A PRIMEDIA Intertec publication

$10.00

S&VC

July 1998

sound & video contractor

The International Management & Engineering Journal
for Systems Contractors & Consultants

LOUDSPEAKER RIGGING & FLYING
PATCHBAY CARE & SERVICE
INSTALLING WITH SEISMIC CONSIDERATIONS
APPLICATIONS OF MATRIX SWITCHERS

plus INFOCOMM '98 in review

INSTALLATION TECHNOLOGIES

AN EYE FOR DETAIL

Safe loudspeaker design and rigging requires careful planning and knowledge of array configurations.

By **Andrew T. Martin**

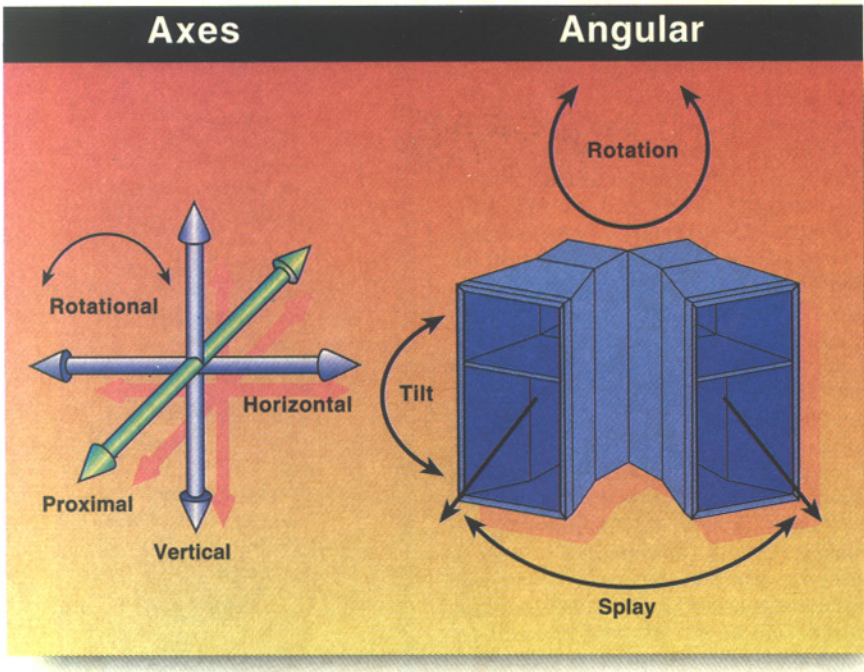

Figure 1. An illustration for quick reference of terms used in this article.

Loudspeaker array theory can be a controversial subject due to the varied opinions regarding the importance of acoustic wavefront alignment, acoustic center alignment, apparent center alignment, cavity resonance effects, point source design implications and other physical and electro-acoustic factors. This article does not intend to argue the significance of any one approach; however, various statements of fact will be made where appropriate. This article does intend to present a multitude of loudspeaker rigging methodologies that are commonly found in the professional audio industry.

Before examining various loudspeaker rigging system approaches, it is vital that the readers understand that all suspension systems must be rated for overhead suspension and must comply with all applicable safety codes for overhead suspension devices. For this reason, some regularly encountered non-compliant rigging systems will not be presented in this article. Additionally, see Figure 1 for an explanation of the terminology to be used in this article.

Function, speed, safety and cost

There are many compromises designed into loudspeaker rigging systems. Among the most often compromised are cost vs. flexibility, cost vs. safety and speed vs. flexibility.

It is an inherent truth that more complex mechanical devices cost more to produce and therefore require a higher investment to own. Loudspeaker rigging systems that are high in function also command a higher investment. The cost vs. flexibility compromise is commonly used as a successful design tactic to

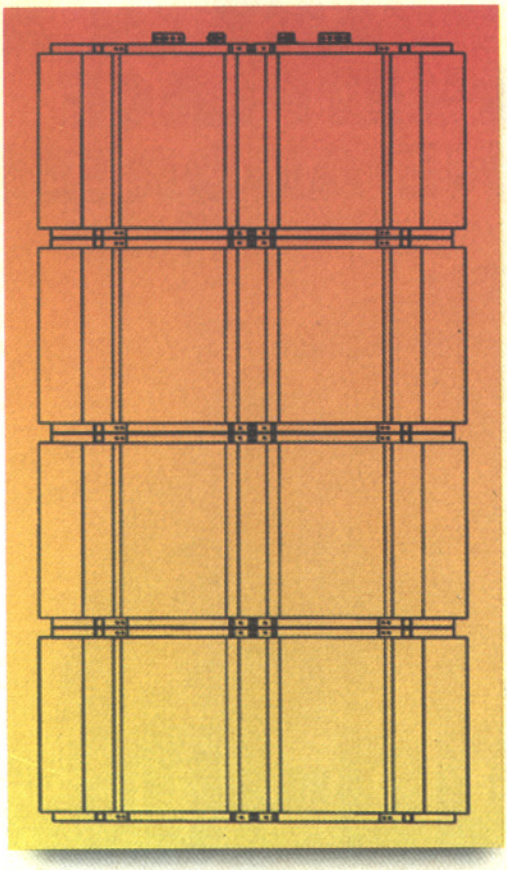

Figure 2. A typical horizontally configured loudspeaker array.

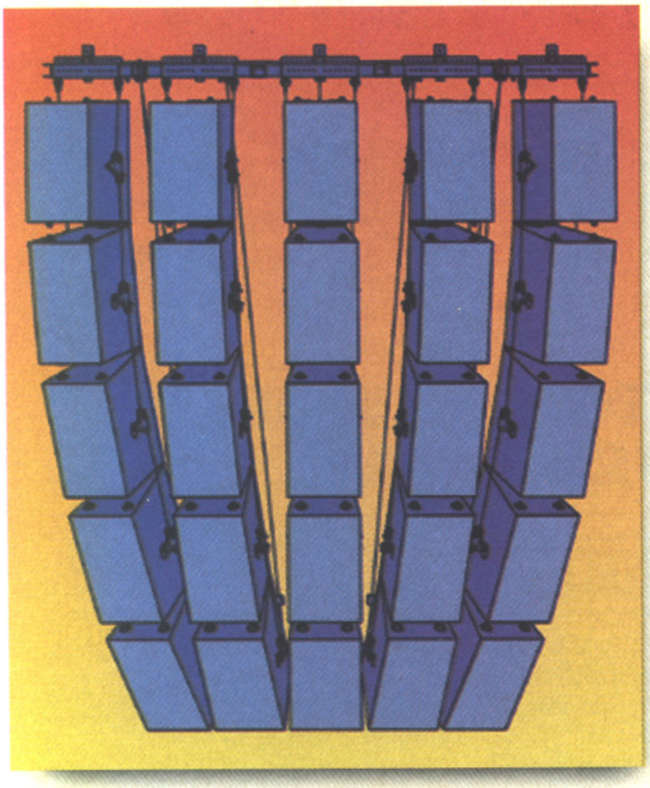

Figure 3. A typical vertically configured (or columnar) loudspeaker array.

reduce the total investment in the rigging system by eliminating unnecessary features. There is no reason to purchase a system with all features imaginable if a simple beam to suspend and tilt an individual loudspeaker will suffice.

On the other hand, although it seems foolish to trade the safety of an overhead suspension system for a lower price, many professionals simply do not realize they are participating in this dangerous practice. The circumstances surrounding the installation and use of an unsafe rigging system often consist of an unfamiliar professional attempting to suspend a cluster to the best of his ability. Unfortunately, even the best intentions can lead to the construction of a dangerous system. I am intimately familiar with phrases and justifications from professionals within the industry that are meant to divert the responsibility for installing a questionable rigging system, including "We just over-build the rigging system," and, "We've always done it like that, and we've never had an accident." Both are clear indicators that the rigging system may be inappropriate for the application and/or unsafe to use. The cost vs. safety compromise has no place in the industry, nor do governmental agencies acknowledge the argument. Safety must always be held paramount to all other concerns.

Speed and flexibility are not often complimentary features of loudspeaker rigging systems, although there are a few systems that accommodate both performance factors well. One popular tactic is to use a speed-sensitive rigging system for touring or portable applications, while investing a bit more time in setting up permanent installations or smaller loudspeaker clusters. There is a break-even point with this tactic; at a certain point, the expense of the time used to set up the rigging system will exceed the additional investment of purchasing a faster rigging system, and vice-versa. As a result, installations can often encounter cost savings by investing in a fast rigging system and saving large amounts on installation labor and other installation expenses.

Loudspeaker alignment

Generally speaking, most electro-acoustic engineers agree that loudspeakers placed properly within a cluster increase sound system intelligibility, a result of the interaction among sound sources within the loudspeaker cluster. Assuming that the loudspeaker is designed well (and taking some liberties for ease of explanation) one can consider the loudspeaker a single energy source within the loudspeaker array. The interaction of energy sources generates various detrimental effects if the energy is not being emitted from each sound source at precisely the same place in space at the same point in time. These effects manifest themselves as comb-filtering and lobing. Comb-filtering consists of very narrow band peaks and dips in acoustic energy, which can easily exceed 30 dB. The net effect of comb filtering is a loss of intelligibility that cannot be equalized or processed back into the system electronically. Lobing effects are similar, but energy lobes can be broader in bandwidth and will emit from the loudspeaker cluster in indeterminate directions. These uncontrolled emissions produce unwanted room reflections and increase ambient noise energy in the environment, thereby reducing intelligibility. Again, lobing effects cannot be equalized or electronically processed out of the loudspeaker system.

There are two ways of dealing with the effects of comb-filtering and lobing. First, the loudspeaker array can be designed and suspended as a point-source array. Second, the loudspeaker array can be intentionally skewed so far off placement that the effects are minimized.

Point-source array technology is the more common of the two practices. Point source simply means grouping together the loudspeakers such that the energy emitted from each loudspeaker originates at the same theoretical point in space. This is difficult to achieve because the loudspeaker enclosure does not behave as a single energy source. The average loudspeaker has multiple acoustic drivers working together to

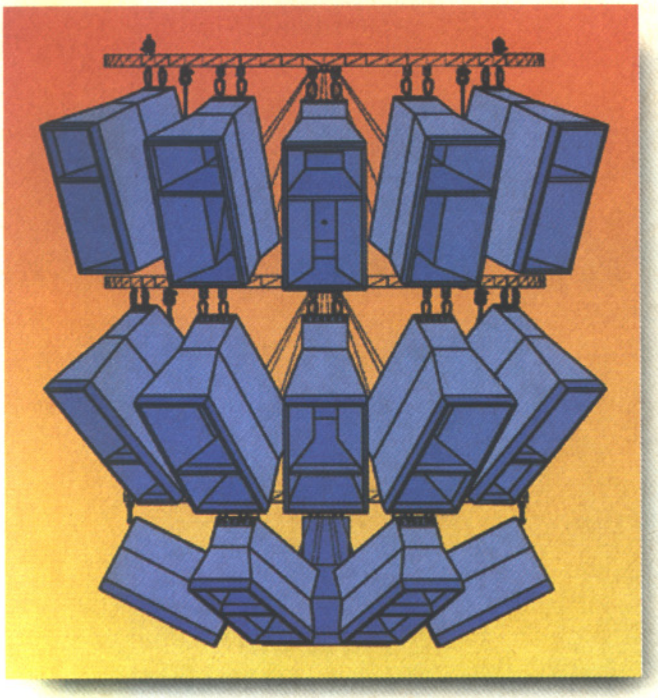

Figure 4. Point-source arrays, a combination of horizontal and vertical configurations, incorporated trade-offs from both approaches.

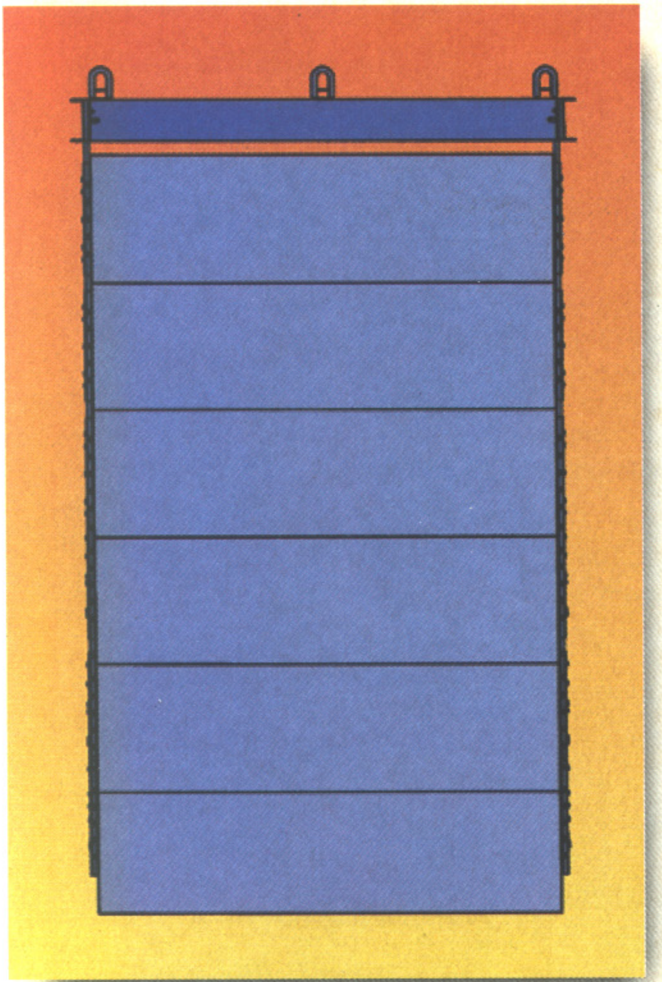

Figure 5. Line arrays, a refined form of vertically configured arrays, close tolerance in the vertical plane to take advantage of close-coupling effects to steer array dispersion and increase acoustic output.

cover the desired range of frequencies; therefore, it is hard to know where to align the loudspeakers in space because the acoustic centers of the high-frequency, mid-frequency and low-frequency drivers within the loudspeaker are located at different points in space. The question then becomes, where do the most noticeable effects occur, because this would be the most likely place to concentrate efforts to array the loudspeakers most appropriately. It is generally agreed that the mid-range and intelligibility ranges of frequencies are the best place to generate a point-source loudspeaker cluster. This means that loudspeaker placement within the array must be controlled to within approximately ¼ inch (6 mm). Most acoustically considerate loudspeaker rigging systems approach this task by aligning the acoustic wavefronts of the loudspeakers. This is not the best location for alignment; however, it often seems to be the most practical way to address a variety of loudspeaker types. By maintaining proper acoustic wavefront alignment, the loudspeaker suspension hardware increases the intelligibility of the sound system.

Intentionally skewing the sound sources can also be effective, although this technique is generally used only within permanent installations because it requires significant electronic delays and measurements to implement correctly. The idea is to place the sound sources so far apart from one another that their energy arrival times to the listener are not perceived as the same source. Then, the sound sources are delayed back to the same point in space. This process is time consuming because many measurements must be taken throughout the environment to be sure the sound sources are not generating lobing or comb-filtering effects off-axis, which would be caused by most directive horn flares and wave guides. Most rigging systems of this type are customized structures with an architectural look predominantly used for permanent installations.

Common rigging systems

Several rigging systems are available from overhead suspension hardware manufacturers. These systems not only save time and effort for the professional, but they also offer product liability protection not available if an individual designs and builds his own rigging hardware. Product liability consequences are a major concern for any industry professional because one accident can mean litigation. The simplest way to minimize product liability exposure is to purchase exclusively hardware intended for overhead suspension from manufacturers that include product traceability controls on their offerings, and then use the products according to instructions.

Horizontally configured arrays (see Figure 2) are designed to hold each loudspeaker enclosure together primarily in the horizontal plane, with the vertical plane secondary. The horizontally configured array enables compact and low-profile loudspeaker clusters to be constructed. The acoustic characteristics of this rigging system are excellent because the acoustic wavefront alignment (zenith) of each loudspeaker can be maintained very closely, while allowing various splay angles between loudspeakers. Additionally, it is possible to align the acoustic wavefront in the vertical plane as well as the horizontal plane, thereby building a pseudo-point-source array. Splay angles and tilt angles can also be maintained with close tolerance and repeatability. Disadvantages of this rigging approach include a higher investment because of system flexibility, a moderate time investment for larger array constructions and potential challenges with energy spill into the venue side areas from severely down-tilted loudspeakers and the changing rotation of the loudspeakers within the row.

Vertically configured arrays (see Figure 3), also called columnar arrays, are designed to hold the loudspeakers primarily in a vertical orientation, with the horizontal plane secondary. This approach to suspending loudspeaker clusters can be very fast to assemble and disassemble; it can also easily focus energy to many zones within a venue. However, the vertically configured array is not practical when building a point-source array because of the need to gap the columns apart from one another in order to allow splay angles between columns. Additionally, it is very difficult to maintain a coherent zenith alignment in the vertical plane as the loudspeakers are tilted down. It is possible, however, to retain some vertical alignment for two to three rows of loudspeakers without introducing a tremendous tensional load on the loudspeakers and suspension system.

Point-source arrays (see Figure 4) are a combination of the horizontal and vertical configuration, while incorporating trade-offs from both approaches. When designed with a clear understanding of where the system needs to acoustically perform best, the point-source array can be impressive. These arrays are usually custom built for a specific installation and can be quickly assembled, depending upon the design. Because they are custom designed, the splay, tilt, rotation and zenith can all be appropriately planned.

Line arrays (see Figure 5) are a refined form of a vertically configured array. The line array maintains close tolerance in the vertical plane to take advantage of close-coupling effects to steer array dispersion and increase acoustic output. Line arrays are not usually used in multiple columns and therefore do not realize the effects of horizontal acoustical conflicts.

Rigging hardware

Regardless of the type of loudspeaker array, the system will be only as strong as its weakest link. The importance of safety and conservative design methods cannot be stressed enough when considering the weight of the average loudspeaker array and the overhead suspension placement in most applications. There is simply no room for error or guesswork. The weak link in an array may be the wire rope sling suspending the grid or perhaps the shackle or turnbuckle connecting to an eyebolt. It can also be the loudspeaker enclosure itself or the fitting used to attach to the loudspeaker hardware. The loudspeaker array must be designed to maintain appropriate design factors throughout the rigging system.

Attachment to the structure can be one of the more complicated aspects of rigging loudspeaker arrays because of the variety of installation methods and the multitude of structure construction types. A professional engineer can help a great deal in determining the best method of attachment to the structure. Additionally, a professional engineer can decide if the building is strong enough to support the concentrated load that most loudspeaker arrays will generate on the structure. In some states and/or municipalities, there are structural guidelines that must be followed when rigging a loudspeaker array, and a professional engineer can help with these issues as well as afford liability protection.

Final thoughts

Loudspeaker arrays are constructed in countless variations of styles and approaches, but they all have one thing in common—they are heavy objects suspended above the heads of the public. The priority of the loudspeaker array designer and installer must be placed on the safety of the suspension system and the proper installation of the array. Acoustic characteristics can be accounted for, and proper placement of the loudspeakers can be worked into the array to produce a very coherent loudspeaker cluster without compromising system safety. It is the responsibility of each industry professional to hold himself personally accountable for safe loudspeaker arrays. S&VC

Martin is president/CEO of ATM Fly-Ware. Additional information on the topic of suspending loudspeaker enclosures can be obtained from ATM Fly-Ware at 21000 S. Wilmington Ave., Carson, CA 90810; phone: 888-RIG-MORE; fax: 310-834-5914; Web site: www.atm-fly-ware.com.