixed Price Contracts with Award Fees

An award fee contract is used to motivate a contractor when other incentives cannot be used because contractor performance cannot be measured objectively. Contracts shall establish a fixed price to include normal profit for the effort. The fixed-price will be paid for satisfactory contract performance. The award fee if earned will be paid in addition to the fixed-price (FAR Subpart 16.4).

Example Usage:

Government needs the contractor to create a new product to reduce/abate noise that is not established in the commercial world. Therefore, there are not quantitative metrics available when the contract is written.

Performance Incentives

Performance incentives may be utilized with measurable product characteristics or other specific elements of the contractor's performance. These incentives should be designed to relate profit or fee to results achieved by the contractor with regards to measured product performance.
Technical performance incentives should be utilized in major systems contracts, both in development and in production (FAR Subpart 16.4).

Example Usage:

Performance incentives may be considered with specific product characteristics (e.g. noise reduction/prevention) or other specific elements of the contractor's performance.

Technical performance could be used with the development of a noise reduction/prevention prototype for any type of equipment needed by the government.

Structuring Multiple Incentive Contracts

A structured multiple incentive contract should strive for outstanding results in all incentive areas. It should aim for trade-offs between different incentive areas.

Example Usage:

Multiple-incentive contracts could be used when the performance is being measured for the development of a new noise reduction/prevention prototype, and a fixed-price incentive is being used to provide a reasonable opportunity for the incentives to have a meaningful impact on the contractor's management of the work.

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Value Engineering

Value engineering (VE) attempts to eliminate, without impairing essential functions or characteristics, anything that increases acquisition, operation, or support costs. VE opportunities will be derived from a known problem, a cost driver study, or anything that indicates a product or a process should be improved. Substantial benefits of VE are seen in examples such as eliminating high cost drivers; improving performance, reliability, or producibility; or resolving executive management interest issues.

These contract provisions provide the basis for the contractor to obtain a share of the savings that result from an approved VE effort. The VE provisions in a contract prescribe that the contractor receives a substantial share in the savings accrued as a result of implementation of the change (DoD Contractor's Guide to Value Engineering 2010).

Potential for VE may be found in almost any aspect of a contract or program. A general listing of these aspects (not all-inclusive) applicable to noise reduction/prevention initiatives follows:

- Design or equipment modifications
- Equipment and logistics support
- Facilities and hardware
- Manufacturing processes

Example Usage:

- Design or equipment modifications of aircraft engines to reduce/abate excessive noise
- Equipment and logistics support equipment areas modified in order to reduce noise
- Facilities and hardware redesigned with noise dampening materials to reduce the noise that is admitted through the walls and HVAC ducts
- Manufacturing processes modified to reduce noise produced by the machinery

Engineering out as much noise as possible at the acquisition level will significantly reduce the long term monetary cost and disability of noise induced hearing loss incurred by both government and private agencies.

DoD Noise – Air

Each service's systems can be loosely classified by macro-environments (air, land, and sea) and multiple micro-environments. Each micro-environment can be further broken down by types of systems. *Note that this short assessment of noise issues does not include all possible micro-environments, systems, types of noise, or causes of noise.*

Air Macro - Environments

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Aircraft Flight Operations	• Fixed wing aircraft • Missiles • Rotary wing aircraft • Unmanned aircraft **On-board systems**: • Cockpit systems • Computer systems • Environmental control systems • Loading systems • Weapons systems	• Aircraft pilots • Aircrews • Air Traffic Controllers • Maintenance crews onboard aircraft • Neighboring communities in the flight path • Passengers onboard aircraft • Wildlife around airfield and in flight path	• Design of aircraft parts • Proximity of flight paths to population areas	• Airborne • Impulse • Steady-State • Structure-Borne	• Air Flow • Engines • Propellers • Rotors • Vibration **On-board systems:** • Loading machinery • Mechanical • Warning tones and alerts • Weapons fire

DoD Noise – Sea

Each service's systems can be loosely classified by macro-environments (air, land, and sea) and multiple micro-environments. Each micro-environment can be further broken down by types of systems. *Note that this short assessment of noise issues does not include all possible micro-environments, systems, types of noise, or causes of noise.*

Sea Macro-Environment

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Ocean-going	• Diving Bell • Mine Sweeper • Ship • Submarine	• Personnel • Wildlife	• Design of duct work and noise transmitting materials on ship • Design of equipment parts • Personnel proximity to equipment • Personnel proximity to other personnel • Size of area	• Airborne • Mechanical • Steady-State • Structure-Borne	• HVAC ducts/pipes • Machinery • Vents • Warning tones and alerts

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Ship-board (general)	• Communication equipment • Engine room equipment • HVAC systems • Propulsion system • Sonar/ detection equipment • Weapons system	• Personnel	• Design of ductwork and noise transmitting materials on ship • Design of equipment parts • Personnel proximity to equipment • Personnel proximity to other personnel • Size of area	• Airborne • Impulse • Mechanical • Steady-State • Structure-Borne	• Ducts/pipes • Gears • Machinery • Motors • Vents • Warning tones and alerts • Weapons discharge
Ship-board Office Space or Operation Center	• Computer systems • Office equipment	• Personnel	• Design of equipment parts • Personnel proximity to equipment • Personnel proximity to HVAC • Personnel proximity to operating personnel • Size of area	• Airborne • Impulse • Mechanical • Steady-State • Structure-Borne	• Ducts/pipes • HVAC machinery • Vents • Warning tones and alerts
Ship-board Specialized Work Spaces (ex. Laboratory, Food Service, Control Room)	• Laboratory machinery (ex. electron microscope, autoclave) • Mixer • Refrigeration machinery • Robotics • Test Machinery	• Personnel	• Design of equipment parts • Proximity to equipment • Proximity to personnel • Size of area	• Airborne • Impulse • Mechanical • Steady-State • Structure-Borne	• Ducts/Pipes • Gears • HVAC machinery • Machinery • Motors • Vents • Warning tones and alerts

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Ship-board Maintenance Facilities	• HVAC systems • Maintenance machinery	• Personnel	• Design of duct work and noise transmitting materials on ship • Design of equipment parts • Personnel proximity to equipment • Proximity to personnel in the area • Size of area	• Flow • Mechanical • Steady-State • Structure-Borne	• Ducts/pipes • Exhaust fans • Gears • Machinery • Motors • Vents • Vibration
Flight Deck	• Fixed-wing aircraft • Generator • Maintenance equipment • Mobile lighting units • Rotary-wing aircraft	• Aircraft pilots and aircrew during engine runs and taxi operations • Air Traffic Controllers during taxi operations, engine runs, daily maintenance • Maintenance crews during taxi operations, engine runs, daily maintenance • Personnel onboard in sleeping quarters, office areas, etc.	• Design of aircraft parts • Design of equipment parts • Direction of jet blast	• Airborne • Impulse • Steady-State • Structure-Borne	• Aircraft engine • Engines (in general) • Equipment motors • Mechanical • Rotors • Tires/Treads • Vibration

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Firing Range	• Artillery • Small arms	• Personnel	• Design of equipment • Personnel proximity to equipment • Proximity to personnel in the area • Proximity to wildlife	• Airborne • Impulse	• Spent shell discharge • Vibration • Weapon discharge

DoD Noise – Land

Each service's systems can be loosely classified by macro-environments (air, land, and sea) and multiple micro-environments. Each micro-environment can be further broken down by types of systems. *Note that this short assessment of noise issues does not include all possible micro-environments, systems, types of noise, or causes of noise.*

Land Macro-Environments

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Ground Vehicles	• Car • Personnel carrier (Humvee, APC) • Truck	• Passengers • Personnel	• Design of equipment parts • Personnel proximity to operating vehicles	• Impulse • Mechanical • Steady-State • Structure-Borne	• Air conditioning • Engine • Exhaust systems • Radios • Tires • Vibration • Weapons fire
Tracked Vehicles	• Other tracked vehicle • Tank	• Passengers • Personnel • Wildlife	• Design of equipment parts • Personnel proximity to operating vehicles • Proximity to personnel in the area • Proximity to wildlife	• Impulse • Mechanical • Steady-State • Structure-Borne	• Engine • Gears • Machinery • Tires/Treads • Vibrations • Weapons fire

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Specialized Equipment (ex. Construction)	• Crane • Dump Truck • Plow • Tractor • Transport Equipment (ex. Forklift)	• Personnel	• Design of equipment parts • Personnel proximity to operating vehicles • Proximity to personnel in the area • Proximity to wildlife	• Mechanical • Steady-State • Structure-Borne	• Engine • Gears • Machinery • Tires/Treads • Vibration
Maintenance Facilities	• Heavy machinery • HVAC systems • Maintenance machinery	• Personnel	• Design of equipment parts • Personnel proximity to equipment • Proximity to personnel in the area • Size of area	• Flow • Mechanical • Steady-State • Structure-Borne	• Communication equipment • Ducts/pipes • Exhaust fans • Gears • Machinery • Motors • Vents • Vibration
Airfield	• Fixed-wing aircraft • Generator • Loading systems • Maintenance equipment (ex. APU/GPU) • Maintenance vehicles • Mobile lighting unit • Rotary-wing aircraft	• Aircraft pilots and aircrew during engine runs and taxi operations • Airfield personnel (drivers, security forces, etc.) • Air Traffic Controllers during taxi operations, engine runs, daily maintenance • Maintenance crews during taxi operations, engine runs, daily maintenance	• Design of equipment parts • Proximity to buildings • Proximity to neighboring communities	• Airborne • Impulse • Steady-State • Structure-Borne	• Aircraft engine • Engines (in general) • Equipment motors • Mechanical • Rotors • Tires/Treads • Vibration

Micro-Environment	Types of Systems	Vulnerable Populations	System Considerations	Noise Type	Cause of Noise
Firing Range	• Artillery • Small arms	• Personnel • Wildlife	• Design of equipment • Personnel proximity to equipment • Proximity to personnel in the area • Proximity to wildlife	• Airborne • Impulse	• Spent shell discharge • Vibration • Weapon discharge
Specialized Work Spaces (ex. Laboratory, Food Service, or Control Room)	• HVAC systems • Laboratory machinery (ex. electron microscope, autoclave) • Mixer • Refrigeration systems • Robotics • Test machinery	• Personnel	• Designs of equipment parts • Personnel proximity to equipment • Personnel proximity to personnel • Size of area	• Airborne • Mechanical • Steady-State • Structure-Borne	• Gears • Machinery • Motors • Vents • Warning tones and alerts
Office Space, Operations Center	• Office equipment • Computer systems	• Personnel	• Personnel proximity to equipment • Personnel proximity to HVAC vents/ducts • Personnel proximity to other personnel • Size of area	• Airborne • Mechanical • Steady-State • Structure-Borne	• HVAC ducts/pipes • Machinery • Vents • Warning tones and alerts
Electrical Facilities	• Control systems • Generator • Power production plant	• Personnel	• Design of equipment • Personnel proximity to equipment • Proximity to personnel in the area • Proximity to wildlife	• Ambient • Mechanical • Steady-State • Structure-Borne	• Machinery • Motors • Warning tones and alerts

Standards

Note: According to DODI 4120.24, the Defense Standardization Program, it is recommended that PMs utilize non-government standards when possible. Non-government agencies recognized by the science and technology communities develop their standards based on research, as opposed to military standards, which have been established based on general knowledge or accepted practices, not necessarily proven through research. The following is a list of standards that can be used to develop noise reduction/prevention language.

Department of Defense	
Document	DODI 6055.12 Hearing Protection Program
URL	http://www.dtic.mil/whs/directives/corres/pdf/i605512_030504/i605512p.pdf
Document	DODI 6055.1 DoD Safety and Occupational Health (SOH) Program
URL	http://www.dtic.mil/whs/directives/corres/pdf2/i60551p.pdf

Military Standards, Handbooks and Specifications	
Document	MIL-STD-740 Airborne and Structure Borne Noise Measurements and Acceptance Criteria of Shipboard Equipment
URL	http://www.everyspec.com/MIL-STD/MIL-STD+(0700+-+0799)/MIL-STD-740B_10381/
Document	MIL-STD-740-1 Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment
URL	http://www.everyspec.com/MIL-STD/MIL-STD+(0700+-+0799)/MIL-STD-740-1_10379/
Document	MIL-STD-1474 Noise Limits
URL	http://www.everyspec.com/MIL-STD/MIL-STD+(1400+-+1499)/MIL-STD-1474D_25106/
Document	MIL-HDBK-767 Design Guidance for Interior Noise Reduction in Light-Armored Tracked Vehicles
URL	http://www.everyspec.com/MIL-HDBK/MIL-HDBK+(0700+-+0799)/MIL_HDBK_767_1911/

International Organization for Standardization (ISO)	
Document	ISO 6242-3: 1992 Building Construction – Expression of User's Requirements – Part 3: Acoustical Requirements
URL	http://www.iso.org
Document	ISO 8862: 1987 Air Conditioning and Ventilation of Machinery Control Rooms on Board Ships – Design Conditions and Basis of Calculations
URL	http://www.iso.org
Document	ISO 226: 2003 Acoustics – Normal Equal Loudness Level Contours

International Organization for Standardization (ISO)	
URL	http://www.iso.org
Document	ISO 532: 1975 Acoustics – Method for Calculating Loudness Level
URL	http://www.iso.org
Document	ISO 1999: 1990 Acoustics – Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment
URL	http://www.iso.org
Document	ISO 2631-1: 1997 Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-Body Vibration – Part 1: General Requirements
URL	http://www.iso.org
Document	ISO 2631-2: 2003 Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-Body Vibration – Part 2: Vibration in Buildings (1 Hz to 80 Hz)
URL	http://www.iso.org
Document	ISO 2631-4: 2001 Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-Body Vibration – Part 4: Guidelines for the Evaluation of the Effects of Vibration and Rotational Motion on Passenger and Crew Comfort in Fixed-Guideway Transport Systems
URL	http://www.iso.org
Document	ISO 2631-5: 2004 Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-Body Vibration – Part 5: Method for Evaluation of Vibration Containing Multiple Shocks
URL	http://www.iso.org
Document	ISO 5007: 2003 Agricultural Wheeled Tractors – Operator's Seat – Laboratory Measurement of Transmitted Vibration
URL	http://www.iso.org
Document	ISO 7096: 2000 Earth-Moving Machinery – Laboratory Evaluation of Operator Seat Vibration
URL	http://www.iso.org
Document	ISO 8041: 2005 Human Response to Vibration – Measuring Instrumentation
URL	http://www.iso.org
Document	ISO 10819: 1996 Mechanical Vibration and Shock – Hand-Arm Vibration – Method for the Measurement and Evaluation of the Vibration Transmissibility of Gloves at the Palm of the Hand
URL	http://www.iso.org

American National Standards Institute (ANSI)	
Document	ANSI S1.1: 2004 Acoustical Terminology
URL	http://www.ansi.org

American National Standards Institute (ANSI)	
Document	ANSI S1.6: 2006 Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements
URL	http://www.ansi.org
Document	ANSI S1.11: 2004 Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters
URL	http://www.ansi.org
Document	ANSI S1.13: 2005 Measurement of Sound Pressure Levels in Air
URL	http://www.ansi.org
Document	ANSI S1.40: 2006 Specification and Verification Procedures for Sound Calibrators
URL	http://www.ansi.org
Document	ANSI S2.2: 1959 (R2005) Methods for Calibration of Shock and Vibration Pickups
URL	http://www.ansi.org
Document	ANSI S2.70: 2006 Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand
URL	http://www.ansi.org
Document	ANSI S3.1: 2003 Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms
URL	http://www.ansi.org
Document	ANSI S3.2: 2009 Method for Measuring the Intelligibility of Speech Over Communication Systems
URL	http://www.ansi.org
Document	ANSI S3.4: 2003 Procedure for the Computation of Loudness of Noise
URL	http://www.ansi.org
Document	ANSI S3.20: 2003 Bioacoustical Terminology
URL	http://www.ansi.org
Document	ANSI S3.29: 1983 (R2001) Guide to the Evaluation of Human Exposure to Vibration in Buildings
URL	http://www.ansi.org
Document	ANSI S3.41: 1990 (R2008) Audible Emergency Evacuation Signal
URL	http://www.ansi.org
Document	ANSI S3.44: 1996 (R2006) Determination of Occupational Noise-Exposure and Estimation of Noise-Induced Hearing Impairment
URL	http://www.ansi.org
Document	ANSI S3.73: 2002 (R2007) Measurement and Evaluation of the Vibration Transmissibility of Gloves at the Palm of the Hand
URL	http://www.ansi.org

American National Standards Institute (ANSI)	
Document	ANSI S12.1: 1983 (R2006) Guidelines for the Preparation of Standard Procedures for the Determination of Noise Emission for Sources
URL	http://www.ansi.org
Document	ANSI S12.2: 1999 (R2008) Criteria for Evaluating Room Noise
URL	http://www.ansi.org
Document	ANSI S12.3: 1985 (R2006) Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment
URL	http://www.ansi.org
Document	ANSI S12.6: 1997 Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors
URL	http://www.ansi.org
Document	ANSI S12.7: 1986 (R2006) Methods for Measurements of Impulse Noise
URL	http://www.ansi.org
Document	ANSI S12.9: 1988 (R1998) Quantities and Procedures for Description and Measurement of Environmental Sound
URL	http://www.ansi.org
Document	ANSI S12.10: 2002 (R2007) Measurement of Airborne Noise Emitted by Information Technology and Telecommunications Equipment
URL	http://www.ansi.org
Document	ANSI S12.11: 2003 – Part 1 Measurement of Noise and Vibration of Small Air-Moving Devices, Part 1: Airborne Noise Emissions
URL	http://www.ansi.org
Document	ANSI S12.12: 2002 (R2007) Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Sound Intensity
URL	http://www.ansi.org
Document	ANSI S12.14: 1992 Methods for the Field Measurement of the Sound Output of Audible Public Warning Devices Installed at Fixed Locations Outdoors
URL	http://www.ansi.org
Document	ANSI S12.15: 1992 Acoustics – Portable Electric Power Tools, Stationary and Fixed Electric Power Tools, and Gardening Appliances, Measurement of Sound Emitted
URL	http://www.ansi.org
Document	ANSI S12.16: 1992 (R2007) Guidelines for the Specification of Noise of New Machinery
URL	http://www.ansi.org
Document	ANSI S12.18: 1994 (R2009) Procedure for Outdoor Measurement of Sound Pressure Level
URL	http://www.ansi.org

American National Standards Institute (ANSI)

Document	ANSI S12.19: 1996 (R2006) Measurement of Occupational Noise Exposure
URL	http://www.ansi.org
Document	ANSI S12.23: 1989 (R2006) Method for the Determination of Sound Power Emitted by Machinery and Equipment
URL	http://www.ansi.org
Document	ANSI S12.30: 1990 Guidelines for the Use of Sound Power Standard and for the Preparation of Noise Test Codes
URL	http://www.ansi.org
Document	ANSI S12.42: 2010 Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures
URL	http://www.ansi.org

Society of Automotive Engineers (SAE)

Document	SAE J 88: 2006 Sound Measurement – Off-Road Work Machines - Exterior
URL	http://www.sae.org
Document	SAE J 184: 1998 Qualifying a Sound Data Acquisition System
URL	http://www.sae.org
Document	SAE J 336: 2001 Sound Level for Truck Cab Interior
URL	http://www.sae.org
Document	SAE J 366: 2001 Exterior Sound Level for Heavy Trucks and Buses
URL	http://www.sae.org
Document	SAE J 885: 1986 Human Tolerance to Impact Conditions as Related to Motor Vehicle Design
URL	http://www.sae.org
Document	SAE J 919: 1995 Sound Measurement – Off-Road Work Machines – Operator – Singular Type
URL	http://www.sae.org
Document	SAE J 986: 1998 Sound Level for Passenger Cars and Light Trucks
URL	http://www.sae.org
Document	SAE J 1013: 1992 Measurement of Whole Body Vibration of the Seated Operator of Off-Highway Work Machines
URL	http://www.sae.org
Document	SAE J 1074: 2000 Engine Sound Level Measurement Procedure
URL	http://www.sae.org
Document	SAE J 1166: 1998 Sound Measurement – Off-Road Self-Propelled Work Machines – Operator-Work Cycle

Society of Automotive Engineers (SAE)	
URL	http://www.sae.org
Document	SAE J 1174: 1985 Operator Ear Sound Level Measurement Procedure for Small Engine Powered Equipment
URL	http://www.sae.org

U.S. Navy	
Document	OPNAVINST 9640.1A Shipboard Habitability Program
URL	http://doni.daps.dla.mil/default.aspx
Document	Military Sealift Command Instruction (COMSCINST) 9330.6D Accommodation Standards for Military Sealift Command Ships
URL	http://www.msc.navy.mil
Document	Naval Sea Systems Command T9640-AB-DDT-010/HAB Shipboard Habitability Design Criteria Manual
URL	http://habitability.net

U.S. Army	
Document	Army Regulation (AR) 40-5 Preventative Medicine
URL	http://armypubs.army.mil/epubs/40_series_collection_1.html
Document	AR 40-10 Health Hazard Assessment Program in Support of the Army Acquisition Process
URL	http://armypubs.army.mil/epubs/40_series_collection_1.html
Document	PAM 385-63 Range Safety
URL	http://armypubs.army.mil/epubs/385_series_collection_1.html

U.S. Air Force	
Document	AFOSH 48-20 Occupational Noise and Hearing Conservation Program
URL	http://www.e-publishing.af.mil/shared/media/epubs/AFOSHSTD48-20.pdf
Document	Air Force Instruction (AFI) 36-2226 Combat Arms Program
URL	http://www.af.mil/shared/media/epubs/AFI36-2226.pdf

National Aeronautics and Space Administration (NASA)	
Document	NASA-STD-3001, Volume 1: 2009 NASA Space Flight Human System Standard, Volume 1: Crew Health
URL	https://standards.nasa.gov/released/NASA/NASA_STD_3001_Vol_1.pdf
Document	NASA-STD-3001, Volume 2 (DRAFT) NASA Space Flight Human System Standard, Volume 2: Human Factors, Habitability, and Environmental Factors
URL	http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20090026456_2009026283.pdf
Document	NASA/SP-2010-3407: 2010 Human Integration Design Handbook (HIDH)
URL	http://ston.jsc.nasa.gov/collections/TRS/_techrep/SP-2010-3407.pdf

American Society for Testing and Materials (ASTM)	
Document	ASTM F1166-95a, 2006 Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities
URL	http://www.astm.org
Document	ASTM F1337-91, 2001 Standard Practice for Human Engineering Program Requirements for Ships and Marine Systems, Equipment, and Facilities
URL	http://www.astm.org

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