THE EFFECTS OF BIT RATE REDUCTION ON PHYCHOACOUSTICAL WATERMARKS

2017 IEEE BTS SYMPOSIUM

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WHY THIS IS IMPORTANT TO UNDERSTAND?

- Watermarks are commonly used as a key part of a system to estimate radio and TV audiences
- Not all source material is delivered to the broadcast facility in a linear format
- Not all broadcast chains are linear. HD Radio is not linear.
- We do not yet fully understand the effects of audio compression with regard to the transmission of acoustical watermarks
- This could have a significant effect on reported ratings.

WHAT ARE WE DOING TO OUR AUDIO? WHAT IS ALL THE BUZZ ABOUT?

PPM ENCODING TONES (BUZZ SAW)

PHASES OF THE RESEARCH:

- Define the goals
- Engineer Test Setup
- Acquire equipment
- Obtain Permissions
- Part1: Verify the test devices are valid and correlate to real world effects
- Part2: Test for sensitivities to amplitude changes
- Part 3: Run a control test for repeatability
- Part 4: Test Different format music
- Part 5: Test different audio compression algorithms

HOW TO MEASURE WATERMARK TRANSMISSION?

- Nielsen PPM Monitor
- Telos TVC Monitor
- Limitations of Nielsen Monitor Capabilities
- TVC Capabilities
- Confidence Level
- Reset Interval Count

HOW TO MEASURE WATERMARK TRANSMISSION?

Legacy Arbitron PPM Confidence Monitor

New Nielsen PPM Confidence Monitor

Telos Voltair

3 PARTS TO THIS RESEARCH PROJECT

- Test the TVC for correlation with Nielsen Meter Counts
- Evaluate the effects of bit rate reduction *BEFORE* PPM Encoding
- Evaluate the effects of bit rate reduction *AFTER* PPM Encoding

TVC
TELOS TVC MONITOR

TVC REPORTING CAPABILITIES

- IP Port with 400 millisecond updates
- Confidence level 0.00-1.00
- Reset Interval Indication
- Designed a program to capture and monitor data stream output from TVC
- This program counts the reset intervals per minute or per 10 second time frame depending on the duration of material being measured
- Program averages confidence level per minute or per 10 second time frame
- Used 1 minute averaging for long form analysis
- Used 10 second averaging for individual songs

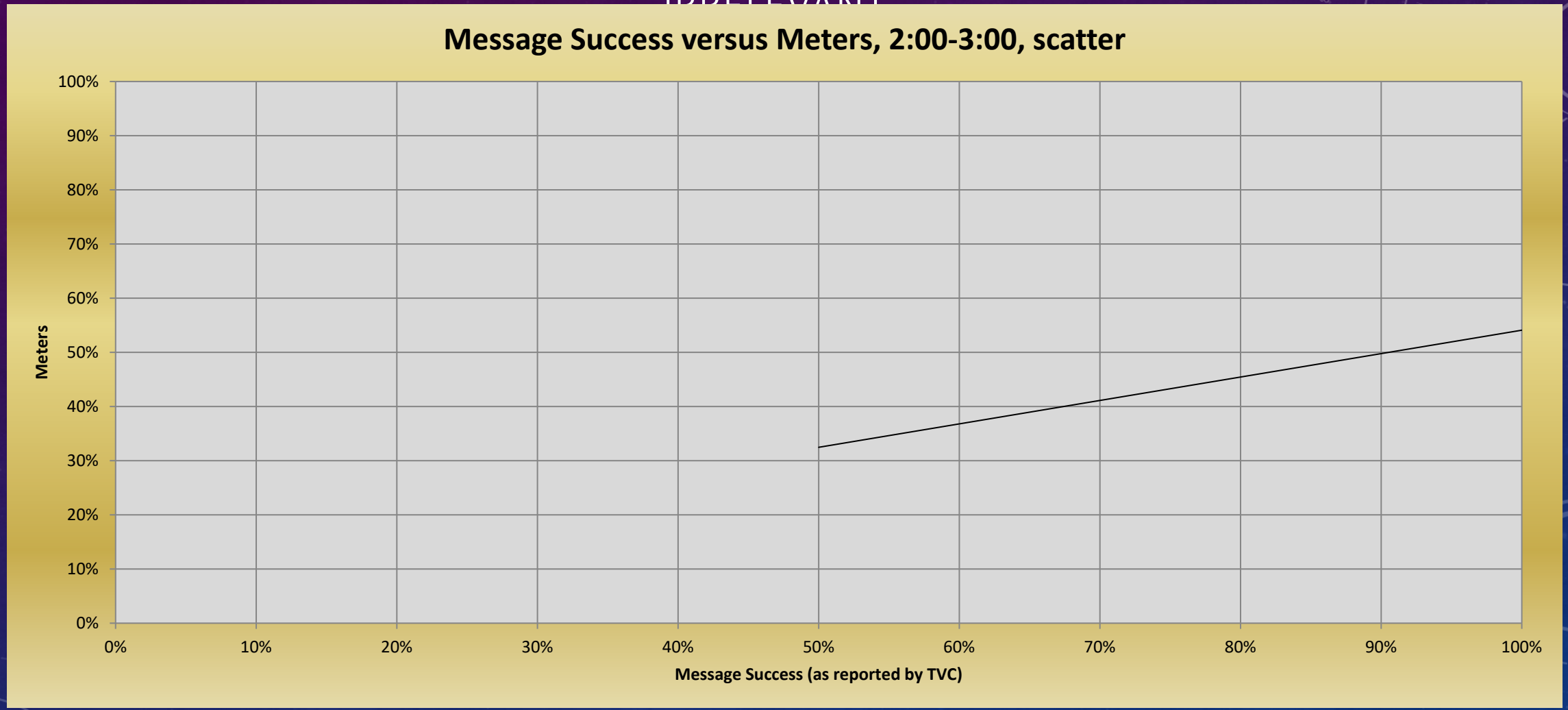
TVC CORRELATION WITH REAL WORLD RESULTS FROM NIELSEN

- Several days of recording each station off the air from a tuner (Analog FM)
- Used 3 different musical formats (Hip Hop, Country, Soft Rock)
- Program averages each minute confidence level
- Program counts reset intervals/hour
- Raw meter count data from Nielsen for the same time period acquired
- Graphing same scale “X” axis for time to compare results of meter count verses confidence level and reset interval counts

TVC CORRELATION WITH REAL WORLD RESULTS FROM NIELSEN

- Message Broadcast from encoder every 4.8 Seconds
- 60/4.8=12.5 messages/minute
- Every minute alternates with 12 or 13 messages
- Message Success=Success/Opportunities
- There are either 12 or 13 opportunities/minute
- Scatter graphs show best fit line for correlation

TVC CORRELATION WITH NIELSEN METER COUNTS (CLASSIC ROCK) "VERTICAL SCATTER IRRELEVANT"



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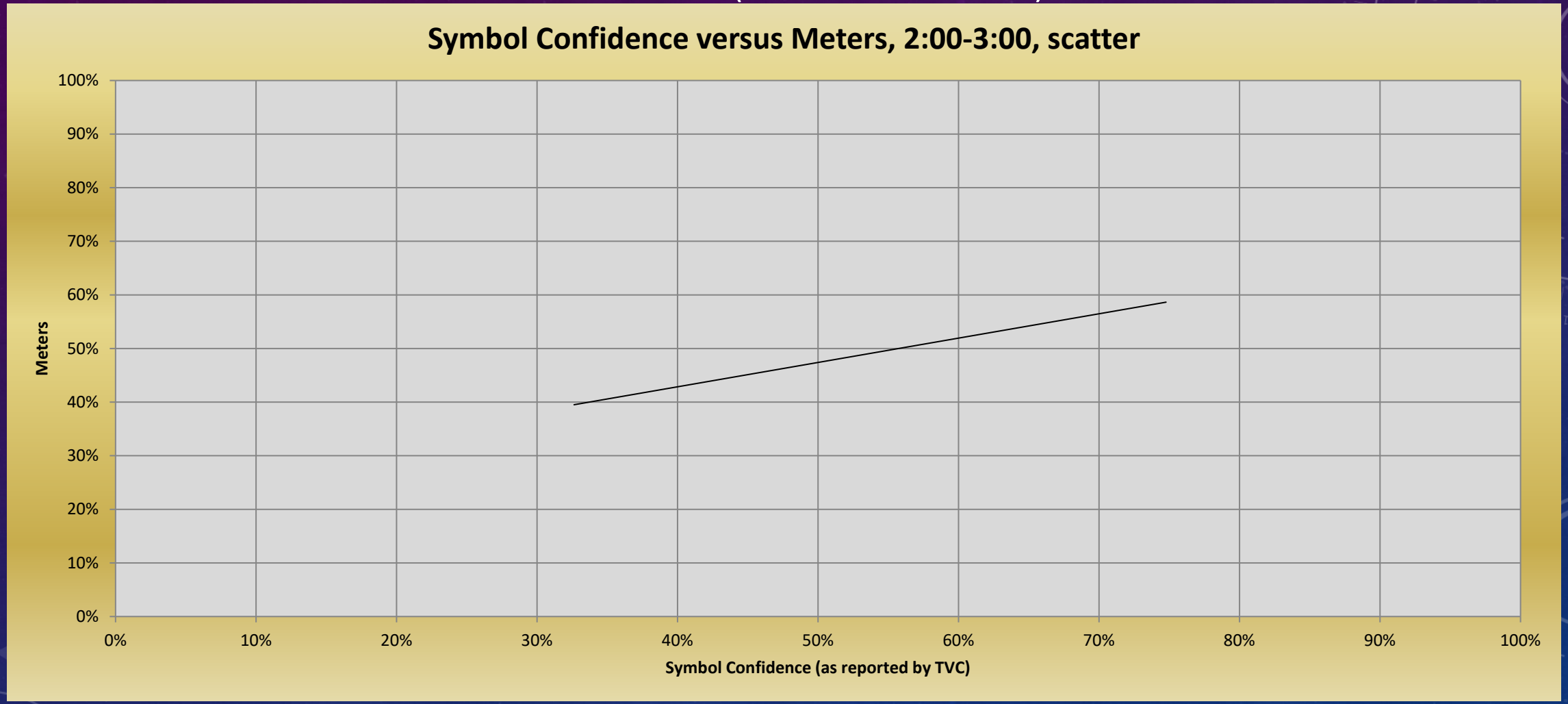
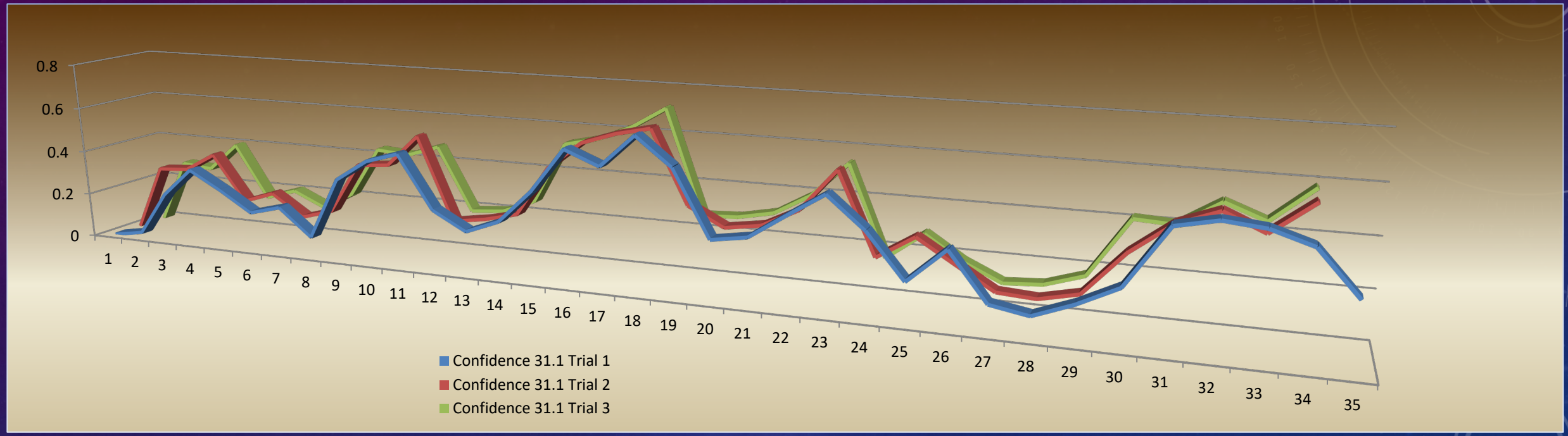


2016/2017 OVER THE AIR TEST BLOCK DIAGRAM

2016 OVER THE AIR TEST RESULTS
BIT RATE REDUCTION AFTER ENCODING



Vertical Scale: Confidence Level

Horizontal Scale: Minutes into program (Irish Music WBQT HD-2)

3 trials to demonstrate repeatability

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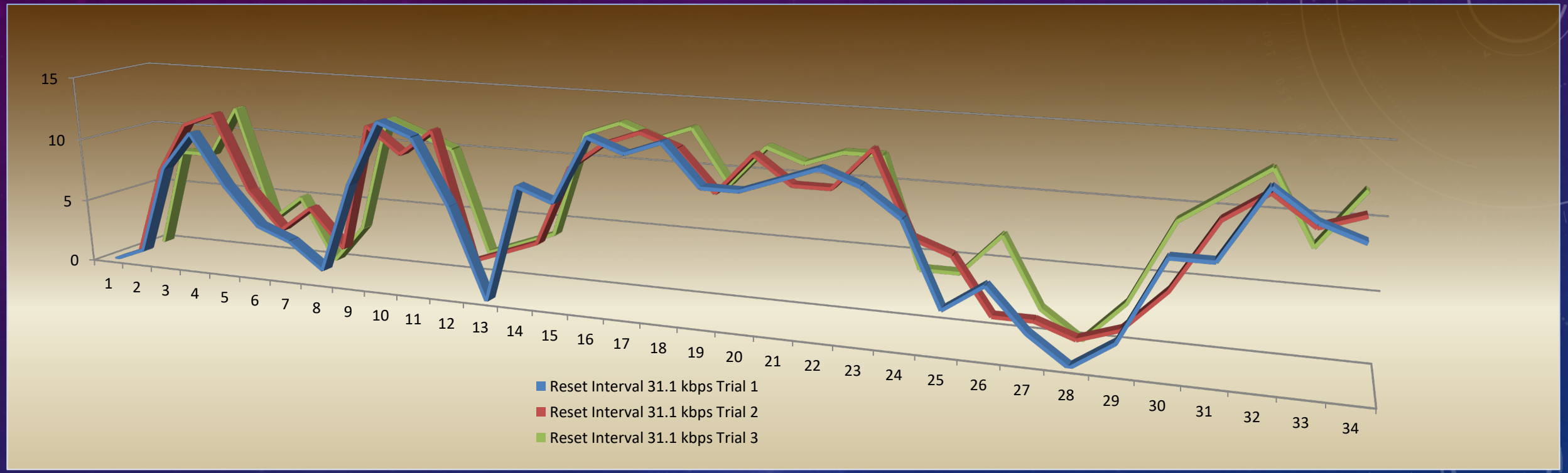

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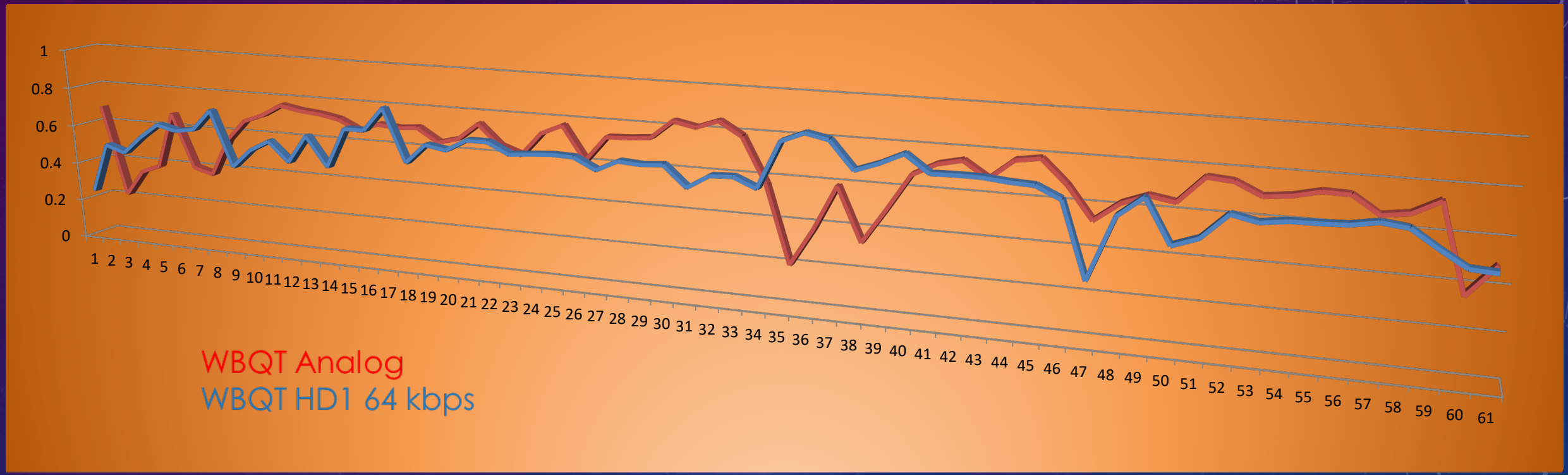

Vertical Scale: Confidence Level
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WBQT (Hip Hop) off air test analog vs.
HD1 @ 64 kbps

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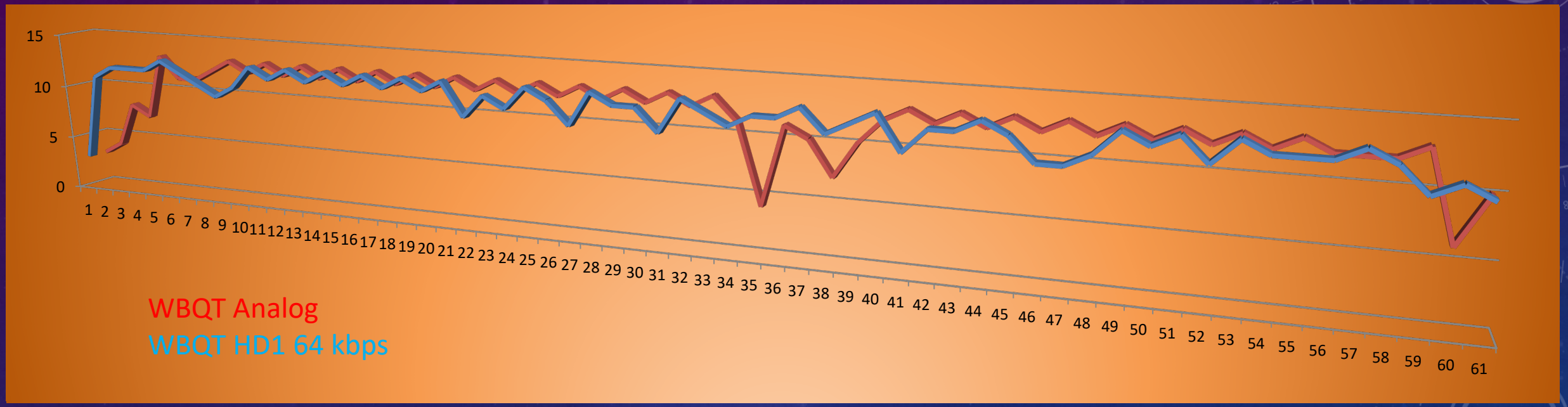

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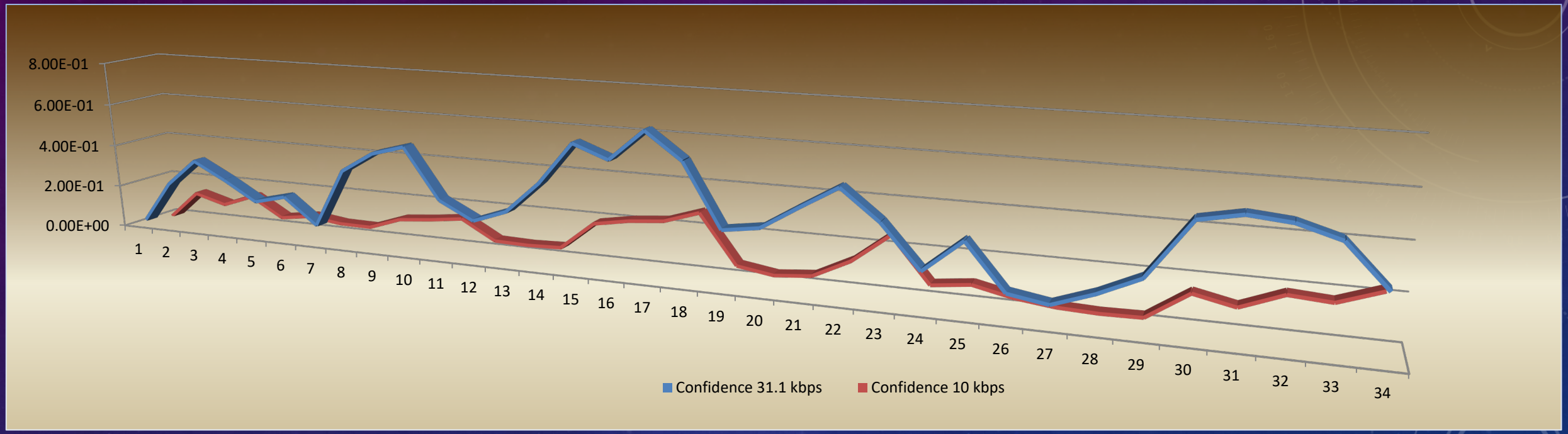

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(Irish Music WBQT HD-2)
31.1kbps is Normal, 10 kbps minimum

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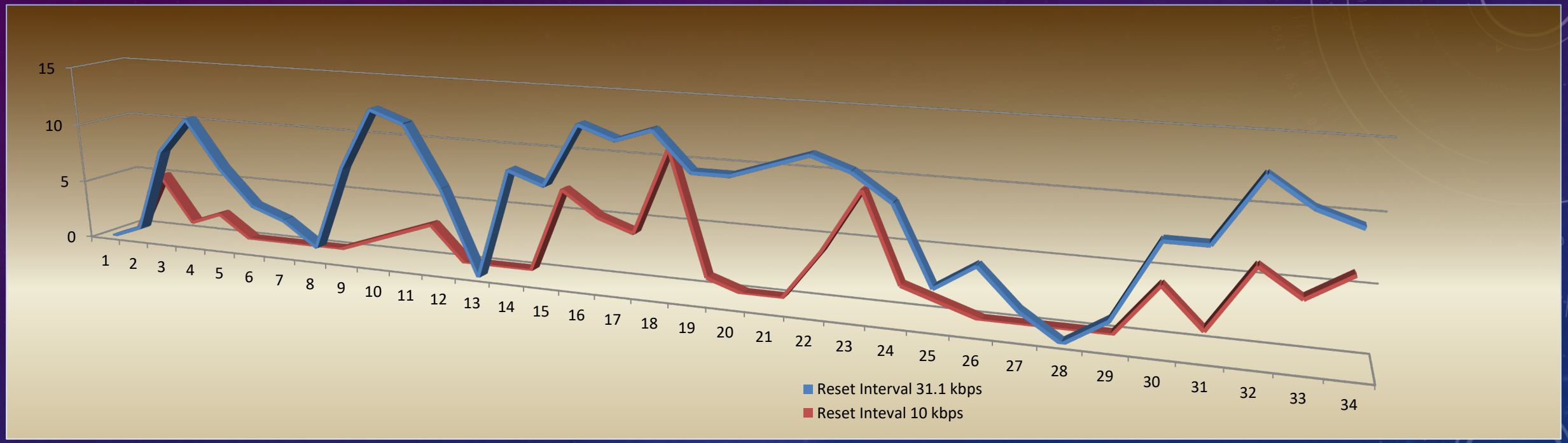

Vertical Scale: Reset Interval Count
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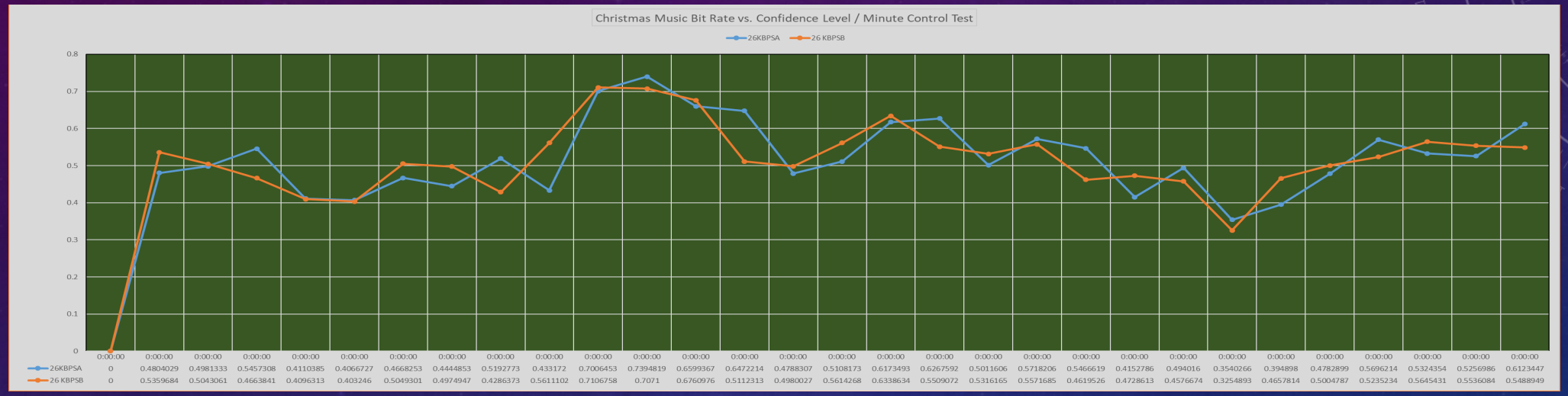
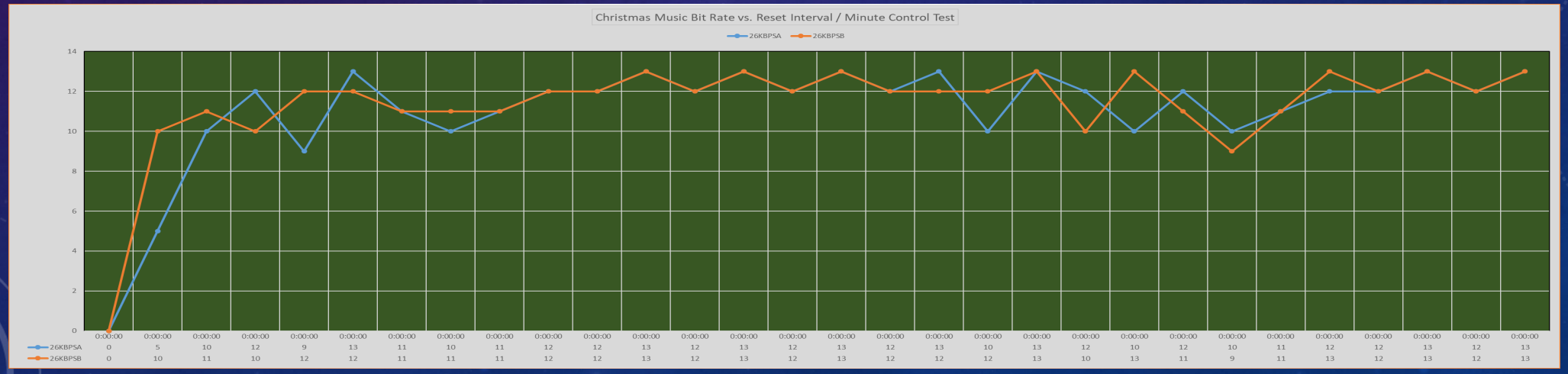
(Irish Music WBQT HD-2)
31.1kbps is Normal, 10 kbps minimum

SO WHAT IS NEW THIS YEAR?

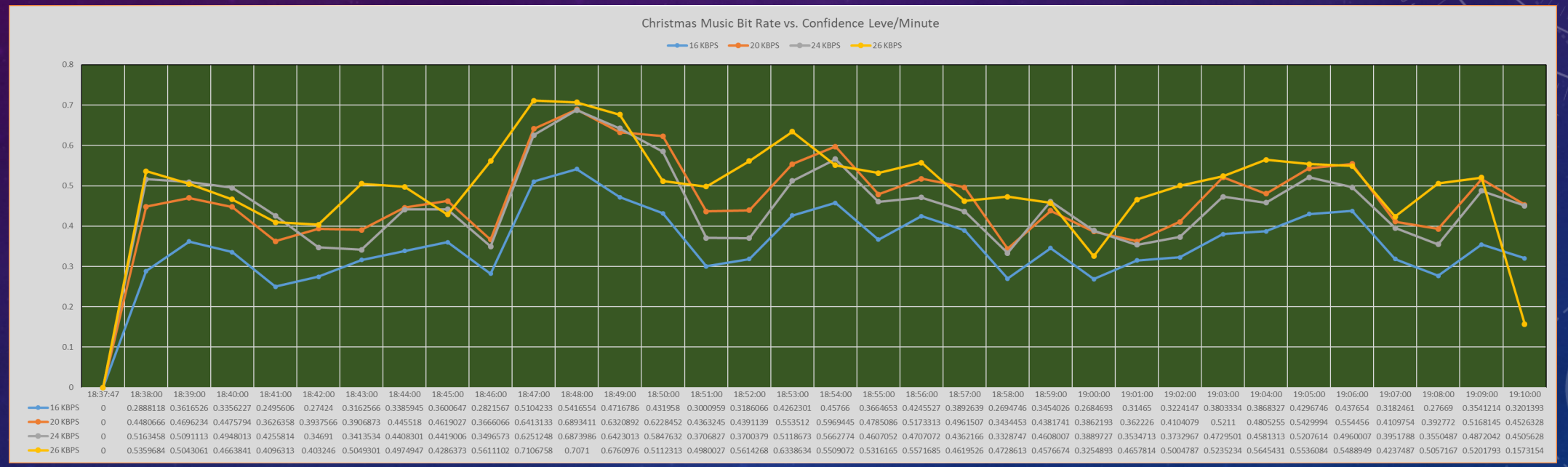
- Concentrate on lower bit rates (32 kbps -16 kbps)
- Look at audio processing effect on watermarks (audio compression, not bit rate reduction)
- What are the implications (if any) of using lower bit rates for (HD-2 or higher) over the air transmission?
- What are the implications (if any) of using audio compression on watermark transmission?

2017 HD-2 OFF AIR TESTS – CONTROL TEST FOR REPEATABILITY (WMJX BOSTON HD-2) 26 KBPS





2017 HD-2 OFF AIR TEST - CONFIDENCE LEVEL VS TIME, VARIOUS BITRATES (16,20,24, AND 26 KBPS)



	18:37:47	18:38:00	18:39:00	18:40:00	18:41:00	18:42:00	18:43:00	18:44:00	18:45:00	18:46:00	18:47:00	18:48:00	18:49:00	18:50:00	18:51:00	18:52:00	18:53:00	18:54:00	18:55:00	18:56:00	18:57:00	18:58:00	18:59:00	19:00:00	19:01:00	19:02:00	19:03:00	19:04:00	19:05:00	19:06:00	19:07:00	19:08:00	19:09:00	19:10:00
16 KBPS	0	0.2888118	0.3616526	0.3356227	0.2495606	0.27424	0.3162566	0.3385945	0.3600647	0.2821567	0.5104233	0.5416554	0.4716786	0.431958	0.3000959	0.3186066	0.4262301	0.45766	0.3664653	0.4245527	0.3892639	0.2694746	0.3454026	0.2684693	0.31465	0.3224147	0.3803334	0.3868327	0.4296746	0.437654	0.3182461	0.27669	0.3541214	0.3201393
20 KBPS	0	0.4480666	0.4696234	0.4475794	0.3626358	0.3937566	0.3906873	0.445518	0.4619027	0.3666066	0.6413133	0.6893411	0.6320892	0.6228452	0.4363245	0.4391139	0.553512	0.5969445	0.4785086	0.5173313	0.4961507	0.3434453	0.4381741	0.3862193	0.362226	0.4104079	0.5211	0.4805255	0.5429994	0.554456	0.4109754	0.392772	0.5168145	0.4526328
24 KBPS	0	0.5163458	0.5091113	0.4948013	0.4255814	0.34691	0.3413534	0.4408301	0.4419006	0.3496573	0.6251248	0.6873986	0.6423013	0.5847632	0.3706827	0.3700379	0.5118673	0.5662774	0.4607052	0.4707072	0.4362166	0.3328747	0.4608007	0.3889727	0.3534713	0.3732967	0.4729501	0.4581313	0.5207614	0.4960007	0.3951788	0.3550487	0.4872042	0.4505628
26 KBPS	0	0.5359684	0.5043061	0.4663841	0.4096313	0.403246	0.5049301	0.4974947	0.4286373	0.5611102	0.7106758	0.7071	0.6760976	0.5112313	0.4980027	0.5614268	0.6338634	0.5509072	0.5316165	0.5571685	0.4619526	0.4728613	0.4576674	0.3254893	0.4657814	0.5004787	0.5235234	0.5645431	0.5536084	0.5488949	0.4237487	0.5057167	0.5201793	0.1573154

STUDIO TESTING -- EVALUATING PPM WATERMARK TRANSMISSION PRIOR TO OVER THE AIR BROADCASTING USING AUDIO PROCESSING LOCATION IN THE CHAIN AS A VARIABLE:

- Test with significant audio processing applied before the PPM Encoder
- Test with significant audio processing applied after the encoder
- Evaluate any patterns that may indicate a trend toward favoring a particular technique

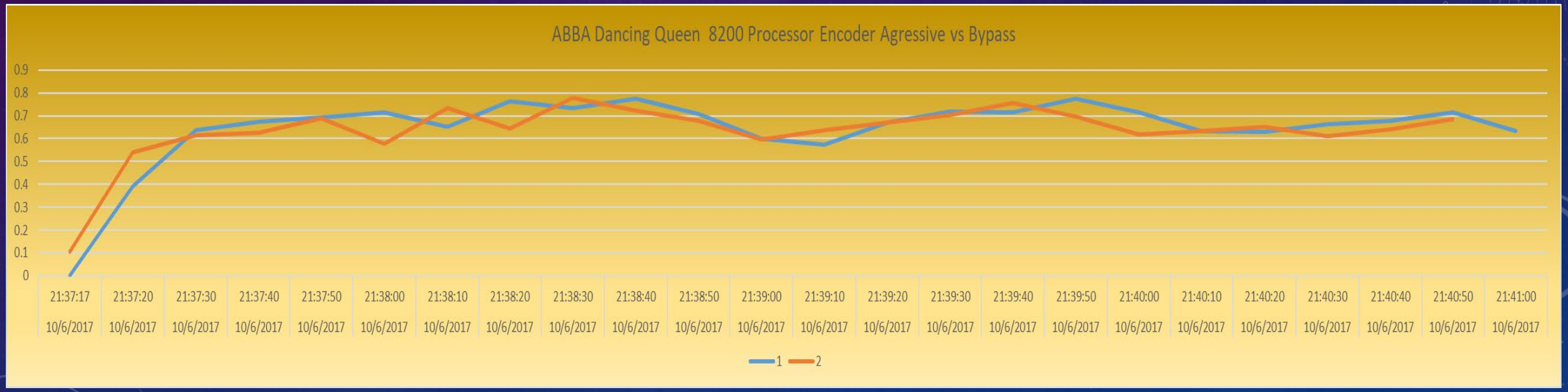
TEST CONFIGURATION “A”

TEST CONFIGURATION “B”

EFFECTS OF AUDIO PROCESSING ON WATERMARK RECOVERY

AUDIO SOURCE-->PROCESSOR-->ENCODER-->TVC→PC
TEST CONFIGURATION "A"

BLUE=AGGRESSIVE PROCESSING, ORANGE=NO PROCESSING



EFFECTS OF AUDIO PROCESSING ON WATERMARK RECOVERY

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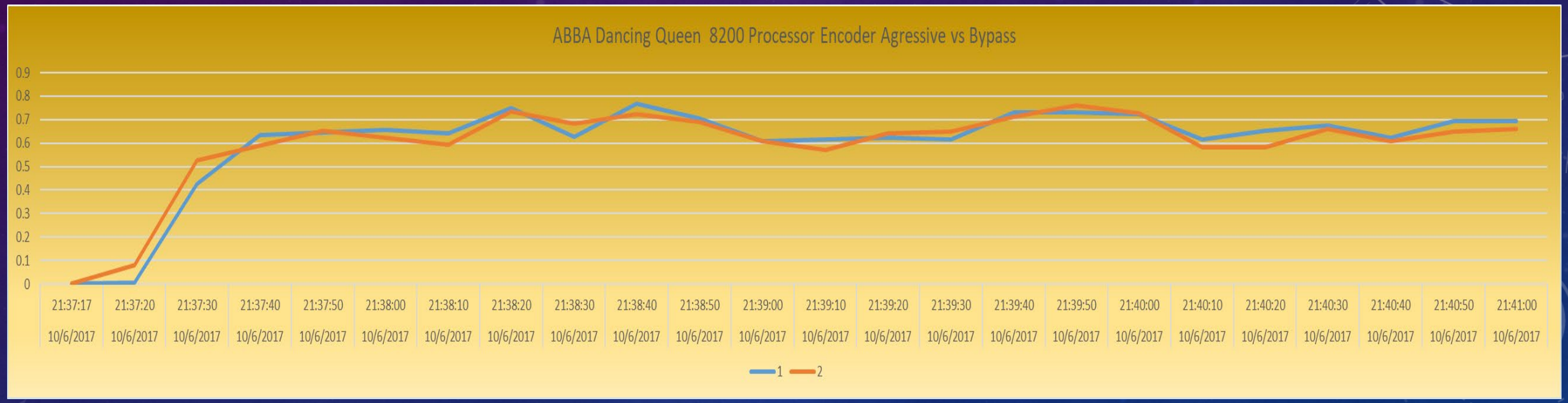
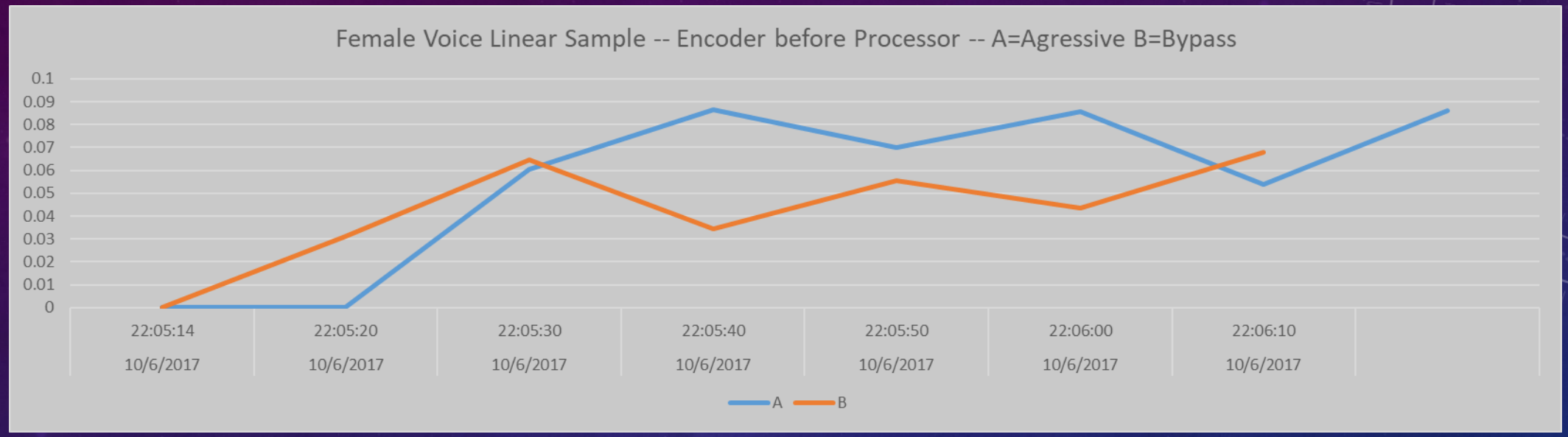
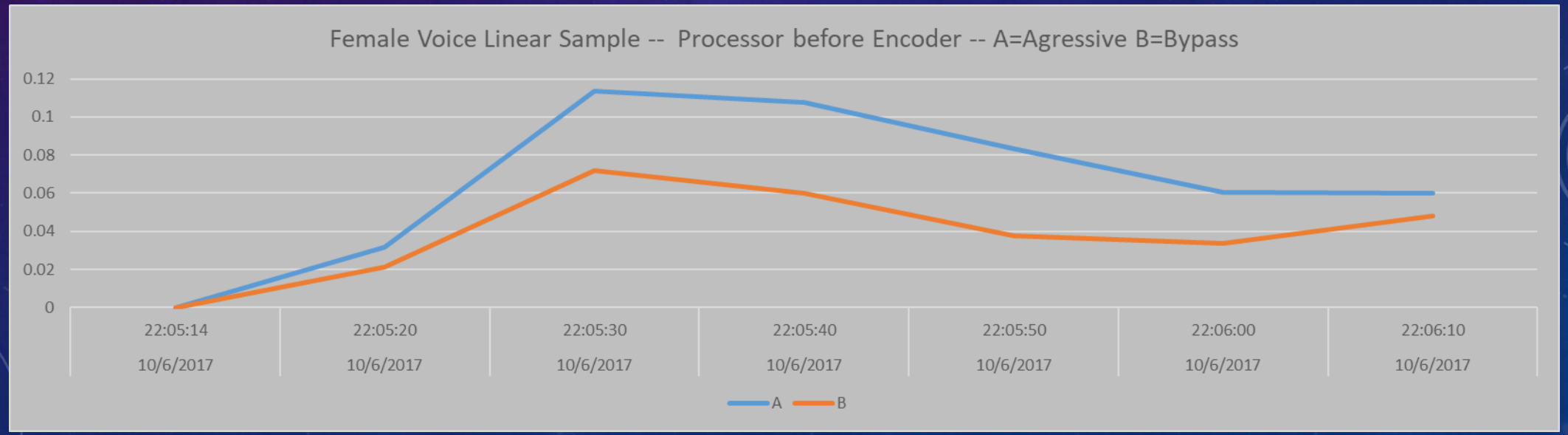


DRY VOICE COMPARISON: AGGRESSIVE AUDIO PROCESSING VS TOTALLY BYPASS AUDIO PROCESSING





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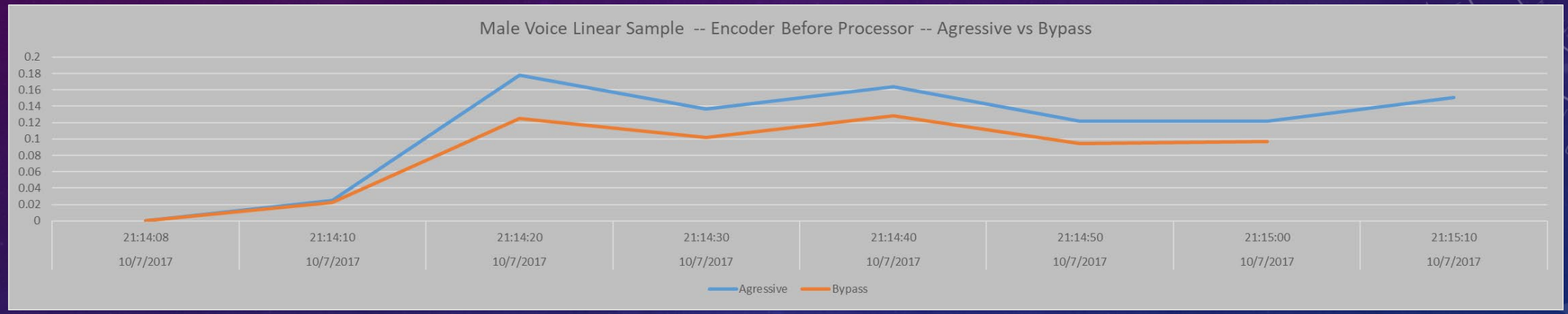
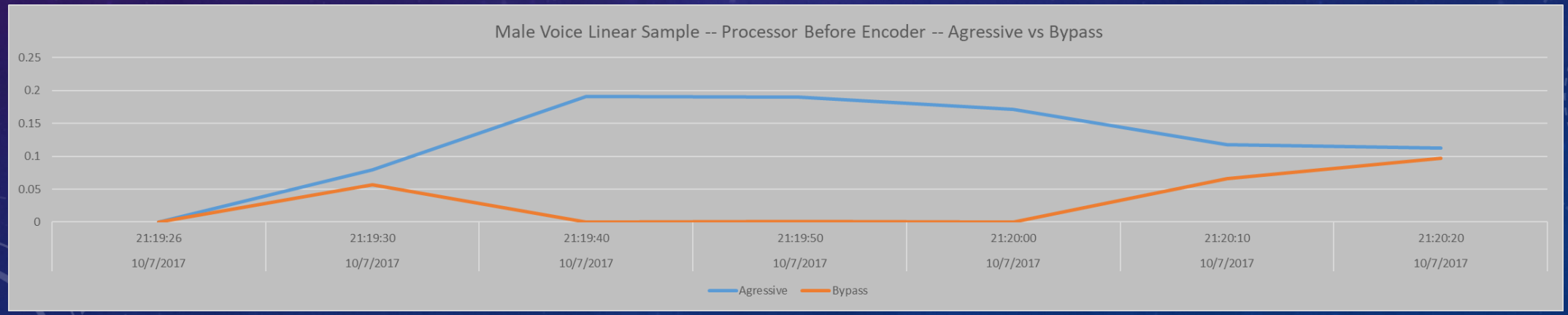
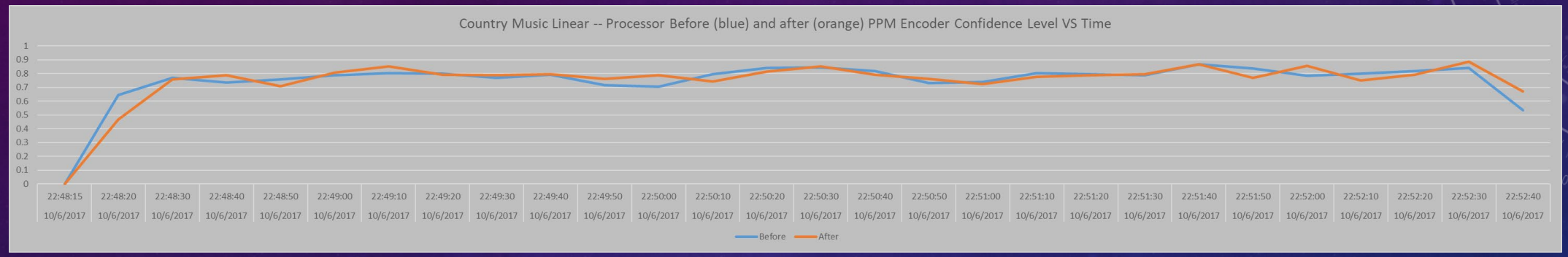
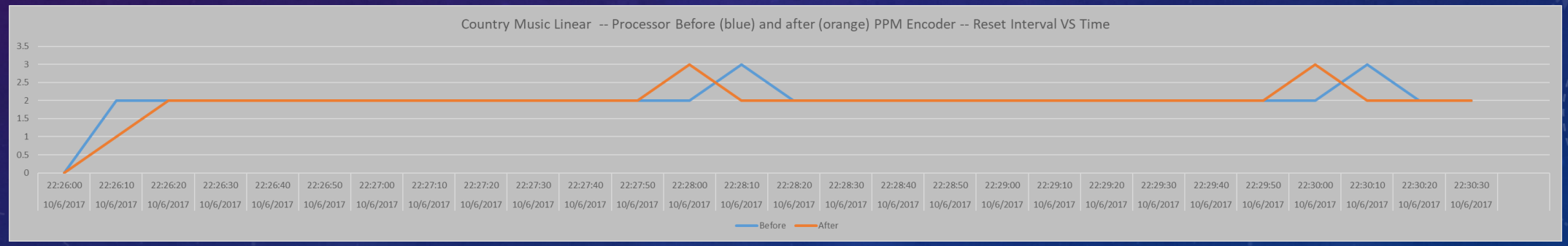


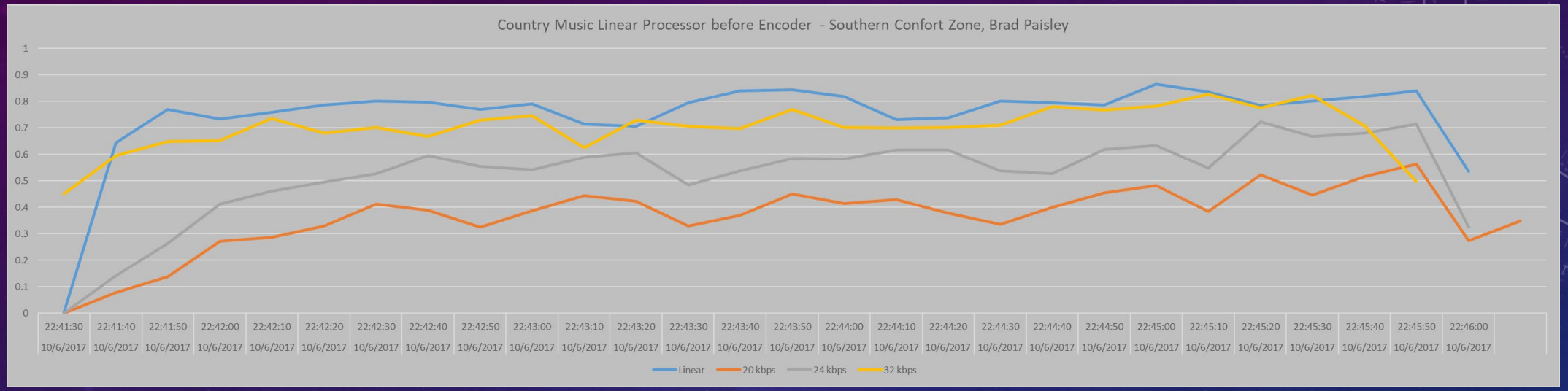


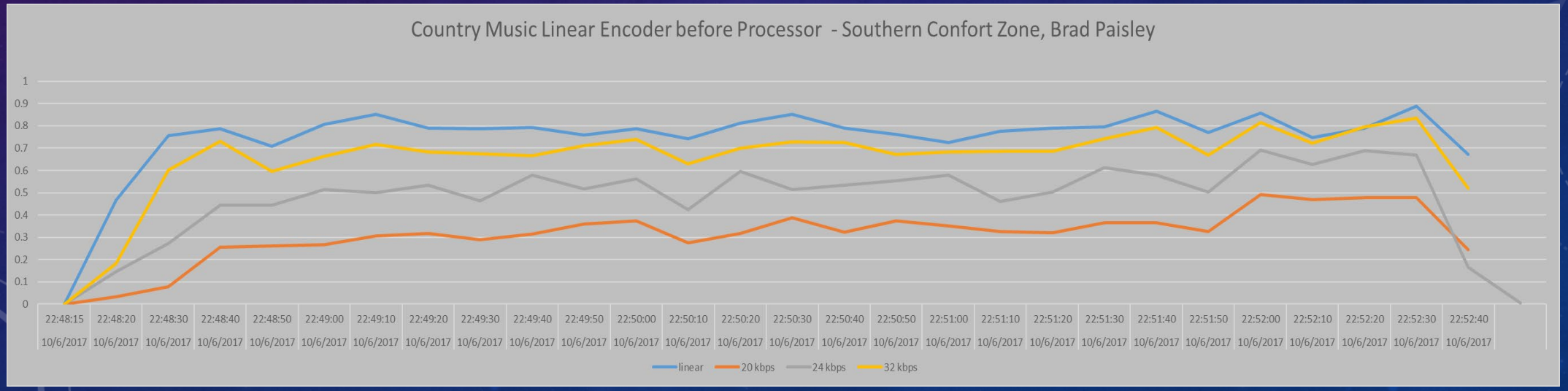
COMPARISON OF AUDIO PROCESSING PLACEMENT (SOUTHERN COMFORT ZONE, BRAD PAISLEY)



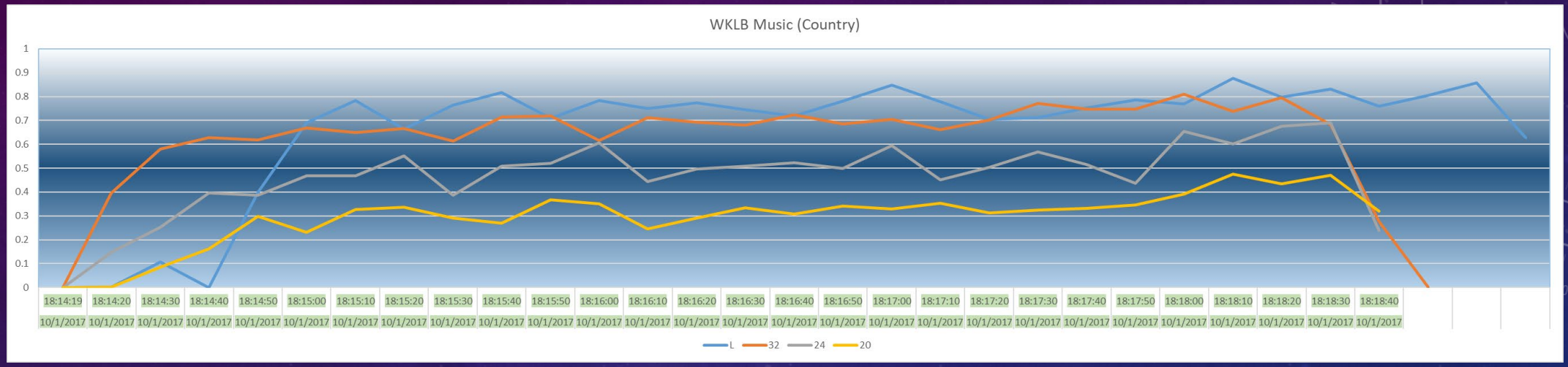


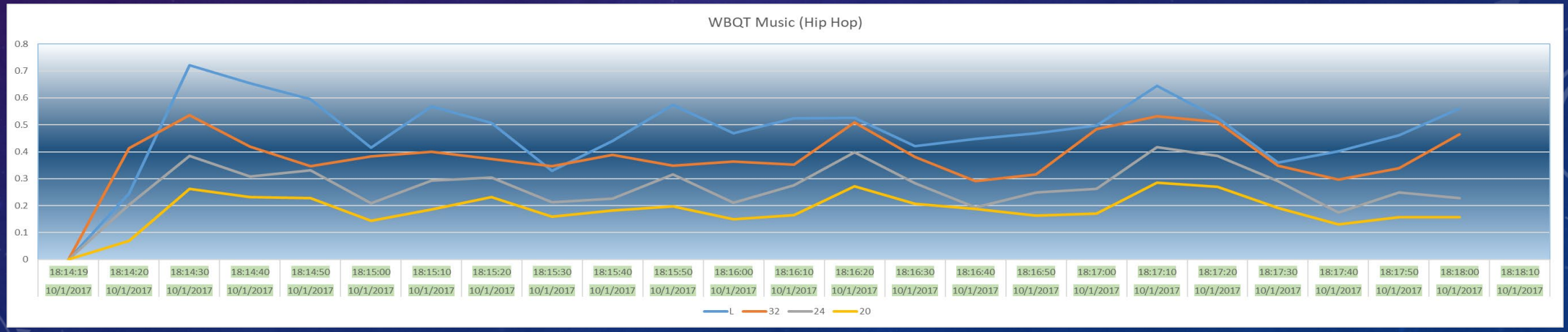
DIFFERENT BIT RATES VS. PROCESSOR PLACEMENT



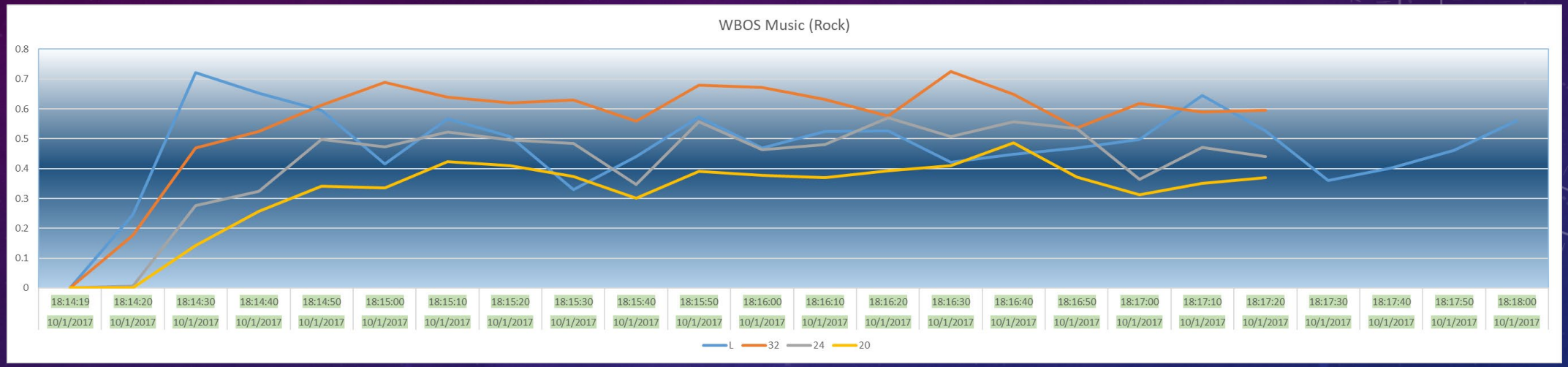


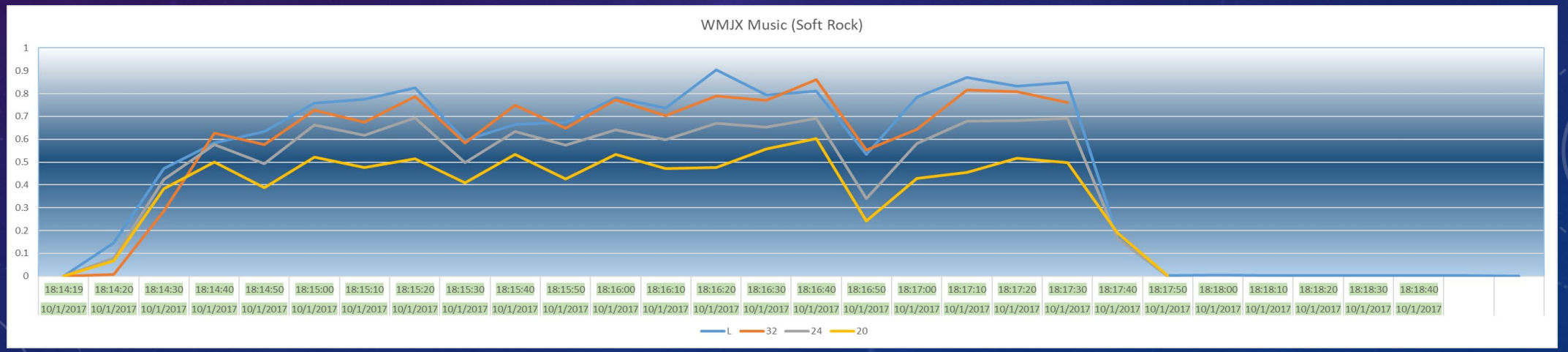
WKLB AND WBQT MUSIC CONFIDENCE LEVEL VS TIME





WBOS AND WMJX CONFIDENCE LEVEL VS TIME





CONCLUSIONS:

- Bit Rate Reduction does have an effect on passing the acoustical watermarks
- Most music benefits from a higher bit rate, although 64 kbps does not seem to suffer much compared to linear
- At the lower bit rates (<32 kbps) watermark detectability is predictably degraded especially with music content
- Voice seems to benefit from MP3 compression especially at 32 kbps
- Locating the audio processor before the PPM Encoder seems to help watermark transmission particularly with dry voice
- These measurements are a moving target and have many variables. The more data obtained, the higher confidence in the meaning of the measurements
- More study is needed to raise the confidence in the ideas presented here today.

SPECIAL THANKS TO:

- Telos for the TVC Evaluation
- Milford Smith and Greater Media for the ability to test on air during the experimental period
- Mike Cooney and Beasley Media Group for the ability to test on air during the experimental period
- Dan Griscom for his guidance in programming and designing tests
- Dr. Barry Blesser for his advice and knowledge
- Geoff Steadman for his insight and loaner equipment
- Ted Ruscitti for advice and guidance
- Mark Pagliarulo for adjusting the HD Radio Importers for testing
- Justin Weiner for obtaining test audio samples

QUESTIONS?