Call for Proposals

For

ATSC-3.0 PHYSICAL LAYER

A Terrestrial Broadcast Standard

ATSC Technology Group 3 (ATSC 3.0)

March 26, 2013

1 Introduction

The Advanced Television Systems Committee (ATSC) is an international, non-profit organization developing voluntary standards for digital television systems. ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries. The ATSC DTV Standard (applicable documents include A/52 and A/53, available at http://www.atsc.org/) has been adopted for use in terrestrial broadcasting by the United States, Canada, Mexico, South Korea, Guatemala, Honduras and the Dominican Republic.

ATSC is in the process of developing a new standard with advanced performance and functionality made possible by new technologies and strategies. This next generation broadcast television standard known as ATSC 3.0 must provide improvements in performance, functionality and efficiency which are significant enough to warrant the challenges of a transition to a new system.

ATSC 3.0 should maximize the one-to-many (point-to-multipoint) attribute of broadcasting which enables a highly efficient means for distribution of popular content to an unlimited number of receivers. ATSC 3.0 should provide robust mobile services to un-tethered devices that move, such as phones, tablets, laptops and personal televisions. Since these devices are likely to move across borders, it is highly desirable that the specification contains core technologies which will have broad international acceptance and enable global interoperability. ATSC should continue its efforts to facilitate cooperation among the appropriate international organizations.

The goal of this Call for Proposals (CFP) is to identify technologies that could be combined to create a new physical layer of an ATSC 3.0 Standard.

2 Scope of Work

ATSC is in the process of developing a standard for a new delivery method of real-time and non-real-time television content and data to fixed and mobile devices.

The project includes an assessment of technical requirements, research of possible solutions, and development of documentation to provide a complete specification for fixed and mobile services using new broadcast signals. Wherever practical, the standard shall utilize and reference existing standards that are found to be effective solutions to meet the requirements. Robustness of service for devices operating within the ATSC 3.0 service area should exceed that of current ATSC systems and that of cell phone and other devices enabling services similar to ATSC. Consideration will be given to technologies and proposals that enable a smooth transition from existing systems for both broadcasters and consumers. The initial scope of work for TG3 is as follows:

> "The ATSC 3.0 Technology Group (called TG3) will develop voluntary technical Standards and Recommended Practices for the next-generation digital terrestrial television broadcast system. ATSC 3.0 is likely to be incompatible with current broadcast systems and therefore must provide improvements in performance, functionality and efficiency significant enough to warrant implementation of a non-backwards-compatible system. Interoperability with production systems and non-broadcast distribution systems should be considered."

It has been envisioned that the ATSC 3.0 system will be designed with a "layered" architecture in order to leverage the many advantages of such a system, particularly pertaining to upgradability and extensibility. The specific layering architecture will not be predetermined, but designed as the specification is created. To set a proper course toward that end, however, a generalized layering model for ATSC 3.0 has been proposed, as shown in Figure 1. This model may be further subdivided and more tightly defined as work progresses, but it provides basic guidance for work to begin on the system in discrete and clearly separable areas. The scope of this Call for Proposals is limited to the base layer of this model, the ATSC 3.0 Physical Layer, which corresponds to Layer 1 and 2 of the ISO/IEC 7498-1 model.

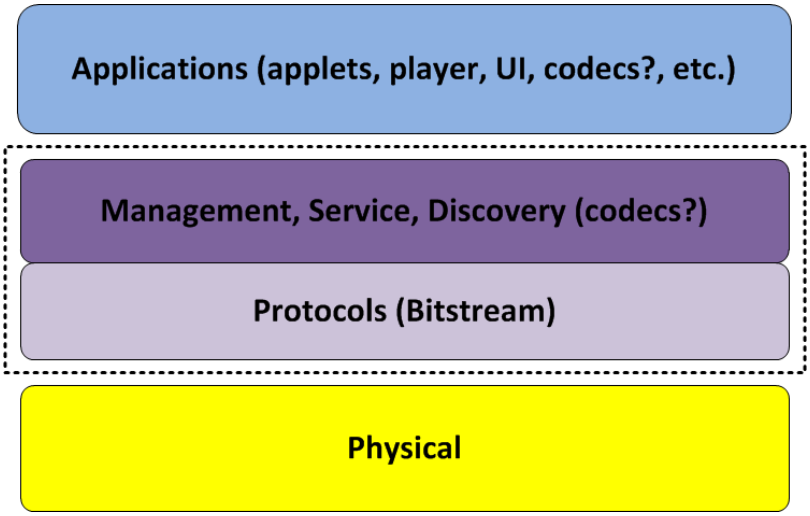

Figure 1 ATSC 3.0 Generalized Layer Architecture

ATSC's Specialist Group on Physical Layer, TG3/S2, will develop a skeletal physical layer, and its ad-hoc groups will add detail. As elements (pieces from proposals) of a physical layer are agreed to in the ad-hoc groups, a baseline physical layer model will be built. A top level physical layer model is described in Section 5 as a guide to how work will be divided up. One key point to be addressed is the transition from the current A/53 physical layer.

3 Glossary

There are multiple potential receiver types and reception conditions. To identify environments of receiving devices, four device types are defined to determine combined performance of a receiver and its antenna. Those are Fixed Device, Handheld Device, Vehicular Device and Portable Device. Further term definitions follow.

Fixed Device	A stationary receiving device with a separate high-mounted (10 m AGL) antenna.
Handheld Device	A small form factor receiving device suitable for carrying in hand, purse or pocket. The antenna is built-in, either internal or deployable. Normal operation is either at pedestrian speeds walking or at vehicular speeds in a moving vehicle.
Vehicular Device	A receiving device intended for operation at speeds up to those normally achieved by vehicles, such as automobiles, mini-vans or high-speed trains. The antenna would normally be roof-top or window-mounted.
Portable Device	A receiving device that uses a built-in or set-top antenna, transportable to different locations but stationary during use.
Quality of Service (QoS)	Quality of Service is the idea that a certain level of performance to a data flow can be measured and to some extent guaranteed in advance. It relies on metrics such as bit rate, delay, jitter, packet dropping probability, bit error rate, etc.
Ultra High Definition (UHD)	Video with an image format (sample structure) of 3840 × 2160 or 7680 × 4320 and other characteristics as specified in ITU-R BT.2020.
High Definition (HD)	Video with an image format (sample structure) of 1280 × 720 or 1920 x 1080 and other characteristics as specified in SMPTE ST 296, SMPTE ST 274, and ITU-R BT.709-5.
Real Time (RT)	Content that is consumed concurrent with reception.
Non-real Time (NRT)	Generally refers to content that is delivered in advance of its use and stored. May refer to

	content that is delivered faster than real-time, such that buffering is required in the receiving device.
MPEG-2 Transport Stream (TS)	ISO/IEC 13818-1.
Broadcast	Distribution architecture (as defined in an IEEE/IETF sense: broadcast/multicast/unicast – in other words, one-to-all, one-to-many, or one-to-one, as both Ethernet and IP architectures can be configured, for example). Broadcast feeds both an over-the-air service (it's the only architecture supported there), and an online distribution service (wired or wireless).
Channel	A digital medium that stores or transports a digital television stream.
Content	Content comprises one or several forms of Essence, each with its associated Metadata. Examples are Video Essence, Audio Essence, and Data Essence, plus the relevant Metadata. Thus, Content can include television programming, related or unrelated data, and software applications.
Essence	Fundamental program material, including video, audio, graphics, data and the like, that, together with Metadata, constitute content. Unlike Metadata, Essence has inherent stand-alone value. Essence often is described in terms of a specific type of program material, e.g., video essence, audio essence, data essence, and the like.
FEC	Forward Error Correction
Metadata	Data describing other data. Unlike Essence, Metadata has no inherent stand-alone value.
Service	A collection of media components presented to the user in aggregate; components can be of multiple media types; a Service can be either continuous or intermittent; a temporally continuous Service can consist of a sequence of events.

4 Evaluation of Physical Layers and Physical Layer Components

It is ATSC's intent to create a comprehensive and complete physical layer solution to enable ATSC 3.0 services and products drawing upon submitted physical layer technologies. This will be implemented using proponents' submissions or portions thereof. Selection of physical layer components (e.g. modulation and FEC coding) will be directed to optimizing the physical layer performance for fixed and mobile services in a variety of modes of operation. Section 5.2 lists a number of areas that are desired in the physical layer, with additional other technologies of interest listed in Section 5.3.

Wherever practical, ATSC would like to maximize interoperability by incorporating technologies from existing solutions. This may be accomplished by reference to existing standards, or particular parts of standards.

Respondents to this CFP are encouraged to submit complete or partial physical layer solutions fulfilling Section 5.2 requirements. Based on the submitted proposals, a skeleton framework (or frameworks, if necessary at first) will be developed and then specific elements of the framework(s) will be analyzed and evaluated. Please be advised that proposals of specific elements will be evaluated against similar elements of other proposals (physical layers or specific technologies), and for their contribution to over-all performance in a complete physical layer.

5 Functional Requirements and Physical Layer Model Definition

ATSC 3.0 is aiming to deliver terrestrial broadcast services in the low/high VHF and UHF TV broadcast bands to television receivers. The overall physical layer is intended to provide television service both to fixed devices and to mobile devices. An example physical layer is shown below. It is not intended to restrict technical solutions fulfilling the functional requirements in Section 5.2. General system level requirements are given to scope the technology given in Section 5.2.

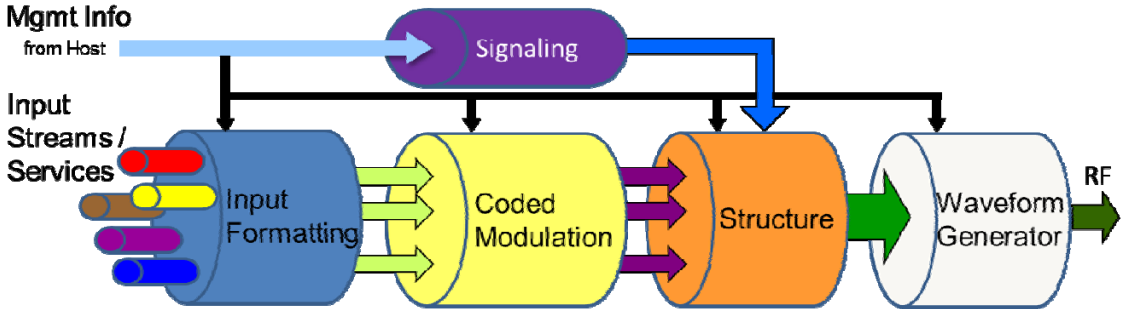

Figure 2 Example Physical Layer Diagram

5.1 End to End System Considerations

This document describes physical layer requirements. Furthermore, there are system considerations that are supported indirectly by the physical layer. Such considerations are listed in Table 1.

Table 1 Typical System Considerations

Aspect	Supported Capability	Comment
Physical Layer Input Protocol	Specified by proponents	Standard interface from next layer TBD
Supportable Bit Rate *	Sufficient to support UHDTV resolution for fixed devices and HDTV resolution for portable, handheld and vehicular devices	Subject to codec
Service Area	Indoor reception	Applies to fixed and portable devices
	Handheld and Vehicular Mobile reception	With embedded and/or external antennas
Service Classes and Essence Types	Real Time and Non Real Time; video, audio and other	For example, FEC can be optimized for the service classes in either physical or upper layers.
Applications	User-location determination	System clock with GPS Time accuracy
Emergency Services	Rapid wake up	Actual Spec TBD
Service Protection	End-to-end Conditional Access	Defined common encryption methods
Content Protection	Digital Rights Management	Defined common encryption methods
Separate Access	Service components can be accessed independently	Subject to packaging of service components e.g., video and primary audio may or may not be in common access unit
Return Channel	Unicast IP network	Interactive services require feedback from users

***** Note that it is the intention for the ATSC 3.0 system is to support delivery to fixed devices of content with video resolutions up to Ultra High Definition 3840 × 2160 at 60 fps, or such higher frame rates and/or resolutions as may be determined to be desirable and practical. The intention of the system is to support delivery to portable, handheld and vehicular devices of content with video resolution up to High Definition 1920 × 1080 at 60 fps. The system is also expected to support lower video resolutions and frame rates than those stated above. Support for delivery to fixed devices of content with video resolution higher than 3840 x 2160 is a possible goal of ATSC 3.0, but it is recognized there are several open issues in this regard. It is also recognized that improvements in other video parameters, such as higher dynamic range, increased color depth, and greater color gamut are also important. In addition, ATSC 3.0 is expected to support

audio formats with larger numbers of audio channels than currently used (for example, up to 22.2 channels), broadcast systems and/or other sound technologies.

Transition to the ATSC 3.0 Physical layer technology from the existing ATSC A/53 technology needs to be understood. Technologies and/or transition plans are desired to enable a smooth transition for broadcasters, Consumer Electronics manufacturers and consumers. With these system considerations in mind, a broad set of physical layer functional requirements for fixed receivers utilizing existing broadcast networks has been drafted. This scenario is the main usage model of terrestrial receivers today; therefore, this usage model must be covered as a baseline case. Other usage models for handheld, portable and vehicular devices, special antenna configurations, etc. are in consideration.

5.2 Functional Requirements

Table 2 Functional Requirements

Requirement	Value	Notes
Spectral Efficiency	**0.5 → 10.0 bits / s / Hz Multiple levels of content source coding quality shall be enabled.**	**C/N range of 0 → 31 dB with scalable bit rates, i.e. multi-mode. Different QoS types and levels (e.g., for FEC) for each service shall be supported.**
Higher Data Rate	**30% data rate increase of payload (or more) over 19.392658Mbit/sec in 6MHz Channel at 15dB C/N**	**The physical layer should also improve the reception robustness, e.g., better than 15 dB C/N, for better indoor and pedestrian reception.**
Maximum Excess BW	**< 0.15**	**Spectral efficiency (depends on mode of operation)**
Channel Model Tolerance	**Listed in table 4 below…**	**Additional channel models may be invoked during the evaluation process.**
Improved Reliability and Robustness	**Robustness to ISI, robust indoor reception by fixed and handheld devices, robust outdoor reception by fixed, portable, handheld and vehicular devices.**	**The new physical layer should be very robust against multipath distortion and should have strong physical layer synchronization capability**
SFN	**Support large service areas**	**Tolerate long man-made echoes**
Flexible Physical Layer	**Physical layer shall support configurations for differing**	**Fixed / Portable / Mobile devices in Urban / Rural settings with simultaneous support of**

	coverage scenarios, topographies and morphologies. Seamless changes to robustness and data rate of portions of streams shall be enabled.	**UHD and mobile HD services. Robust adaptive support for mobile and fixed services shall be supported.**
Portable Antenna Support	**Robust Reception with scalable bit rates**	**Layered service support (additional description available in ATSC A/174: 2011 Mobile Receiver Performance Guidelines)**
Emergency Alert System	**Fast reporting of emergency alerting (low latency message…more robust service)**	**EAS is important for public safety**
Future Extensibility	**Allow for independent data pipes (may imply block interleaving)**	**scalability / extensions could be possible with independent data pipes which enables physical layer expandability**
Preserve Battery Life	**Portable, Handheld and Vehicular device support.**	**Possible Time diversity to save battery life**
Cross Layer signaling	**Extra input/output ports to PHY**	
Multiple Service Support	**Physical layer shall enable concurrent delivery of multiple, separate service with different data rates and FEC**	**Each service can have different constant bit rates or varying bit rates.**
Bandwidth Agility	**Adjustable channel bandwidth above and below 6MHz in fixed increments**	**Ability to optimize usage of available spectrum.**

5.3 Other Technologies of Interest

This is a list of technologies in which at least some interest has been expressed. No decision has been reached on desirability or undesirability to include these technologies in a physical layer.

Table 3 Other Technologies of Interest

Target Attribute	Value	Notes
MIMO / MISO	**SFN-Distributed Open-Loop MIMO / MISO**	**Implementation complexities should be considered and a physical layer should work well without MIMO as well.**
Multiple latency modes	**Flexible interleaver settings**	**Low Latency for high CNR**
Transition Plan	**Method to move from A/53 8-VSB transmission to the next technology**	**Technology to migrate to the next generation of broadcast television**

5.4 Channel Models

The following channel models will be used to compare proposed physical layers and/or physical layer pieces. Signals from proposed physical layers / physical layer pieces should tolerate the channel models.

Table 4 Channel Models

Channel Impairments	Value	Notes
AWGN	**Gaussian Distribution**	**Physical layer Benchmark**
TU-6	**Doppler @ 200km/hr @ 695 MHz RF**	**Difficult mobile/pedestrian channel**
Single Path Rayleigh	**Doppler @ 3km/hr @ 177MHz RF**	**Single worst channel**
Pedestrian B	**Doppler @ 3km/hr, 200km/hr operating in the upper VHF(177MHz) and UHF (695MHz) television bands.**	**Most representative of suburban mobile/pedestrian channel**
Single 0dB Echo	**$h(t)=\delta(t) + \delta(t-0.9*\Delta MAX)*e^{jwt}$** **$\delta$ = impulse function** **ΔMAX = 100+µsec**	**Fixed channel reception. Natural echoes are known to reach 100+µsec, man-made echoes (SFN) can be longer. Modes are desired to support this. Note $w=2\pi f$; f = 1Hz**

5.5 Performance Measuring Technique

Table 5 Performance Measurement Technique

Parameter	Value	Notes
Data Loss	**1 error event in 5 seconds @ FEC output**	**Output of receiver FEC (e.g., a packet error of one IP packet containing 7 TS packets) is targeted as a measuring point, but is NOT intended to be an acceptable error rate in operation.**
SINR range	**0 to 31dB**	**Depending on bps/Hz capacity**

6 Schedule

6.1 Project Schedule

The target date for completion of the standards documentation should take account of the time needed for professional and consumer manufacturers to develop equipment for implementation before such services can be introduced. This emphasizes the need for the standards work to be started and completed as soon as possible. A few milestones of interest:

December 2013: Baseline physical layer proposal main elements complete.

May 2014: Baseline physical layer proposal complete.

December 2014: Final draft physical layer specification for Candidate Standard.

December 2015: Validation and verification by prototype implementation complete; Proposed Standard.

6.2 CFP Response Schedule

Responses to this CFP are due as follows:

August 23, 2013:

Respondent Information Form (Appendix 1)
Overview of Proposal
Statement regarding Bylaws and Procedures Review and agreement
Statement indicating intent to comply with the ATSC Patent Policy
Statement indicating intent to comply with the ATSC Copyright and Reference Policy
Statement Regarding Respondent Resources

September 27, 2013:

Detailed Description of Proposal
Compliance Chart (Appendix 2)

Consideration of responses received after the dates above shall be at the sole discretion of ATSC.

7 Form of Submission

A proposal of acceptable form responding to this CFP must include the following:

7.1 Respondent Information Form

Each proposal in response to this CFP must include a completed Respondent Information Form, given in Appendix 1.

7.2 Overview of Proposal

In order for TG3 to properly evaluate the proposal, the ideas should be described in as much detail as possible. Include the status of the work—e.g., concept only, simulation, or prototype. Provide a general description of the proposal, including the basic technologies used. Proposal performance and complexity assessment should also be given.

Respondents must further provide the following information:

- A broad, top level description of the proposal.
- Which areas of Section 5.2 and/or Section 5.3 the proposal addresses.

- What specific trade-offs are involved in implementing the proposed technology (i.e., robustness versus payload).
- A list of assumptions relating to the proposal, especially made to any included simulation results
- A list of existing standards from ATSC and other organizations to be incorporated in the proposed solution.

7.3 Detailed Proposal

Respondents must provide a detailed technical description of their proposal, including background information on basic technologies as appropriate. Respondents should provide detailed documentation suitable for use in an ATSC Standard.

Respondents are encouraged to provide as much information as possible to TG3 as to how the proposed solution is achieved and limitations, if any, so the initial evaluation process can move forward in a timely manner.

If special test procedures are required to evaluate the proposed physical layer, then identify—in general terms—the test procedures recommended.

7.4 Compliance Form

The Compliance Form for this CFP is given in Appendix 2. A completed copy of this form must be included as part of a respondent's submission.

8 Consideration Process

8.1 Areas to be considered

The following constitutes a partial list of considerations that may be used by TG3 to evaluate proposals as the project moves forward:

- Does the proposal adequately address the requirements identified in Section 5.2 of this CFP?
- If the proposal does not specify a complete physical layer, can it be combined easily other required technologies?
- Is there, in the judgment of TG3, a likelihood that the proposal will accomplish what the respondent has claimed?
- What is the physical layer efficiency including the tradeoffs between robustness, number and quality of services (including picture & sound) that can be achieved relative to the payload?
- To what extent is the physical layer extensible for future services?
- What is the complexity of the implementation for broadcasters and receiver component manufacturers?
- Can, in the judgment of TG3, the proposal be reduced to final form (hardware and/or software) within a time consistent with the Project Schedule described in Section 6.1.?

8.2 Combining Technologies

It is expected that some proposals resulting from this CFP may result in physical layers that are not mutually exclusive and which may be combined to provide greater functionality than originally proposed by the respondents. Such inter-physical layer functionality among respondents is encouraged by TG3. The ATSC reserves the right to combine various technologies into a final physical layer, which will then be documented as an ATSC Standard.

8.3 ATSC Due Process

Determination of whether a proposed methodology is incorporated into an ATSC Standard or other technical document shall be done in accordance with the due process of ATSC as described in the ATSC Bylaws and ATSC Procedures for Technology Group and Specialist Group Operation. Respondents to this CFP must state that they have reviewed and agree to abide by these ATSC rules.

9 Intellectual Property

All respondents to this CFP must follow the guidelines detailed in the following sections.

9.1 ATSC Patent Policy

Respondents to this CFP must state that they will comply with the ATSC Patent Policy.

9.2 Copyright

Respondents to this CFP must provide ATSC with the right to publish, copy, and distribute their proposed specifications as required by section 15 of the Operational Procedures for Technology Groups and Subcommittees (B/3).

9.3 Non-Disclosure

Consideration of proposals will take place in ATSC technical meetings, which are open to individuals with a direct and material interest in the work. Therefore, ATSC cannot enter into non-disclosure agreements. Respondents must be willing to provide ATSC with enough technical detail to enable the development of standards without a non-disclosure agreement.

9.4 Information Sharing

ATSC reserves the right to share responses to this CFP with other organizations supporting the development of next generation DTV standards.

10 Respondent Resources

Respondents must provide a statement that they have the financial ability and resources to participate in the ATSC evaluation process and, if selected, to fully develop their proposal into a working physical layer.

The end-result of the work of TG3 will be to produce an ATSC Standard. Accomplishing this goal will require testing—both laboratory and field tests are planned. This testing process may involve certain costs to respondents that—at the date of issue of this CFP—could not be estimated.

11 Subject to Change

ATSC reserves the right to modify or withdraw this CFP without notice.

12 No Commitment

ATSC reserves the right to not revise existing standards or to develop new standards based upon this CFP.

13 No Compensation

ATSC is a voluntary standards organization. ATSC will not provide compensation for responses to this CFP that result in specifications embodied in our Standards.

14 Submission of Responses to CFP

All submissions should be made in both an electronic and printed form. Send an electronic version (in Adobe Acrobat format) to:

Mark Richer, President, ATSC: mricher@atsc.org

Jerry Whitaker, Vice President, Standards Development, ATSC: jwhitaker@atsc.org In addition, send two printed copies of each submission to:

Mark Richer
President
Advanced Television Systems Committee
1776 K Street NW
Washington, D.C. 20006

+1 202 459 6690 (voice)

It is anticipated that respondents may have questions relating to this CFP. Questions relating to the work of TG3 should be directed to Mr. Whitaker or Mr. Richer.

APPENDIX 1 – RESPONDENT INFORMATION FORM

Respondent Name:	
Primary contact name:	
Address	
Mail stop or internal designation	
City, State (or Province)	
Postal Code and Country	
e-mail address	
Voice phone number	
Fax number	
Secondary contact name:	
Address	
Mail stop or internal designation	
City, State (or Province)	
Postal Code and Country	
e-mail address	
Voice phone number	
Fax number	

APPENDIX 2 – CFP COMPLIANCE CHART

Respondent Name:		
Required Item	**CFP Section**	**Response**
Respondent agrees to support ATSC in its efforts to create and evaluate complete systems up to and including hardware implementation.	1.0	□Yes □No
Respondent Information Form Submitted	6.1	□Yes □No
Overview of Proposal Submission	6.2	□Yes □No
Detailed Proposal submission	6.3	□Yes □No
Submission of statement regarding Bylaws and Procedures Review and agreement	8.1	□Yes □No
Submission of statement indicating intent to comply with the ATSC Patent Policy	8.2	□Yes □No
Submission of statement indicating intent to comply with the ATSC Copyright and Reference Policy	8.3	□Yes □No
Submission of statement Regarding Respondent Resources	9.0	□Yes □No