Audio/Video Synchronization Standards and Solutions A Status Report

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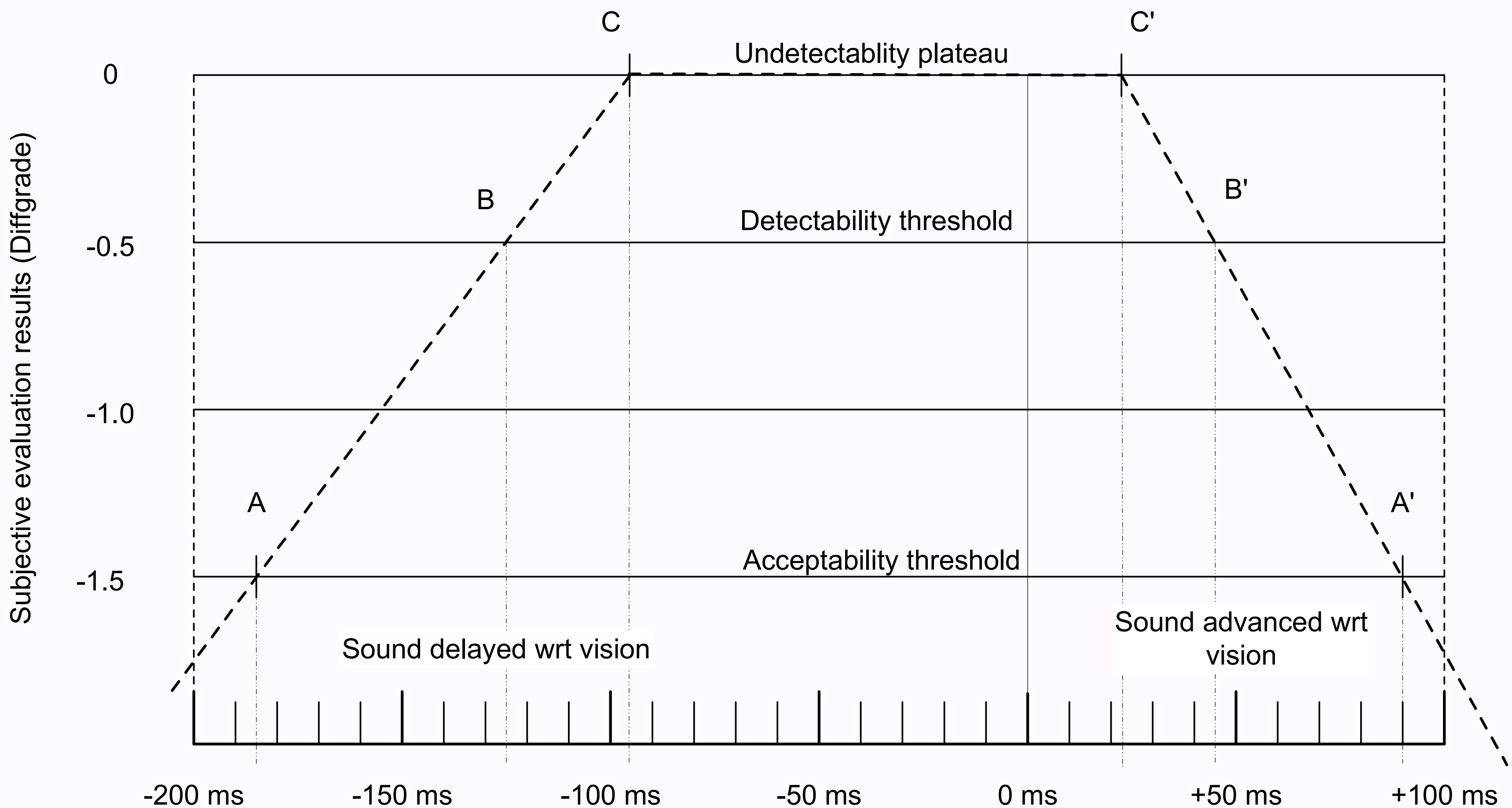
Advanced Television Systems Committee

ITU-R BT.1359-1 (1998)

Only International Standard on A/V Sync

- Subjective study with *EXPERT* viewers
  - SDTV not HDTV images
  - CRT displays, of course
- At first glance it seems loose: +90 ms to -185 ms as a "Window of Acceptability"
  - In their terms, positive values are audio advanced relative to video, negative is delayed relative to video
  - We will examine these results more closely…
  - The numbers were statistically significant for each point
- Remember, the measurements were *very* carefully made
  - Expert viewers
  - 20" CRT monitors
  - fixed viewing distances

ITU-R BT.1359 Figure 2



ITU-R BT.1359 Figure 2

ITU-R BT.1359 Figure 2

- Let’s quickly look at Figure 2 versus Fixed Pixel Display rates
  - 30/1.001 Hz (or 33.3 ms per image)
  - 25 Hz (or 40 ms per image)
- This may be informative…

Figure 2 with Fixed Pixel Display Timings Shown

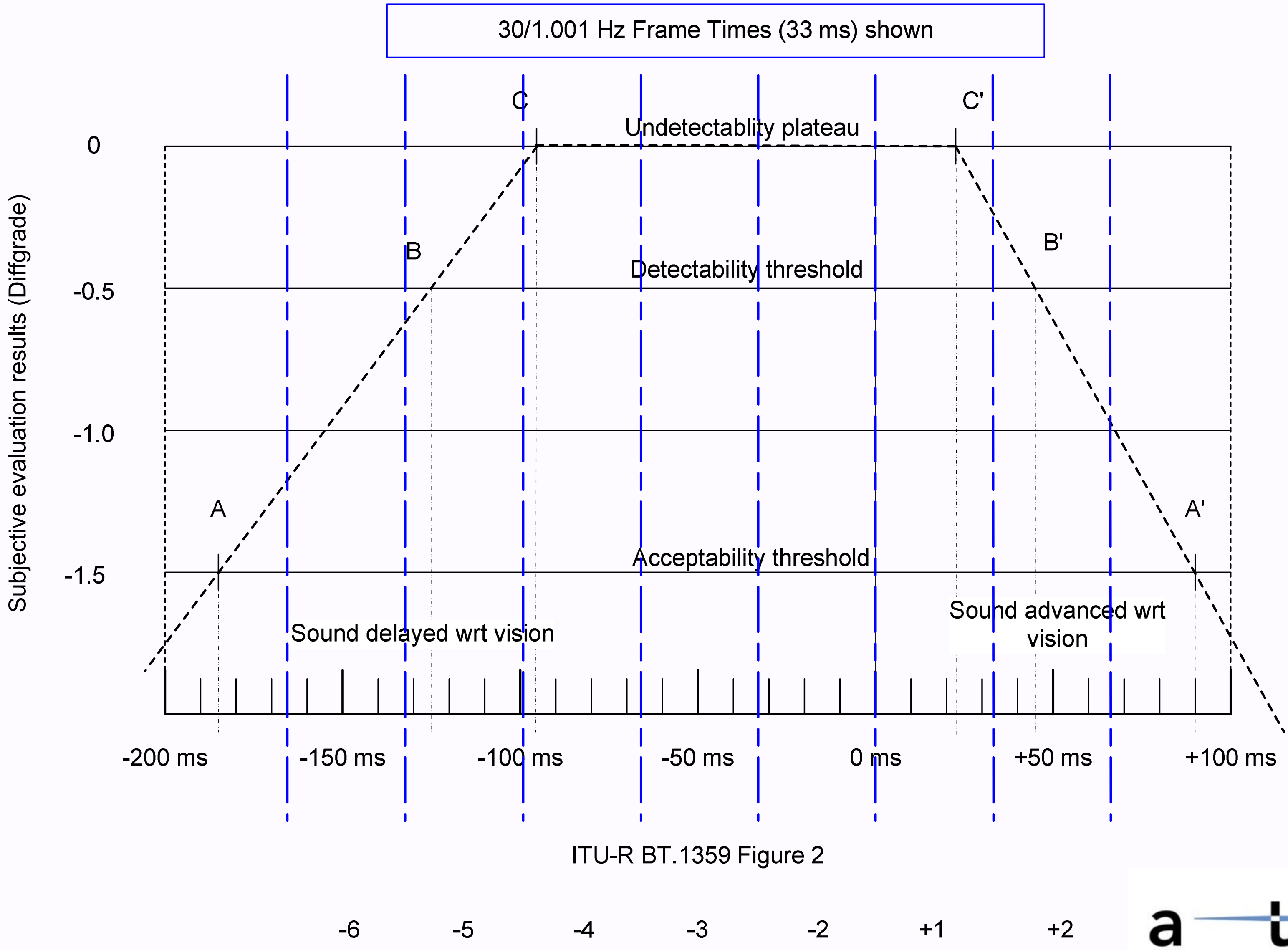
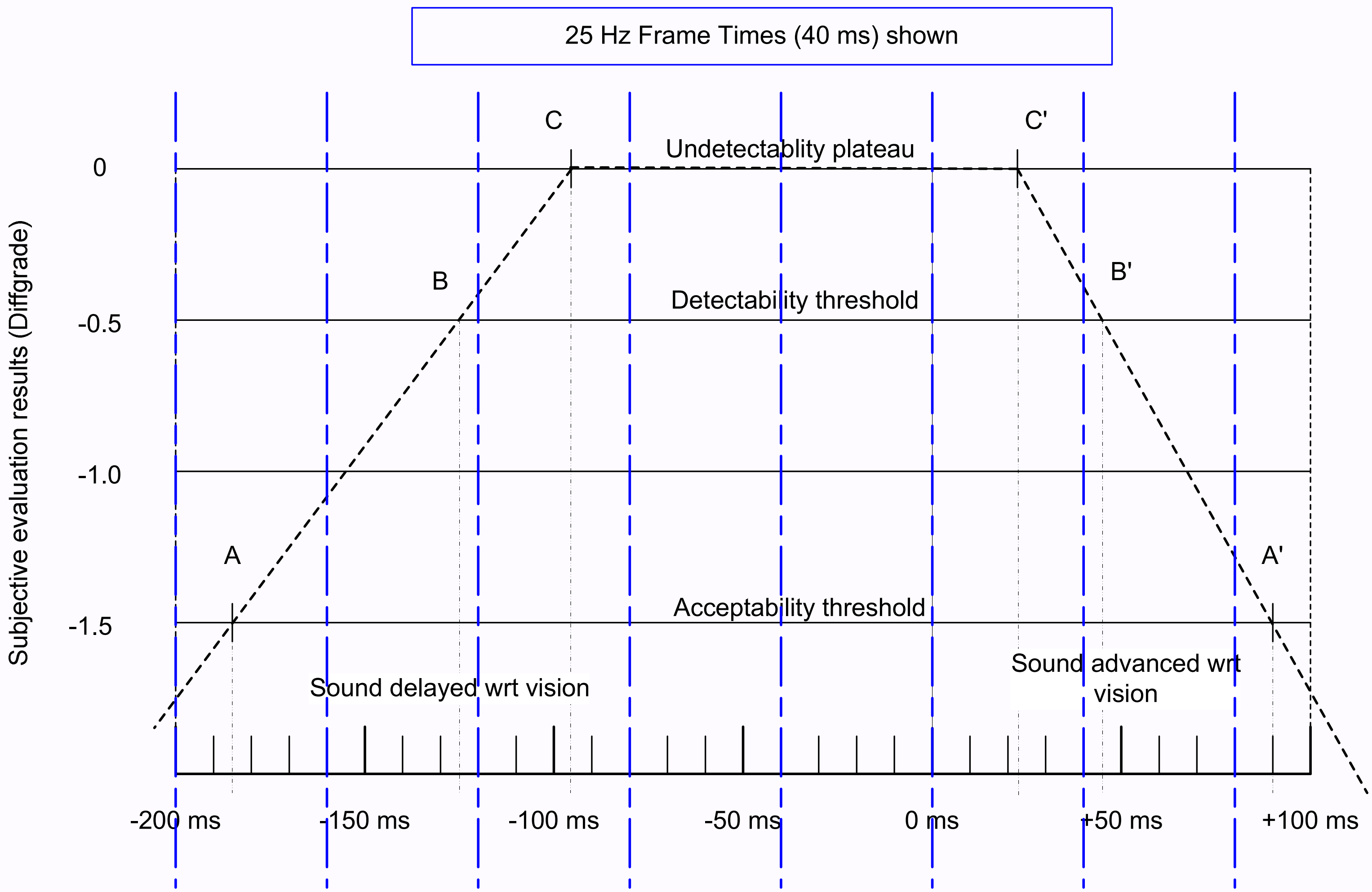


Figure 2 with Fixed Pixel Display Timings Shown

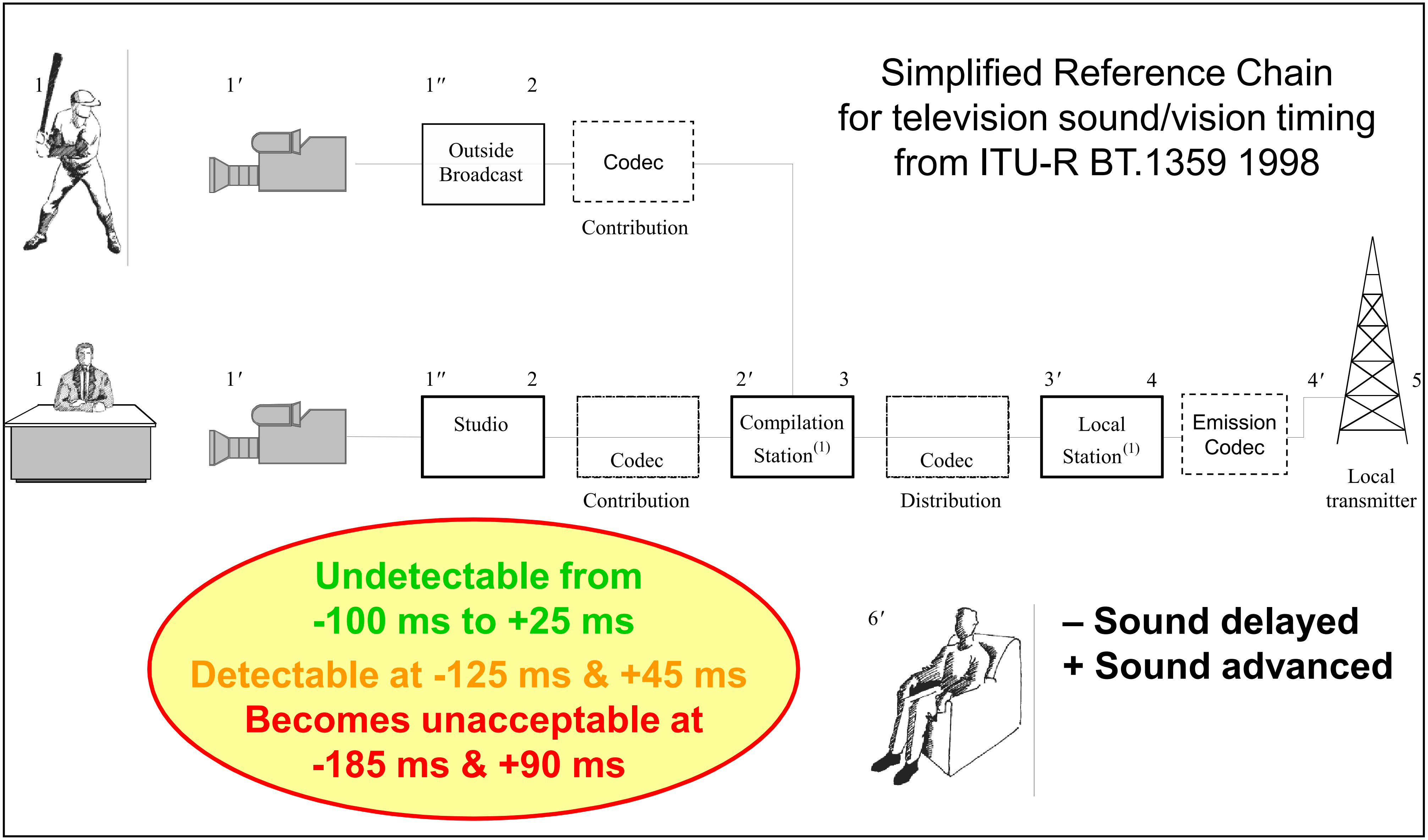


ITU-R BT.1359 Figure 2

Fixed Pixel Display Timings

- Interesting results
- Note that both charts assumed interlaced video
  - So 1080P/60 or 1080P/50 display times are half that shown
- The measured values with CRTs line up fairly well with FPM times for detectability
  - Most of the ITU study measurements were with 25 Hz video (except the Japanese, who used 30 Hz)
- Note that the Acceptance threshold is merely 2 frames advanced for either frame rate!
  - Our brains are used to sound being delayed in nature (by distance)
  - Our brains are confused when sound precedes the vision!

Lip Sync is an End-to-End Issue



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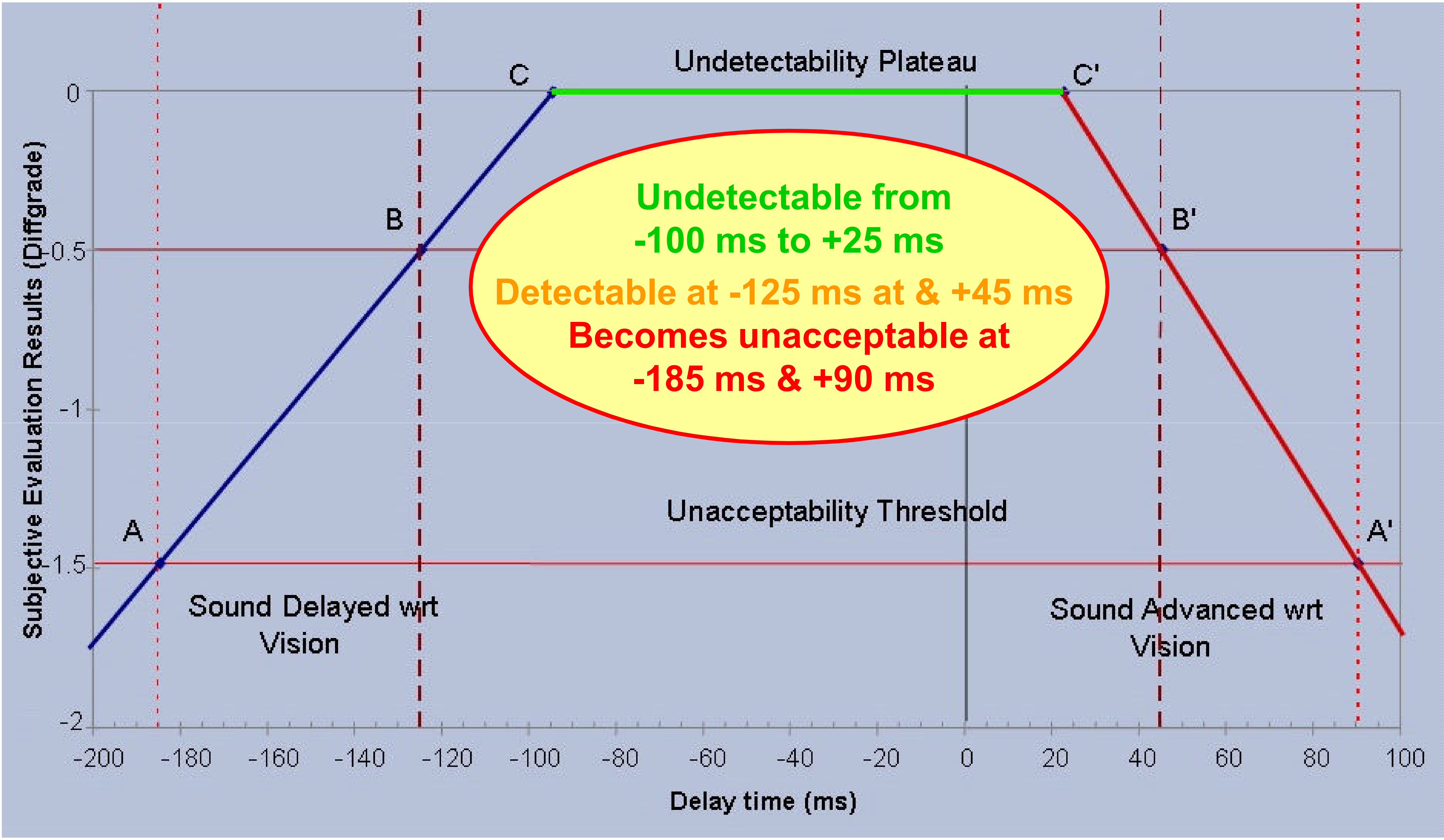
Subjective Tests

- Subjective tests for the ITU-R BT.1359 standard were carried out in Australia, Japan and Switzerland in 1995 and 1996
  - Used PAL and NTSC video
  - Tube cameras, 22” CRT displays
  - 6x picture height
- New tests carried out this year by JEITA in Japan
  - HD, CCD cameras, large flat panel displays, 3x picture height
  - Results to be published later this year
  - Will possibly show lower threshold levels
  - ITU standard may need to be revised ??

ITU-R BT.1359 Thresholds



Recommended Tolerances

At the input to the transmitter/emission encoder

ITU BT.1359	1998	-30 ms	+22.5 ms
ATSC IS/191	2003	-45 ms	+15 ms
EBU R37	2007	-60 ms	+40 ms
		– Sound delayed	+ Sound advanced

Undetectable from
-100 ms to +25 ms

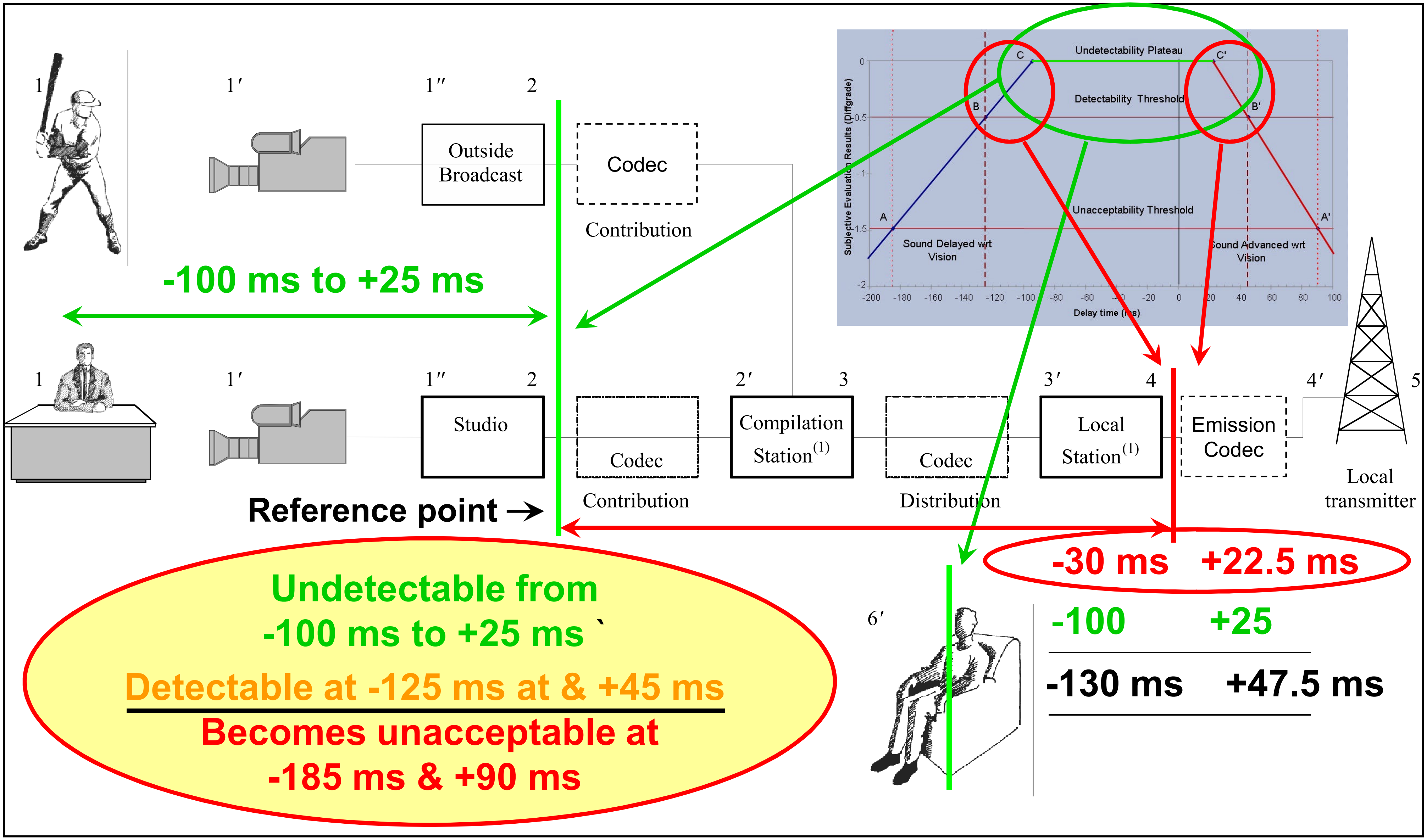
Detectable at -125 ms at & +45 ms

Becomes unacceptable at
-185 ms & +90 ms

ATSC and EBU tolerances are for absolute A/V timing errors

ITU tolerance is for the A/V timing difference in the path from the output of the final program source selection element to the input to the transmitter for emission

Link Budget



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Broadcaster Tolerance

- Given the level of uncertainty of A/V sync coming out of production and the:
  - Variability of consumer devices
  - Variability in viewing conditions
- In order to have reasonable expectation that viewers will see acceptable lip sync:
  - The broadcaster has no choice but to target a very low or zero error through the chain from reference point to emission encoder
  - There is little or no spare budget to allocate!

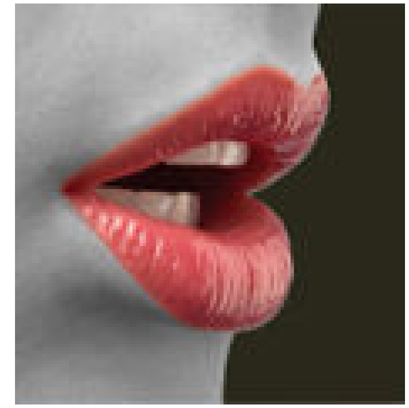
Correct Sync Errors Where they Occur

- Good system design can correct for known and predictable differential delays
  - Solid state cameras
  - Frame synchronizers
  - Vision switchers, format converters, etc.
  - Flat panel monitors with associated audio monitoring
- Fixed and variable delay compensation
  - Available from various manufacturers
  - Control signals from some video devices allow automatic delay switching
  - Care needed to avoid audio artifacts
- Some errors in the chain cannot be predicted or corrected automatically where they occur

Out of Service Measurement

- Clapper board
- Electronic clapper boards
- Beep-flash systems
- Sarnoff Visualizer™

In Service Measurement



- Pixel Instruments LipTracker ™
- Asaca TuLips ™
  - Both use sophisticated analysis of lip movements and associated audio sounds to establish an absolute measurement of sync error at any point in the chain
  - Applicable when moving lips are clearly visible
  - May not be very practical for real world broadcast systems

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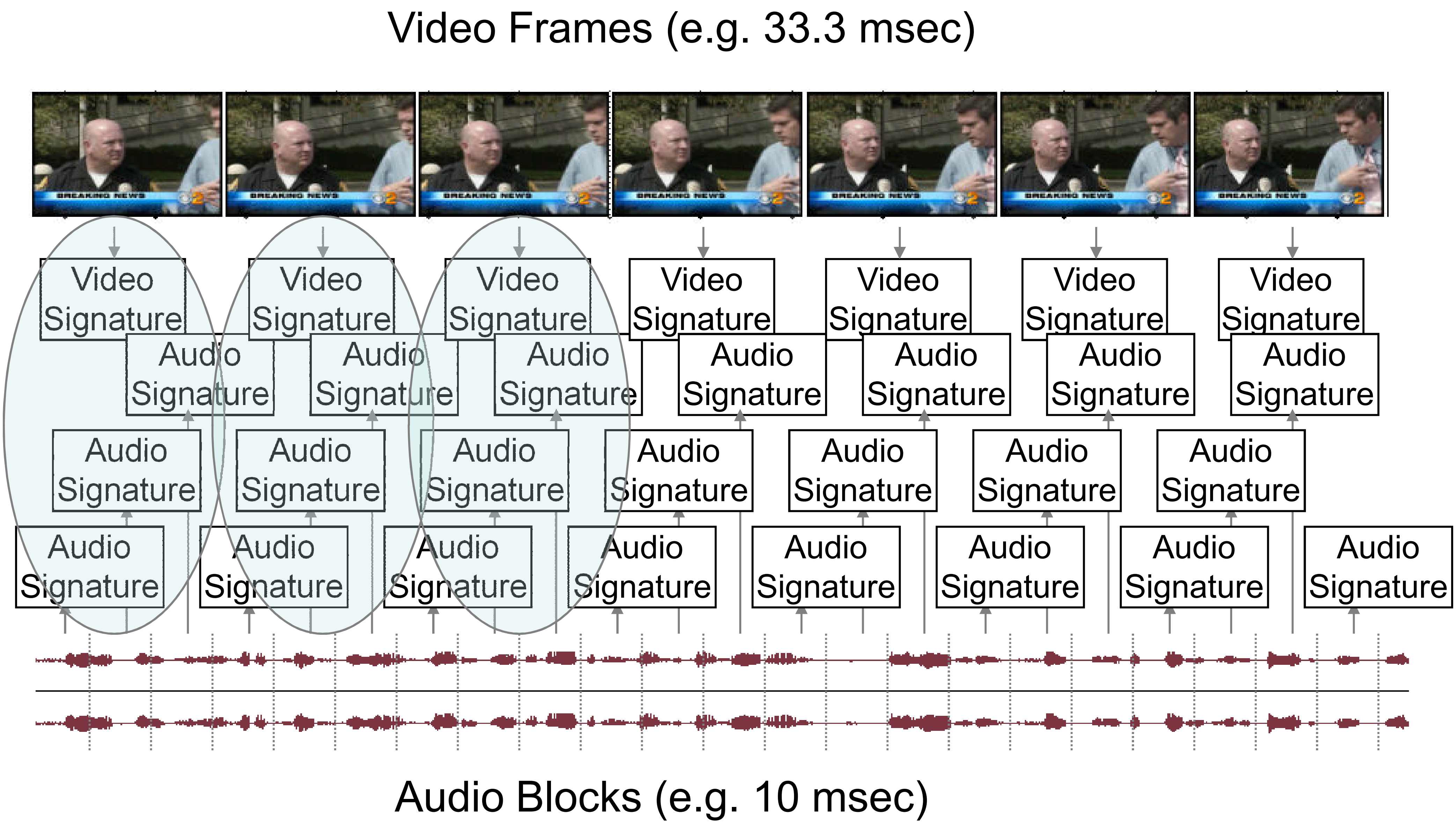
What Is Needed?

- A dynamic in-service method that can respond in near real time
  - Works *while content is playing* - not a calibration method
- Not reliant on any specific signal format or interface so it can be carried through all the different parts of the entire signal chain
  - Particularly needed for the professional parts of the delivery chain
  - Possible application for consumer devices

A/V Signature / Fingerprint / DNA

- Extract features from <u>both</u> audio and video and combine together in an *independent data stream*
- Use <u>fingerprinting</u> methods that are resilient to processing of the audio and video signals
  - Designed to allow typical types of processing (data rate compression, format changes, etc.)
- This data stream may be called an *A/V Sync Signature, Fingerprint, or "DNA"*
  - Relies on generating the signature at a point where A/V sync is *known to be correct*
  - From that point on the system is designed to *measure and maintain* the relative audio/video timing that was present when the signature was generated

A/V Synchronization Signature



Slide courtesy of Dolby

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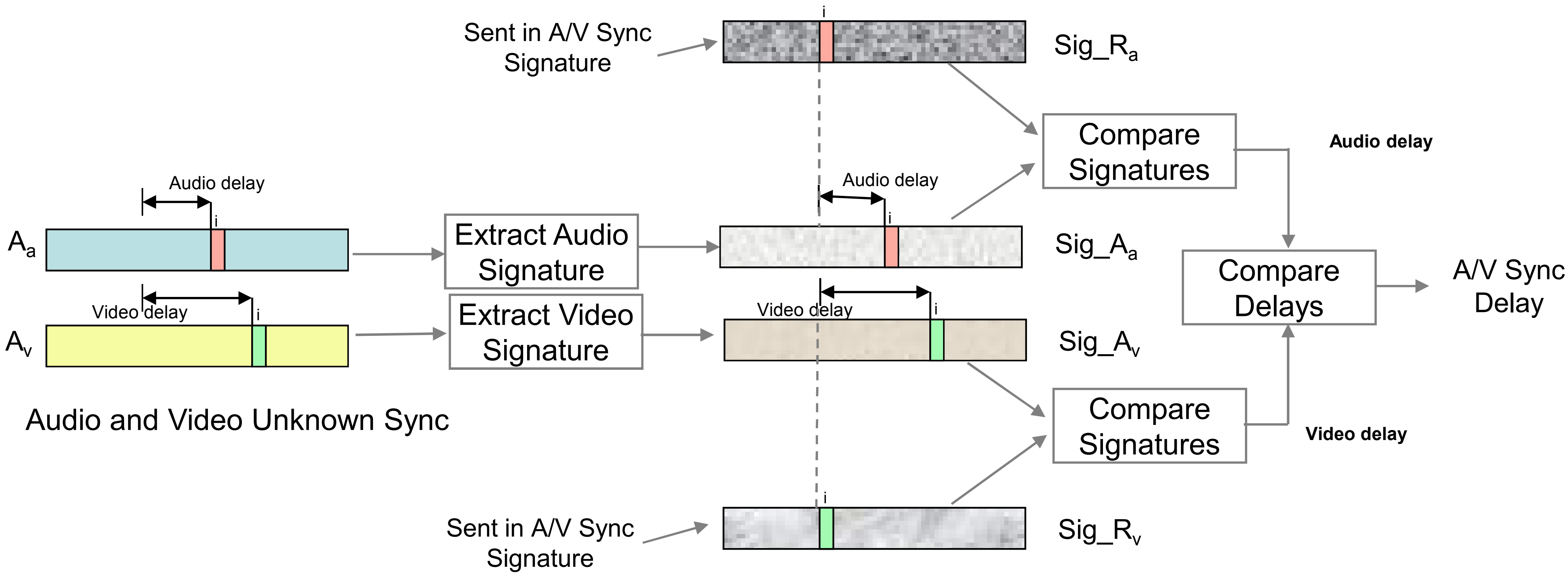
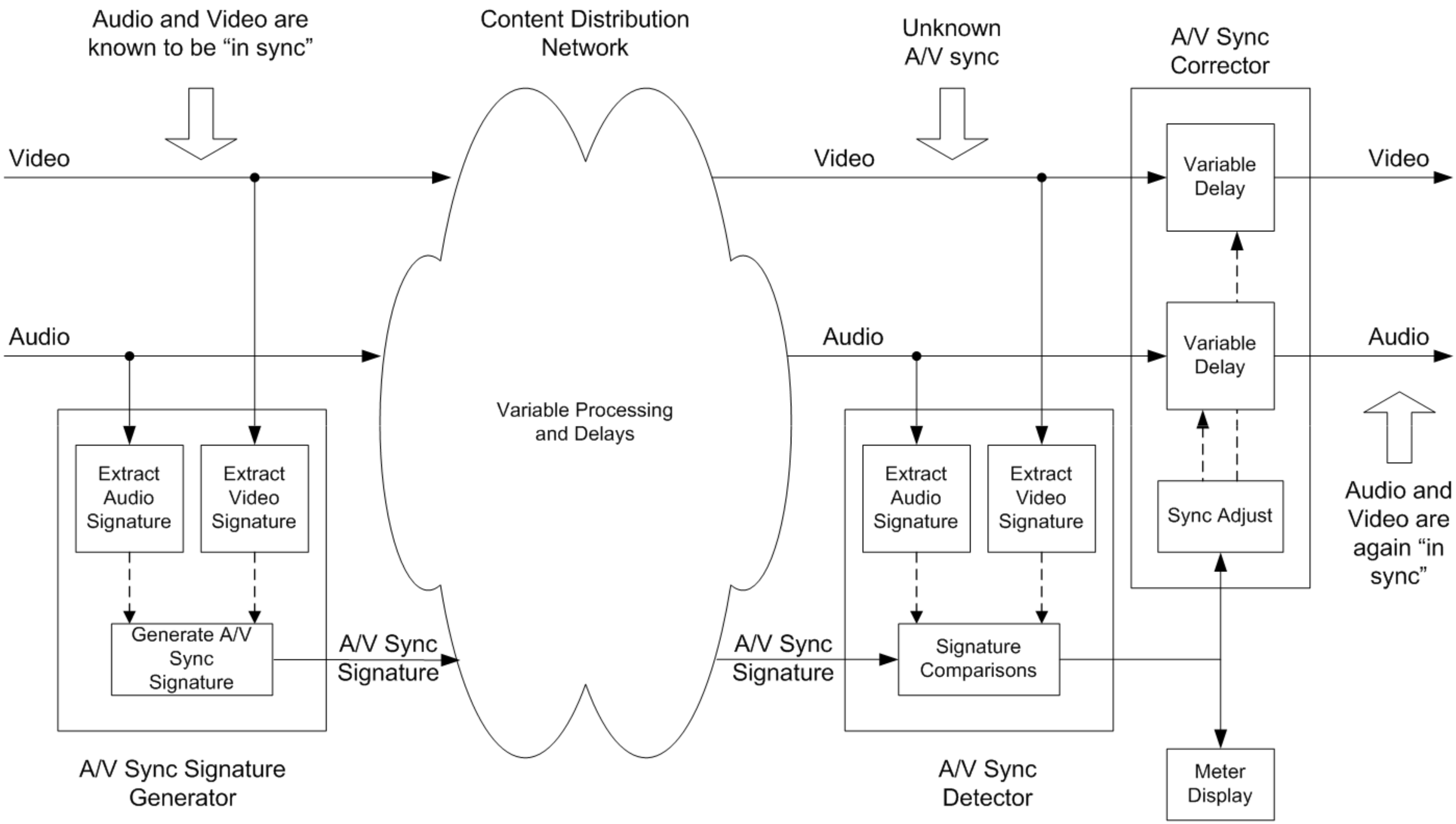
A/V Sync Signature Comparison



- Difference between audio delay and video delay is the A/V sync error

Slide courtesy of Dolby

A/V Sync Correction



Dolby A/V Signature Real-Time System

Slide courtesy of Dolby

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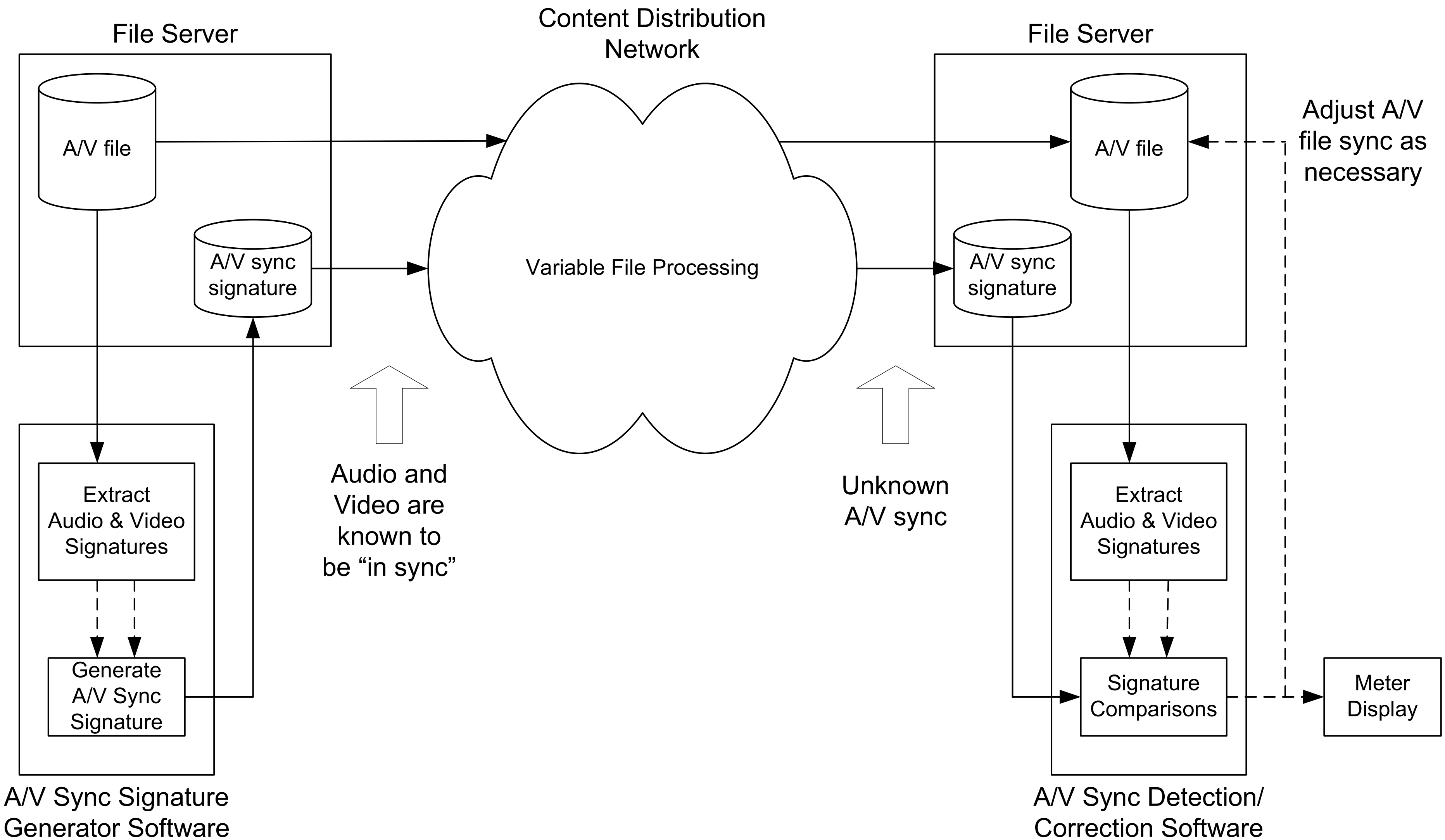
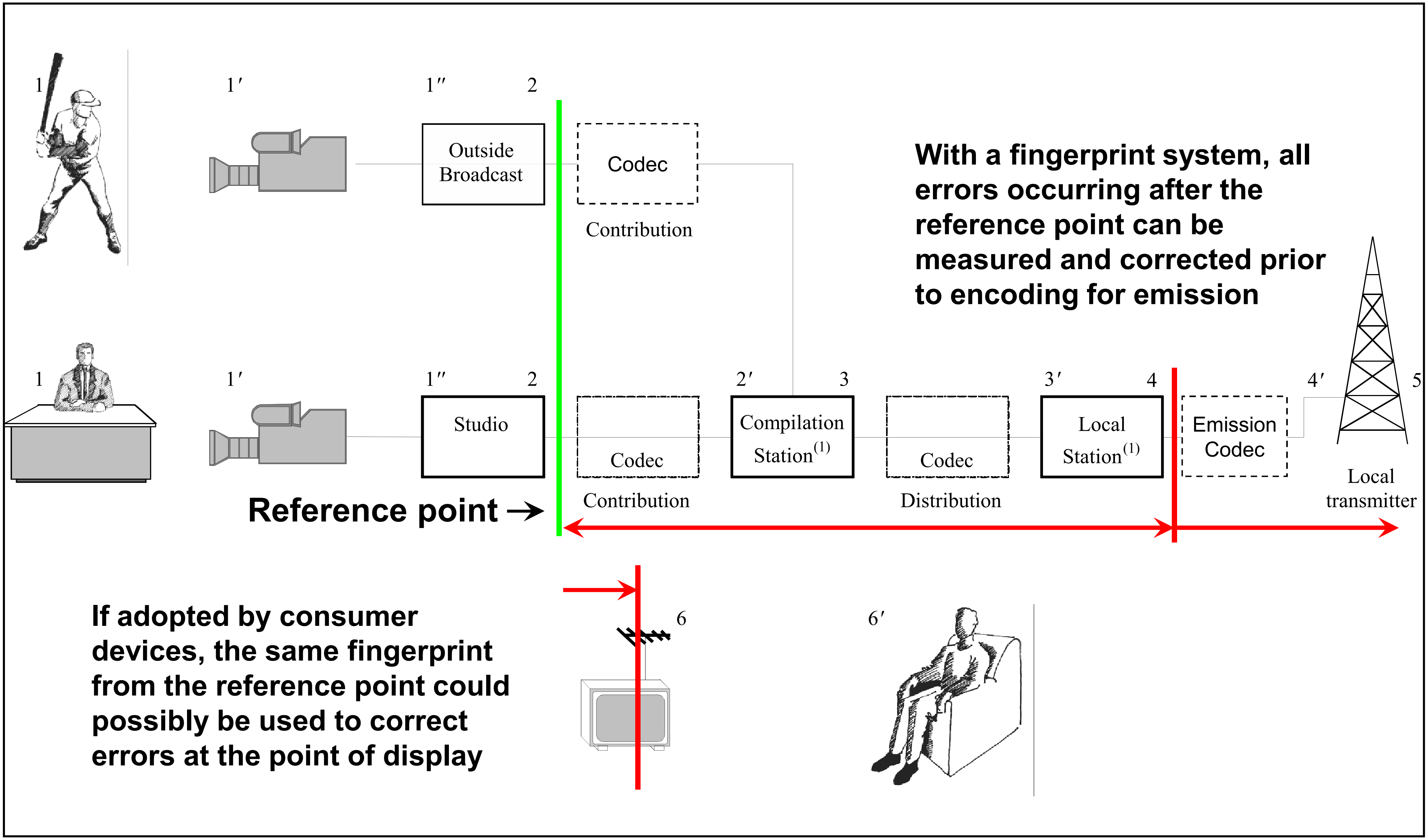
A/V Sync Correction



Dolby A/V Signature File-based System

Slide courtesy of Dolby

Broadcast Chain



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Products/ Technologies

- Evertz IntelliTrak™
- Miranda Densite HLP-1801
- Sigma Electronics Arbalest™
- K-Will QuMax 2000™
- Dolby A-V Signature
  - All use A-V signature / DNA / fingerprint metadata
  - All assume correct sync at the input reference point
  - All measure errors at downstream point, enabling errors to be corrected automatically

A Standardized Fingerprint?

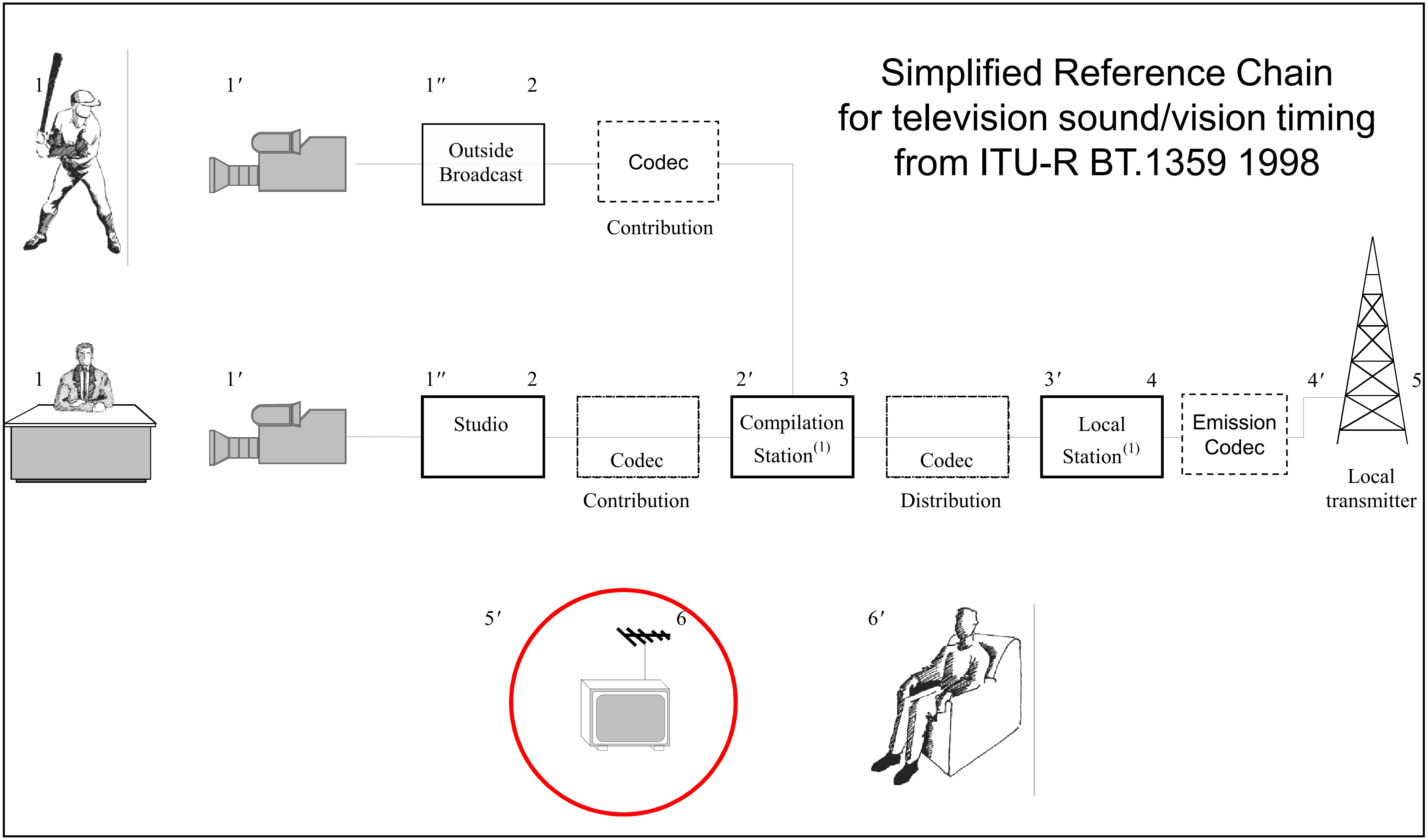
- Entire program chain usually not under control of broadcaster
- From user's perspective, it is highly desirable for equipment from different manufacturers in different parts of the chain to interoperate
- Is standardized fingerprint metadata for A-V sync the solution ?
- Standardized transport methods ?
- Seeking input from broadcasters and users on what they want from manufacturers

SMPTE 22TV Standards Work

A-V Sync Measurement and Assessment

- Project scope: Define recommended techniques for audio-video synchronization error measurement, and techniques and environment for synchronization assessment
- Specific tasks: Determine requirements for consistent out-of-service measurements and in-service assessments and measurements of audio-visual synchronization errors, as may be necessary and practical.

DTV Receivers



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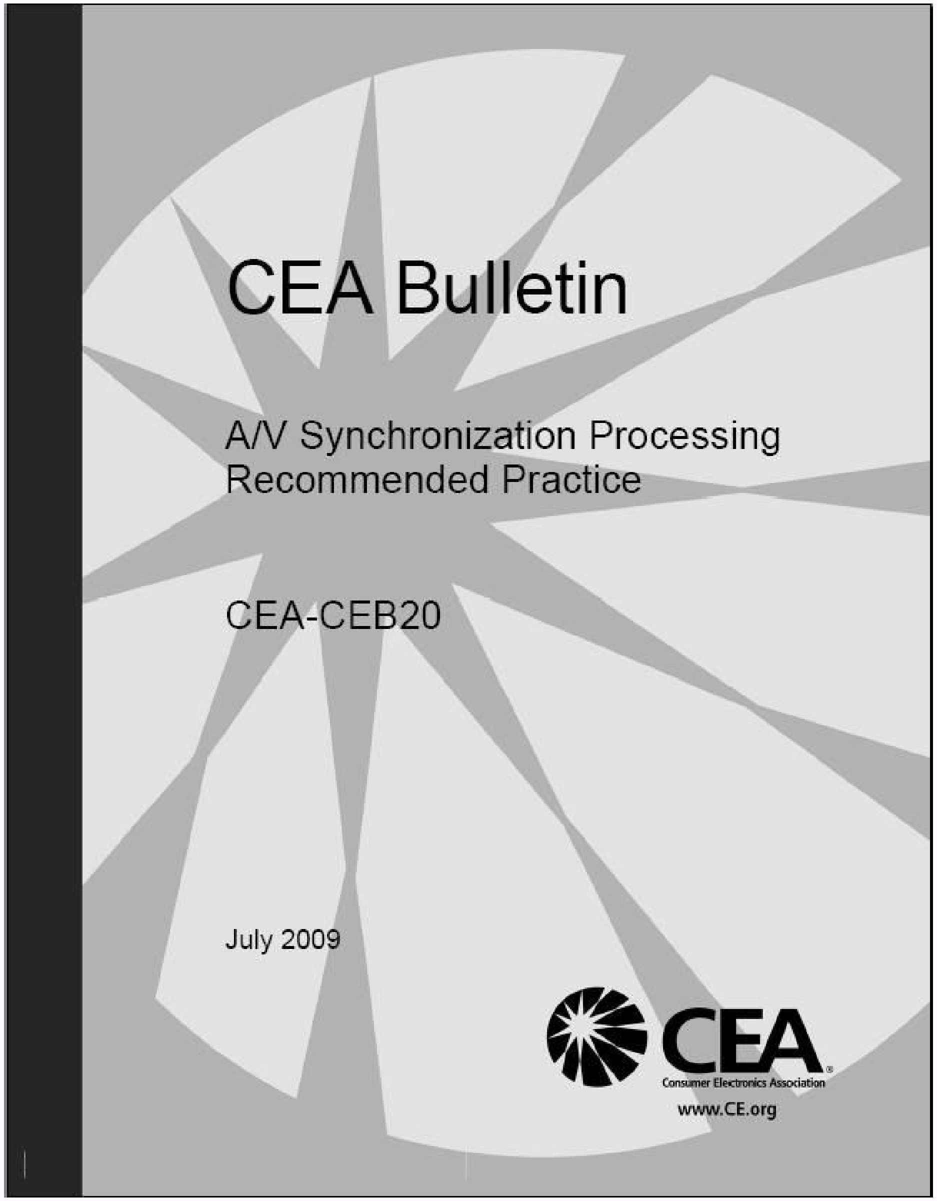
CEA-CEB20


CEA Bulletin

A/V Synchronization Processing
Recommended Practice

CEA-CEB20

July 2009

CEA
Consumer Electronics Association
www.CE.org

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CEA-CEB20

- "A/V Synchronization Processing"
  - "… outlines the steps that an MPEG decoder should take to ensure and maintain audio/video synchronization. Such synchronization is necessary for end-viewer satisfaction."
- Written assuming the reader has a fundamental understanding of MPEG-2 Systems, but not of "real world" conditions

Real-world Conditions

- Why is this important?
  - Designers often are not aware of the types of input disruptions that are common and the consequences of those to decoding
  - Designers forget seemingly obvious things, such as PCR wrap-around
  - Designers may not understand the importance of frequent cross-checking of clock samples between separate audio and video decoder ICs

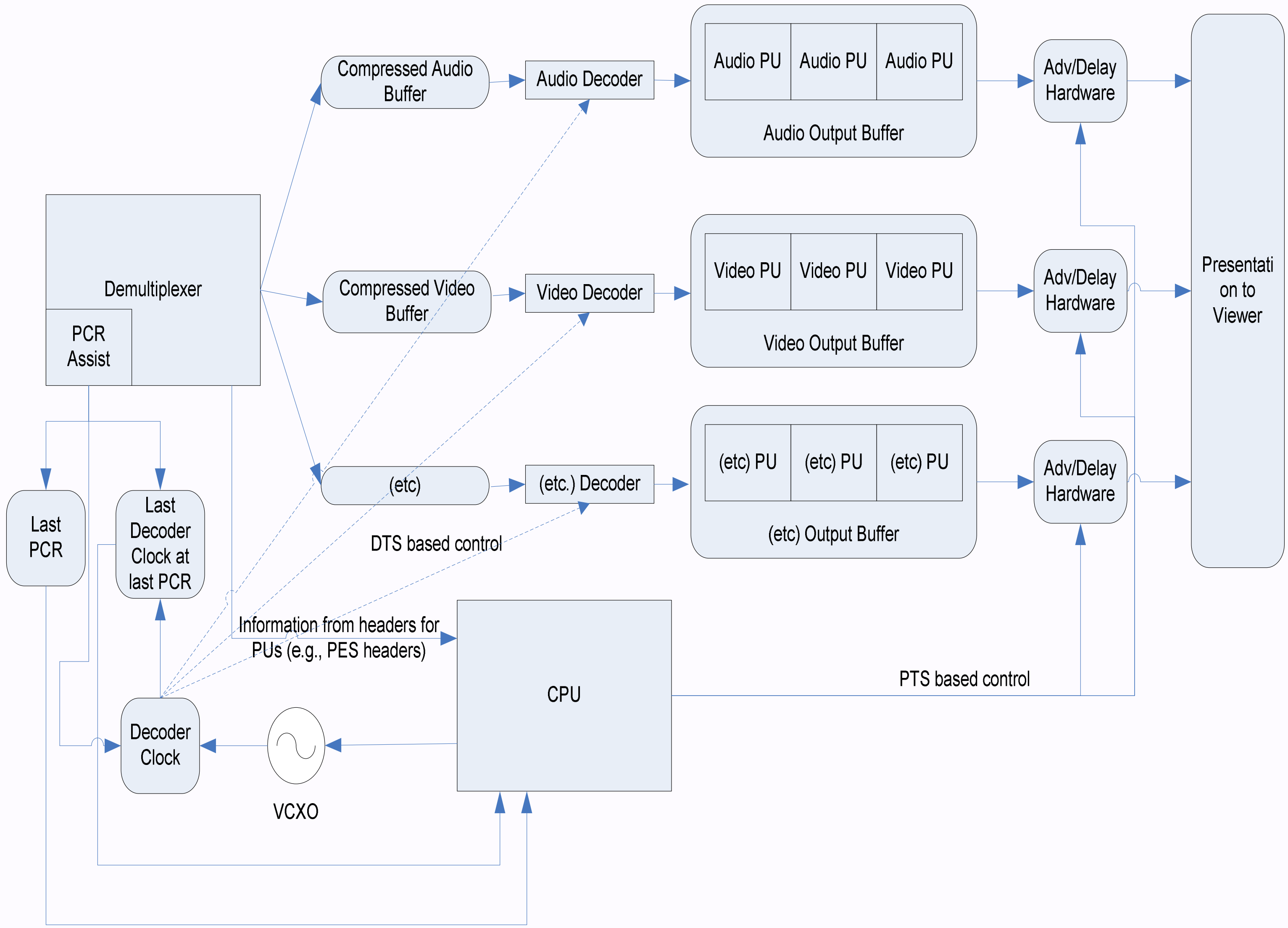
Real-world Conditions

- The industry continues to see new entrants into the decoder market
  - Both for professional as well as home use
  - Even experienced engineers (with traditional video/audio backgrounds) make horrible assumptions about MPEG
- While CEB20 will assist, it cannot be regarded as a “panacea”

CEB20 Major Topics

- Receiver Architecture Model
- Decoder Clock Startup and Maintenance
- Presentation Time Processing
- Advanced Transport Stream Processing for Recording or Remote Playback
- Carriage of MPEG-2 TS over IP networks

Receiver Hardware Reference Model



Receiver Architecture Model

- Demultiplexer PCR Assist
  - How the demux hardware can assist keeping clocks accurate
- Decoder Clock
- Hardware for buffer management
  - Identifies issues with variance in buffer sizes between SDOs (DVB vs. ATSC/SCTE)
  - Discusses maintenance of A/V sync at a high level
- Audio and Video Output Clocks

Decoder Clock Startup and Maintenance

- Startup
- Disturbances to the MPEG Transport Stream
- Major Adjustments
  - System Time-Base Discontinuity
  - Recommended Decoder Clock Error Event Recovery Method
- Minor Adjustments

Presentation Time Processing

- Startup
- Practical Considerations
  - This is a key area… and needs attention paid to it
- Adjustments
- Major Adjustments

Advanced Transport Stream Processing for Recording or Remote Playback

- Partial Transport Stream Recording
  - Recovery of SPTS from MPTS
  - Clock maintenance in such a situation
- Maintaining Inter-packet Timing Relationships During Playback of Recorded Content
  - Critical for recovered SPTS
  - Pointers to two documented methods of doing this

THANK YOU