Conformance Testing for the ATSC 3.0 Standard

This short white paper looks into the importance of creating a Test Suite for when new technology standards are created. Test Suites enable effective market adoption and interoperability in the marketplace.
1. Executive Summary

Conformance testing is a key factor in enabling the market introduction of devices that are compliant to a new standard. This testing facilitates the introduction of high quality devices meeting the specification which drives the adoption and conformance of the standard.

The availability of a test suite is a building block for conformance and interoperability. It allows the industry to reduce the barriers and costs associated with mass adoption of a new standard in the industry. With this in mind, the design, development, distribution, support and maintenance of the test suite needs to be carried out in accordance with the specific objectives and needs of the Industry. This whitepaper provides an overview of approaches on testing for conformance, and how these apply to the ATSC 3.0 standard.

2. Introduction

There are a number of components to testing and certifying a technology. Here are some definitions:

**Conformance testing** – A process to verify that implementations meet the technology specifications. It is based on the existence of common and unique test procedures, covering technology specifications and corresponding test materials in the form of a test suite. It is used to certify that implementations are conformant to the standard. As well as being utilised throughout development, it is performed on fully integrated devices that implement the standard. Conformance testing is a key component to ensure interoperability among devices of different vendors.

**Interoperability testing** – A method for determining whether two or more technology component implementations of a standard from different vendors function together. This is based on testing with available test material and implementations. Typically, the testing is aimed at checking that interoperability at a user level has been achieved. It is performed throughout the development of technology specifications, and via interoperability events/Plugfests. It is typically performed when enabling interoperability during the deployment of new technology or standards.

**Plugfest** – An event, usually done ad-hoc, either to validate an approach during the creation of a standard, or to bring implementers together to work through interoperability problems once the standard has been adopted. They are significantly more effective when test materials are agreed prior to the event. In the early drafting phases, Plugfests achieve some validation of a technical approach from a self-selecting sample of interested parties. Later, Plugfests can be used to drive
out practical interoperability challenges as the ecosystem matures and the standard starts to be used. They are usually voluntary, and tend to focus on a specific feature of the technology as opposed to exhaustively covering all cases, failure modes, or corner cases, i.e. outputting canonical test material is not the focus.

**Test suite** – A collection of test cases and a test harness, i.e. a framework for executing the test cases and a repository for storing test results. A test case verifies conformance or interoperability for a particular requirement in the technology specification. A test suite would usually be created for each technology specification, defined according to a specific test method. It is often created as a supporting component of a specification to foster adoption, conformance and hence, interoperability. Test materials typically are:

- Identifiable i.e. each test will usually have a unique identifier, a version number, a reference to the unique specification requirement being tested, the pre-requisite terminal capabilities required for a test to be valid, and a pass criteria.
- Packaged as a comprehensive and consistent set for distribution.
- Test each feature in as simple and minimal way as possible i.e. a unit test for each unique requirement in the specification.

** Certification Regime** – A process often used by industry bodies to manage and foster adoption of a technology, sometimes combined with the use of a logo that helps consumers and the industry identify and have confidence in the technology. It is usually composed of both conformance and interoperability testing.

3. The Need for a Conformance Test Suite

3.1 Why Build a Test Suite?

A test suite used for conformance testing a standard, is implemented against the specifications of that particular technology standard. It is a powerful tool to validate and improve the specifications themselves; the necessary precision of authoring a test case identifies specification ambiguities and forces them to be addressed early during the development of the standard, prior to market adoption.

The development of a common, unique test suite demonstrates that a standard is testable and ready for adoption.

Standard implementations always require extensive testing prior to entry in the market during the product development lifecycle. The availability of a common, unique test suite reduces overall cost in the industry for developing tests by reducing the need to duplicate internal development of test materials. A test suite can therefore improve time to market for equipment manufacturers, as a clear testable standard is available to develop against. A common set of test materials allows a minimum quality bar for technology providers to meet, and this drives better quality and an earlier availability of the technology.

Without the promotion and availability of a test suite, equipment manufacturers tend to implement reduced or incomplete versions of the standard, in parts of the specifications that are not testable or in use. This creates the potential to have features omitted, or incorrectly implemented, thus causing issues with devices in the field not working correctly.
3.2 The Importance of Test Suites in the Broadcasting Industry

Strong conformance to standards and interoperability is particularly important for a horizontal, retail market, like free-to-air DTT, where there is not a single operator/MSO who can enforce the end-to-end conformance of the content distribution to the Consumer Premises Equipment (CPE). The availability of a test suite that supports interoperability testing makes it easier to verify that CPE and head-ends work together, as it reduces the number of needed test cases: for M CPE and N head-ends only, M+N tests would be needed, not M*N.

In the horizontal market, a CPE vendor is normally making a one-time sale with no guarantee of future upgrades for the user. A good Test Suite can ensure all the required functionality is implemented and conforms to the specification at the point of sale. A lack of CPE conformance and interoperability can result in poor take-up of the technology, consumer irritation and high costs for operators trying to deal with end-user issues after deployment.

A high degree of interoperability can future-proof the network, allowing for the exploitation of new business models such as targeted advertising to work across the majority of devices. It also makes broadcaster head-end changes and new applications easier and cheaper to deploy, since there are less CPE specific conformance issues to work around.

In general, the availability of a test suite allows objective validation of CPE implementations for the purposes of receiver white lists, operator selection of receivers, logo schemes, etc.
3.3 The Role of a Conformance Test Suite within ATSC 3.0

ATSC 3.0 is a new standard, with advanced technologies defined for the physical, transport, application and runtime layers of the system. While each of these can, and will be developed and tested by adopters in their internal development and with plugfests, service launch will necessarily also involve integrating components from many parts of the fledgling ecosystem.

In order for successful launch of ATSC 3.0 services that are compelling and meet consumer expectations, final production devices on the market need to be interoperable and implement correctly the key features that will drive revenue for manufacturers and broadcasters.

A conformance test suite for ATSC 3.0 would validate the complete implementation of a device including the hardware, firmware, software and broadcast components to verify conformance to the wide range of standards set out in ATSC 3.0. It will iron out issues in the definition of the standard, adding clarity and correcting errors. It will also enable manufacturers to adopt the standard with speed and save wasteful duplication of effort.

The development of a test suite for ATSC 3.0 would ultimately speed up market adoption of the technology as well as facilitating consumer and industry satisfaction. Therefore, we believe the ATSC should dedicate resources to provide a conformance test suite, as time to market is critical for its members. Building a test suite would provide the most effective and practical measure to support implementation of this new standard.

4. Considerations

4.1 How to Define the Test Suite - What Should It Test and How Should It Work?

The process of building a conformance test suite begins with the specifications of the standard. For ATSC 3.0, being a comprehensive standard that spans from the physical to application layer with many different use cases, there is a need to prioritise test areas on the basis of key criteria for the success of the ATSC 3.0 standard:

- Individual requirements within technology specifications should be identified as:
  - Mandatory features,
  - Optional features that if implemented must be implemented as per the specification, or
  - Optional features.

- Use cases key to the success of services, devices and for consumers should be prioritised.

It is important to define early on the high level requirements and the role of a test suite as it vastly impacts test suite design. Whether the test suite is targeted mainly as an internal development aid (e.g. W3C test suites) or it is defined for conformance testing to be used within a certification regime, this has direct implications in the test suite coverage and design. In general, a conformance test suite has more requirements: test IDs and careful version management of the test suite, formal approval of the test cases, handling of broken tests, etc.

For conformance regimes it is recommended that a mechanism for test suite management is put in place, to be able to add tests as the standard evolves i.e. as the market demand emphasises some features over others or technologies develop and new requirements are identified. An adequate level of test coverage should be identified as this has a direct impact on testing times, complexity and overall cost. A trade-off between the cost of implementing a test suite versus the costs of executing a test suite versus
the quality of test results (i.e. the maximum likelihood of finding bugs) needs to be identified where the following best practices apply:

• Prioritisation of core functionality vs corner case areas of the specification and market input required.
• Prioritisation of testing of mandatory normative functionality, mandatory optional functionality, informative functionality (e.g. performance and stability requirements).

Once the above issues are broadly agreed, the best technical approach can be identified:

• It is a best practice to separate the individual use case or test purpose (sometimes known as test assertion) from actual test implementation as this helps to better capture and agree test coverage before wading into the implementation.
• Service model of the test harness, on the basis of whether it needs to be locally set up by each implementer or available in the cloud.
• Definition of features of the test harness e.g. whether it needs to simulate broadcast playout, include a test management system, serving of web applications, VOD streaming server, DRM server, etc.
• Level of automated Vs manual testing.
• Level of metadata required for each test case e.g. test ID, test purpose, specification clauses tested, mandatory/optional, etc.
• Decision on whether a single, standard test harness should be provided or if different test harnesses can be built against a well-defined test specification.
• Decision on format of the test results i.e. machine readable (e.g. XML or JSON) or manual (e.g. spreadsheet or documents). This will depend on what role the test report will play as part of a wider conformance regime.

The decision on the above points need to be commonly agreed and formalised in a test specification document which:

• Is agreed by the relevant industry consortia and stakeholders.
• Serves as the requirements document for whoever contributes or builds the test suite.
• Provides clarity and on what is in the test suite, what the overall testing approach is, what equipment needs to be purchased, etc.
4.2 How to Create the Test Suite?

The development of a test suite can follow different models and this choice depends on required timescales and available budget. Options are the following:

- **Sourcing material from a nominated supplier (or suppliers):**
  - In this case, the organisation needs to agree a method to select suppliers and a business model to fund the development (work can be paid in full, based on revenue share, supplier resale, etc.). This option has the advantage that industry can set the IPR model according to its specific needs. Supplier contracts give more predictability on scope, timescales, quality and also ongoing support and maintenance terms.

- **Voluntary effort:**
  - It is based on shared source code management e.g. GitHub, etc.
  - Its success deeply depends on a considerably higher level of project management resources to coordinate activities, which needs a dedicated budget.
  - Voluntary based test suite development will be longer, will have less predictable timescales, less predictable quality and will not necessarily get all the test material within the expected timelines.
  - Has a different approach to IPR. Agreement is needed on applicable open source contribution and distribution licenses.
  - Test suite maintenance and support is also voluntary and can become a burden on the organisation, which, without control can render a test suite difficult to use.
  - Voluntary contributions solicited via members tend to favour those with technology interests to pursue and so focus on some areas but not others of interest of the wider Industry.

The analysis of what other existing approaches and materials can be reused to create a test suite is highly recommended as this has the potential to significantly reduce cost and encourage take-up. As ATSC 3.0 makes reference to many existing standards it will be important to identify what existing materials can be used. The following analysis on existing materials should be carried out:

- Under what terms are they licensed i.e. is it allowed to modify and/or distribute the test materials?
- Do the tests need to be modified to fit the current purpose?
- How can they be integrated into the overall test suite design e.g. will the results be in an acceptable machine-readable format, do they have test IDs, etc.

Once the test suite materials are created, one of the most important stages of the process is defining a clear, a well-defined acceptance process for each test case so it is clear when a test case is ready to become part of the approved test suite. It is therefore recommended the following:

- Unfinished or non-validated tests cannot be allowed to be part of the test suite as they could be unwittingly used.
- Definition of a clear procedure for test material approval e.g. test case code reviews, execution of tests against implementations, static validation of HTML, JavaScript, etc.
- Organisation of Plugfests and interoperability events. If the test suite is made available at such an event it can serve to simultaneously find issues in receiver implementation as well as find issues in the test cases.
4.3 How to Distribute the Test Suite?

Once the test suite is created, there are different options available for the distribution of a test suite within the Industry:

- A suite could be freely available on an openly available server, or
- Restrictively distributed by an organisation under strict licensed terms.

The decision on the specific distribution mechanism depends on the nature of the certification regime and also on the degree of public domain information (website or otherwise) that is needed so that potential licensees know what is in the test suite and how to license and obtain it. The basic and final objective is to enable as wide a use as possible, while ensuring the test materials do not get misused or improperly distributed.

Also, the decision on license terms of the test suite will impact the distribution method and should cover the following topics:

- Identification of what terms from other contributors and IPR holders (open source or otherwise) need to be incorporated.
- Decision on whether users of the test suite should be expected to pay for using it.
- Decision on whether users of the test suite should be allowed to make claims of passing the test suite (e.g. if they haven’t run all the tests).
- Decision on whether users of the test suite should be allowed to modify the test suite before running the tests.
- Decision on whether users of the test suite should be allowed to redistribute the test suite.

Other important topics are related to how often new versions of the test suite should be redistributed, how it should be versioned and what is the sunrise period when an update is introduced. Particular care should be paid in case of an open source model for distribution as it needs to be defined how the enforcement of a particular set and version of tests would work. Test Suites are of low value if implementers are all running slightly different test suites.

The test suite can be distributed via different physical mechanisms, like for instance web download or physical media (it should be taken into account that it is possible for the test suite to be several tens of GB). Another important aspect is related to the most appropriate level of protection for the test suite e.g. password protected download, watermarking, etc. Also, the administrative point of view of distributing and licensing needs to be taken into account:

- Who manages the admin side of getting the test suite license agreement properly executed?
- Who collects payment (if applicable)
4.4 How to Provide Support and Maintenance for the Test Suite?

Mechanisms for support and maintenance of the test suite should be defined to allow a seamless evolution and improvement of the test suite for the benefit of the implementers and certification regimes.

Specifically, a process for fixing bugs in the test cases and the test harness should be defined, with explicit timelines for making fixes. Also an issue tracking system for reporting issues should be identified, together with a party that is responsible for maintaining it. This process should also define a test challenge procedure which identifies the party responsible for arbitrating whether a test case has a bug or the receiver implementation is at fault.

It should be clearly defined how fixes will be made available, i.e. trickled out or bundled into formal releases, depending upon the nature of the surrounding conformance regime, if any.

There should also be an agreed mechanism for support and maintenance work, i.e. whether it can be done under contract, or on a voluntary basis. It is also important to distinguish between maintenance releases (fixing or extending test cases for the same specification version) to upgrade releases (adding and modifying tests for a new version of the specification).
About Eurofins Digital Testing

Eurofins Digital Testing are leading media and device testing specialists, operating globally with testing facilities in the UK and Hong Kong. They provide specialised digital media consultancy, testing tools and services to validate digital media and device conformance for multiple standards across the world. Eurofins Digital Testing is part of the Eurofins Group and with over 16,000 employees worldwide, Eurofins has a network of more than 200 laboratories in 36 countries. The company delivers complete testing solutions to manufacturers, broadcasters, operators and related media and device supply chains, covering terrestrial, satellite, cable and IP delivery. This includes conformance and certification testing for standards and operator regimes as well as the provision of bespoke media delivery solutions.

Eurofins Digital Testing is an active member of, or, provides solutions for; key technologies and standards such as CI Plus, DVB, DASH-IF, Dolby, HbbTV, HE-AAC, HEVC, HGi, OIPF, RDK, UPnP and W3C.

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