

AIRS Recording Instructions - Version 8

WHAT IS THE AIRS?

The AIRS (Acoustic Instrument Reproduction System) is a spatial instrument reproduction system. Its goal is to recreate the authentic presence of a live instrument, capturing multiple directional perspectives of the instrument's natural radiation pattern and reproducing them from matched directions in the playback space.

A real acoustic instrument does not radiate sound uniformly in all directions. A guitar projects differently from its soundboard, its back, its sides, and above and below. The same is true for all natural sound sources. These directional differences are part of what makes an acoustic instrument sound real and physically present in a room.

The AIRS captures those directional perspectives using multiple microphones placed around the instrument. Each microphone signal is then reproduced by a dedicated speaker driver pointing in the same direction as the microphone faced during recording. There is no mixing, no processing, and no manipulation of the spatial relationships between channels. The signal path is a direct one-to-one translation from microphone to speaker.

A listener moving around an AIRS should experience something analogous to walking around the original performer. The spatial character of the instrument, its directional radiation pattern, its tonal differences from different angles, the way it projects into the room, is preserved and reconstructed in the playback space. Unlike immersive systems that strive to recreate an environment, the AIRS reproduces the sound radiation of the actual instrument in an existing environment.

SCALABILITY TO FULL BAND REPRODUCTION

A single AIRS cabinet reproduces one instrument. Multiple cabinets placed in the room can reproduce a full ensemble. Three AIRS cabinets driven by a 16-channel amplifier, 15 channels total, can reproduce a three-piece band with each instrument occupying its own physical position in the room. Each instrument has its own spatial presence, its own radiation pattern, its own position for the listener to walk around. The AIRS does not have a sweet spot for the listener. Instead, everywhere in the listening area offers a unique auditory perspective, just like a true live performance.

THE 5.1 FORMAT AND SPATIAL RESOLUTION

The 5.1 format allocates five directional channels per instrument plus an optional sixth channel for extended low-frequency reproduction if the five main drivers cannot provide sufficient bass extension on their own. The preference is to achieve adequate low-frequency response through the main drivers alone, utilizing the sixth channel for a subwoofer when relevant.

RECORDING INSTRUCTIONS

GOAL

Capture the instrument with multiple microphones placed at a similar distance from the instrument's primary sound-radiating area, while minimizing capture of room reflections and environmental acoustics.

The recording environment should be as acoustically damped as possible. Sound baffles are your friend and reflective surfaces are not. The closer the recording environment is to an anechoic chamber, the better.

RECORDING FORMAT

Record all tracks at 48 kHz sample rate and 24-bit depth. This is the optimal balance between audio quality and storage space for AIRS recordings, and ensures compatibility across playback systems. Do not use 44.1 kHz, which sacrifices high frequency resolution, or 96 kHz and above, which produces unnecessarily large files without meaningful audible benefit for this application.

WHAT YOU WILL NEED

- 5 matched small-diaphragm cardioid condenser microphones.
- 1 omni reference microphone. An analyzer measurement microphone is optimum.
- 1 additional microphone for the floor. Ideally a boundary/plate mic such as a Shure Beta 91A. Any mic with minimal coloration and good low-frequency response will work.
- A recording space with minimal acoustic reflections.
- A piece of string approximately 2 to 3 feet long for distance checking.

WHY CARDIOID MICROPHONES ARE PREFERRED

In addition to their directional advantages, capturing more of the instrument and less of the environment, cardioid mics also improve the low frequency balance of AIRS recordings. The AIRS cabinet houses five drivers in a shared enclosure whose low frequency output sums coherently at playback, producing significantly more bass energy than any single driver would alone. This is a predictable physical consequence of the multi-driver design.

Cardioid microphones placed at 2 to 4 feet from an instrument exhibit a natural reduction in low frequency response at that distance. This is a well-known characteristic of cardioid capsules called the distance effect, the inverse of proximity effect. Where a cardioid close to a source boosts bass, a cardioid at greater distances gradually rolls off low frequencies. This rolloff helps compensate for the low frequency exaggeration created by the five-driver summation at playback.

The omni reference microphone on Track 7 provides an accurate tonal reference of the instrument as it actually sounds, against which the cardioid captures can be compared and calibrated.

MICROPHONE PLACEMENT

Record 8 tracks total in the following order:

Track 1 - Front Left Mic (musician's right) Place approximately 2 to 4 feet from the closest sound-radiating area of the instrument, in front and angled approximately 45 degrees toward the left side. This mic will be reproduced by the forward-left-facing speaker.

Track 2 - Front Right Mic (musician's left) Mirror image of the Front Left mic. Match distance, height, and placement as closely as possible. Reproduced by the forward-right-facing speaker.

Track 3 - Up Mic Place centered directly above the instrument at the same distance from the sound-radiating area used by the other mics. Reproduced by the upward-facing speaker.

Track 4 - Down Mic Place low to the ground below the instrument, angled upward and pointing toward the primary sound-radiating area. Reproduced by the downward-facing speaker and/or the subwoofer.

Track 5 - Rear Mic Place 2 to 4 feet from the sound-radiating area directly behind the musician. Objects normally present during performance such as a person or a chair may partially or fully block this mic from the instrument. This is acceptable. A slightly greater distance than the other mics is fine if the musician's position requires it. Reproduced by the rear-facing speaker.

Track 6 - Ground Mic Place on the floor directly in front of the musician, instrument, or chair to capture low-frequency content. For a drum set, place on the opposite side of the kick drum from the Down Mic. Reproduced by the downward-facing speaker and/or the subwoofer.

Track 7 - Omni Reference Mic Place directly in front of the instrument, centered between the Front Left and Front Right mics, above the Down Mic at the same distance from the sound-radiating area. Serves as a flat tonal reference for comparison against the cardioid captures and for calibrating any playback EQ correction. A flat omni measurement mic is strongly preferred.

Track 8 - Click Track Record a click track for timing reference. If adding an instrument to an existing recording, maintain or re-record the original click track.

MICROPHONE HEIGHT GUIDELINES

- Front Left, Front Right, Rear, and Omni Reference mics should all be approximately level with the instrument and at roughly the same height.
- These mics should ideally sit midway in height between the Up mic and the Down/Ground mics.
- For drum sets, aim for a height closer to the drums than to the cymbals.

DISTANCE AND LOW FREQUENCY RESPONSE

Mic distance affects low frequency capture in two ways. First, increasing distance reduces the proximity effect boost that cardioids exhibit very close to a source. Second, beyond about 18 inches a cardioid begins to gradually reduce its low frequency response relative to an omni at the same position. This distance-related rolloff is intentional in the AIRS recording protocol and is part of why cardioids are preferred. Two to three feet is a good starting distance for most instruments. For drum sets, 3 to 4 feet may be more appropriate and will produce a more pronounced low frequency rolloff in the capture, further reducing the playback summation excess.

Keeping the instrument at a consistent distance from all five mics throughout the recording is important. Any movement that significantly changes the distance to one or more mics alters the low frequency balance between channels and will be reproduced at playback as a spatial imbalance.

GAIN AND LEVEL SETTINGS

Set all preamp gains to the same position across all channels. The goal is to preserve the natural sound field as captured. Some mics will naturally record less level due to their position relative to the instrument, and this is intentional. A rear mic placed behind the musician will be quieter than the front mics, and that difference should be retained. The one-to-one relationship between microphone and speaker depends on these level relationships being preserved from capture through reproduction.

If different microphone models are used, small gain offsets to compensate for sensitivity differences are acceptable. Regardless of mic type, follow these priorities:

- Avoid clipping. Check levels at the musician's loudest and reduce gain on any channel that clips.
- Avoid excess noise floor. Confirm all channels sit comfortably above the noise floor at the musician's quietest.
- Do not adjust individual channel gains once recording begins. Any change alters the spatial balance of the captured sound field.

If gain offsets are applied, note the values in writing or photograph the preamp settings for future reference.

OBSTRUCTIONS ARE FINE

The musician or instrument physically blocking or partially obstructing some microphones is acceptable and expected. This is part of the spatial character being captured.

TONAL CALIBRATION RECORDING - VERY IMPORTANT

Before the musical performance, have the musician or another person speak normally while seated in the playing position. A human voice is essential for frequency calibration. Additionally, gently tap each microphone and announce which mic it is. This helps identify channels and verify placement during post-processing.

DOCUMENTATION

Please upload two or three photographs of the microphone setup showing placement of all mics from a few angles. These images will be used for compensation, calibration, and future reference.

ADDITIONAL APPLICATION: DIRECTIONAL SOUND SOURCE

The AIRS cabinet can also be used as a controllable directional sound source independent of its instrument reproduction function. In this mode audio is fed to one or more of the five drivers

simultaneously and the radiation pattern is shaped through signal routing and per-channel control of level, equalization, time delay, polarity, and phase.

Because each driver faces a different direction, selectively routing audio to individual drivers or combinations steers the primary radiation axis toward any coverage zone or combination of zones, producing a wide range of directional and pattern shapes.

Independent control of level, EQ, delay, polarity, and phase on each driver allows precise shaping of what frequencies go where, when they arrive, and how they interact. Delay steers the wavefront, polarity introduces cancellation in specific zones, phase creates frequency-dependent pattern variation, EQ directs tonal content directionally, and level sets the contribution of each driver to the combined radiation pattern. Used together these tools give the operator continuous dynamic control over the cabinet's directional behavior.

Applications include theatrical sound design, installation art requiring spatially dynamic audio, acoustic treatment of problematic room zones, and live performance contexts where directional control of a monitor or effects source is desirable.

PRIOR ART AND RELATED RESEARCH

The goal of reproducing an acoustic instrument's directional radiation pattern through a loudspeaker system has been explored in acoustics research for several decades. Understanding what has been done and how the AIRS differs is useful context.

Academic researchers have extensively studied and measured the radiation patterns of orchestral instruments, building large databases of directivity measurements recorded in anechoic chambers using surrounding spherical microphone arrays. These databases are used primarily for concert hall simulation, room acoustics research, and auralization.

Several research groups have built compact spherical loudspeaker arrays specifically to reproduce instrument radiation patterns. Penn State University developed a 20-channel compact spherical loudspeaker array capable of reconstructing the frequency-dependent radiation patterns of different orchestral instruments, used for concert hall measurement research. IRCAM in Paris built multi-loudspeaker devices to emulate the emanation of sound from acoustic instruments and voices in live performance contexts. The Institute of Electronic Music and Acoustics in Graz developed the IKO (Icosahedral Loudspeaker), a spherical array used as a compositional instrument in electroacoustic music.

All of these systems share a common approach: they use digital signal processing, spherical harmonic decomposition, and mathematically derived filter banks to analyze an instrument's radiation pattern and then synthesize it through a controlled loudspeaker array. The instrument's spatial character is reconstructed through computation.

The AIRS takes a fundamentally different approach. Rather than analyzing and synthesizing radiation patterns mathematically, it captures them directly. Each microphone records the instrument from the direction its corresponding speaker will reproduce. There is no decomposition, no filter bank, and no mathematical reconstruction. The spatial information is

preserved through the recording process itself and passed through without complex manipulation.

This direct capture and reproduction approach has not been documented in the research literature. The AIRS is not a simplified version of existing systems. It is a different method based on a different philosophy, one that prioritizes transparency and simplicity over mathematical completeness, and direct capture over computational synthesis.

The name carries a second meaning. *Ars* is the Latin word for art or craft, skill applied with intention and care. *Ars musica* is the art of music. The word appears in the ancient aphorism *ars longa, vita brevis*: art is long, life is short. It is one of the oldest statements about the human desire to preserve creative work beyond the moment of its creation. This is precisely what the AIRS does. The performance ends. The art continues.