



ENVIRONMENT FOR AUDITORY RESEARCH

The Environment for Auditory Research (EAR) is an auditory perception and communication research center permitting state-of-the-art spatial perception and communication research in various indoor and outdoor acoustic environments. The areas of current and planned research activities include:

- Auditory spatial orientation
- Auditory distance and depth estimation
- Auditory virtual displays design
- Acoustic signature detection and identification
- Auditory icons and warning signals design
- Perception of moving sound sources
- Speech communication studies
- Soldier auditory performance studies in natural environments

The EAR is a part of the modern laboratory system being developed at the Human Research and Engineering Directorate of the U.S. Army Research Laboratory (ARL-HRED). The facility is located in the ARL-HRED complex at Aberdeen Proving Ground (MD, USA) and consists of the Control Room and five listening spaces; Sphere Room, Dome Room, Distance Hall, Listening Laboratory, and OpenEAR (under construction; to be open in September 2008). Capabilities of the EAR laboratory include:

- Compliance with NC-15 noise criteria resulting in background noise levels close to the threshold of hearing
- Semi-anechoic listening conditions reducing early acoustic reflections to negligible levels
- Extensive and flexible means for sound production by 600+ sound sources
- Acoustic and electroacoustic means for changing spatial properties of sound
- Wide-range heating and cooling ranges to permit climate simulation
- Adjustable lighting conditions varying from complete darkness to high intensity illumination
- Integrated control room permitting full control of research activities in all research spaces
- Rapid comparison of listener performance under well controlled laboratory conditions and real world field conditions
- Microphones, remote controlled cameras, and data collection devices for complete monitoring of listener behavior in any of the research spaces from the Control Room.

CONTROL ROOM

The Control Room is an integrated control center permitting complete control of instrumentation and research activities in all five listening spaces. It contains the front-end of all instrumentation and stimuli generation systems. The audio system of the EAR is powered by 4 computers and includes extensive and automatic switching capability. The system is capable of generating up to eight (8) independent auditory stimuli at any or all (approximately 600) loudspeaker and earphone locations throughout the facility.



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Functionality of the Control Room enables control and monitoring of as many as four simultaneous experiments conducted in various spaces of the facility from a single location. In addition, audio and video capabilities of the Control Room can be used to provide audio-video demonstrations and instructions for new users, experiment participants, and visitors.

SPHERE ROOM

The Sphere Room is a 300 square foot auditory virtual reality space designed to investigate:

- Integrity of auditory virtual spaces
- Realism of complex auditory simulations
- Effects of Head-Related Transfer Function on auditory perception
- Effect of helmets and other headgear on spatial orientation



The room contains 57 test loudspeakers separated by 30 degrees in vertical and horizontal directions and constituting a sphere surrounding the listener.

This loudspeaker configuration enables virtual sound sources movement and sound projections in an almost full 360° spherical angle.

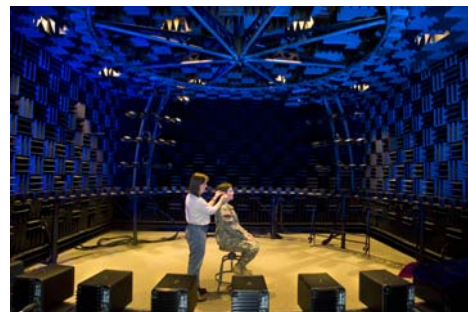
Up to eight (8) stationary or moving sound sources may be presented to any combination of the 57 loudspeakers permitting generation of realistic and dynamically changing acoustic environments.

DOME ROOM

The Dome Room is a 525 square foot space designed to study the human's ability to localize real or virtual, single or multiple, and stationary or moving sources distributed in a hemispherical space.

The space is designed to accommodate a wide range of:

- Spatial orientation and sound source localization experiments
- MOUT simulation experiments by combining the Dome Room, Distance Hall, and OpenEAR capabilities in one complex environment.



The room contains a removable horizontal circular array supplemented by two movable vertical arcs that together can accommodate up to 240 loudspeakers

Individual loudspeakers are arranged on the horizontal array at a 2° separation for a total of 180 loudspeakers placed along the circle perimeter.

The remaining 60 loudspeakers populate two vertical arcs that can be positioned either side-by-side, to form a 180° arc, or to form any other angular configuration.

Moving sound sources can be simulated by panning sounds across the loudspeaker array or by manipulating time delay and intensity of phonic signals.

DISTANCE HALL

The Distance Hall is a 70 foot long acoustically treated space designed to study auditory distance estimation and the effects of sound source movement toward and away from the listener on sound source detection and identification. Acoustic configuration and audio capabilities of the Distance Hall permit extensive investigation of:

- Localization and tracking of sound sources moving in a predetermined manner toward and away from the listener
- Auditory distance and depth estimation
- Tracking of sound sources moving above the listener (e.g., flying bullets)
- Detection and recognition of sound sources appearing far away from the listener



The main sound projection system of the Distance Hall consists of 180 loudspeakers arranged in linear groups of five that are suspended from the ceiling every 5 feet along the length of the hall in three parallel lanes to form 12 rows of 15 loudspeakers each across the hall.

A reconfigurable rectangular Sound Wall is installed at the far end of the Distance Hall to simulate an endless space by minimizing reflections from the distant wall. The wall consists of nine vertical panels of five loudspeakers each that can be placed together or used as the individual panels.

LISTENING LABORATORY

The Listening Laboratory is a unique multipurpose 300 square foot room for studying the effects of space acoustics and sound sources configurations on sound perception.

Acoustic features and instrumentation of the Listening Laboratory were designed to facilitate:

- Comparative studies of various existing and proposed sound reproduction and sound reinforcement systems
- Comparison of loudspeaker, headphone, and bone conduction sound reproduction systems
- Effects of room acoustics, noise level, and reverberation time on speech communication



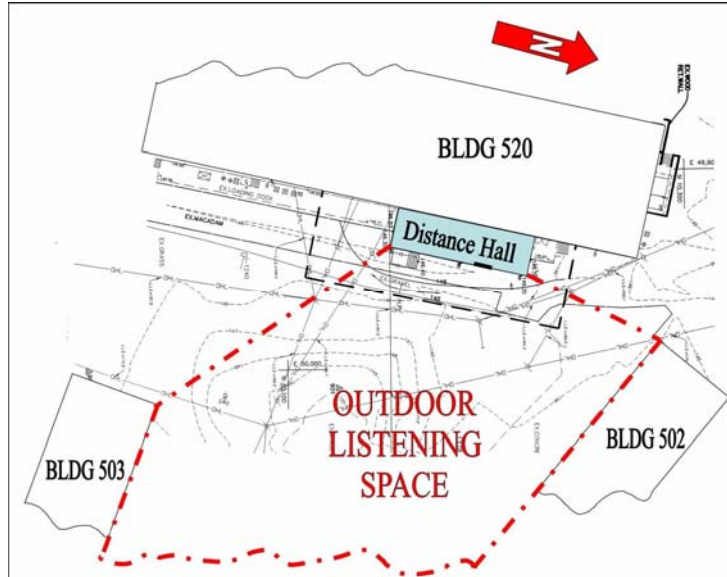
The Listening Laboratory is equipped with 16 wideband loudspeakers and 2 low frequency loudspeakers which can be arranged to represent various sound reproduction systems or to simulate the effects of several talkers such as those in a Tactical Operations Center

Removable individual sound absorptive panels covering wooden walls provide means to study both the global effects of room reverberation and the effects of discrete sound reflections on sound perception. The absorptive paneling can be removed all together or individual panels can be placed on the walls in any desired combination.

OpenEAR

OpenEAR is a 48,000 square foot outdoor extension of the EAR complex designed to replicate studies conducted in the laboratory environment in a natural field environment with the same listeners at almost the same time to reduce data uncertainty resulted from laboratory and field studies conducted at different times and with different listeners.

Using OpenEAR any experiment conducted under strictly controlled conditions in the Distance Hall can be immediately repeated by opening the door, repositioning the listening station, and presenting the same stimuli in the outdoor setting to assess the effects of temperature, humidity wind, noise, and reflections from surrounding buildings and ground on auditory performance using the same listeners at practically the same point in time.



Outdoor loudspeakers and microphones can be also arranged in various special configurations to study specific effects of natural environments on sound propagation.

By using the Dome Room, Distance Hall, and OpenEAR together various urban terrain configurations typical of city warfare can be simulated.

The ARL Environment for Auditory Research is a unique and powerful research tool, and in combination with the capabilities of the OpenEAR creates a research complex unmatched at any military, academic, or industrial facility world-wide. It is truly a national asset.

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