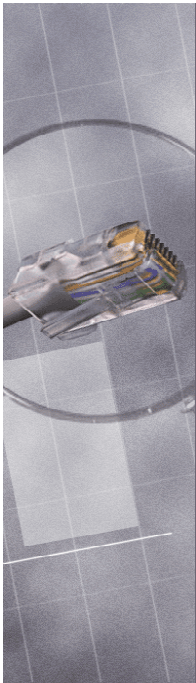


## **AES67-2018: PICS**

A basis for interoperability assessment



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### THE TELOS ALLIANCE®



Livewire, Axia studio systems, AES67

# AES67-2018 has a new annex

AES67-2018

- 42 -

## Annex G (Normative) - Protocol implementation conformance criteria

1 of AES67 that is claimed to conform to the standard shall complete the following PICS proforma.

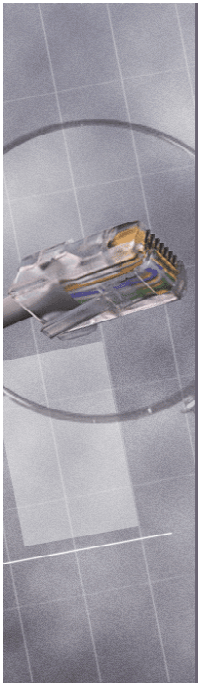
2 The PICS for the implementation in question. The PICS is a statement of which capabilities and options of the protocol have been implemented. The purposes by various parties, including the following:

3 Implementer, to reduce the risk of failure to conform to the standard through oversight;

4 Capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PICS proforma, by the supplier of the implementation,

5 The possibility of interworking with another implementation by the user, or potential user, of the implementation (note that, while interworking can often be predicted from incompatible PICS);

6 Appropriate tests against which to assess the claim for conformance of the implementation, by a protocol tester.

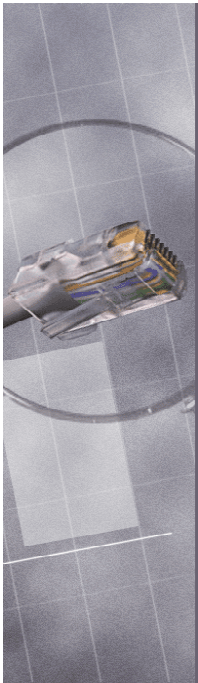


## What does the "PICS" mean?

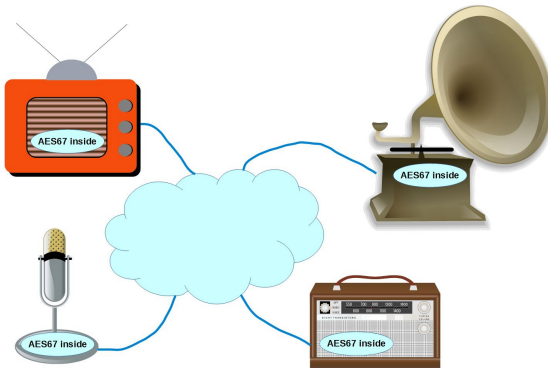
- P - Protocol
- I - Implementation
- C - Conformance
- S - Statement

It may seem - once a protocol is implemented, it is supposed to be conformant to the specification. Right?

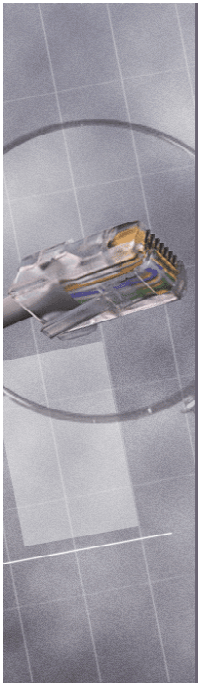
Then, why the PICS proforma in the standard is about 30 pages long?



## Will this work?



Hmm .... Why should it not?



## I believed it must work ...

### **Currently running:**

- Multichannel audio network at 48 kHz
- All existing equipment has AES67 support

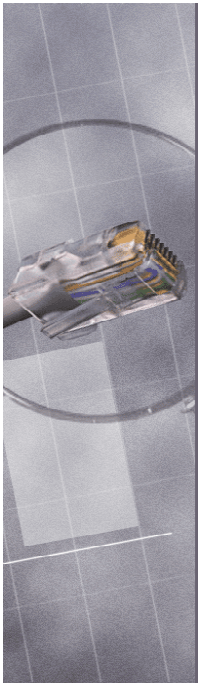
### **Looking for:**

- 8-channel source device

### **Device under evaluation:**

- Multichannel audio up to 8 channels
- AES67 supported

Perfect! All covered.



## ... but it didn't!

### Required:

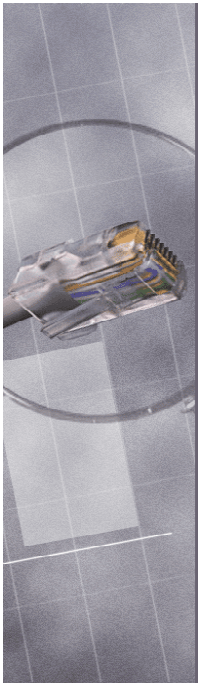
- Multi-channel audio 1 to 8 channels
- AES67 interoperability mode - 1 ms packet time

### Offered:

- Multi-channel audio 1 to 8 channels
- AES67 interoperability mode - 1 ms packet time: supported for 1- and 2-channel streams.
- Other channel counts available with 0.25 ms packet time only

### Result:

- The evaluated device cannot be used for the intended purpose



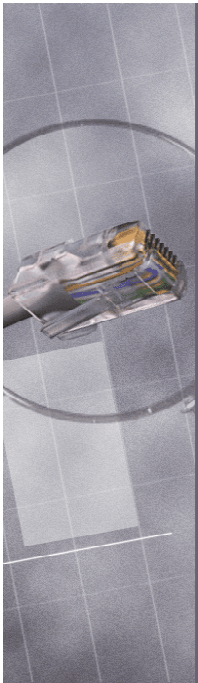
## Who is at fault?

- The evaluated device declares support of AES67
- The evaluated device is actually compliant with AES67 as it offers all mandatory features
- The user is looking for the most basic AES67 interoperability mode

It seems sensible to expect a perfect match, but it failed.

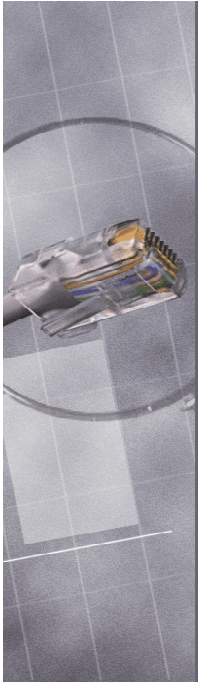
**This requires a solution.**





## Roots of the problem

- Most of specifications leave some freedom to the implementer.
- Even a thing as simple as RS232 allows framing variants and multiple bitrates.
- Bigger and more complex standards are more likely to include features, which are optional. That means, the implementer decides whether they will, or will not be supported.  
**Applies to AES67**
- Behind simple names, there may be rather complex concepts hiding. This is a good soil for incomplete or biased interpretations.  
**Applies to AES67**

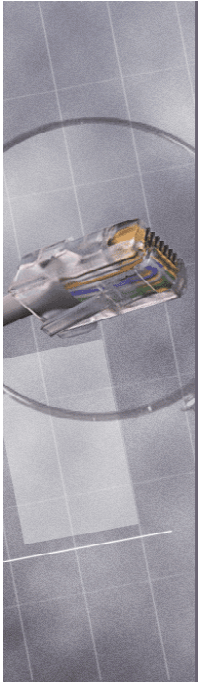


# Roots of the problem

Possible causes of false expectations:

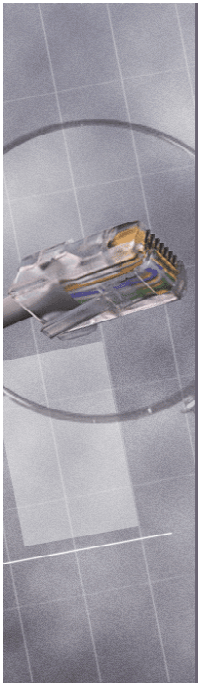
- Optional features or other variables existing in the specification
- Use of wording that does not preclude different understandings of either requirements of the standard, or claims made by equipment providers, or both.

If any of these factors are present, just saying that something is made to meet this specification is not enough, and more details are needed.



## PICS comes to help

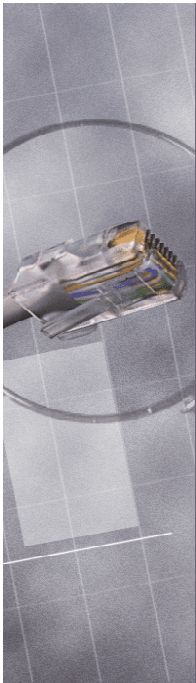
PICS is a commonly used name for an additional document, which often is supplied together with a specification, where the just discussed details are provided.



# PICS comes to help

The AES67 PICS brings the following benefits:

- To **all**: It provides a key to proper interpretation of requirements and claims.
- To **implementers and testers**: It provides a checklist with clearly defined criteria.
- To **integrators and users**: It lists precisely which capabilities and options of the protocol have been implemented.



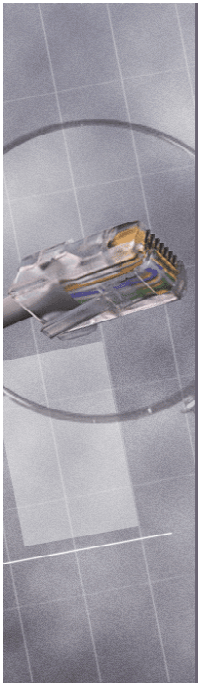
# History

Starting point:

## AES67-2013 ELEMENTARY REQUIREMENTS LIST

For full text and references, see **AES67-2013: AES standard for audio applications of networks - High-performance streaming audio-over-IP interoperability**

Clause Number	FEATURE	Required "shall"	Recommended "should"	Optional "may"	Notes
<b>4 Synchronization</b>					
4.0	Synchronization of a common clock shall be achieved using IEEE 1588-2008 Precision Time Protocol (PTP).				
4.0	Devices shall support the IEEE 1588-2008 default profiles.				Except for devices using AVB synchronization (4.3)
4.0	Devices supporting the default profiles shall use IPv4 encapsulation as described in IEEE 1588-2008 annex D.				
<b>4.1 IP network synchronization</b>					
4.1	Devices on standard IP networks should use the media profile defined in annex A.				
4.1	Devices may use the default profiles on IP networks.				
<b>4.3 AVB network synchronization</b>					
4.3	AVB networks may use their native IEEE 802.1AS synchronization profile in preference to the default profiles or media profile.				

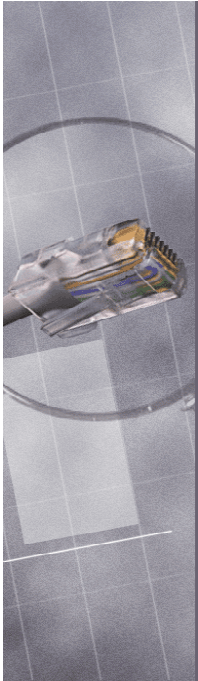


# History

## Testing experiment at Telos:

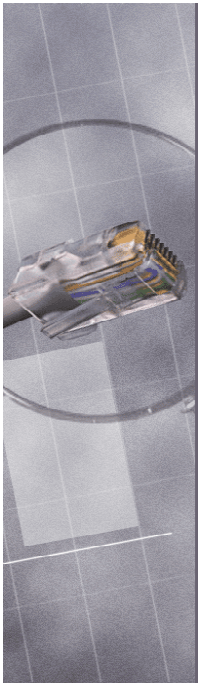
- A test for both the device and the PICS
- Before the start of actual testing it became clear that there will be countless questions about criteria and methods
- As a result an internal document was created in our testing lab, which added criteria and procedure descriptions to the original form

7.5 Sender timing and receiver buffering				
7.5-1	Receivers shall have a buffer capacity at least 3 times the packet time.	1	Receive a stream with controlled known jitter value, listen to audio, check for receiver <u>underruns</u> in diagnostic data	<ul style="list-style-type: none"> <li>• No audible defects and no buffer <u>underruns</u>, as long as the received packet is not delayed relative to its normal position in the received stream by more than 3 packet times.</li> </ul>
7.5-2	Receivers should have a buffer capacity at least 20 times the packet time or 20 ms whichever is smaller.	2	Receive a stream with controlled known jitter value, listen to audio, check for receiver <u>underruns</u> in diagnostic data	<ul style="list-style-type: none"> <li>• No audible defects and no buffer <u>underruns</u>, as long as the received packet is not delayed relative to its normal position in the received stream by more than 20 packet times or 20ms whichever is smaller.</li> </ul>
7.5-3	Senders should transmit at the nominal transmission time with a variation of 1 packet time or less.	2	Packet capture with timing statistics	<ul style="list-style-type: none"> <li>• Offset from the nominal transmission time should not exceed 1 packet time</li> </ul>
7.5-4	Senders shall transmit data at the nominal transmission time with a variation of no more than 17 packet times or 17 ms whichever is smaller.	1	Packet capture with timing statistics	<ul style="list-style-type: none"> <li>• Offset from the nominal transmission time must not exceed 17 packet times or 17 ms whichever is smaller</li> </ul>



# History

- The internal document was proposed to the AES SC working group and served as the starting point for the PICS proforma that we have in the current revision of the standard.
- It took many hours of editing work and teleconferences until the working group got the document ready for review and comments.
- During the work it was understood that defining procedures for all clauses would delay releasing of the PICS annex too much. As a tradeoff, procedures were excluded from the current revision.



## Current status

**Is it finished? No.**

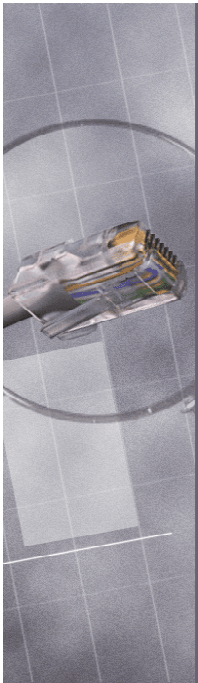
**Is it useful in its current shape? YES!**

The working group had to make a difficult decision - make it available to implementers and users sooner rather than have them to wait for a more refined document.

Improvements desired:

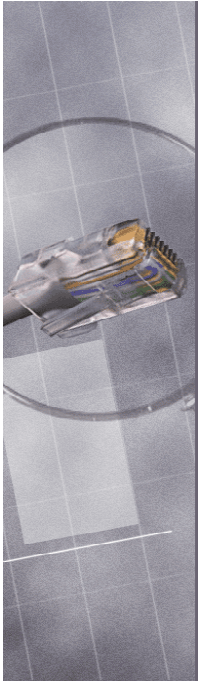
- There are still some ambiguities waiting for improvement
- Most importantly, it is missing test procedure definitions





## You can participate

- Share your ideas, concerns, criticisms now
- Send me an email later: [gints@latnet.lv](mailto:gints@latnet.lv)
- Join the AES SC development group **SC-02-12-M**



# Structure of the PICS annex

- Follows the structure of the standard, clause by clause
- Color-coded requirement levels. A number provided for b/w print

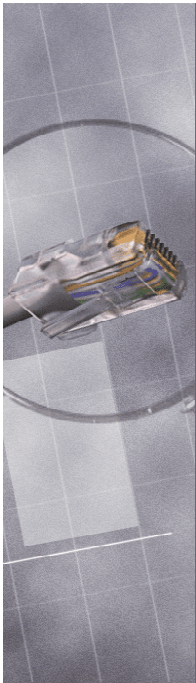
Table G.1 - Requirement levels

Requirement level	Requirement language
1	Shall (requirement)
2	Should (strong suggestion)
3	May (permission)
0	Informative

- “Notes” column - criteria for making the test decision
- “Supported” column - test result in a “Yes / No” form

Statement Number	Feature	Requirement level	Notes	Supported
4.0-1	Synchronization of a common clock shall be achieved using IEEE 1588-2008 Precision Time Protocol (PTP)	1	Mark as supported if the device supports IEEE 1588-2008 Precision Time Protocol (PTP)  Indicate support per operation mode: <ul style="list-style-type: none"> <li>• Slave: Yes/No</li> <li>• Master: Yes/No</li> </ul>	Yes [ ] No [ ]  Yes [ ] No [ ]

- Test procedure and conditions - presently not included, future work



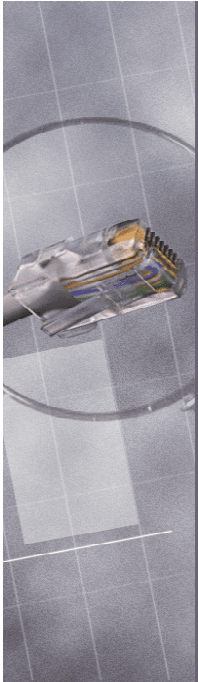
# PICS summary

## PICS Summary

= multiple choice

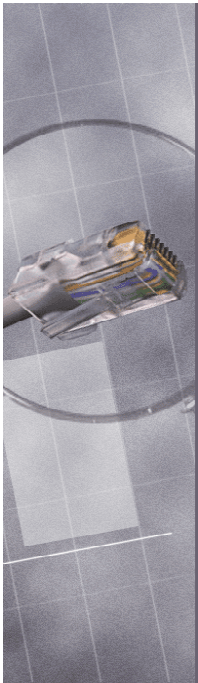
= single (exclusive) choice

	Choice					Remark	PICS statement number(s)
Transport	Multicast	Unicast				Note: unicast doesn't necessarily indicate SIP support	6.1-5, 6.1-6, 6.1-8, 6.1-9, 7.6-1, 7.6-2, 7.6-3
QoS configuration	Configurable markings with standard defaults	Fixed standard markings	Configurable, other defaults	Other markings, not configurable		Indicate whether markings are changeable through device configuration and whether standard default DSCP markings (EF for PTP, AF41 for RTP) are used.	6.2-2, 6.2-3, 6.2-4, 6.2-5, 6.2-6
Sample rates	48 kHz	44.1 kHz	96 kHz				7.1-1, 7.1-2, 7.1-3
Packet times	1 ms	125 $\mu$ s	250 $\mu$ s	333 $\mu$ s	4 ms		7.2.1-1, 7.2.1-2, 7.2.1-3, 7.2.1-4, 7.2.1-5, 7.2.1-6, 7.2.2-17.2.2-2
PTP profiles	IEEE1588 Default	AES67 PTP Media	ST2059	IEEE 802.1AS (AVB)			4.3-1, A.0-1
SDP transport	Manually	RTSP	SAP	SIP			10.2-1
Discovery	Proprietary (specify)	SAP	mDNS	NMOS IS-04		indicate supported modes; SAP = Dante AES67 mode, mDNS = RAVENNA; proprietary = any	9-1



## Using PICS for system planning

- Early prediction of failure to interwork
- Optimizing features and costs through detailed study of capabilities



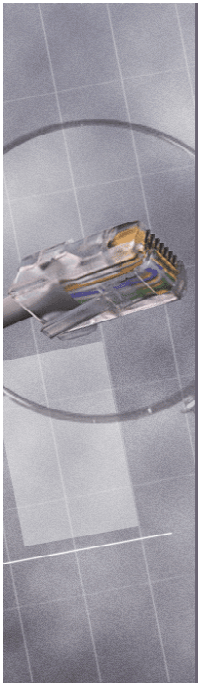
## Using PICS for system planning

Match the fundamental capabilities

- Synchronization: PTP master / slave / both
- Audio streaming: receive / send

Match detailed features

- Transport and QoS behavior
- Stream and content formats – packet times, channel counts, sampling rates, encodings
- Transmission time variation and receive buffering



## Completing the PICS form

- Clause by clause, mark items with “Yes” or “No”
- Devices are allowed to support only:
  - PTP master or slave operation
  - Sending or receiving of audio streamsIf a capability is not supported at this level, it is to be excluded from testing entirely.
- Some clauses offer the “n/a” option:
  - “No” - feature has failed the test. May disqualify the device.
  - “n/a” - feature does not need to be tested. No effect on the final qualification.

## Completing the PICS form

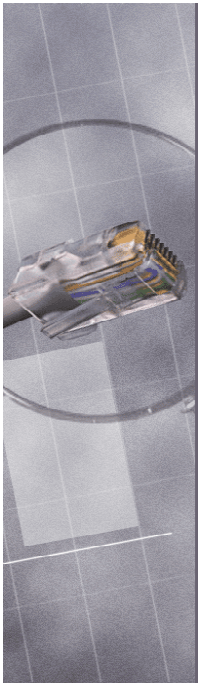
Issues with the “n/a” option:

- There are some oversights in the PICS form
- The approach needs refinements

Two levels of applicability conditions:

- based on fundamental capabilities
- specific feature-related conditions

6.2-7	Senders may be configured to use the same DSCP values for multiple classes.	3	Test applicable if DSCP values are configurable Mark as supported if the device implements a method to configure the same DSCP values for multiple classes.	Yes [ ] No [ ] n/a [ ]
6.2-8	Senders may be configured to use classes in addition to those shown in table 1.	3	Mark as supported if the device implements a method to configure additional traffic classes	Yes [ ] No [ ]

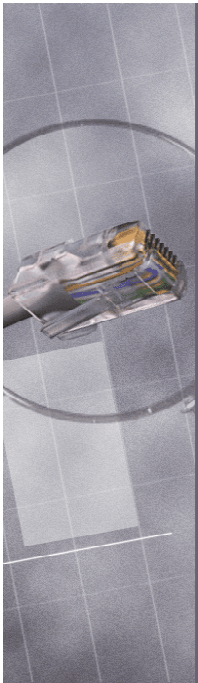


## Quick guide for getting lost

### What the standard says:

- All devices **shall** support 48 kHz sampling rate.
- Devices **should** support 96 and 44,1 kHz sampling rates.
- **When** operating at **48 kHz** sampling rate:
  - 1. Receivers **shall** support both L16 **and** L24 encodings
  - 2. Senders **shall** support **either** L16, **or** L24, **or both** encodings
- Receivers **shall** support reception of streams with **1 to 8** audio channels.
- Receivers **may** support streams with **more than 8** channels.
- Senders **shall** be able to offer at least one stream with **8** channels **or fewer**.
- Senders **may** support streams with **more than 8** channels.



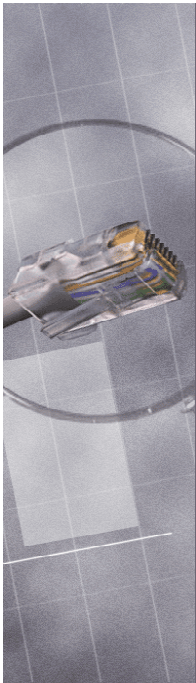


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- Senders **shall** be able to offer at least one stream with **8** channels **or fewer**.
- Senders **may** support streams with **more than 8** channels.

*PICS is here to state precisely which “shall’s”, “should’s”, “may’s”, “and’s”, and “or’s” are implemented, and which are not.*

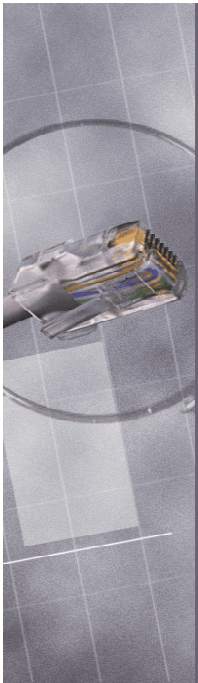


## Is it always clear what “supported” means?

“The 48kHz sampling rate is supported.”

### Possibilities:

- Manufacturer has indicated the 48 kHz sampling rate in the data sheet, but there is no actual implementation. *Plain fraud*
- Implementation has been attempted but has not been verified to any degree. *Super-optimistic*
- Implementation has been verified to generally work, but testing has been loose and inconsistent. *Very optimistic*
- Any one or more stream modes with 48 kHz have been properly verified. *Reasonable or too loose?*
- All mandatory stream modes with 48 kHz have been properly verified. *Reasonable or too strong?*
- All mandatory and recommended stream modes with 48 kHz have been properly verified. *Reasonable or too strong?*
- All mandatory, all recommended, and all implemented additional modes with 48 kHz have been properly verified. *Reasonable or overkill ?*



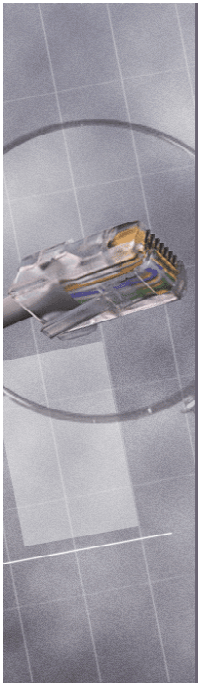
## Is it always clear what “supported” means?

In reality it is more complicated.

- The 48 kHz sampling rate is one of the viewing angles, and there are others:
  - encoding types
  - stream channel counts
  - packet times
- Also, there are “all” and “any one” conditions, applied differently to sending and receiving.
- Altogether it produces a large multidimensional and irregular capabilities matrix.

If included into PICS in its raw form, the matrix would be too cumbersome both for testers and users.

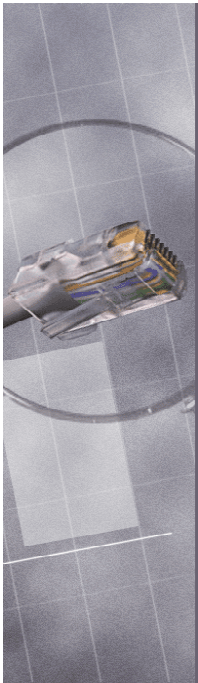
**We needed a different solution.**



## Resolving the capabilities matrix

- There seems to be no single universal approach that would be perfect for all cases
- Need to balance between sufficient detail level and ease of practical use

AES67 defines a tradeoff approach to resolve this issue.



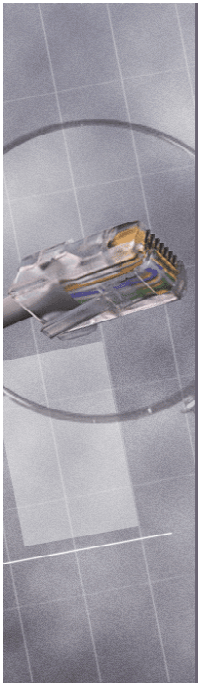
## Resolving the capabilities matrix

### G.4 – Qualification criteria for encoding and streaming capabilities

This is another small section after the PICS proforma. It explains the approach and provides a compact feature enumeration for reference.

The equipment provider declares the features that are to be included in AES67 conformance testing.

**“Supported” = Verified in combination with all other declared features**

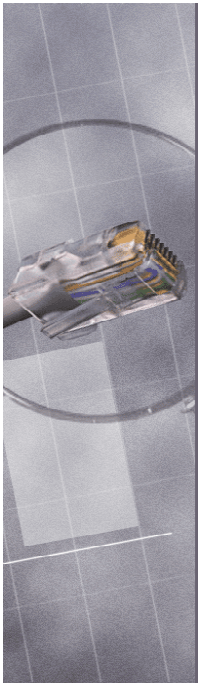


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- 2 channels, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16				
L24				

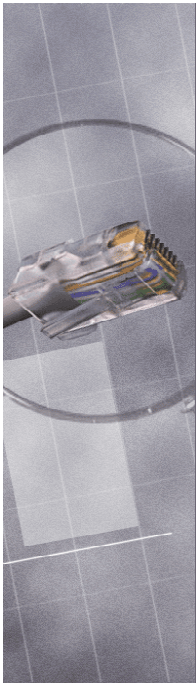


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- 2 channels, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16				
L24				



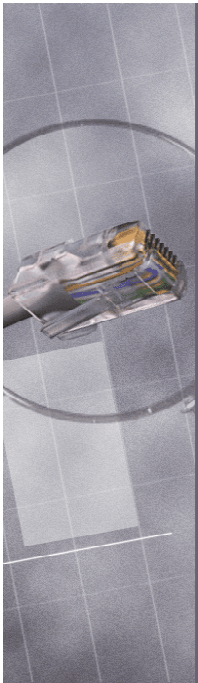
## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- 2 channels, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16				
L24				



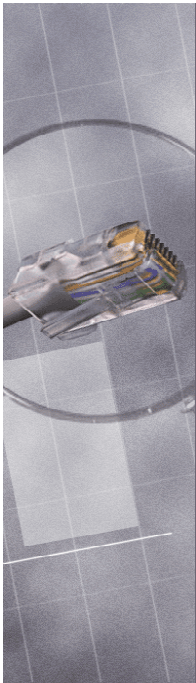


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- 2 channels, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16				
L24				

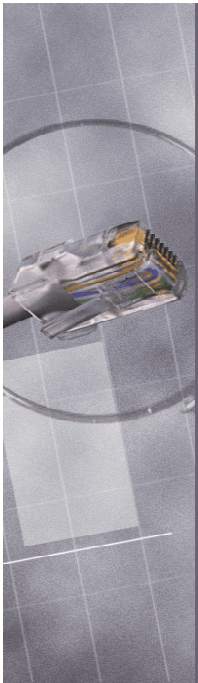


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- 2 channels, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16				
L24				

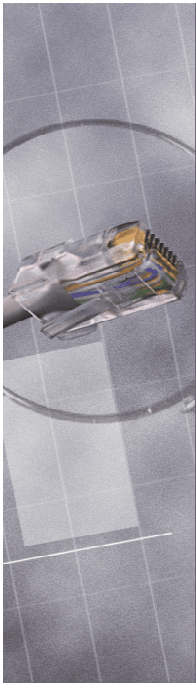


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- **2 channels**, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16	■		■	
L24	■		■	

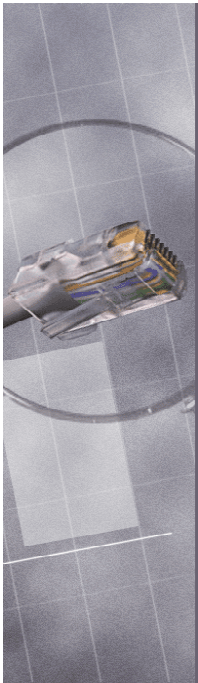


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- **2 channels, 8 channels**

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16				
L24				

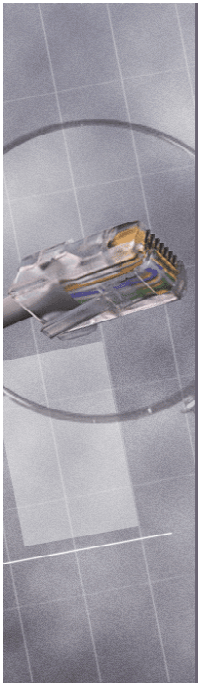


## Resolving the capabilities matrix

Declared:

- L16 / 48 kHz, L24 / 48 kHz
- 1 ms, 0.25 ms
- 2 channels, 8 channels

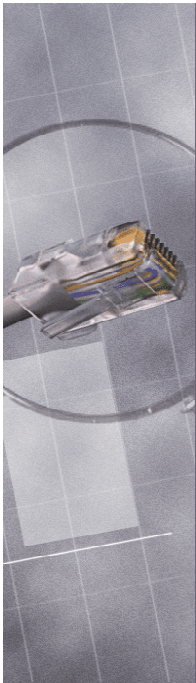
	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16	Y	Y	Y	Y
L24	Y	---	Y	Y



## Resolving the capabilities matrix

- Plan A**      **Declared:**
- L16 / 48 kHz, L24 / 48 kHz
  - 1 ms, 0.25 ms
  - 2 channels, 8 channels

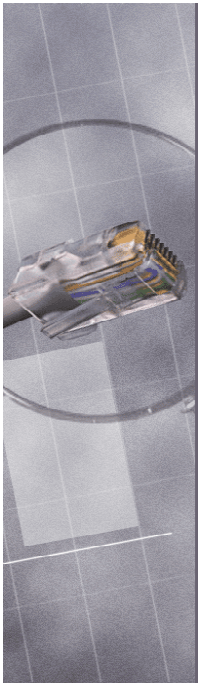
	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16	Y	Y	Y	Y
L24	Y	---	Y	Y



## Resolving the capabilities matrix

- Plan B**      Declared:
- L16 / 48 kHz, L24 / 48 kHz
  - 1 ms, 0.25 ms
  - 2 channels, 8 channels

	1 ms		0.25 ms	
	2ch	8ch	2ch	8ch
L16	Y	Y	Y	Y
L24	Y	---	Y	Y



## Resolving the capabilities matrix

Missing a combination with a declared feature makes the feature under test unsupported in the AES67 conformance meaning.

It does not necessarily mean that the feature is generally compromised.

- **Is this approach perfect? No.**

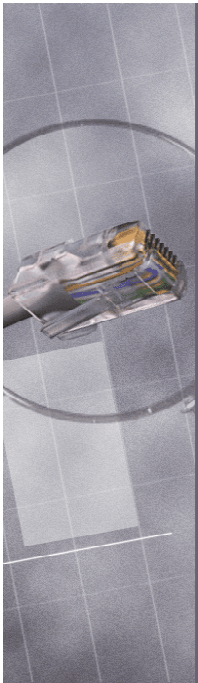
It has somewhat limited flexibility in telling what the device is actually capable of.

- **Is this approach useful? YES!**

The meaning of “supported” is clearly defined.

Further improvements may be possible – future work.

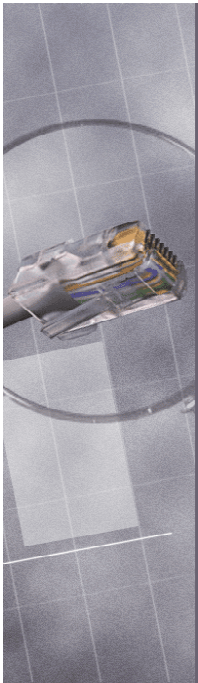




## Ready for formal certification?

...capability is considered supported if it is **verified** ...

What does “**verified**” mean?

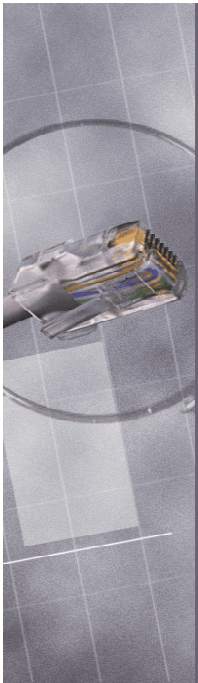


## What does “verified” mean?

It may seem simple, but there is a lot of freedom, unless the testing procedure is precisely defined.

Factors possibly to affect results of testing a receiver:

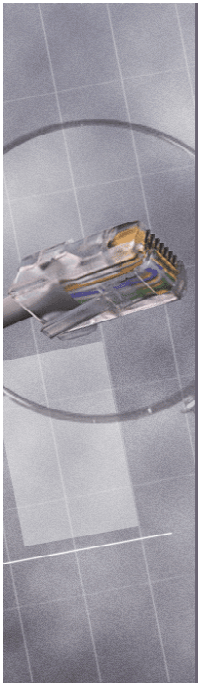
- Evaluation method
- Tester’s skill level – critical for listening tests
- Source stream content type
- Source stream timing properties
- Duration of the test



## What does “verified” mean?

Evaluation methods:

- Listen to audio - sensitive to the skill level
- Visually examine the signal waveform
- Measure the noise and distortion in the signal
- Compare the behavior against a “known-good” implementation
- Compare the behavior against special test equipment



## What does “verified” mean?

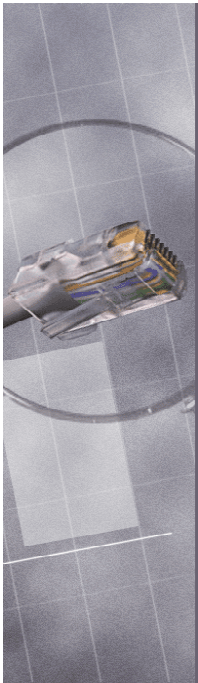
Content type:

- Music
- Speech
- Noise
- Sine tone

Speech would mask most glitches.

Music would mask significant part too.

Sine tone is most revealing, still it would mask incidents happening close to zero crossings.



## What does “verified” mean?

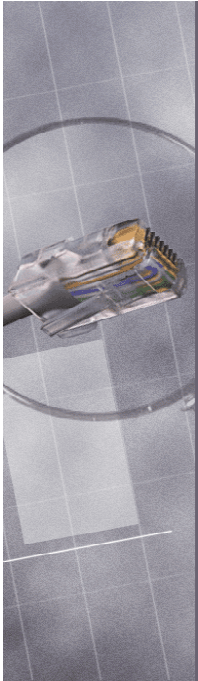
Source stream timing properties:

- Perfect packet timing
- Random jitter
- Deterministic bursts at known intervals.

Perfect packet timing - most forgiving to receiver design flaws.

Random jitter - would produce the potentially problematic conditions time by time, but difficult for the listener to keep concentrated.

Deterministic bursts at known intervals help the human listener to focus. However, due to the nature of human reaction it may provoke false positives.



## What does “verified” mean?

Duration of the test:

- A few sec?
- A few minutes?
- Hours, days, weeks?

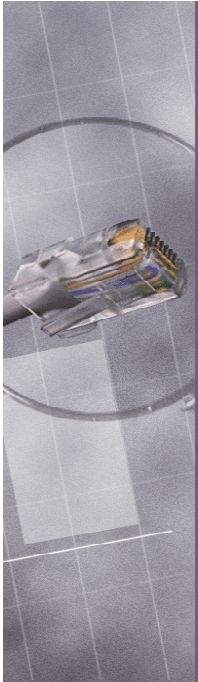
Depends on the type of the property under test.

Example: Synchronization performance or buffering:

A few seconds of test would not reveal most of design or implementation stability issues

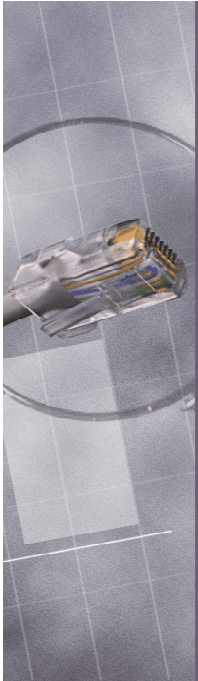
Goals:

- The test must be sufficiently long to not miss infrequent incidents
- The test must not be too long, to be feasible and economically justified



## Ready for formal certification?

- To calibrate claims and expectations, clearly, more guidance for testing is needed.
- Defining formal test procedures is a complicated and time consuming work. Hopefully a future project.

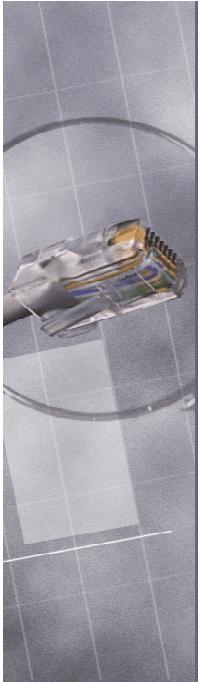


## Ready for formal certification?

Costs and benefits:

- AES SC
  - Efforts need to be sponsored by companies
  - Helps to improve the quality of the standard
  
- Manufacturer
  - Testing expenses grow – consuming test equipment and labor
  - Better testing is stimulated, hence higher quality of the product on market
  
- End-user
  - Wins from precise knowledge of product capabilities
  - Wins from better product quality
  - May suffer from some increase of the equipment cost due to stronger testing requirements.

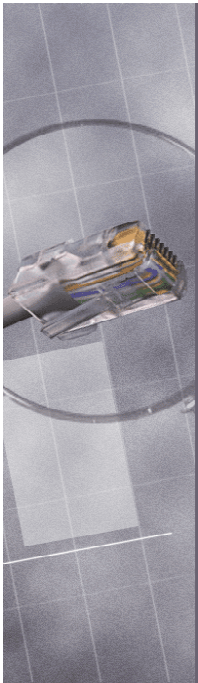




## Ready for formal certification?

How much of investment is justified?

- The goal is to help users and through them stimulate adoption of the standard.
- Supposedly the efficiency of investment is going to fall as the work proceeds into finer details.
- At some point further investment into the specification work and product testing may stop transforming into adoption benefits completely.



# AES67-2018: PICS

A basis for interoperability assessment

- Email me: [gints@latnet.lv](mailto:gints@latnet.lv)
- Consider contributing to AES67 development through the AES **SC-02-12-M** project group