Voltair

Ratings. Confidence.

25 seven™

THE TELOS ALLIANCE

Voltair Overview
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About 25-Seven Systems

25-Seven Systems specializes in audio technologies and products that address the unique problems of radio broadcasters, networks and content providers. The company was launched in 2003 by a group of veteran broadcasters with extensive audio experience and a significant portfolio of intellectual property. 25-Seven joined The Telos Alliance in 2012. Its products are designed and built in the United States.

Legal Notices

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Contents

WHY VOLTAIR?

It's all about your listeners. Your people, your programming, your gear… they're all focused on building and retaining your audience.

We don't have to tell you about the direct link between the size and composition of your audience—as measured and reported by Nielsen—and your advertising revenue. That's why it's vital to you that every panelist in your market is accurately measured and that every station is playing on a level field.

Introducing Voltair, designed to give you greater confidence that your station is realizing the end-to-end PPM system performance that Nielsen intends. And that you have earned.

This white paper explores how Voltair helps you better understand and navigate the PPM technology you use every day—one that has a profound effect on your ratings and revenue.[1] We'll look both at the processes underlying the end-to-end PPM system, how Voltair operates upon them and the ways it allows you to focus more on your listeners.

Ratings, Programming & Technical Operations

Radio ratings has been called "a game of inches," where winners and losers are sometimes decided by the thinnest of margins. Station management teams have always carefully monitored their markets' listener data and taken action to maximize ratings and revenue.

Since the introduction of PPM, many program directors report making more dramatic changes than ever before. For example, dayparts have been moved, local breaks have been reduced, and programming clocks have become more rigid in response to the hard, quarter-hour boundaries of PPM credit. Likewise, the industry has seen changes in audio processing practices, airchain device order and other station engineering procedures—all in service to PPM performance.

Because PPM ratings data are provided on a delayed basis, stations lack the means to conduct real-time analysis of audience response. Programmers have had limited insight into what efforts are of benefit and why. Hence, most station efforts to optimize their PPM performance have been trial and error, with little insight into what may or may not be effective.

How Voltair Can Benefit You

25-Seven has been following the deployment of PPM since its launch. We've spoken with many program directors and engineers, getting their perspectives on the overall system architecture and the results of their optimization efforts.

As with any complex system, there are outlying cases, unanticipated properties, changes in behavior and seemingly random events that influence the entire PPM ecosystem. The

[1] While Voltair can improve confidence that you are getting the market share you deserve, it cannot affect the actual number of panelists listening to your station.

variety of stations, formats, markets and listener demographics contribute to this complexity, and to the difficulty of optimizing performance.

25-Seven is well prepared to address these challenges, thanks to our years of helping broadcasters create and deliver audio content that captures audience attention.[2] Dr. Barry Blesser heads our research and development team. Blesser is one of the founders of digital audio in the 1970s, a former President of the AES, a former professor at M.I.T., and the inventor of the first commercial digital reverberation product for EMT in 1976. He has been a technical and management consultant for more than 40 years. Blesser is recognized for his contributions to a wide variety of professional disciplines, including audio signal processing, auditory perception, pattern recognition, aural architecture, career development, and engineering management.[3]

In developing Voltair, we were also able to apply the collective expertise of the other companies of The Telos Alliance in technologies that relate directly to audio watermarking as applied by PPM—audio processing, coding technology and ancillary data streams.

After researching the publicly available data on PPM, our team of broadcast and audio experts uncovered the variables that contribute to PPM integrity. More importantly, we developed Voltair to provide you with the tools you need to monitor and analyze these variables, providing you with data to inform your technical and programming decisions.

What did we find?

> **Audio Content**—The spectral characteristics of your audio content—music, announcer voices, etc.—may negatively impact the robustness of your PPM encoding. Simply put, some audio content encodes well while other content does not.[4]
>
> **Panelists' Environment**—Meters may not detect particular content because of panelists' acoustic environments. A song or voice may not, for example, decode as well in a car as it does in a bedroom.

To address these issues, we needed to account for the highly complex set of interactions among the encoding and decoding processes, the audio properties of content, and listeners' acoustic environments. We developed a totally new set of easy-to-use tools for Voltair to analyze and help you manage the consequences of these interactions.

Operating transparently in your air-chain, Voltair:

- Monitors and analyzes the robustness of your PPM encoding across all of your program content.

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[2] 24-Seven's Precision Delay has a unique Watermark Safe Mode that protects the integrity of PPM codes during delay builds and exits.

[3] In 2006, MIT Press published Blesser's book *Spaces Speak, Are You Listening? Experiencing Aural Architecture*.

[4] Many broadcasters are under the false impression that only voices may result in weak encoding, when music content may also have encoding issues.

- Offers visibility into how panelist listening environments may influence watermark decoding, using models of acoustic spaces where panelists are wearing or carrying their meters.
- Includes advanced audio signal processing to enhance the detectability of the PPM watermark codes within the context of your programming objectives.
- Empowers programmers to make informed decisions to address potential weaknesses in either encoding or decoding. For example:
    - You can compensate for changes in programming material and listening environments during different dayparts and program types.
    - You may choose to balance strong and weak program segments within each quarter-hour time segment to produce successful decoding and get the earned credit for the full segment.

Voltair also serves as an off-line tool to identify produced and live content with low encoding confidence. New programming elements—liners, promotions, etc.—may be created with greater confidence of strong encoding.

EXPLORING THE PPM ECOSYSTEM

PPM Overview

In 2006, Arbitron® introduced Portable People Meter® (PPM) technology to broadcasters. Following its acquisition by Nielsen® in September 2013, Arbitron was rebranded Nielsen Audio®.

PPM uses a proprietary audio watermarking technology that embeds ID codes in broadcast streams. This ambitious system is deployed in major markets in the United States and several other countries to gather data and establish metrics about radio listening habits.

The PPM system includes hardware Studio Grade Encoders (SGE) that stations place in airchains of their analog and HD Radio broadcasts (as well as their Internet streams, if they choose) to insert the watermark into their content.

At the other end, PPM metering devices are worn or carried by members of the public referred to as panelists. The meters are designed to detect and log data on the audio watermarking codes in audio programming to which they are exposed.

Data collected from meters are uploaded to Nielsen, aggregated, interpreted and published in the form of ratings.

Understanding Audio Watermarking

The PPM data injected into your broadcast audio is a watermark.[5] Audio watermarking has been around for decades, and borrows its name from paper watermarks on books, stamps and currency. Watermarks, engineered to be as undetectable and tamper-proof as possible, serve as a method of authentication and data communications.

Watermarking is now commonly used in Digital Rights Management (DRM) for copyrighting software, audio and video content, and to control and track its distribution. All these systems, from the oldest to the most modern, use some form of masking to hide the watermarks.[6]

In the analog audio realm, the process of encoding injects hidden signals into the audio in a way that the ear cannot easily detect; new sounds are masked within the original audio signal. The masking process often takes place in real time based on the sonic properties of the incoming audio.

There are many approaches to masking. For example, during periods of dense audio, high-energy signals can be injected and still remain concealed, while in moments of silence, nothing can be injected without being audible.

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[5] This discussion is provided to give Voltair users background information. The algorithms used in the PPM system and the data contained in the PPM watermark are Nielsen's trade secrets. 25-Seven has no specific knowledge of the watermarking algorithm used in the PPM system.

[6] Audio watermarking may be thought of as the aural equivalent of steganography, where added images are concealed within other pictures.

Even the best audio watermarking technology has trade-offs between encode reliability and audio quality. The higher the watermarking energy received at the decoder, the more robust the system, but the greater the likelihood that encoding tones will "break through" the masking audio and be audible to some listeners. Conversely, the quieter the tones, the less likely they will break through, but the more fragile and less reliable the decoding becomes.

The injected audio contains symbols or sounds with unique information. A critical number of these would need to be injected in order for the intended "message" to be conveyed. An encoding algorithm will typically utilize data redundancy to increase the likelihood that a full message can be extracted.

Once successfully encoded, the watermarked audio is transmitted to a final location where a separate process extracts the injected information. This extraction process requires the watermark symbols be "heard" by a decoding device.[7] When enough symbols are successfully decoded, they are assembled into a complete "message" and you have a successful communication of the watermark signal. In the PPM ecosystem, the audible signal is detected and decoded by the meter worn by the panelists.

Many factors can degrade this decoding process, including the fidelity of the audio path, background noise levels, acoustic properties of the space, and placement of the decode device.

In summary, audio watermarking relies on the ability to hide an information signal within the audio program, to transmit the audio program to the decoder without significant degradation of the signal, and the ability to extract the message from the final signal arriving at the decoder.

Programming Content

Many radio professionals believe that certain audio source materials encode better than others. As discussed above, watermarking relies on a masking technique in which codes are buried in the audio. Some types of audio may not have the characteristics required to allow masking. If there is insufficient audio energy in the frequency spectrum that the watermarking process uses, there is no place to "hide" such codes. With insufficient encoding, PPM may not give any panelist credit for listening to the station.

Different styles of music may interact with PPM in a way that biases the credited listening. Hard rock is generally observed to produce strong watermarking, while smooth jazz produces comparatively weaker watermarking energy.[8] One cannot, however, rely on these generalizations of encodability between similar pieces of musical content.

Some male and female speakers (be they announcers or call-in guests) seem to result in very weak watermarking. There is a possibility that on-air talent, even those attracting

[7] In the PPM ecosystem, the intent is for the meter to listen to the same radios and other audio devices as the panelist that carries or wears it. Nielsen provides each panelist with a special adapter to support headphone listening.

[8] We've found one sample of Irish music that produces absolutely no watermarking energy.

large actual audiences, could suffer ratings penalties because their voice characteristics are a mismatch to the PPM algorithms and may not be encoded as well as others. As with musical genres, broad assumptions about what types of voices have low encodability are not possible, but Voltair provides confidence in real time.

Panelists' Environments

As we've discussed previously, the PPM ecosystem is complex and comprised of many inter-related parts. Station personnel tend to think of the pieces that are located at the station, i.e. program source, audio processing, PPM Encoder, and transmitter as the full system. While these elements determine what arrives at the listener's radio, they are just a part of a larger system.

An equally important and overlooked element in the equation is the listener's acoustic environment. Varying environments may have a huge impact on whether the watermark codes survive to provide ratings credit. This "veiled" aspect of the system consists of the panelist's environment, including location of the radio, location of the PPM meter, the acoustic transmission between them, and the extraneous noise of the environment. Simply delivering encoded signal to the radio receiver does not guarantee that a panelist's PPM meter will be able to recognize the station ID.

From a meter's perspective, the ideal listening situation is a panelist with a hard-wired connection to his radio through the PPM meter, i.e. listening on headphones with the Nielsen-provided adapter. In this case, there is no environment that might degrade decode performance. But in the real world, use of the headset adapter is uncommon.

More typically, the listening environment will be an open space which can be as varied as an automobile with road and traffic noise, a kitchen with cooking noise and a crying baby, or a sports bar or restaurant with a lot of background chatter. In such environments, watermarking leaves the radio but may not arrive at the PPM meter with sufficient energy to be detectable. Further complicating the environmental factor is that panelists may move around during the day, listening in different locations on different radios.

BENEFITING FROM VOLTAIR

Monitoring & Analyzing PPM Encoding

Knowing that the PPM system is working properly is essential; common wisdom in radio today is, "If you aren't encoding, you might as well be off the air". We would add, "decoding" to this equation as well.

Nielsen's encoders offer little information about encoding status. A front panel LED displays when encoding is functioning properly.[9] Nielsen also provides a separate, off-air Encoding Monitor designed to create a notification when it detects a several-minute absence of watermarked content. Status is indicated by a front panel LED and can be remotely accessed using contact closures or serial connection.

While these are useful problem indicators, they're insufficient means to monitor a highly complex system and provide confidence in end-to-end PPM integrity.

Voltair's monitoring dashboard fills that need, using multiple means to measure and analyze PPM performance and providing information upon which you can act.

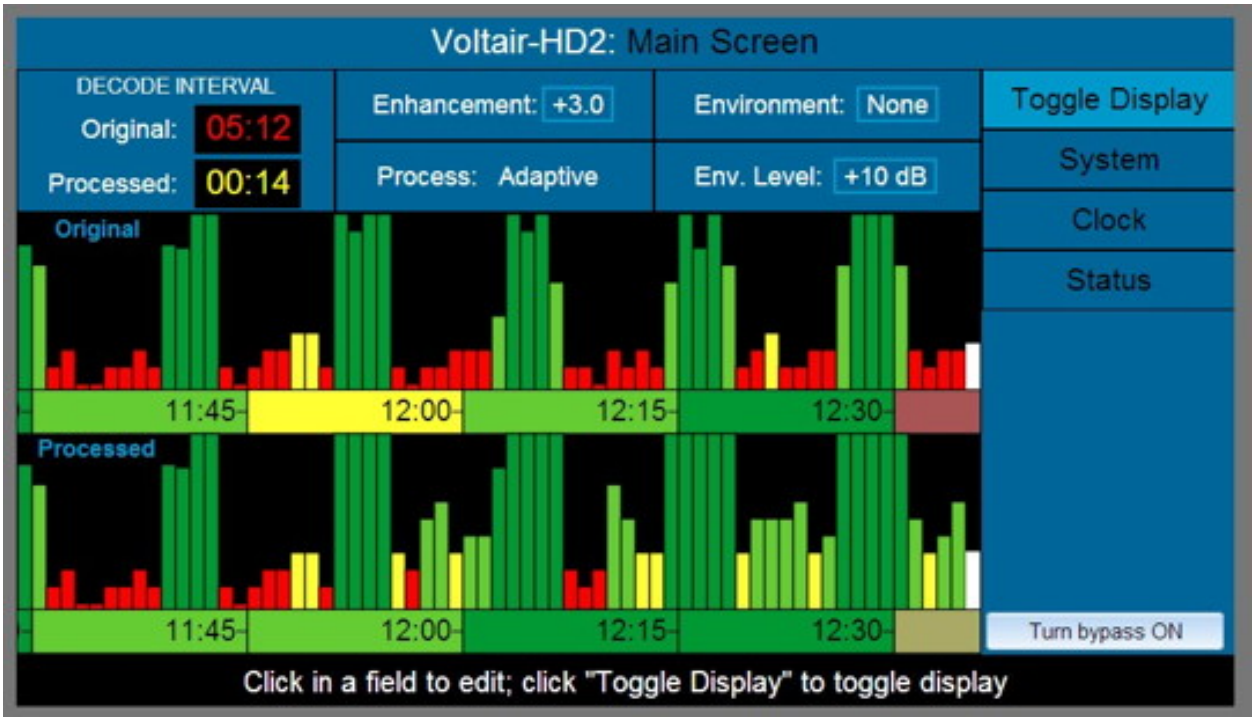
Confidence Display

PPM credit is awarded on hard quarter hour intervals. The Confidence Display shows a graph of the last hour history of relative encoding strength. The horizontal scale displays time-stamped quarter hour blocks, with green/yellow/red color indication to reflect encoding strength for each 15-minute period.

Vertical bars on this display represent a single minute within each 15-minute block. Bar color and height, indicate relative confidence levels.

- A full height green bar indicates energy was generated during the minute for very high confidence of successful decoding.
- A single red pixel line indicates insufficient audio energy for that minute, due to the absence of encodable audio or dead air. In such cases, your confidence in the decode process should be extremely low.
- Gradients between these maximum and minimum levels provide a map of confidence over time.

[9] Encoding status is not directly accessible for remote monitoring. However, logic outputs permit remote monitoring when the encoder is in bypass mode and, as a result, not encoding. The encoder will enter bypass mode when it detects a problem, such as a high temperature warning. The unit defaults to bypass mode when it is unpowered and bypass may also be manually selected.



There are parallel confidence displays: “Original” represents watermarking confidence for the encoder alone. “Enhanced” represents watermarking confidence after adaptive enhancement processing by Voltair. If Enhancement is set to 0, there is no enhancement processing applied and these graphs will be identical.

Environmental Simulation, discussed below, affects the Confidence Display.

Energy Meter

Voltair’s Energy Meter appears as the most current indication (rightmost) on the Confidence Display, indicating the presence of audio energy that has encoding potential. While the Confidence Display takes time to register the other graphed minutes in each quarter hour block, the Energy Display serves as a quick activity indicator that encodable audio is present.

Values on the Energy Display are relative and can be used to compare different program materials, as well as the benefit of Voltair enhanced encoding.

Decode Interval Display

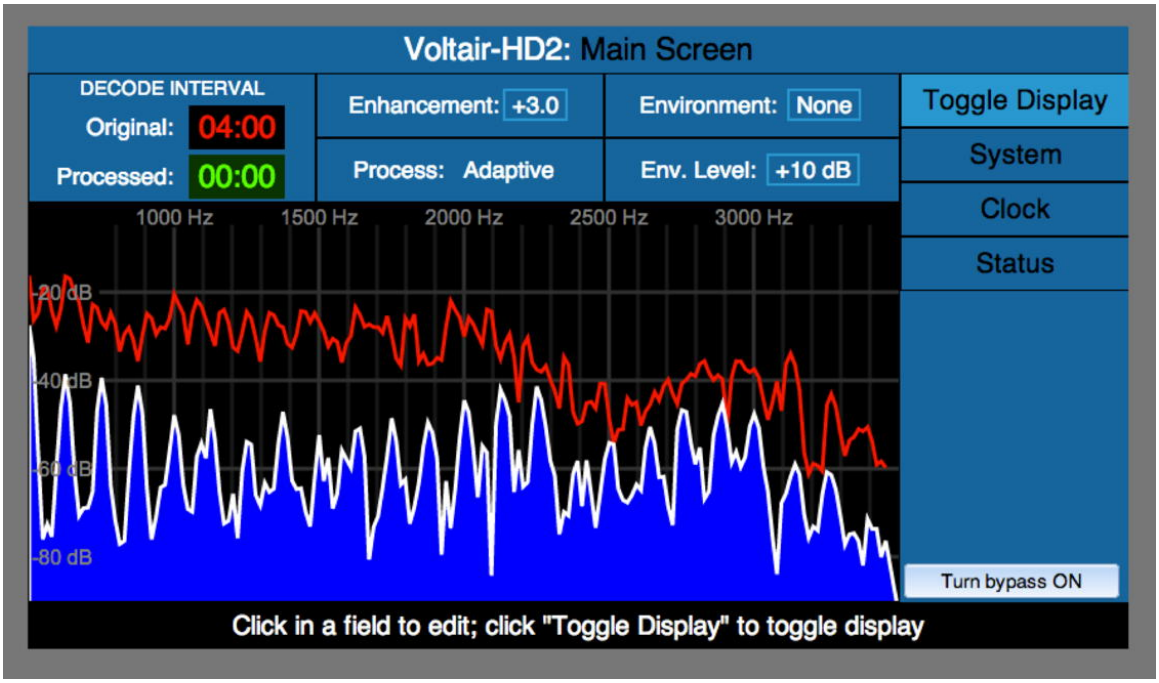
This tool models the amount of elapsed time since the last, complete watermark data message was successfully decoded. Times for the original source audio and, if used, Voltair enhanced audio are displayed. Display colors change to yellow or red when a full message does not appear for longer-than-optimal time periods and the display flashes green to indicate message completion.

Outputs on Voltair’s GPIO interface allow remote notification for three decode intervals that may be indicative of watermark data messages failing to decode successfully.

Used in conjunction with other Voltair tools, this display allows comparison of the decode interval between different types of program content, as well as the effect of Voltair enhancement.

RTA Display

The Real Time Analysis (RTA) display shows the critical spectral region for the input signal to the SGE. It shows peak (red) with hold and average (blue) levels. Generally, the higher, denser and more consistent the energy displayed across the spectrum, the better the probability of strong encoding.



Analyzing Listening Environments

Because the success of PPM watermark decoding may be compromised by ambient sounds at panelists' locations, the environment of panelists can create an unintended technical bias. That could result in the demographics of the listening *environments* influencing ratings, as opposed to habits of the *listeners*, as is intended.

As an example, consider a panelist sitting in a restaurant with hard surfaces, reflective walls and other diners chatting and clanking dishes. While a station might be playing at a reasonable level, if the levels of the ambient sounds are higher than the watermark code energy, these sounds may be overwhelmed by other sounds in the environment.

Voltair provides a simple way to determine the degree to which program units will be detectible in acoustic environments. This analysis of the possible effect of listener environments on PPM code survivability is performed by injecting ambient audio into an internal "closed loop" simulator and noting the changes reflected on Voltair monitoring tools.[10]

Voltair's displays give you feedback on a multiplicity of time scales—from a few seconds to 60 minutes—under simulated environmental conditions Most importantly, the monitor function is not just about how the watermark data leaves the transmitter, but also about what is likely to be heard by the portable PPM.

The environmental simulations currently provided are field recordings deemed representative of their respective categories.

Sports	Crowd noise and chanting as experienced in an open arena
Restaurant	Background conversations, plate and other associated noise in a reverberant space
Vehicle	Low frequency road noise, traffic noise, wind noise
Kitchen	Pots, pans and kids in a live, reverberant space
None	Direct connection, equivalent to using headphones plugged in to a PPM meter

The simulator allows you to adjust the ambient audio level and view the effect on the Decode Interval and Confidence Displays. Environmental simulation levels are adjustable on a scale of -60 dB to +10 dB. Obviously, the higher the level of simulation, the more difficult it will be for some types of audio to be decoded. Nominally, -20 dB denotes background audio that is 20 dB lower than program audio. With a 0 dB, setting, ambient audio would be basically equivalent in energy to the station sound source. With +10 dB setting, ambient audio would generally overwhelm the station sound source.

[10] The simulator does not inject this audio into the program chain and there is no possibility a listener will hear it.

The choice of which environment to simulate, and at what levels to conduct the simulation, should be based on your assumptions about what percentage of your listeners are in certain environments at different times during the day.

Encoding Enhancement

To address the complex technical issues related to audio watermarking, we've drawn on the deep knowledge of the companies of The Telos Alliance in audio processing, coding technology, ancillary data streams and delivering audio content that captures audience attention.

The result? Voltair incorporates an extremely smart and fast adaptive processor. The resulting enhancement benefits both the strength of encoding and reliability of decoding. And Voltair helps you be more confident in your end-to-end PPM system without altering or otherwise compromising the integrity of the PPM data.

You control the multiple, sophisticated processes of Voltair's enhancer with a single control. Using the Voltair monitoring and analysis tools—as well as your ears—you can identify content with low encoding/decoding confidence and apply the amount of enhancement at levels you determine to be appropriate.

Voltair allows you to define and remotely switch among three enhancement level presets, as well as bypassing processing altogether. These selections can be made via GPIO triggered by your automation system, a time-based scheduler or other externally connected means. For example, during a talk show with a host voice with low encoding confidence, you may remotely trigger a high level of enhancement. During commercials, or other content with moderately dense content and, therefore, higher confidence, enhancement at a lower level may be triggered.

Modest amounts of Voltair enhancement may make a real difference in hostile acoustic environments. Note that raising enhancement above a certain point may—to some listeners—have an audible effect on air as watermarking energy "breaks through" the masking audio content and becomes audible.

Excessive Voltair processing may put you at risk of annoying—and losing—some PPM panelists. These artifacts sound like a primitive reverb or doubling effect. Or it may sound somewhat distorted, ringing and even unpleasant. As your ear learns the signature sound of break through events, you will get better at hearing the tones and know when to modify the applied enhancement.

Sometimes, however, allowing watermark break through may be acceptable. A good example is a talk show during drive time. The voices of some presenters and guests may be problematic in terms of encoding. Road noise can further degrade the decoder's ability to receive the tones. Enhancement may help mitigate less than optimal encoding and to overcome the road noise. In this case, you may want a higher level of enhancement for greater PPM system confidence for the environments of the largest number of your listeners. And you may choose to use less enhancement when a similarly sounding program is airing at midnight, when listeners are in a less hostile environment.

Making Better Programming Decisions

While Voltair integrates a number of advanced technologies, its most significant value may be to help guide programming.

As previously explored, all audio content may not encode equally well. Some songs and some spoken word content provide less opportunity for encoding to succeed.

But it's best not to rely on these generalities. The only things we know for certain are that white noise will encode well and that dead air will never encode. Confidence in all other audio content will vary based on the interactions of a number of dynamic factors.

With Voltair, you'll guess less and know more.

Using its monitoring and analysis tools, you can determine which content tends to create strong versus weak watermarking energy, and how the watermarks fare in typical listening environments. You can apply this knowledge to:

- Schedule content in which you have high confidence into each quarter hour.
- Apply Voltair enhancement, or
- Make scheduling modifications *and* use Voltair enhancement.

A practical objective for many programmers will be to balance strong and weak program segments within each time unit to produce sufficient confidence that you will get the earned credit for the unit of time.

Producing PPM-Compatible Content

Voltair is as appropriate in program directors' offices and production studios as it is in the air chain.[11]

Insights into the characteristics of songs, production bits and even talents' voices can provide valuable guidance when scheduling quarter-hour units and determining when to apply Voltair's enhancement feature.[12] You may allay fears that production-studio creativity could inadvertently hurt your ratings.

Examples of production applications for Voltair:

- Existing content assets may be evaluated for encoding confidence within the context of multiple listening environments to inform scheduling and Voltair enhancement decisions.
- New programming elements—liners, promotions, etc.—may be produced with greater confidence of strong encoding.
- Voice talent may be assessed to determine if changes in delivery may effect encoding confidence.

[11] To operate properly, Voltair needs to be connected to a Nielsen encoder.

[12] Voltair enhancement is a real time process and cannot be applied to recorded material.

Network and Remote Operation

All 25-Seven products are designed for maximum flexibility and reliability. Voltair is no exception. Features include:

- A web interface that offers remote monitoring and control of all major functions
- Network operation centers can concurrently log into multiple Voltair units
- Comprehensive GPIO
    - Output alarms when low-confidence content is detected
    - Inputs to modify adaptive processing levels
- Relay bypass system providing maximum fail-safe protection against power loss or system failures are engineered to guard against dead or unencoded air
- Encoder bypass monitor puts Voltair into bypass mode when it detects a Nielsen encoder is in its bypass mode
- Updates available via web download

VOLTAIR AND *YOUR* RATINGS

Your revenue relies on your Nielsen ratings. The overriding purpose of Voltair is to increase your confidence that those ratings accurately reflect the listening habits of PPM panelists.

As you work to get credit for all the ratings you've earned, keep the following in mind:

- Even one meter's worth of PPM data can make a measurable difference in your ratings.
- Insights into how your audio content is handled by PPM can show you ways to improve the robustness of your PPM encoding.
- Consideration of PPM panelists' listening environments can guide changes that may improve the reliability of PPM decoding.
- When you have confidence in the end-to-end PPM system performance of your stations' signals, you also have more confidence in the relationship between ratings and your programming decisions.

Voltair won't increase your actual listenership. But it will help you be more confident that PPM panelists listening to your station are correctly measured.

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THE TELOS ALLIANCE™

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