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OPERATING EUROVISION AND EURORADIO

Tech 3371

THE TECHNOLOGY PYRAMID FOR MEDIA NODES

MINIMUM USER REQUIREMENTS TO BUILD AND MANAGE AN IP-BASED MEDIA FACILITY USING OPEN STANDARDS & SPECIFICATIONS

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Abstract

This document presents the requirements of the EBU user community regarding IP-based facilities. The document deals with the ensemble of technologies that a *Media Node*[1] needs to support to enable broadcasters to design, build, operate and maintain an IP architecture based on the SMPTE ST 2110 Standards.

The document is aimed at broadcasters and system integrators who need to define and design their requirements for a live IP infrastructure. In addition, the document provides the industry with a clear understanding of what users expect from mature IP Studio equipment.

The structure of the document follows the concept of the Media Node Technology Pyramid that sets out the minimum stack of technologies needed to build and manage an IP-based media facility.

The work involved in this document was conducted by the experts of the EBU Strategic Programme on infrastructure & security, and it is based on the lessons learned from the first IP-based facility projects within the EBU membership. This third version was updated and enriched to reflect the latest state of the market and practical experience gained by a growing number of implementers.

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[1] A Media Node has one or more physical or software-based device(s) that can send (Sender) and/or receive (Receiver) media streams.

Conformance Notation

This document contains both normative text and informative text.

All text is normative except for that in the Introduction, any section explicitly labelled as 'Informative' or individual paragraphs which start with 'Note:'.

Normative text describes indispensable or mandatory elements. It contains the conformance keywords 'shall', 'should' or 'may', defined as follows:

'**Shall**' and '**shall not**':	Indicate requirements to be followed strictly and from which no deviation is permitted to conform to the document.
'**Should**' and '**should not**':	Indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others. OR indicate that a certain course of action is preferred but not necessarily required. OR indicate that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.
'**May**' and '**need not**':	Indicate a course of action permissible within the limits of the document.

Default identifies mandatory (in phrases containing **"shall"**) or recommended (in phrases containing **"should"**) presets that can, optionally, be overwritten by user action or supplemented with other options in advanced applications. Mandatory defaults shall be supported. The support of recommended defaults is preferred, but not necessarily required.

Informative text is potentially helpful to the user, but it is not indispensable, and it does not affect the normative text. Informative text does not contain any conformance keywords.

A conformant implementation is one that includes all mandatory provisions ('**shall**') and, if implemented, all recommended provisions ('**should**') as described. A conformant implementation need not implement optional provisions ('**may**') and need not implement them as described.

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Minimum User Requirements to Build and Manage an IP-based Media Facility using Open Standards & Specifications

EBU Committee	*First Issued*	*Revised*	*Re-issued*
TC	Dec. ’18	June ’20 (v.2)	April ’23 (v.3)

Keywords: IP-based, Media facility, Media Node, Media stream, Technology stack, SMPTE ST 2110, NMOS.

1. Introduction

The following are requirements of the EBU user community regarding IP-based facilities. The document deals particularly with the ensemble of technologies that a *Media Node* needs to support to enable broadcasters and vendors to design, build, operate and maintain an IP architecture based on the most recent version of the SMPTE ST 2110 Standards.

The target audiences are broadcasters and system integrators who need to define and design their requirements for a live IP infrastructure. In addition, the document provides the industry with a clear understanding of what users expect from mature IP Studio equipment.

The document assumes that the reader is familiar with the terms and nomenclatures used in SMPTE ST 2110, together with general IP architecture and design rules.

2. The Technology Pyramid for Media Nodes

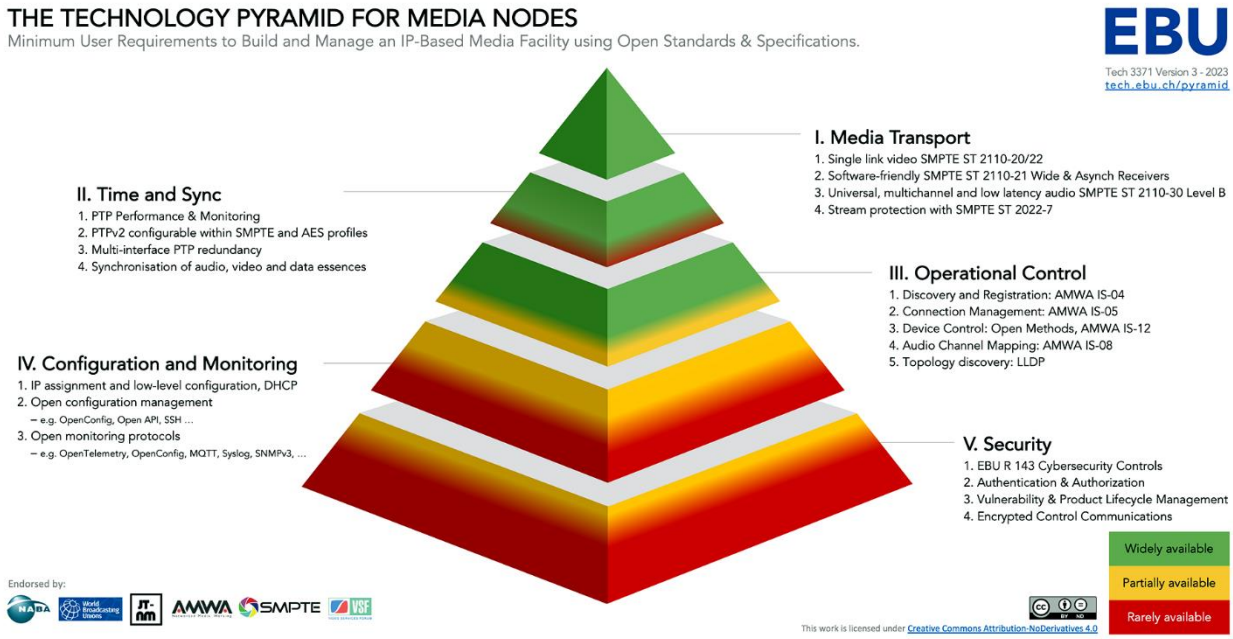


Figure 1: Minimum user requirements to build and manage an IP-based media facility
(for clarity, a larger version of this figure is provided on page 14)

3. General Principles

All the technologies and standards used to compose the Media Node Pyramid:

1. Shall strive to reuse existing IT and Internet Standards (e.g., IETF, IEEE, W3C, etc.), architecture patterns and best practices to leverage the R&D investments of this much wider industry.
2. Should be implementable in software running on standard IT systems, so enabling flexible, agile, scalable and secure infrastructures.
3. Should use Open standards and specifications, i.e.:
    - Documentation should be adequate for developing a custom solution (e.g., provided reference implementations, API and modules documentations).
    - Documentation shall be accessible to the public, it shall not require a Non-Disclosure Agreement (NDA), it should be actively maintained, and it should be free to obtain so that any implementer or user can consult it.
    - If the standard or specification includes patented technology, it should be covered by a fair, reasonable, and non-discriminatory royalty-free licencing policy (RAND-Z or RAND-RF) or at least shall have fair, reasonable and non-discriminatory licencing policy (FRAND) so that the technology is accessible to all users.
4. Shall use Semantic Versioning[2] and so improving communication and collaboration between developers and users, reducing the risk of compatibility issues, and making it easier to manage software releases.
5. Shall provide a clear support programme and committed ongoing support, including security updates, that fit the needs of the project lifecycle, to ensure longevity and sustainability of the installation.
6. Implementations should conform to the most up-to-date version of the undermentioned open standards and specifications, unless there is a specific version mentioned in this document.
7. Media Nodes should have been tested by a recognized authority such at the Joint Taskforce on Networked Media (JT-NM) Tested event[3].

4. Pyramid Layers

The numbering in this section corresponds to that in Figure 1.

I Media Transport

At the pinnacle of the Media Node Pyramid are the Standards that are crucial for encapsulating and carrying media content, utilizing the SMPTE ST 2110 *Professional Media Over Managed IP Networks* suite. Nonetheless, when it comes to deploying media over IP within a facility, ST 2110 is not enough and must be supplemented with other technologies. Therefore, ST 2110 is just the starting point of the Pyramid.

I.1 Single link video: SMPTE ST 2110-20/22

.1 To achieve ease of operation, effective troubleshooting, and to maximize the density of network usage, it is recommended that video Media Nodes utilize SMPTE ST 2110-20[4] single link streams and avoid the use of SMPTE ST 2110-23. For example, a single 59.94 Hz UHD

[2] https://semver.org (free)

[3] https://www.jt-nm.org/jt-nm-tested (free)

[4] https://ieeexplore.ieee.org/document/9973247 (paid)

stream necessitates a 25 Gigabit Ethernet (GbE) port, and a high-density device such as a multiviewer or a vision mixer would be best served by a bidirectional 100 GbE connection.

.2 SMPTE ST 2110-22[5] *Constant Bit-Rate Compressed Video* may be utilized along with VSF TR-08:2022 *Transport of JPEG XS Video in ST 2110-22*[6] for several long-distance or remote production scenarios where bandwidth is limited.

I.2 Software-friendly SMPTE ST 2110-21 Wide video Receivers

to get the flexibility expected from IP-based media:

.1 Receivers shall support SMPTE ST 2110-21[7] Wide type and therefore be able to receive both Wide and Narrow streams.

.2 Receivers should offer an option for the SMPTE ST 2110-21 Asynchronous type to be able to receive streams not on the same reference clock.

I.3 Universal, multichannel, low latency audio: SMPTE ST 2110-30 Level B

.1 In addition to SMPTE ST 2110-30[8] Level A, which is compatible with all AES67[9] and ST 2110-30 devices, audio Senders and Receivers shall support Level B to support low latency applications.

.2 Audio Receivers shall have a buffer capacity at least 20 times the packet time to allow a range of hardware and software implementations.

.3 Receivers shall be compatible with AES67 including random RTP clock offset so that they can be used with all AES67 Senders on the market.

.4 AES67 Senders shall provide a mode for ST 2110-30 compatibility, e.g., zero RTP clock offset, so that they can be used across TV, radio and online media production systems.

.5 Media Nodes often need multiple Senders and Receivers so users can group audio channels that belong together in the same stream: 5.1 programme into a 6-channel stream, stereo audio description into a 2-channel stream, 1-channel for a microphone, etc.

I.4 Stream protection with SMPTE ST 2022-7

.1 For protection of streams, Media Nodes shall provide at least two separate Ethernet media interfaces using SMPTE ST 2022-7:2018 *Seamless Protection Switching of RTP Datagrams*[10];

.2 Receivers shall support SMPTE ST 2022-7:2018 Class D with Ultra Low Skew 150 µs that is adapted to engineered LAN with adding minimal latency.

.3 Receivers shall report late or lost packets on each redundant stream so that degraded protection can be diagnosed.

II Time and Sync

Real-time media requires synchronisation in many use cases. SMPTE ST 2110 systems rely on IEEE 1588-2008[11] (PTPv2) as clock synchronization mechanism with media-specific profiles and

[5] https://ieeexplore.ieee.org/document/9893780 (paid)

[6] https://vsf.tv/download/technical_recommendations/VSF_TR-08_2022-04-20.pdf (free)

[7] https://ieeexplore.ieee.org/document/9973262 (paid)

[8] https://ieeexplore.ieee.org/document/8167392 (paid)

[9] https://www.aes.org/publications/standards/search.cfm?docID=96 (paid)

[10] https://ieeexplore.ieee.org/document/8716822 (paid)

[11] https://ieeexplore.ieee.org/document/4579760 (paid)

behaviours.

II.1 PTP Performance

.1 Media Nodes shall not experience visual or audible disturbance when there is a momentary erroneous behaviour or an interruption for up to 5 minutes of the PTP clock distribution, so that is it tolerant to short PTP loss.

.2 When the PTP reference returns from a momentary interruption of up to 5 minutes, the Media Node shall gracefully re-align itself with the clock without causing a visible or audible glitch in the media output.

.3 The Media Node shall report about the PTP state and parameters preferably using the IETF RFC 8575 *YANG Data Model for the Precision Time Protocol*[12] or at least IETF RFC 8173 *Precision Time Protocol Version 2 Management Information Base*[13], so that it can be monitored.

II.2 PTPv2 configurable within SMPTE and AES profiles

.1 PTP parameters of Media Nodes shall be configurable within the union of the ranges covered by all profiles SMPTE ST 2059-2[14] profile, the AES67 media profile and the IEEE-1588 default profile so that we can use the Media Nodes for the full range of possible operational scenarios.

.2 However, it is recommended to the users to select an operational point within the range of AES-R16-2021 *PTP parameters for AES67 and SMPTE ST 2059-2 interoperability*[15] so that it is compatible with equipment previously delivered on the market that might be limited to one of the two profiles.

.3 PTP Master capable Media Nodes shall be set to slave-only mode by default so that there is no risk that the Media Node becomes the Grandmaster the first time it is used.

II.3 Multi-interface PTP redundancy

.1 Media Nodes shall be capable of selecting its master clock across all its media interfaces so that it can use PTP redundancy for seamless failover.

II.4 Synchronisation of audio, video and data essences

To maintain high production quality, for audio, video and/or other data streams that have been captured together and that have passed separately through several Media Nodes, it must be possible to easily realign them at key points in the production process as proposed in AMWA MS-04 *NMOS Identity and Timing Model*[16]. ST 2110-10:2022 *System Timing and Definitions*[17] revision provides new options to enable parts of this approach in a system – See *Annex C Timestamp Methodology Notes (Informative)*. To support this:

.1 Media Nodes capturing or generating new streams with RTP timestamps reflecting the sampling instant shall signal `TSMODE=SAMP` as per section *8.7 RTP Timestamp Mode and Delay*, so that the timestamp values can be used across signals similarly marked when mixing audio and/or video together.

[12] https://www.ietf.org/rfc/rfc8575.txt (free)

[13] https://www.ietf.org/rfc/rfc8173.txt (free)

[14] https://ieeexplore.ieee.org/document/9452731 (paid)

[15] https://www.aes.org/publications/standards/search.cfm?docID=105 (paid)

[16] https://specs.amwa.tv/ms-04/ (free)

[17] https://ieeexplore.ieee.org/document/9973256 (paid)

.2 Media Nodes that derive an output stream from an ST 2110 input stream shall offer the time-preservation capability of section *7.9 RTP Timestamps of Derived Signals*.

.3 Additionally, Senders shall include `TSDELAY` in their SDP with a value representative of their transmission delay that can be used by control systems to infer the delays accumulated along signal processing paths.

.4 Receivers used to re-synchronize streams that are meant to be presented together – such as the audio of a video - shall verify if the RTP Timestamp of the incoming stream can be used for realignment with `TSMODE=SAMP` indicated in their SDP. They should expose their *Link Offset Delay* in their control API so that an external controller can set the delay it needs to correct.

III Operational Control

The ability to discover media sources and connect them to destinations easily and securely is a key requirement to enabling basic operation. Control of operational parameters enable multi-vendor integration of controllers.

.1 Media Nodes shall pass the tests for the supported NMOS specifications and versions using the latest NMOS Test Suite[18].

III.1 Discovery and Registration: AMWA IS-04

.1 Media Nodes shall support the latest published version of AMWA IS-04 *NMOS Discovery and Registration Specification*[19].

.2 They shall support IS-04 *Node API* with unicast announce so they can be discovered in large-scale routed networks.

.3 They shall support IS-04 *Registration API* calls so that they can register themselves in the registry.

.4 Sources that send essences (video, audio and ancillary data) that belong together shall use the *group hints* tag to get registered as a group, according to AMWA BCP-002-01 *Natural Grouping of NMOS Resources*[20].

.5 Senders shall provide their valid SDP information through the IS-04 *transport file*.

.6 When a Sender format configuration is modified (resolution, colour space, number of channels in an audio stream, etc.), the Sender Media Node shall signal the change through IS-04 to allow a Broadcast Controller to remake the connection if required.

.7 For Media Nodes using JPEG XS transport, they shall follow AMWA BCP-006-01 *NMOS With JPEG XS*[21].

.8 (Informative) Media Nodes will soon benefit from AMWA BCP-002-02 *Distinguishing Information for NMOS Node and Device Resources*[22] (Work in progress specification at the time of publication) to better identify the NMOS Resources in the registry.

III.2 Connection Management: AMWA IS-05

.1 Receivers shall support the latest published version of AMWA IS-05 *NMOS Device Connection*

[18] https://github.com/AMWA-TV/nmos-testing(free)

[19] https://specs.amwa.tv/is-04 (free)

[20] https://specs.amwa.tv/bcp-002-01 (free)

[21] https://specs.amwa.tv/bcp-006-01 (free)

[22] https://specs.amwa.tv/bcp-002-02 (free)

Management Specification[23] so that they can be connected to Senders that are registered in the IS-04 registry.

.2 Receivers shall support single and bulk connections and immediate, staged and scheduled activation so that they can do salvos and automated connection scenarios.

.3 Senders shall support *IS-05* for configuration of their Multicast groups so they can be assigned and managed via a controller.

III.3 Device Control: Open Methods

.1 Operational parameters of Media Nodes shall be controlled by an Open method so that they can be controlled by a third-party controller.

.2 If Media Nodes need to act on an event (e.g., GPI) or tally, Media Nodes may support AMWA IS-07 *NMOS Event and Tally Specification*[24].

.3 (Informative) Soon, operational parameters of Media Nodes could be controlled using AMWA IS-12 *NMOS Control Protocol*[25] and MS-05 *NMOS Control Architecture*[26] (Work In Progress Specification at the time of publication).

III.4 Audio Channel Mapping: AMWA IS-08

.1 Audio Receivers with a matrix capability shall use the latest published version of AMWA IS-08 *NMOS Audio Channel Mapping Specification*[27] so that a Broadcast Controller can select the channel arrangement within a stream to be used by the Receivers.

III.5 Topology discovery: LLDP

.1 Media Nodes shall support *Link Layer Discovery Protocol* (LLDP) part of IEEE 802.1AB[28] so that it can locate on which switch and interface it is connected to inform a Network Controller or as tool for troubleshooting and integrity check.

IV Configuration and Monitoring

Ease of configuration, monitoring and alarming is key to successfully operate and maintain an IP based facility.

IV.1 IP assignment and low-level configuration: DHCP

.1 Media Nodes shall support IETF RFC 2131 *Dynamic Host Configuration Protocol*[29] *(*DHCP) for static or dynamic IP assignment on all its interfaces so that it can be brought to the network with a proper management of IP addresses.

.2 Media Nodes shall have DHCP enabled at first time boot.

.3 Media Nodes shall support the use of the IETF RFC 2132 DHCP options[30]: 1 (Subnet Mask), 3 (Router), 6 (DNS), 12 (Hostname), 15 (DNS Domain name of client), 51 (Address Lease Time); 81 (Client Fully Qualified Domain Name).

.4 Depending on the application, when a relevant parameter of the Media Node is configurable

[23] https://specs.amwa.tv/is-05 (free)
[24] https://specs.amwa.tv/is-07 (free)
[25] https://specs.amwa.tv/is-12 (free)
[26] https://specs.amwa.tv/ms-05-01 (free)
[27] https://specs.amwa.tv/is-08 (free)
[28] https://ieeexplore.ieee.org/document/7433915 (paid)
[29] https://www.ietf.org/rfc/rfc2131.txt (free)
[30] https://www.ietf.org/rfc/rfc2132.txt (free)

through a DHCP option, it should support it. For instance: 2 (Time Offset in Seconds from UTC), 4 (Time Server), 7 (Log server), 66 (TFTP Server), 67 (Bootfile-Name), 119 (Domain Search List).

.5 Media Nodes may support IS-09 *System Parameters Specification*[31] to obtain global configuration parameters that are common across the system.

IV.2 Open configuration management

.1 Media Nodes shall be configurable by an Open method so that configuration can be managed by a common tool enabling change management, firmware updates, rollback, etc. Preferably, this should be done by supporting an Open API, a YANG model/OpenConfig, or at least by a remote config file or SSH.

.2 (Informative) AMWA is working on an API for getting and setting "day-one" configuration parameters via NMOS.

IV.3 Open monitoring protocols

.1 Media Nodes shall provide sufficient Alarming with ability to set a threshold for key fault indicators so that it brings the attention of the operator quickly to solve the issue; This shall be done using an Open method such as SNMPv3 (IETF RFC 3410[32] and others).

.2 Media Nodes shall provide real-time Telemetry with detailed information and measurements on timing, media streams and control in a way that a monitoring tool can aid diagnostics and predict system degradation before an outage occurs. This shall be done using Open methods e.g., OpenTelemetry[33], OpenConfig[34], OASIS Message Queue Telemetry Transport (MQTT)[35], etc.

.3 Media Node should provide Logging information about its state, so that it can be used for potential problem investigation. This Log information shall be available using Open methods such as RFC 5424 *Syslog protocol*[36] and should have the ability to set different levels of detail so that it can be collected by a remote server.

V. Security

Compared to isolated SDI connections, the use of IP networking for real-time media devices introduces additional cybersecurity risks.

Ensuring cybersecurity requires a continuous effort during the development and production lifetime of a Media Node, both from vendors and users. Vendors must follow cybersecurity best practices, implementing basic security features in Media Nodes and managing the product lifecycle and any discovered vulnerabilities. Moreover, U**sers** must also **keep up with security patches and deploy devices in a secure fashion.**

V.1 EBU R 143 Cybersecurity Controls

.1 To mitigate the most basic risks, Media Node shall at least implement:

- Critical items (P1) of the section AA. *Authentication and Authorization* of EBU R 143

[31] https://specs.amwa.tv/is-09 (free)

[32] https://www.ietf.org/rfc/rfc3410.txt (free)

[33] https://opentelemetry.io (free)

[34] https://www.openconfig.net (free)

[35] http://docs.oasis-open.org/mqtt/mqtt/v5.0/os/mqtt-v5.0-os.html (free)

[36] https://www.ietf.org/rfc/rfc5424.txt(free)

Cybersecurity for media vendor systems, software & service[37], version 2.3 or higher, preventing unauthorized access and should preferably allow AA-03 *Role based access control (RBAC)* and AA-01 *Central Authentication*.

- Critical items (P1) of item OS-02 *Vulnerability management* and OS-03 *Product lifecycle* to mitigate the risks of discovered vulnerabilities.

.2 Media Node shall comply with the vendor and product security controls with the critical provisions (P1) in EBU R 143. Non-compliance for specific controls shall be clearly indicated and motivated.

.3 Media Node should comply with the important recommendation (P2) security controls in EBU R 143.

.4 Media Node may comply with the best-practice arrangements (P3) security in EBU R 143.

V.2 Encrypted control communications

.1 All networked control traffic shall be protected using current authentication and encryption mechanisms as per EBU R 143 item *EN-03 Data in transit*.

.2 All NMOS APIs should support AMWA BCP-003 *Security recommendations for NMOS APIs*[38] and should support AMWA IS-10 *NMOS Authorization Specification*[39].

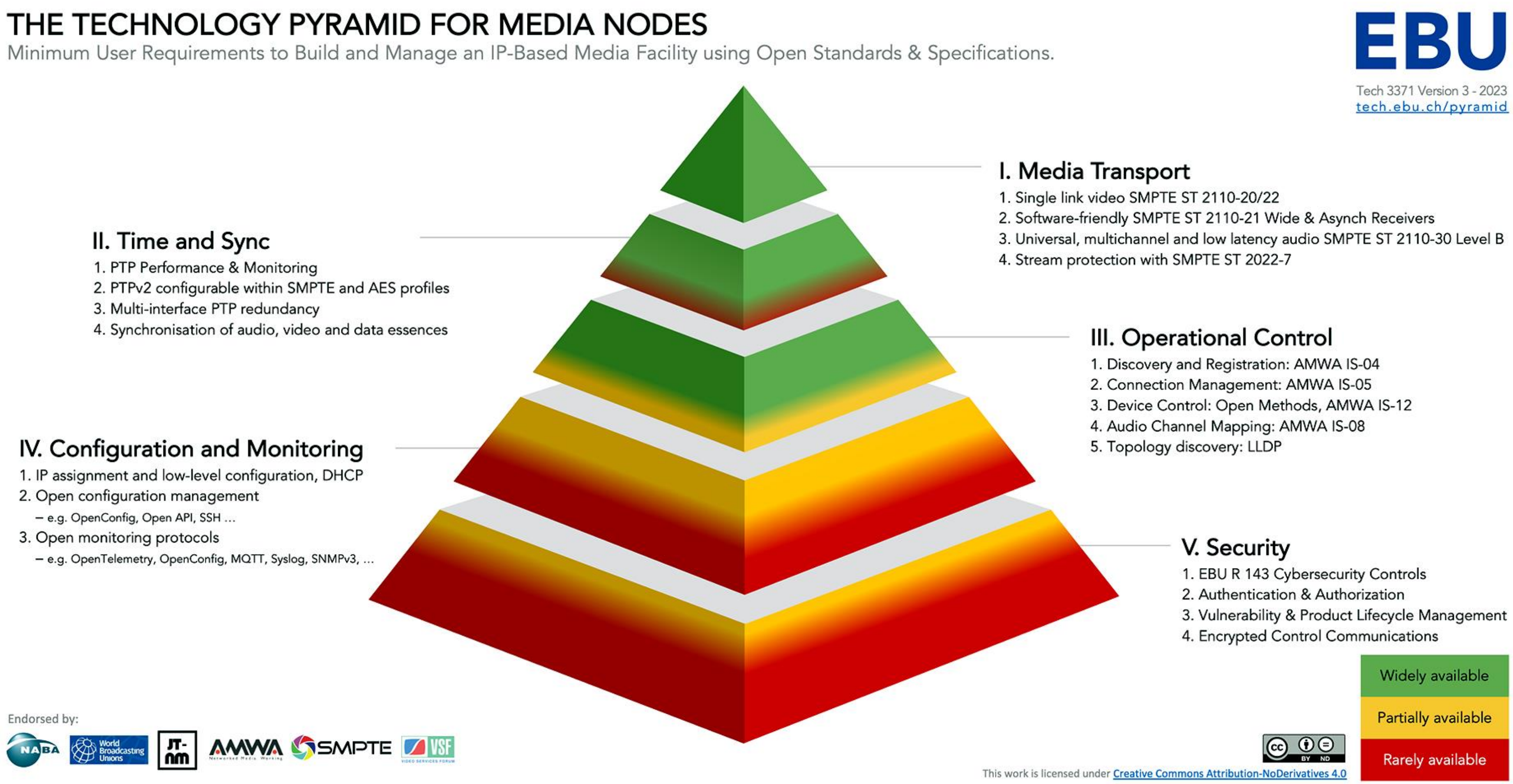
.3 Media Node vendors shall keep track of the current best practices to ensure their Media Nodes support secure versions of cryptographic protocols and deprecate insecure versions. For example, at the time of writing, media nodes shall support TLS 1.2 or later since IETF RFC 8996[40] deprecates TLS 1.0 and 1.1.

[37] https://tech.ebu.ch/publications/r143 (free)

[38] https://specs.amwa.tv/bcp-003 (free)

[39] https://specs.amwa.tv/is-10 (free)

[40] https://www.ietf.org/rfc/rfc8996.txt (free)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