


CINEMA SOUND SYSTEMS

**RAISING THE BAR
THROUGH NEW STANDARDS**

WELCOME!



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SMPTE Standards Series

- Series of quarterly webcasts designed to inform about significant SMPTE Standards development efforts
- Open to members and non-members
- Powered by SMPTE's Professional Development Academy (SMPTE PDA)

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Today's Guest Speaker

Brian Vessa
Executive Director, Digital
Audio Mastering
Sony Pictures Entertainment



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PRESENTATION OVERVIEW

1. Overview of Cinema Sound System Requirements and Challenges
2. Existing SMPTE Standards
3. Consistency Challenges
4. Immersive Sound Systems-Overview
5. Immersive Sound Systems-Challenges
6. SMPTE-Meeting the challenges
7. TC 25-CSS Plan of Attack
8. Summary

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**CINEMA SOUNDTRACKS--MIX ONCE,
PLAY EVERYWHERE**

- Mix in one or more dubbing theaters that are set up and calibrated to current standards
- Play in a variety of exhibition theaters of various sizes and shapes, each having a different sound system and theoretically calibrated to the same standards
- The soundtrack should sound consistent in all of the venues

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**CINEMA SOUNDTRACKS--MIX ONCE,
PLAY EVERYWHERE**

- Quite often....it doesn't
- Making a movie soundtrack sound consistent in multiple venues is a big challenge
- Cinema sound is inconsistent....
 - Between mixing stages
 - Between the mixing stage and exhibition theater
 - Between exhibition theaters

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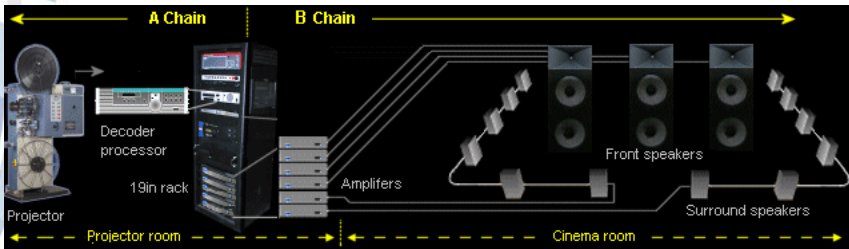


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CINEMA SOUND SYSTEMS: REQUIREMENTS AND CHALLENGES

Cinema A and B Chain Diagram



From Lenard Audio web site
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CINEMA SOUND SYSTEMS: REQUIREMENTS AND CHALLENGES

- Screen speakers
 - Produce most of the sound
 - Must be capable of delivering high volume levels across the full audio spectrum with full fidelity
 - Must be capable of covering the entire auditorium
 - Are often multiple boxes of cone speakers and horns
 - Newer designs may include line arrays

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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

Screen speakers



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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

Screen speakers in baffle wall



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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

- Surround speakers
 - Generally used for ambience and panned sound effects
 - Generally require less power and frequency range per speaker, though modern soundtracks challenge this
 - Much smaller than screen speakers and are usually a single 2 or 3 way cabinet
 - Multiple surround speakers are used per surround channel for coverage

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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**
Surround speakers



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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

- Subwoofer speakers
 - Generally used for low frequency effects and music, occasional voice effects
 - Must deliver very high volumes in a narrow range of frequencies cleanly
 - Generally multiple subwoofer cabinets are used for to get level and coverage
 - Should cross over from the screen speakers with similar perceived character

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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**
Subwoofer speakers




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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

Subwoofer speakers



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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

- Amplifiers
 - Should amplify and not color
 - Should have excellent frequency and transient response
 - Must handle sustained level and large peaks without clipping
 - Should match in power with speaker efficiency to deliver required SPL cleanly

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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

- Equalizers
 - Can be in the cinema processor or a separate unit
 - 1/3 octave band EQ is common; parametric EQ's are also used
 - Modern designs can be controlled from a networked computer and the settings saved
 - Systems can utilize overall system EQ and separate crossover EQ

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**CINEMA SOUND SYSTEMS:
REQUIREMENTS AND CHALLENGES**

- The screen
 - Is never friendly to sound
 - Has transmission and reflection issues
 - Generally creates a smearing effect
 - Traditional perforated screens usually require high frequency compensation
 - Silver screens are even more challenging
 - Newer woven screen designs are promising

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CINEMA SOUND SYSTEMS: REQUIREMENTS AND CHALLENGES

- Cinema room acoustics
 - Good acoustic design is very important
 - Room reverb should be short-damping is generally required
 - Close reflections and “slap” must be controlled-these interfere with perceived imaging and intelligibility

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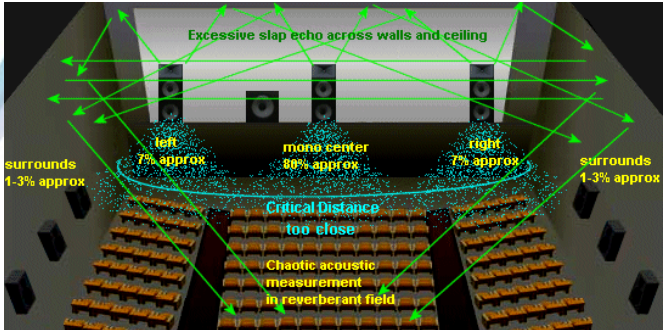


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CINEMA SOUND SYSTEMS: REQUIREMENTS AND CHALLENGES

Cinema Room Acoustics



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SYSTEM SETUP AND CALIBRATION

- HAVE EXPERTS TO DO IT RIGHT FROM THE BEGINNING!
 - Cinema system and acoustical design
 - Physical installation
 - Coverage angles
 - Calibrating crossovers
 - Surround delay
 - Subwoofer/screen time alignment
 - Electroacoustic calibration
 - SPL calibration

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THE CURRENT STANDARDS

- The current standard for the electroacoustic response of cinema theaters is SMPTE ST 202
- The current recommended practice for sound pressure level (SPL) in cinema theaters is SMPTE RP 200
- The current recommended practice for audio reference levels is SMPTE RP 155

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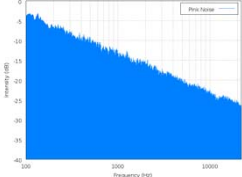
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CURRENT STANDARDS: HIGHLIGHTS

- The current standards are built around measurements using:
 - Wideband pink noise* as a test signal
 - One or more calibrated microphones
 - A 1/3 octave real time analyzer
 - A sound pressure level meter set to C weighting and slow response

*Wideband pink noise has equal energy per octave in the audio band



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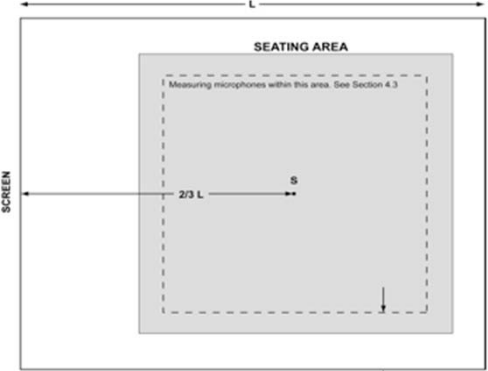


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CURRENT STANDARDS: HIGHLIGHTS

Microphone Placement Area



From SMPTE
ST 202 Figure 4
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CURRENT STANDARDS: HIGHLIGHTS

- Preferred microphone characteristics
 - Calibrated pressure-sensitive omnidirectional
 - ½" capsule or smaller. (¼" is typical)
- Microphone placement
 - Mixing stage: At mixer's and producer's positions, behind console
 - Exhibition theater: Position "S" and 4 others, or one mic moved to 5 positions
 - 3-4' high, > 6" above seat, > 3' apart
 - > 16 feet from screen, > 5 feet from walls
 - 90 degree angle (straight up)

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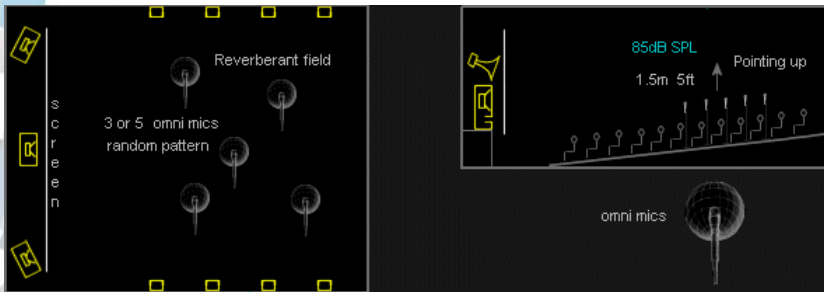


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CURRENT STANDARDS: HIGHLIGHTS

Microphone Placement Diagram



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CURRENT STANDARDS: HIGHLIGHTS

- Microphone spatial averaging
 - Can measure multiple mics one at a time (“multiplex”), store, then temporally average
 - Or, measure one mic in several positions, store, temporally average
- Real Time Analyzer
 - The result is displayed on a real time analyzer (RTA) in 1/3 octave bands and is called the “electroacoustic response”
 - By employing slow averaging, the display can be “smoothed” to show a “curve”

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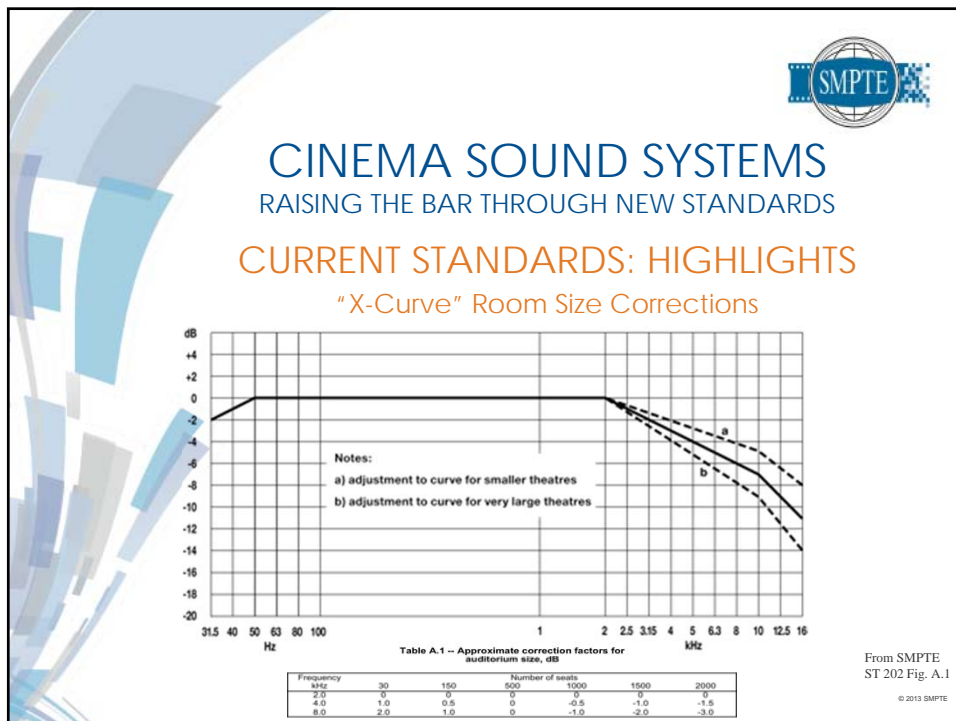
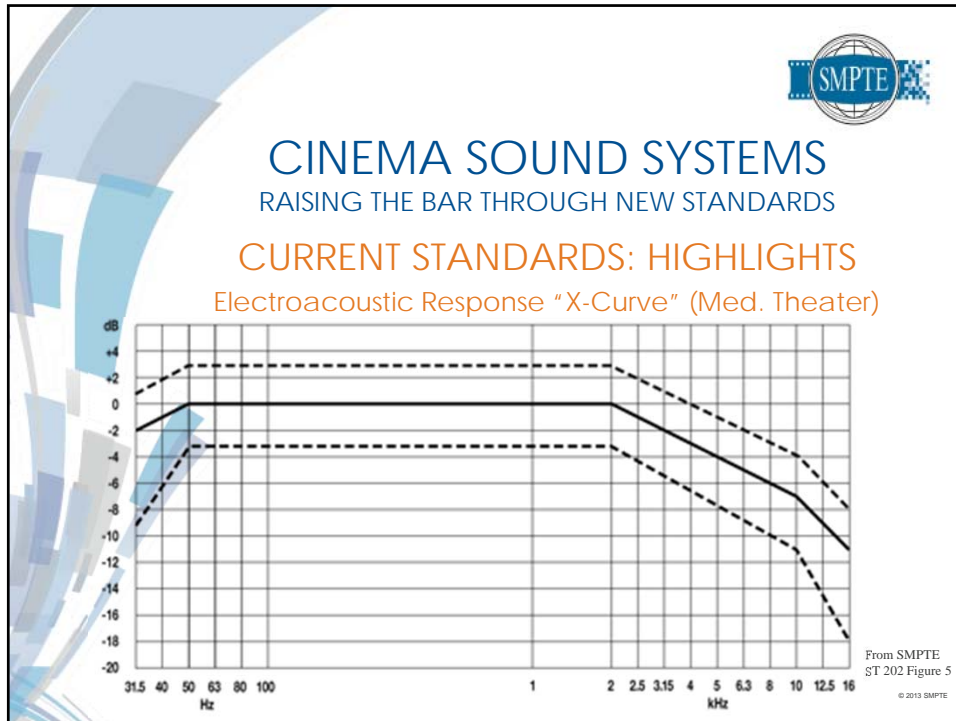
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CURRENT STANDARDS: HIGHLIGHTS

Real Time Analyzer (1/3 octave bands)

| | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|
| 16 | 20 | 25 | 31.5 | 40 | 50 | 63 | 80 | 100 | 125 | 160 |
| -1.4dB | -3.0dB | -2.7dB | 2.4dB | 1.0dB | -4.3dB | 4.5dB | -1.5dB | -1.4dB | -4.0dB | -3.3dB |
| 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1.25k | 1.6k | 2k |
| -0.2dB | 0.5dB | 0.0dB | -4.7dB | -1.4dB | -0.4dB | -1.5dB | -0.7dB | 1.2dB | 2.8dB | 0.3dB |
| 2.5k | 3.15k | 4k | 5k | 6.3k | 8k | 10k | 12.5k | 16k | 20k | Ref level |
| 1.4dB | -0.6dB | 2.6dB | 1.5dB | 3.5dB | 0.1dB | 7.6dB | 9.2dB | 13.6dB | 0.0dB | 52.8dB |

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CURRENT STANDARDS: HIGHLIGHTS

- Electroacoustic Response Characteristics
 - Is a steady-state response
 - Shows the response in the room, not of the speakers
 - A combination of direct sound and reverberant sound
 - Affected by HF air attenuation
 - Affected by the screen HF attenuation
 - Affected by temperature and humidity

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CURRENT STANDARDS: HIGHLIGHTS

- X-Curve Characteristics
 - Flat from 50Hz to 2kHz in a medium room (e.g. 200-500 seats)
 - High end rolloff at 3db/octave 2kHz to 10KHz
 - 6 db/octave rolloff above 10KHz
 - Low end rolloff at 3db/octave below 50Hz
 - Overall tolerance range is +/- 3db, more at very low frequencies

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CURRENT STANDARDS: HIGHLIGHTS

- Electroacoustic response by speaker:
 - Screen speakers to match X-Curve +/- 3dB
 - Surround speakers extend flat response to 4K or higher depending on proximity to audience
 - Subwoofer: Flat within 3dB from 25-120Hz
 - Expected screen and surround speaker electroacoustic response is subject to room size corrections

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CURRENT STANDARDS: HIGHLIGHTS

- Calibration and equalization overview:
 - System integrity is checked
 - Wideband pink noise is injected into the system at reference level, one speaker at a time
 - Active crossovers are checked and adjusted if needed
 - System equalization (generally in 1/3 octave bands) is applied to bring the electroacoustic response within spec. Parametric EQ can also be used.

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CURRENT STANDARDS: HIGHLIGHTS

- Sound pressure level measurements:
 - Overall SPL is an average taken across the measured bandwidth. This is expressed as the number of decibels above the threshold of hearing
 - This averaging is “weighted” to account for how we hear.
 - “A” mimics how we hear medium level sounds, which peaks in the upper midrange
 - “C” mimics how we hear loud sounds and is flatter-rolls off at high and low frequencies
 - “C” weighting is used in current standards

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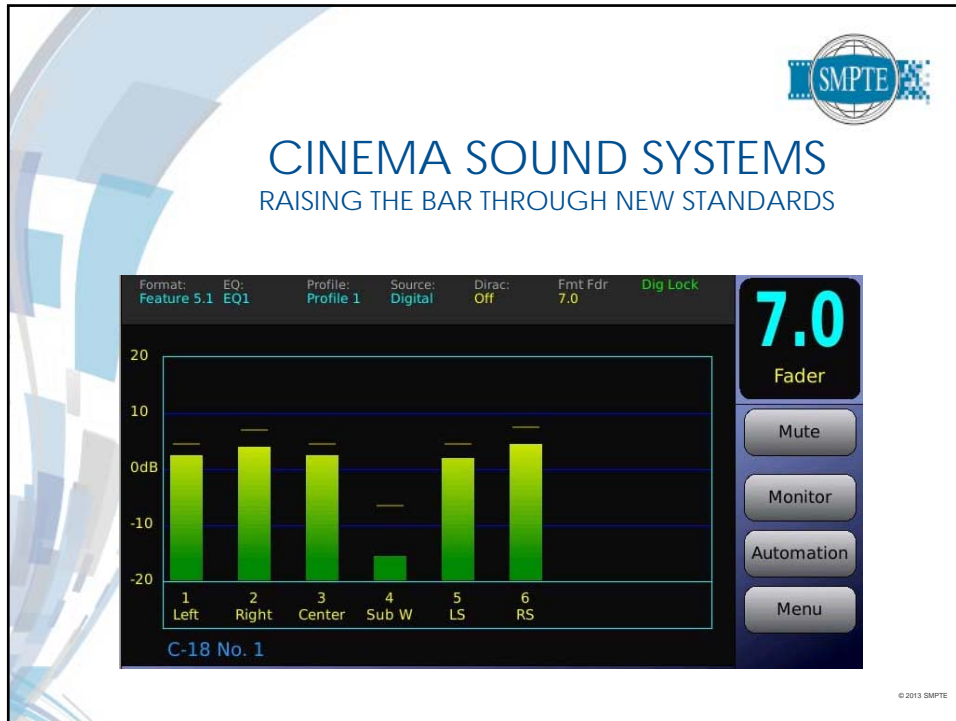


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CURRENT STANDARDS: HIGHLIGHTS

- The audio reference level for cinema SPL measurements is:
 - -20 dBFS on a digital PPM meter (“0VU”) (mix stage)
 - “7” or “0” level on a cinema processor (exhibition theater)

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CURRENT STANDARDS: HIGHLIGHTS

- SPL measurement and adjustment:
 - Performed after electroacoustic calibration is complete with same microphone setup
 - Wideband pink noise is again injected into the system at reference level, one speaker at a time
 - The gain to each speaker is adjusted for SPL measurements as follows:
 - 85 dBC SPL for each screen speaker
 - 82 dBC SPL for each surround array
 - Approximately 91 dBC for the subwoofer*

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CURRENT STANDARDS: HIGHLIGHTS

Handheld SPL Meters



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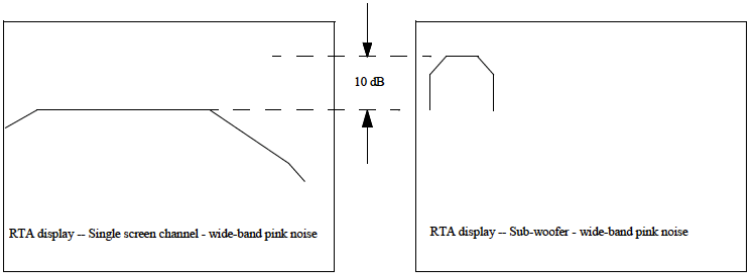
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CURRENT STANDARDS: HIGHLIGHTS

Subwoofer SPL With RTA

*Set subwoofer 10db higher in its passband than the screen speakers' passband value



RTA display -- Single screen channel - wide-band pink noise

RTA display -- Sub-woofer - wide-band pink noise

10 dB

From SMPTE
RP 200 Figure 4
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Figure 4 – Measurement of subwoofer sound-pressure level, digital LFE sound-track, using real-time analyzer




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**THE CHALLENGE: ACHIEVING
CONSISTENT RESULTS**



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**THE CHALLENGE: ACHIEVING
CONSISTENT RESULTS**

- Standards by nature look good on paper!
- Applying standards in the real world can be very challenging
- There are many factors that can cause inconsistent results

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THE CHALLENGE: ACHIEVING CONSISTENT RESULTS

- Technicians have different equipment and different approaches to measurement
- Pink noise test signals vary
- Microphone responses vary
- Cinema sound systems vary
- Every theater space has its own character and no two rooms are exactly alike

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THE CHALLENGE: ACHIEVING CONSISTENT RESULTS

- Achieving sound consistency through replicating measurements has issues
- Our ears do not hear like measurement data
- Measurements will look different depending on where you put the microphone(s) in the room and the characteristics of the room itself
- Our ears and brain compensate- measurements do not

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THE CHALLENGE: ACHIEVING CONSISTENT RESULTS

- A “flat” speaker system, when measured in a cinema reverberant space using the methodology in ST 202, should measure similar to the “X-curve”
- The reverse is not necessarily true—equalizing a system to strictly match the “X-curve” target on an analyzer does not automatically result in flat system response or a good sounding system

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PERFORMANCE CHALLENGES

- There is 20 dB of available level above reference prior to hitting digital full scale
- At 0 dBFS, a screen speaker must deliver 105 dBC cleanly to the audience as measured 2/3 back in the auditorium
- The much smaller surround speakers must deliver 102 dBC
- Subwoofers must deliver >110 dBC in their passband
- These numbers are at the extreme edge of what many cinema sound systems can do

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**IMMERSIVE SOUND SYSTEMS:
NEW DIMENSIONS IN CINEMA SOUND**

- Several immersive “3D” cinema sound systems have been introduced recently
- These systems make the entire auditorium part of the soundfield
- Most add the additional dimension of height in some way
- All have additional surround speakers
- Some have additional screen speakers
- Some have additional subwoofer speakers

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**IMMERSIVE SOUND SYSTEMS:
NEW DIMENSIONS IN CINEMA SOUND**



**AURO-3D
System**

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**IMMERSIVE SOUND SYSTEMS:
NEW DIMENSIONS IN CINEMA SOUND**



DOLBY
ATMOS
System

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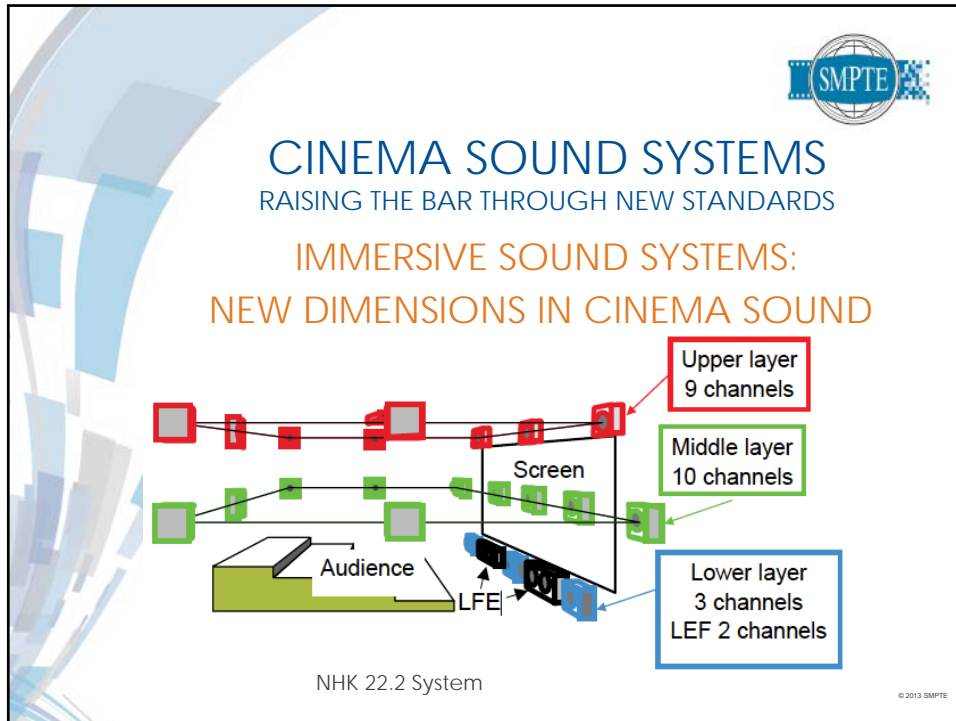
**IMMERSIVE SOUND SYSTEMS:
NEW DIMENSIONS IN CINEMA SOUND**




"IOSONO is making movies
sound so much more lively."
Seo Jung, CEO of CJ CGV

IOSONO
System

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IMMERSIVE SOUND SYSTEMS: NEW PERFORMANCE CHALLENGES

- The desire to make all of the cinema room part of the soundfield puts a higher demand on the surround speakers than in traditional systems
- In order to more closely match the frequency response of the screen, surrounds are often bass managed
- These subwoofers will likely require different characteristics than the LFE subs

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IMMERSIVE SOUND SYSTEMS: INSTALLATION CHALLENGES

- Each system has its own concept of how to attain immersive sound
- Each has challenges when installing into a given space to obtain the desired effect
- Aiming is critical, and is very dependent on the room
- Dubbing stages and exhibition theaters have different requirements for coverage
- More speakers, more details!

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**IMMERSIVE SOUND SYSTEMS:
NEW CHALLENGES FOR STANDARDS**

- No B-chain Standards yet exist
- Height is uncharted standards territory. We don't hear height as well as front and sides
- Standards for the bass management of surrounds are needed
- Performance parameters are needed so installers and manufacturers have guidelines

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**IMMERSIVE SOUND SYSTEMS:
NEW CHALLENGES FOR STANDARDS**

- No standards exist for soundtrack mastering
- No standards exist for delivery to the theater
- Special DCP's must be created in many cases
- Standardized file formats are needed for archiving and later playability

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**IMMERSIVE SOUND SYSTEMS:
NEW CHALLENGES FOR STANDARDS**

“So...
what are you gonna do about it
that’s what I’d like know?”

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SMPTE IS ON THE CASE

- The Theater B-Chain Study Group was formed in March, 2010 to study the situation
- This group produced a set of recommendations for new Standards that was submitted to the SMPTE Standards Committee (“ST”)

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SMPTTE IS ON THE CASE

- Based on this work, the SMPTE Standards Committee formed a new Technology Committee, 25CSS, in October 2012
- This is the very first SMPTE standards committee dedicated solely to cinema sound
- Indicates a strong commitment to cinema sound as 50% of the movie experience

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TC-25CSS PROJECT GOALS

- The sound standards of the future must be built on concepts that more closely model how people hear
- New measurement and calibration techniques must be developed that are tailored to human perception
- These must be able to be performed in a straightforward way to achieve consistent audible results
- Developing cinema sound system performance parameters is also key

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TC-25CSS PLAN OF ATTACK

- First wave-optimize current methods
- Second wave-moving forward
- Third wave-pushing the envelope
- Set the stage for the future

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TC-25CSS PLAN OF ATTACK

FIRST WAVE: OPTIMIZE CURRENT METHODS

- Four subgroups have been formed:
 1. Ad Hoc Group: Modern Measurement and Calibration
 - Output-SMPTE Recommended Practice:
 - Step-by-step procedure for cinema sound system calibration
 - Best practice using current standards and modern measurement technology

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TC-25CSS PLAN OF ATTACK

FIRST WAVE: OPTIMIZE CURRENT METHODS

2. Ad Hoc Group: Digital Pink Noise Test Signal

- Output-SMPTE Standard for pink noise algorithm
- Create:
 - Audio file
 - DCP
 - Reference implementation

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TC-25CSS PLAN OF ATTACK

FIRST WAVE: OPTIMIZE CURRENT METHODS

3. Ad Hoc Group: Analysis of data collected by the B-chain study group

- Output-Report with comparative data, data analysis and conclusions

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TC-25CSS PLAN OF ATTACK
FIRST WAVE: OPTIMIZE CURRENT METHODS

4. Study Group: Immersive Audio Systems-
B-chain and Distribution

- Output-Report-recommend standards work
- Output-Project work statements
 - ❑ Common audio delivery format
 - ❑ B-chain parameters and calibration standards

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TC-25CSS PLAN OF ATTACK
SECOND WAVE: MOVING FORWARD

1. Study Group-New electroacoustic standards and calibration methods
 - Output-Project Plan
2. Ad-Hoc group-Immersive audio content-common delivery format
 - Output-SMPTE Standard
3. Ad-Hoc group-Immersive sound system measurement and calibration
 - Output-SMPTE Recommended Practice

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TC-25CSS PLAN OF ATTACK
THIRD WAVE: PUSHING THE ENVELOPE

1. Ad-Hoc Group-New electroacoustic standards and calibration methodology
 - Output-SMPTE Standard and Recommended Practice to replace current
2. Ad-hoc group-Cinema sound system performance parameters
 - Output-SMPTE Standard, Recommended Practice and/or Engineering Guideline

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TC-25CSS PLAN OF ATTACK
FUTURE WORK:

1. Cinema acoustics parameters
 - Output-SMPTE Standard, Recommended Practice and/or Engineering Guideline
2. Soundtrack loudness calibration methodology
 - Output-SMPTE Recommended Practice and Engineering Guideline
3. Crystal Ball.....?

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AND THE ULTIMATE GOAL:

IMPRESSIVE AND CONSISTENT
CINEMA SOUND!

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IT TAKES A VILLAGE.....

- Mixers, sound designers, engineers, studios, manufacturers and exhibitors need to participate in order for new standards to be relevant and adopted
- Proponents must demonstrate benefits to key industry players
- Develop a transition plan and timeline that works for all concerned
- This transition must not interrupt movie production and distribution

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RAISING THE BAR THROUGH NEW STANDARDS

SUMMARY

1. Sound reproduction can vary by venue
2. Cinema sound systems have innate requirements and challenges
3. Calibration using current standards and practices does not always produce consistent results
4. Immersive sound systems produce additional challenges
5. SMPTE is working to create new standards
6. The industry must unite in the creation and adoption of these new standards

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IT'S OUR VILLAGE.....

If you are interested, please join us:

1. Join SMPTE and become a participating member:
<https://www.smpte.org>
2. Join the standards community:
https://kws.smpte.org/apps/org/workgroup/stds_comm/
3. Join TC-25CSS
<https://kws.smpte.org/apps/org/workgroup/25css/>

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THANK YOU!

Brian_Vessa@spe.sony.com

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The central graphic is a white rectangle with a thin black border. On the left side, there is a decorative graphic of overlapping blue and grey curved shapes. The SMPTE logo is in the top left corner of this rectangle. The main text is centered and uses a mix of blue and orange colors.