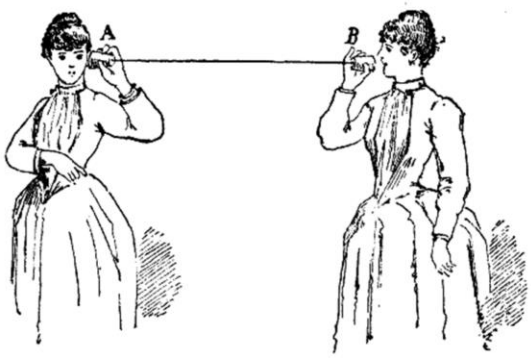
Welcome



YAMAHA
commercial audio

Audio Engineering Society
Melbourne Section Inc.

Welcome to Yamaha
Premium Piano Centre

YAMAHA
commercial audio

Audio Engineering Society
Melbourne Section Inc.

Welcome to Yamaha Premium Piano Centre

- Simon Tait (Systems & Applications Engineer)
- Yamaha Audio Technology Solutions
- 'Natural Sound' philosophy

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Quick history on myself

Quick overview of Yamaha ATS

It all comes back to the 'NS' in our most famous speakers…

Active Acoustic Enhancement (AAE)

Lots of acronyms…

- Active Acoustic Enhancement (AAE)
- Active Architecture (AA)
- Assisted Reverb (AR)
- Electronic Acoustic Enhancement (EAE)
- Active Field Control (AFC)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

We'll start with Active Acoustic Enhancement…which has been known by many names throughout the years….

But we'll stick with AAE

Active Acoustic Enhancement (AAE)

Lots of history…

- Philips Ambiophony (1950's)
- Lexicon LARES (1988)
- Yamaha AFC (v1 1987, v2 2008, v3 2012)
- VRAS (1993) -> Meyer Constellation (2005)
- 3D convolution (Astro, LISA, Soundscape)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

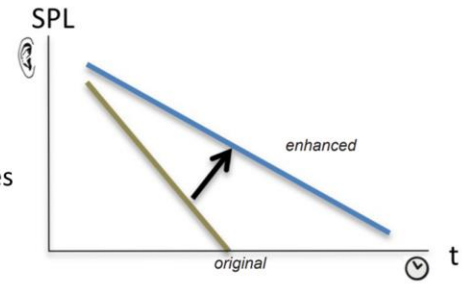
Fixing up acoustic shortcomings in venues using electronics goes back some 60 or 70 years

The most well known examples here embody the main principles of operation which I'll be talking about tonight.

Active Acoustic Enhancement (AAE)

Basic Concepts

- Increase reverb time
- Alter acoustic profile
- Mask acoustic anomalies



YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

These are the basic concepts of any of the systems available today. We use AAE systems to increase overall reverberation, or to deliberately colour the reverberation, or to mask acoustic weirdness

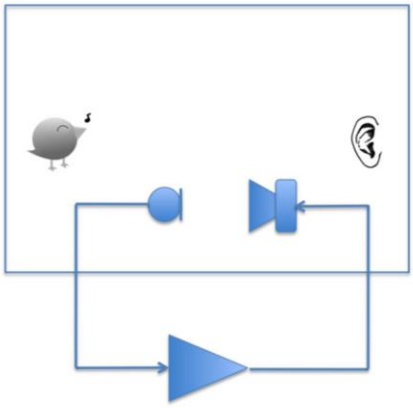
AAE systems cannot decrease reverberation time; they can only extend the natural acoustic behaviour by either regeneration, convolution or a combination of both approaches

Active Acoustic Enhancement (AAE)

Basic Concepts

- Regenerative

Regenerate room's existing energy with closed mic/speaker loop



YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

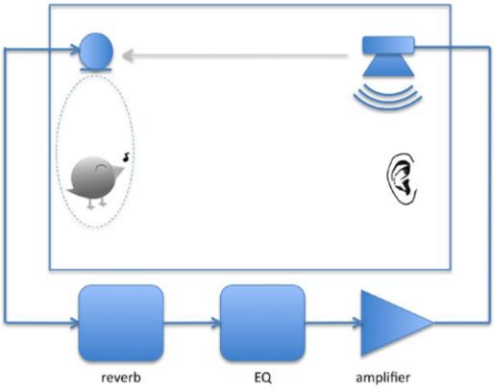
Regenerative

Active Acoustic Enhancement (AAE)

Basic Concepts

- In-Line

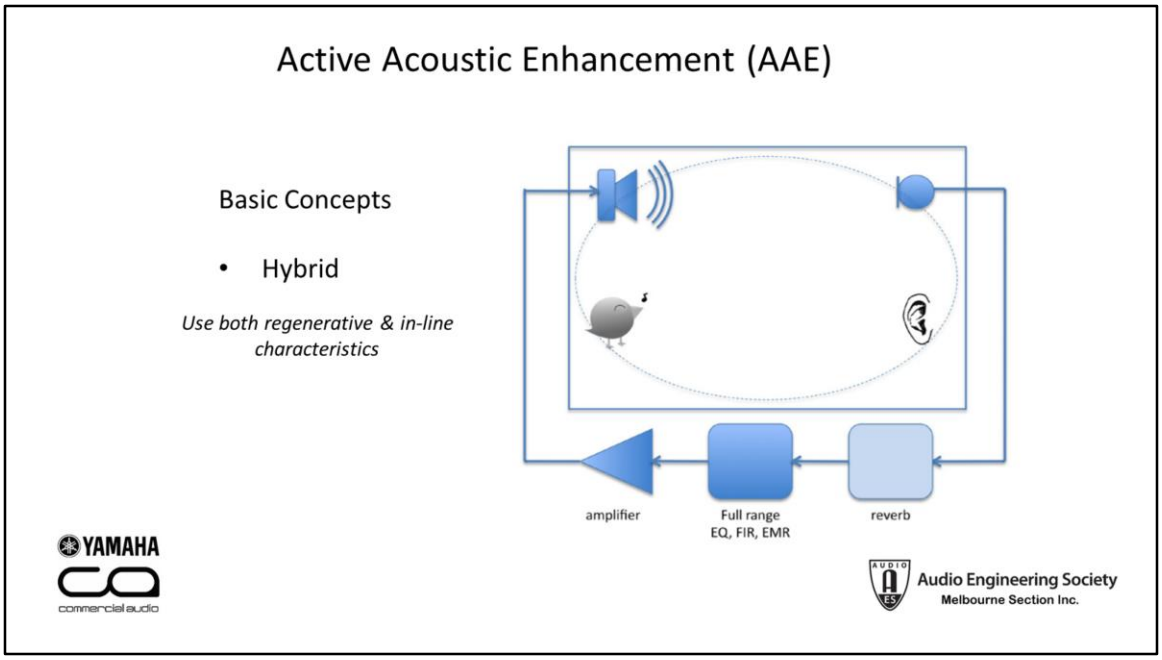
Convolve mic signal with I.R from some other reverberant field (results in 2 fields superimposed)



YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

In-line



Hybrid

Both Yamaha AFC3 and Meyer Constellation are examples of Hybrid Regenerative systems (although they approach system stability in different ways)

Active Acoustic Enhancement (AAE)

Spoken word demo

- 3 Presets
  - Idle
  - Voice Lift
  - Large Hall

YAMAHA
commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Spoken word demo

- Idle
  - Intended for everyday use
  - Generally cannot be perceived, until turned OFF
  - Takes the 'edge' off the room's dryness

(System ON)

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Spoken word demo

- Idle
  - Intended for everyday use
  - Generally cannot be perceived, until turned OFF
  - Takes the 'edge' off the room's dryness

(System OFF)

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Spoken word demo

- Voice Lift
  - For full room (if lots of ppl = lots of absorption)
  - Still 'sounds like the room'…only a bit longer
  - Hands-free P.A. system

(System ON)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Spoken word demo

- Voice Lift
  - For full room (if lots of ppl = lots of absorption)
  - Still 'sounds like the room'…only a bit longer
  - Hands-free P.A. system

(System OFF)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Spoken word demo

- Large Hall
  - If room is too dry, there is not much to 'regenerate'
  - Some FIR convolution helps to fill the emptiness
  - This preset is ~2.2seconds RT60…*WAY* over the top for this room ☺

(System ON)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Basic Concepts

- System stability and minimising feedback is key!
- Maximising closed-loop gain whilst retaining system stability requires extensive tuning

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

System stability is paramount. Otherwise ringing, howling and excessive coloration can occur

Usual tuning timeframe is a week, only after the system is completely installed and functional tests are passed

Active Acoustic Enhancement (AAE)

Why?

- Acoustics must match the programme
- Audience's experience
- Performer's experience
- Remedy acoustic problems
- Makes commercial sense

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Now I'll run through the main reasons why a venue would invest in an AAE system

Active Acoustic Enhancement (AAE)

Why?

- Acoustics must match the programme
  - RT60 @ octave bands (RT profile)
  - ER/REV energy (EDT)
  - Clarity (C50)
  - Intelligibility (STI)

Optimal criteria differs between musical styles, theatre, dance, speech, sports, etc

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

The acoustic behaviour of the venue must match the programme content. You don't put a Symphony Orchestra in a lecture theatre…

The ideal room acoustic differs greatly between different types of content.

We can measure (and to some degree, control) the various acoustic parameters of the room to suit the program material.

Active Acoustic Enhancement (AAE)

Why?

- Audience's experience
  - Could the lecturer be heard?
  - Was I listening to the stage or the black boxes?
  - Could the soloists nuances be heard?
  - Did it sound like the record?
  - Listening effort & fatigue?

The audience's satisfaction is the most important metric on whether the venue is commercially successful!

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

WHY MUST THE ACOUSTIC MATCH THE PROGRAMME??

Because the acoustics have a direct effect on the experience of the fee-paying audience member

Whether they realise it or not!

Active Acoustic Enhancement (AAE)

Why?

- Performer's experience
  - Can I hear the ensemble?
  - Can the audience hear me?
  - Good sound encourages good performance

Uncomfortable performers = lousy performances!

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

WHY MUST THE ACOUSTIC MATCH THE PROGRAMME??

The performer, or lecturer, will respond accordingly to good or bad acoustics.

Active Acoustic Enhancement (AAE)

Why?

- Remedy acoustic problems
  - AAE cannot reduce RT60!
  - But it can mask flutter, slap-back & spectral anomalies

(Case study :: AFC3 masks slap-back from rear wall)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

We cannot use AAE systems to suck acoustic energy from a room,

But we can use it to mask certain anomalies

Active Acoustic Enhancement (AAE)

Why?

- Makes Commercial Sense
  - Modern venues are now multipurpose
  - Even heritage venues employ AAE
  - Mechanical solutions are $$$$

Flexible acoustics = wider market = more bookings

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Economics play a critical part in an AAE investment.

Mechanical solutions have been used before, Sage Gateshead in UK is a good example

Active Acoustic Enhancement (AAE)

How?

- "Successful Design" criteria
- Design inputs & required data
- System architecture
- Installation
- Commissioning & Tuning

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

We will now talk about how we implement an AAE system, from conception to completion

Active Acoustic Enhancement (AAE)

How?

- "Successful Design" criteria
  - Meets target RT & acoustic profile
  - Sounds natural
  - Adapts to the intended program material
  - Users will use it and benefit from it
  - Should be aurally "invisible"
  - Untrained staff can turn it on/off
  - Meets budget

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

In general, these are what we see as the criteria for a "Successful Design"

Active Acoustic Enhancement (AAE)

How?

- Design inputs & required data
  - What's it for? Fix deficiencies? Enhancement?
  - Existing BG noise & RT profile
  - Existing ER & REV energy (EDT & RT60 @octaves)
  - Critical distance (Dc)
  - Room dimensions & layout (where is the audience?)
  - Performer location (does layout change?)
  - Expected performance metrics

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Before we put pen to paper, we need to gather a lot of information….

Active Acoustic Enhancement (AAE)

How?

- System Architecture
  - Sub-systems for ER, stage, under-balcony, LF etc?
    - ER system may be needed if walls are too absorptive / diffractive, or if audience is a long way from stage
    - Stage shell system so performers can hear each-other, or if RT(stage) ≠ RT (audience)
    - Under-balcony system to 'remove' ceiling & improve 'connectedness'
    - LF system for 'warmth' & <100Hz RT

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

We now need to address the design criteria with an actual design…

Active Acoustic Enhancement (AAE)

How?

- System Architecture
  - Number & types of loudspeakers…
    - Critical distance (Dc)
    - Directivity
    - Power handling
    - Mounting points & cable paths
    - Architectural integration

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Loudspeaker location, distance from listeners, and spacing….

Active Acoustic Enhancement (AAE)

How?

- System Architecture
  - Microphones
    - Separate ER & REV? (Cardioid + Omni?)
    - Critical distance (Dc)
    - Permanent mounting points vs Dc
    - Cable paths
    - AFC3 uses 4qty (usually)
    - Head amp qty
    - Low noise, flat response

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Microphone quantity, placement etc

Active Acoustic Enhancement (AAE)

How?

- System Architecture
  - Amplification & DSP
    - Amp channels == loudspeaker qty
    - DSP channels == loudspeaker qty
    - Loudspeaker management
    - Very large mixing & delay matrices
    - Lots of parametric EQ
    - Preset handling

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Amplification & DSP must provide the flexibility & grunt to achieve even coverage and sufficient control

Active Acoustic Enhancement (AAE)

How?

- System Architecture
  - Network & Signal transport
    - Hundreds of cross-points even for small rigs
    - Dozens of network ports (Control + Dante)
    - Dante is usually the only practical solution
    - VLAN vs bare metal
    - Fixed IP's (DHCP & IPv4 = convenient but lazy)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Our network must be fast & powerful enough to handle many dozens if not hundreds of uncompressed (48kHz 24bit) UDP channels, plus some TCP control data.

We do not like sharing networks with other services; we always specify our own Yamaha SWP or SWR gigabit switches and set fixed IP addresses.

Active Acoustic Enhancement (AAE)

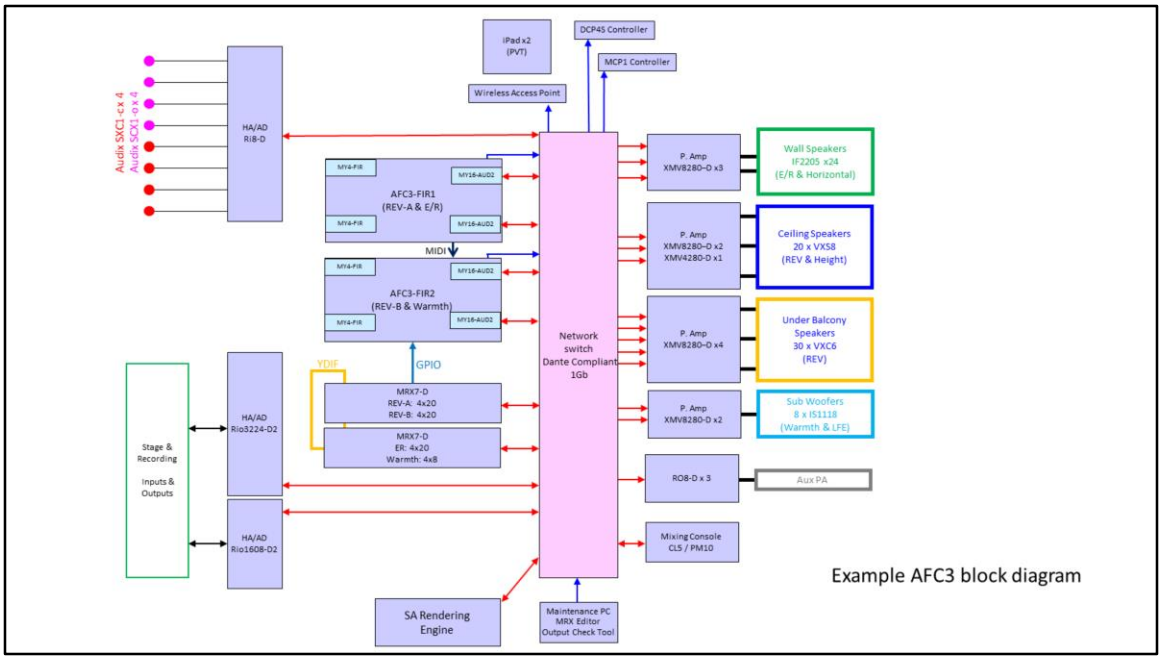
How?

- System Architecture
  - Rackspace & Power
    - Ventilation spaces
    - Ease of maintenance
    - Heat management
    - Max output power consumption

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Lots of amps, lots of DSP, lots of GPO's, lots of copper coming in and out….



Example AFC3 block diagram

Active Acoustic Enhancement (AAE)

How?

- Installation
  - Design documentation
  - Km's of loudspeaker cable
  - New build vs Heritage
  - Experience matters

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Usually the consultant or contractor will produce the design doc's with guidance from us, but the actual installation is 100% carried out by the contractor (with our support of course)

Active Acoustic Enhancement (AAE)

How?

- Commissioning & Tuning (Pre-tuning stage)
  - Power up (test breakers, sequencing, etc)
  - Assign system ID's & IP's as per documentation
  - Establish basic system dashboard for testing
  - Verify max network load handling
  - Pink noise flash / sine sweep of each loudspeaker
  - Verify all terminations (channel, phase etc)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Basic stuff…is it all plugged in and wired correctly??

Check EVERY SINGLE signal path using dual FFT software

Active Acoustic Enhancement (AAE)

How?

- Commissioning & Tuning (Tuning stage)
  - Setup dual FFT (Smaart, EASERA, E.A Toolbox etc)
  - Setup omnidirectional radiator
  - Set initial gain (relative SPL) of loudspeakers
  - Set delay of each loudspeaker
  - Set various PEQ stages for various speaker busses
  - Optimise loop gain (balance gain with coloration)
  - Optimise FIR convolution settings (if used)
  - Observe limits of 'natural' system performance
  - Setup basic presets

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

How?

- Commissioning & Tuning (Verification stage)
  - Testing with musicians / performers
  - Subjective feedback, client discussion
  - Revise targets if necessary (eg: RT spectrum)
  - Revise presets as required
  - More testing with musicians / performers
  - Lock in presets (and lock down the system!)
  - Measure room I.R. (ie: OFF, Preset 1/2/3 etc)

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Quality Indicators

- Measured results (Did we achieve the RT targets?)
- Subjective (Does it sound natural?)
- Applicability (Do the presets work for each type?)
- How do the performers feel?
- Aural vs Visual Stimulus (Am I being tricked?)
- Are untrained staff able to use it?
- Value for money?

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Spatial Audio (SA)

AKA…

- Immersive Audio
- Spatial Surround
- Dolby Atmos
- Object-based Audio

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

OKAY….Now that we have installed a truckload of speakers, amps, DSP etc…

…We may have accidentally built ourselves a system capable of rendering WFS objects!

Spatial Audio (SA)

For live applications

- Wave Field Synthesis (WFS)
  - Scale-able (to a degree)
  - Large listening area (relatively)
  - Tolerant to loudspeaker layout (to a degree)
- Ambisonics
  - Good for headphones (HRTF) or defined areas
  - Not really viable for large listening areas

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Now let's focus on the real-world technical reality behind the industry's adoption of WFS….

Spatial Audio (SA)

For live applications

- Wave Field Synthesis (WFS)

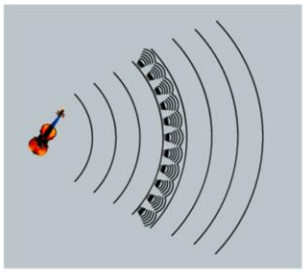


Image :: IRCAM

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

WFS allows us to synthesise the actual wavefront of an object, as if it were actually originating from a point in space….

This graphic is informative

Spatial Audio (SA)

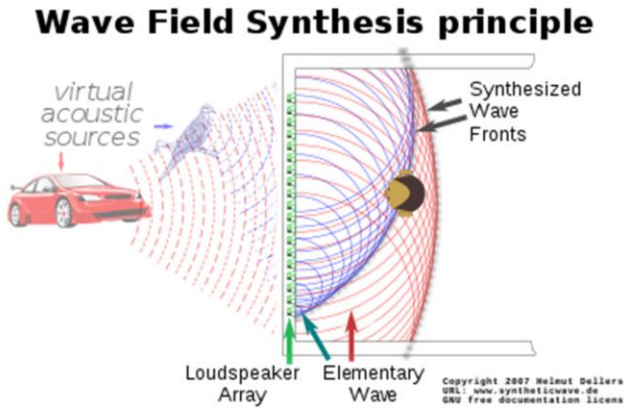


Image :: Helmut Dellers

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

WFS allows us to synthesise the actual wavefront of an object, as if it were actually originating from a point in space….

This graphic is informative

Spatial Audio (SA)

For live applications

- Wave Field Synthesis (WFS)
  - BARCO IOSONO
  - Astro Spatial SARA
  - L'Acoustics LISA
  - D&B Soundscape
  - SPAT (Max/MSP)
  - Soundscape Renderer (Github)
  - WFSupercollider

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

A lot of commercial and free open-source products have entered the market.

It's 2019 and we are standing on the shoulders of giants.

Spatial Audio (SA)

Design Considerations

- How big is the listening area?
- How densely spaced are our loudspeakers?

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

In my experience, we can usually build a functional and ‘passable’ spatial rig without going to extreme lengths with loudspeakers pressed up cheek-to-cheek.

Such a system looks good on a whitepaper, but is impractical and expensive.

The aforementioned software packages have a fair degree of tolerance for loudspeaker spacing, if approached with care…

Spatial Audio (SA)

Design Considerations

- How big is the listening area?
  - Time of flight becomes a consideration if listening area is surrounded by a ring
  - Loudspeaker output required to project adequate SPL to centre of audience

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Rhythmical content can become out-of groove if objects are physically spaced too far apart!!!

We also need to be able to project enough SPL to our audience without damaging the hearing of the nearest audience

Spatial Audio (SA)

Design Considerations

- How densely spaced are our loudspeakers?
  - RULE OF THUMB :: Loudspeaker spacing should equal *at least the distance to the nearest listener*

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Cheek-to-cheek spacing should be at least the distance to nearest listener

This is why you see maybe only 5 arrays of LISA at the front of a large concert stage…

Even then it is difficult to properly synthesis HF wavefronts

Spatial Audio (SA)

Design Considerations

- How densely spaced are our loudspeakers?
  - RULE OF THUMB :: Loudspeaker spacing should equal *at least the distance to the nearest listener*
  - Even then, the system's ability to render HF is limited if the loudspeaker spacing is too great
  - *Luckily our ears are very forgiving!*

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Once the loudspeakers are spaced too far apart to properly build a nice solid HF wavefront, luckily our ears tend to localise the source's HF element anyway….

Fraunhofer & the licensed product variants have other proprietary tricks to approach this (which I am not privy to)

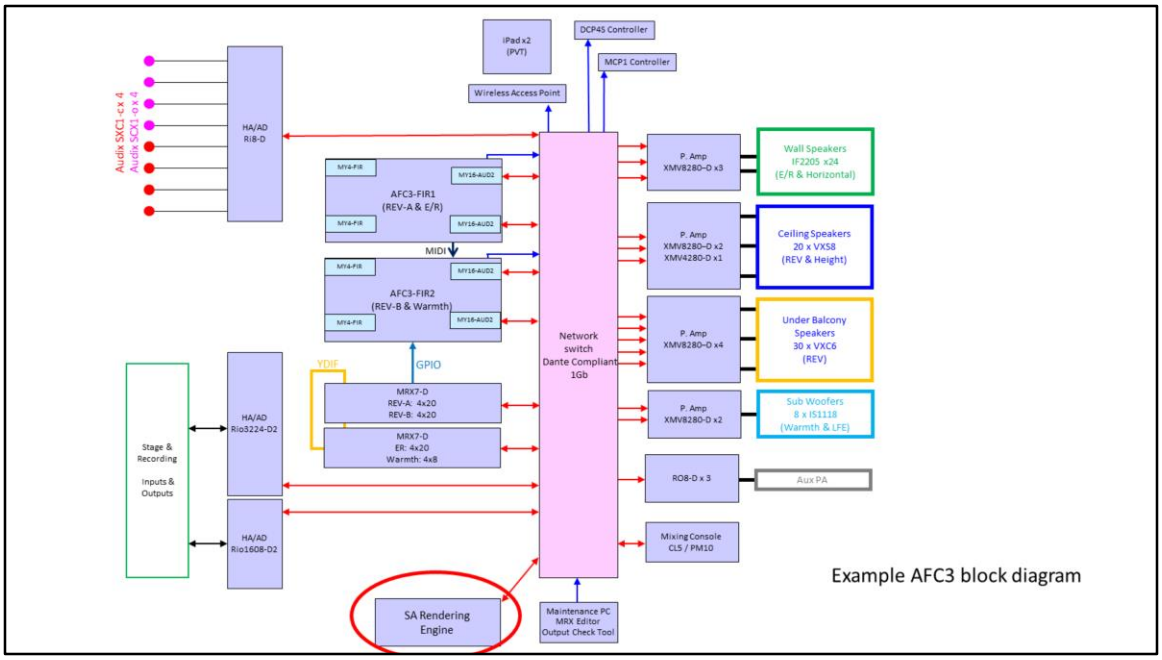
Spatial Audio (SA)

In Practice

- A great deal of our hypothetical AAE system shares components with our SA system
- *The systems can be used in parallel!*

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.



REMEMBER THIS BIT DOWN HERE??!! (SA Rendering Engine)

Active Acoustic Enhancement (AAE)

Object-based WFS demo (with AFC3)

- Idle
  - Intended for everyday use
  - Generally cannot be perceived, until turned OFF
  - Takes the 'edge' off the room's dryness

(System ON)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Object-based WFS demo (with AFC3)

- Idle
  - Intended for everyday use
  - Generally cannot be perceived, until turned OFF
  - Takes the 'edge' off the room's dryness

(System OFF)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Object-based WFS demo (with AFC3)

- Voice Lift
  - For full room (if lots of ppl = lots of absorption)
  - Still 'sounds like the room'…only a bit longer
  - Hands-free P.A. system

(System ON)

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

Object-based WFS demo (with AFC3)

- Voice Lift
  - For full room (if lots of ppl = lots of absorption)
  - Still 'sounds like the room'…only a bit longer
  - Hands-free P.A. system

(System OFF)

YAMAHA commercial audio

Audio Engineering Society
Melbourne Section Inc.

Active Acoustic Enhancement (AAE)

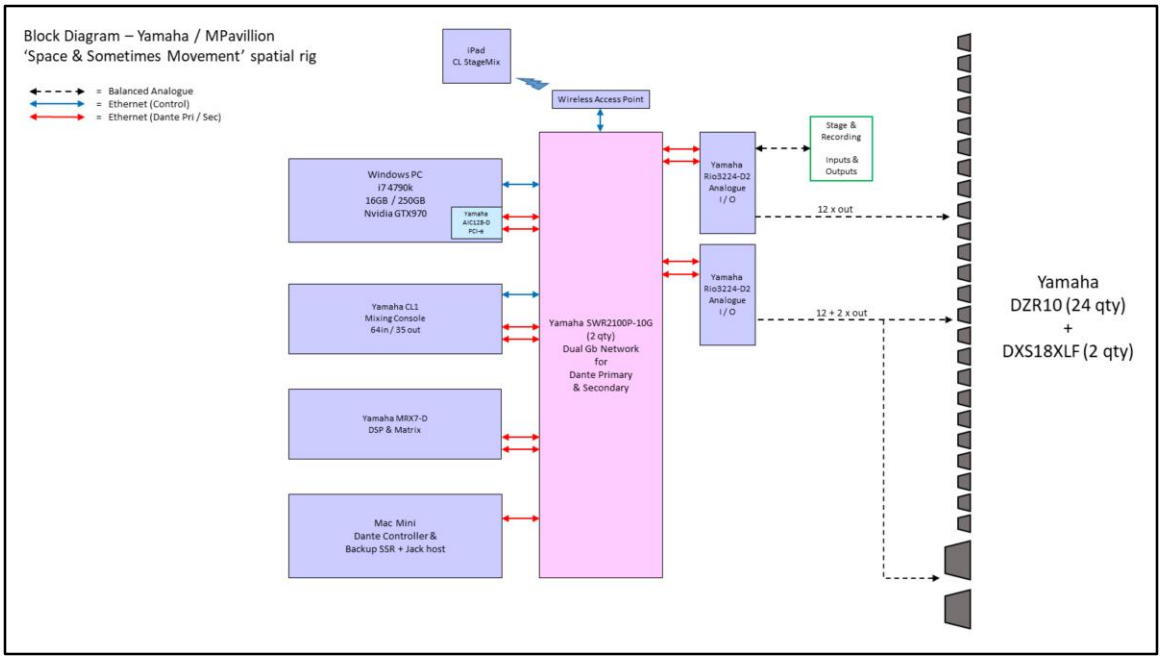
Object-based WFS demo (with AFC3)

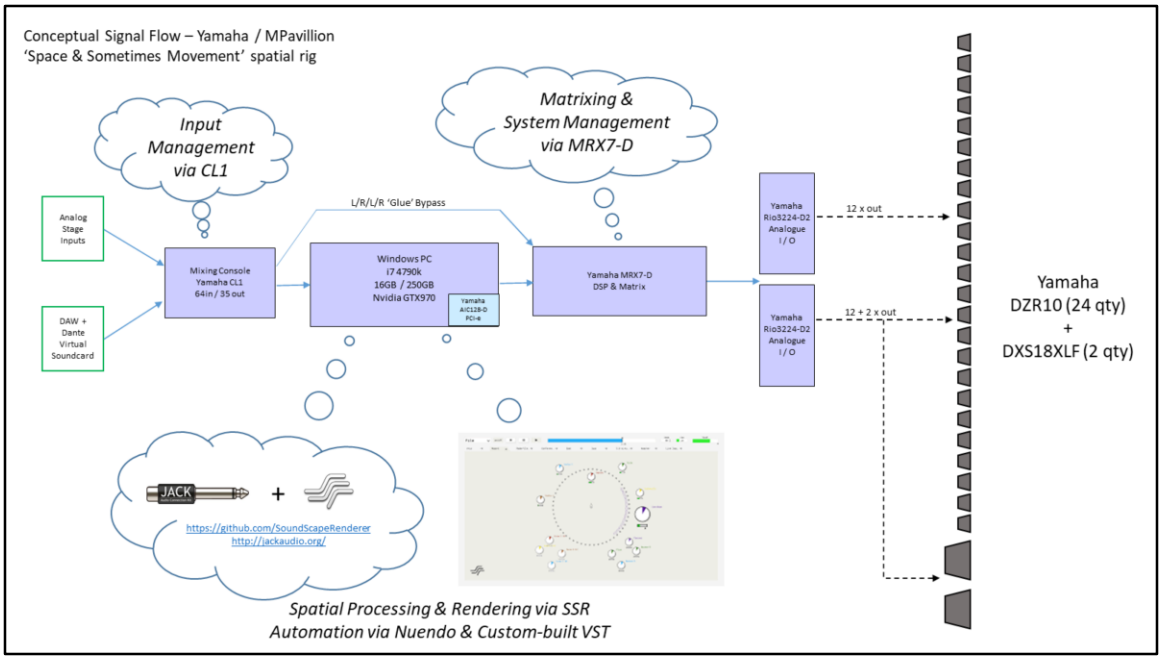
- Large Hall
  - If room is too dry, there is not much to 'regenerate'
  - Some FIR convolution helps to fill the emptiness
  - This preset is *WAY* over the top for this room…but the music is much less 'dry'

(System ON)

YAMAHA commercial audio

Audio Engineering Society Melbourne Section Inc.


Block Diagram – Yamaha / MPavillion
'Space & Sometimes Movement' spatial rig
= Balanced Analogue
= Ethernet (Control)
= Ethernet (Dante Pri / Sec)
iPad
CL StageMix
Wireless Access Point
Windows PC
i7 4790k
16GB / 250GB
Nvidia GTX970
Yamaha
AIC128-D
PCI-e
Yamaha CL1
Mixing Console
64in / 35 out
Yamaha MRX7-D
DSP & Matrix
Mac Mini
Dante Controller &
Backup SSR + Jack host
Yamaha SWR2100P-10G
(2 qty)
Dual Gb Network
for
Dante Primary
& Secondary
Yamaha
Rio3224-D2
Analogue
I / O
Yamaha
Rio3224-D2
Analogue
I / O
Stage &
Recording
Inputs &
Outputs
12 x out
12 + 2 x out
Yamaha
DZR10 (24 qty)
+
DXS18XLF (2 qty)


Conceptual Signal Flow – Yamaha / MPavillion
'Space & Sometimes Movement' spatial rig
Input Management via CL1
Matrixing & System Management via MRX7-D
Analog Stage Inputs
DAW + Dante Virtual Soundcard
Mixing Console Yamaha CL1 64in / 35 out
L/R/L/R 'Glue' Bypass
Windows PC i7 4790k 16GB / 250GB Nvidia GTX970
Yamaha AIC128-D PCI-e
Yamaha MRX7-D DSP & Matrix
Yamaha Rio3224-D2 Analogue I / O
Yamaha Rio3224-D2 Analogue I / O
12 x out
12 + 2 x out
Yamaha DZR10 (24 qty) + DXS18XLF (2 qty)
JACK
https://github.com/SoundScapeRenderer
http://jackaudio.org/
Spatial Processing & Rendering via SSR
Automation via Nuendo & Custom-built VST

Further Reading

(good places to start!!)

General AAE information ::
https://au.yamaha.com/en/products/proaudio/afc/afc3/downloads.html

General WFS information ::
http://www.aes.org/e-lib/browse.cfm?elib=14488 (co-written by the Soundscape Renderer guys)
http://www.aes.org/e-lib/browse.cfm?elib=16663

SA Software Packages (Do a Google Search on these) ::
FREE & Open Source :: Soundscape Renderer (Github) / SPAT for MAX.MSP / WFSupercollider
PROPRIETARY :: d&b Soundscape / L'Acoustics LISA / BARCO IOSONO / Astro Spatial

'Space & Sometimes Movement' event Feb 2019 ::
Latest issue of Audio Technology Magazine (March 2019)

YAMAHA
commercial audio

Audio Engineering Society
Melbourne Section Inc.