



Wireless Innovation Forum Contribution

[Note: This page is removed once the document has been balloted and approved]

Committee: Spectrum Sharing Committee, Working Group 4
Title: Overview of Wireless Innovation Forum Test and Certification Process and Plans
Short Title: WG4 Summary and Plans
Source: Greg Billock
Google
gbillock@google.com

James Neel
Federated Wireless
james.neel@federatedwireless.com

Date: 17 February 2016
Distribution: Unrestricted, Members

Document Summary: Summarizes WG4 activities and plans. Presents development schedule, processes, and test code management procedures.

Notes of Importance:

Action Desired: Request For Comment

Action Required for Closure: Present for consideration by FCC staff and invite staff to participate in WINNF as an observer and contributor to the development process.

Desired Disposition Date: 17 February 2016



Overview of Wireless Innovation Forum
Test and Certification Process and Plans

Working Document WINNF-16-P-0004

Version V0.3.7
17 February 2016

TERMS, CONDITIONS & NOTICES

This document has been prepared by the SSC Work Group 4 to assist The Software Defined Radio Forum Inc. (or its successors or assigns, hereafter “the Forum”). It may be amended or withdrawn at a later time and it is not binding on any member of the Forum or of the SSC Work Group 4.

Contributors to this document that have submitted copyrighted materials (the Submission) to the Forum for use in this document retain copyright ownership of their original work, while at the same time granting the Forum a non-exclusive, irrevocable, worldwide, perpetual, royalty-free license under the Submitter’s copyrights in the Submission to reproduce, distribute, publish, display, perform, and create derivative works of the Submission based on that original work for the purpose of developing this document under the Forum's own copyright.

Permission is granted to the Forum’s participants to copy any portion of this document for legitimate purposes of the Forum. Copying for monetary gain or for other non-Forum related purposes is prohibited.

THIS DOCUMENT IS BEING OFFERED WITHOUT ANY WARRANTY WHATSOEVER, AND IN PARTICULAR, ANY WARRANTY OF NON-INFRINGEMENT IS EXPRESSLY DISCLAIMED. ANY USE OF THIS SPECIFICATION SHALL BE MADE ENTIRELY AT THE IMPLEMENTER'S OWN RISK, AND NEITHER THE FORUM, NOR ANY OF ITS MEMBERS OR SUBMITTERS, SHALL HAVE ANY LIABILITY WHATSOEVER TO ANY IMPLEMENTER OR THIRD PARTY FOR ANY DAMAGES OF ANY NATURE WHATSOEVER, DIRECTLY OR INDIRECTLY, ARISING FROM THE USE OF THIS DOCUMENT.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the specification set forth in this document, and to provide supporting documentation.

This document was developed following the Forum's policy on restricted or controlled information (Policy 009) to ensure that that the document can be shared openly with other member organizations around the world. Additional Information on this policy can be found here: http://www.wirelessinnovation.org/page/Policies_and_Procedures

Although this document contains no restricted or controlled information, the specific implementation of concepts contain herein may be controlled under the laws of the country of origin for that implementation. Readers are encouraged, therefore, to consult with a cognizant authority prior to any further development.

Wireless Innovation Forum TM and SDR Forum TM are trademarks of the Software Defined Radio Forum Inc.

Table of Contents

TERMS, CONDITIONS & NOTICES	ii
1 Introduction	1
2 Scope	1
3 References	3
3.1 Normative references	3
3.2 Informative references	3
4 Definitions and abbreviations	4
5 Test and Certification Process.....	5
5.1 Test Case Classification.....	5
5.1.1 Class 1: Certification.....	5
5.1.2 Class 2: Acceptance	5
5.1.3 Class 3: Evidence.....	6
5.2 Test Cases	6
6 CBRS Architecture Test Code Structure	7
6.1 Test Harness Overview	7
6.2 GitHub Open Source Repository for WG4 Test and Certification	8
6.3 Core Functional Requirements	9
6.4 Test Example: Exclusion Zone Enforcement	11
6.5 Testing Approach for WINNF-Defined Messaging Protocols	12
6.6 Handling Sensitive Test Functionality.....	12
6.7 Process for Verifying Test Code Implements Test Specification.....	12
7 Notional Test Case Development Schedule.....	13
8 History.....	14

Overview of Wireless Innovation Forum Test and Certification Process and Plans

1 Introduction

This document outlines the approach taken by the Wireless Innovation Forum Spectrum Sharing Committee Work Group 4 (Test and Certification) as of February 17, 2016 for the development of conformance tests for components in the CBRS Functional Architecture. Specifically, it outlines the test development processes which are intended to provide evidence of conformance to the communication protocols and functional requirements developed by the Forum in its other activities, anticipated tests, interim test code development plans, and a notional test development schedule.

2 Scope

Pursuant to the FCC’s Report and Order [1] establishing the Part 96 rules for commercial operation in the 3550-3700 MHz band, the Wireless Innovation Forum decided on a functional system architecture intended to describe systems compliant with those rules.

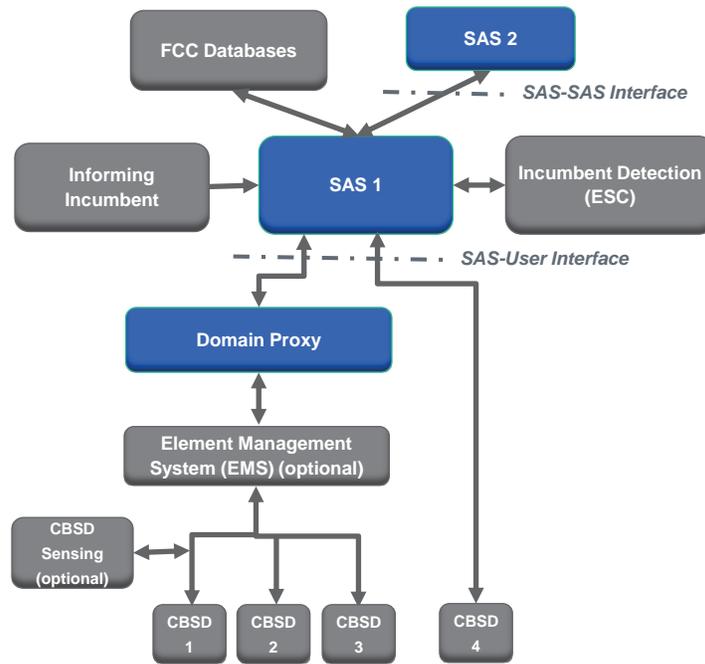


Figure 2-1: SAS Functional Architecture

Figure 2-1 depicts the CBRS Functional Architecture. Work Groups within the Forum have since developed requirements governing device and system operation, as well as specifications governing communications between the SAS and peer SASs in the system-of-systems defining the Spectrum Access System (the SAS-SAS interface), and the specifications describing communications between CBSDs seeking transmission authorization in the band and the SAS (the SAS-User interface).

The approach adopted by Work Group 4 (WG4) to the development of conformance tests for these communications protocols and other related device and system requirements is shown in Figure 2-2 below.

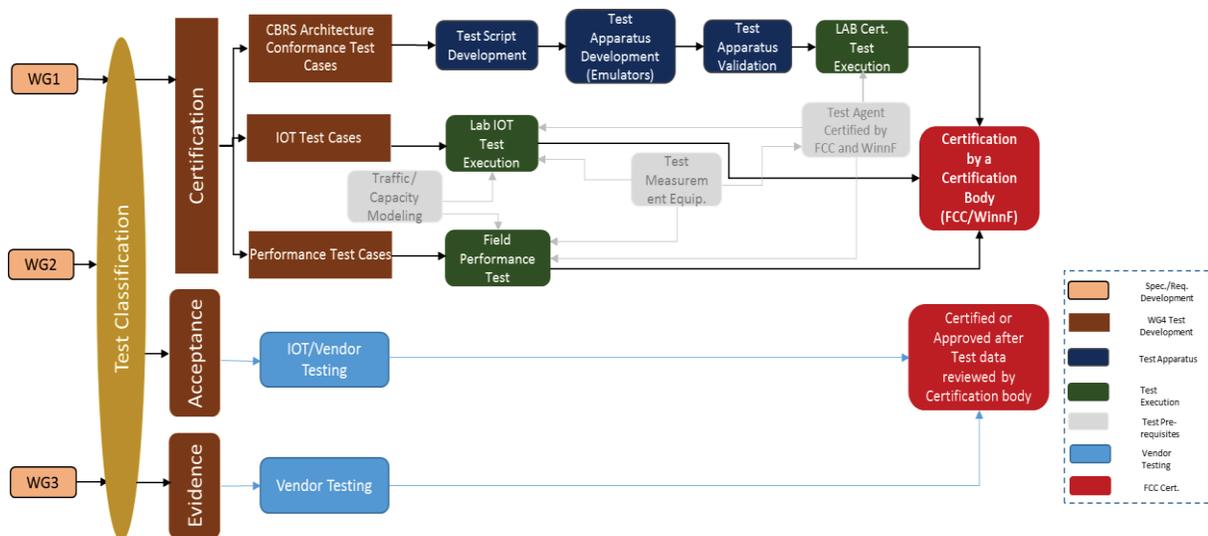


Figure 2-2: Work Group 4 Test and Certification Process

The requirements, protocols, specifications, and interfaces are defined by the Forum Work Groups 1, 2, and 3. The specifications are derived from FCC, NTIA, and DOD requirements. According to requirements and specifications defined by other work groups, WG4 develops the test cases. The certification test cases can be classified in three classes as follows:

- Functional test cases
- Interoperability test cases
- Field/Performance test cases

This technical report focuses on the WG4 approach to developing functional and interoperability test cases which demonstrate compliance with the SAS-SAS interface and SAS-User interfaces as

defined by Work Group 3 (WG3) by the SAS, CBSD, and Domain Proxy elements of the functional architecture. In addition to compliance with these interfaces, SAS administrators will need to meet other requirements to be certified for operation under Part 96. Therefore this process does not describe an approach resulting in an exhaustive set of Part 96 conformance tests. Rather, it focuses on the above communications interfaces as a way to capture the interoperability requirements on SAS, CBSD, and Domain Proxy system elements within the context of Part 96 requirements.

The approach taken by WG4, then, is to address a subset of Part 96 requirements in such a way that compliance with the tests demonstrates for CBSDs and Domain Proxies the ability to seek SAS authorization for transmission in a fashion that satisfies Part 96 requirements as well as interoperability with compliant SASs, and in such a way that compliance for SASs demonstrates the satisfaction of Part 96 requirements for the authorization of CBSDs and interoperability with peer SASs compliant to the Forum specifications.

To facilitate access to the test structure, the test cases will be converted to test scripts and be able to be run in an automated fashion by vendors, test lab facilities, and regulators. These test scripts will be hosted publicly in a source code repository described in Section 6.

3 References

3.1 Normative references

The following referenced documents are necessary for the application of the present document.

3.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [1] FCC Report and Order 15-47A1: "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band", FCC, April 17 2015, https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-47A1.pdf
- [2] FCC Further Notice of Proposed Rulemaking (FNPRM), FCC 14-19 GN Docket No. 12-354, "In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band ", FCC, April 23 2014, https://apps.fcc.gov/edocs_public/attachmatch/FCC-14-49A1.pdf
- [3] SSC-Winn Forum, WG1&3 Task Group, "SAS Functional Architecture", Document WINNF-15-P-0047, Version V1.0.0, September 7, 2015

- [4] SSC-WinnForum, "WG4 Certification Process", Working Document WINNF-15-P-0060, V0.5.0, August 6, 2015
- [5] "NTIA Letter to FCC on Commercial Operations in the 3550-3650 MHz Band," GN Docket No. 12-354, April 14, 2015. Available online: <http://www.ntia.doc.gov/fcc-filing/2015/ntia-letter-fcc-commercial-operations-3550-3650-MHz-band>
- [6] E. Drocella, et. al., "3.5 GHz Exclusion Zone Analyses and Methodology," NTIA Technical Report TR-15-517, June 2015. Available at <http://www.its.bldrdoc.gov/publications/2805.aspx>
- [7] Python Package Index, <https://pypi.python.org/pypi>
- [8] WG4 GitHub Repository, <https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System>
- [9] <http://robotframework.org/>
- [10] Wireless Telecommunications Bureau and Office of Engineering and Technology Establish Procedure and Deadline for Filing Spectrum Access System (SAS) Administrator(s) and Environmental Sensing Capability (ESC) Operator(s) Applications, DA 15-1426, Released December 16, 2015

4 Definitions and abbreviations

CBSD: *Citizens Broadband Radio Service Device:* Fixed or Portable Base stations or access points, or networks of such base stations or access points, that operate on a Priority Access or General Authorized Access basis in the Citizens Broadband Radio Service consistent with this rule part. Does not include End User Devices. For managed networks, it is likely that information exchanges between CBSDs and the SAS would be aggregated through a domain proxy such as a network access manager. For the purpose of this Technical Report, the CBSD may also include such a domain proxy [1,2].

CBRS: *Citizens Broadband Radio Services:* A three-tiered shared spectrum service in 3.5 GHz band that is regulated by the FCC's Report and Order, establishing rules for shared use by licensed and unlicensed users [1,2].

DOD: *Department of Defense*

EMS: Element Management System: Systems and applications for managing network elements on the network element-management layer of the Telecommunications Management Network model in a cellular or small cell wireless environment.

ESC: Environment Sensing Capability: A radio environment sensing element that is responsible for detecting the incumbent presence and operation.

FCC: Federal Communications Commission

IOT: Inter-Operability Test

NTIA: National Telecommunications and Information Administrations

RAN: Radio Access Network

SAS: Spectrum Access System: A system that maintains records of all authorized services and devices in the Citizens Broadband Radio Service frequency bands, is capable of determining the available channels at a specific geographic location, provides information on available channels to CBSDs that have been certified under the Commission's equipment authorization procedures, determines and enforces maximum power levels for CBSDs, and enforces protection criteria for Incumbent Users and Priority Access Licensees, and performs other functions as set forth in the FCC rules. Spectrum Access System shall also refer to multiple Spectrum Access Systems operating in coordination and in accordance with FCC rules [1, 2].

5 Test and Certification Process

5.1 Test Case Classification

In addition to certification specifications and requirements, WG4 test cases should include verification that systems under test support the required error conditions and fault management protection to support incumbent interference management and conform to Forum requirements.

To this end, the relationship between Forum-defined tests and the certification body may be classified in three classes: Certification, Acceptance, and Evidence.

5.1.1 Class 1: Certification

Testing takes place in an independent, secure and supervised test center or by “Certification partners” where selected requirements are tested and officially approved as having met a standard.

5.1.2 Class 2: Acceptance

Testing conducted to determine if the requirements or specifications (e.g. WG2/WG3 specifications) are met. This testing can be done in lab IOT testing similar to how telecommunications equipment is currently tested. This would be focused on black-box system level testing. These tests could be either functional, performance, or IOT test cases.

5.1.3 Class 3: Evidence

Material that is presented that furnishes proof of compliance or operation that will satisfy outside regulators that all necessary tests have been executed and passed.

5.2 Test Cases

The following are examples of tests under consideration in WG4 for possible inclusion in the CBRS Architecture Test and Certification Technical Report (WINNF-15-P-0061) currently under development:

- SAS Conformance Test Specifications
 - SAS Exclusion Zone Test Cases
 - Aggregate Interference Protections and Calculations
 - Protections for FSS Earth Stations
 - Protections for Grandfathered Wireless Protection Zones
 - Protections for Priority Access Licensees
 - Response to ESC Initiated Changes in Spectrum Availability
 - Interference Report Resolution
- SAS Performance Test Cases
- SAS-User Interface Conformance Test Specifications
 - CBSD States and State Transition
 - SAS Discovery
 - CBSD Device Registration
 - CBSD Spectrum Request
 - SAS Spectrum Reassignment/Revocation
 - CBSD Registration Request
 - CBSD Registration Response.
 - CBSD Spectrum Grant Request
 - SAS Spectrum Grant Response to CBSD
 - CBSD Heartbeat Request
 - CBSD Heartbeat Response
 - CBSD Relinquish Request
 - SAS Relinquish Response
 - CBSD Deregistration Request
 - SAS Deregistration Response
 - CBSD Spectrum Inquiry Request
 - SAS Spectrum Inquiry Response
 - CBSD Measurement Report
 - SAS Measurement Report Acknowledgement
- SAS-SAS Interface Conformance Test Specifications
 - Peer SAS discovery
 - Transport aspect
 - SAS-SAS Authentication
 - SAS-SAS Encryption Protocols

- SAS-SAS Information exchange
 - Bulk synchronization
 - Incremental synchronization
- SAS to SAS interface method and protocol details
 - SAS-SAS Protocols
 - SAS-SAS Methods
- Domain Proxy Conformance Test Specifications

6 CBRS Architecture Test Code Structure

6.1 Test Harness Overview

The test harness provides core functionality needed to implement script-based tests of major elements of the CBRS ecosystem, with focus on testing SAS, CBSD, and Domain Proxy elements of the Functional Architecture.¹ The test harness is intended to facilitate black-box / gray-box testing by injecting an externally defined script of messages and data into a device or system under test and comparing the device's or system's responses to expected responses. Examples of functionality envisioned for test harness include²:

- WG3 defined interfaces that conform to the interface protocols
- Other critical interfaces defined by other entities (e.g., FCC data interfaces)
- Test control logic
- Test post-processing
- Test script interface
- Mirrored data repository
- Timing
- Logging

The envisioned configuration of the test harness and the selection of externally defined test scripts may specify which tests are executed, which interfaces are needed, which types of devices are under test, and acceptable results. The test scripts that drive the operation of the test harness will be designed by WG4 as part of each test case's development [4]. Specific scripts may also be automatically generated as part of the test tools maintained by WG4 in its test code repository.³

Beyond what is required to implement the interfaces, the test harness is not envisioned to implement the logic required to emulate the calculations performed by a CBSD or SAS or CBSD

¹ Environmental Sensing Capability (ESC) testing is currently outside the scope of Work Group 4. WG4 will consider testing of the ESC should other WinnForum work groups or task groups establish ESC requirements.

² Similarly, tests that would require the test apparatus to emulate changing incumbent conditions depend on the creation of a standard ESC-SAS interface or other incumbent interface. Under such a scenario, emulating such interfaces should also be added to the test apparatus core functionality.

³ <https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System>

proxy. All such logic should be implicitly defined in the test scripts. This serves the following objectives:

- simplifies the test harness design and implementation
- reduces the need for potentially proprietary code in the test harness
- increases the flexibility of the test harness by externally defining its operation

This harness may also provide extensible interfaces that support the development of various test support tools, such as:

- human interface to control the configuration of the test harness (e.g., define suites of tests)
- result visualization
- test script generation

It is envisioned that the test harness implementation will make extensive use of existing and third party tools, such as the Robot test framework [9].

Compliance test development would follow a structure allowing for automated execution in a variety of contexts. As such, test development will be done in a public repository and under open source licensing policies described in Section 6.2.

6.2 GitHub Open Source Repository for WG4 Test and Certification

Work Group 4 (WG4) in the Wireless Innovation Forum's Spectrum Sharing Committee is developing code to execute its tests, which is maintained in the following publicly accessible open-source GitHub repository.

<https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System> [8]

GitHub was chosen to host the WG4 repository due to its popularity and familiarity among existing Forum members. The repository is being managed as a public repository to address the following objectives:

- The code should be available to the certification bodies (FCC, WINNF, and / or some other party that might be designated by the WINNF) for use in certification, thereby reducing the time required and uncertainty in the certification process.
- The code should be available to 3rd party developers so they can internally test their products, thereby reducing certification time.
- The code should be available to other spectrum researchers and developers who may be willing to comment on or contribute to the process.

While GitHub places no restrictions on the licensing terms applied to its hosted repositories, WG4 chose to make the repository open source under the Apache Software Foundation's version 2.0

license in accordance with the preceding goals, a part of which is its ease of use in derivative products, such as subsequent customizations made by an external certification.

6.3 Core Functional Requirements

To manipulate the interfaces of a SAS or CBSD under test, the test harness is envisioned to provide interfaces corresponding to the interfaces defined by WG3, including the following interfaces⁴:

- SAS-to-SAS [3]
- SAS-to-CBSD (proxy) [3]
- CBSD (proxy) -to-SAS [3]

The test harness interface modules should generally be capable of the following operations:

- transmitting messages to the device or system under test where the messages are defined in the test script with the timing specified by the test script
- receiving messages from the device or system under test and parsing the content of the message
- noting the times of transmission and reception
- logging the messages transmitted and received
- providing the parsed message results to the specified module(s) in the test harness (e.g., data repository, test logic, etc.)
- message queuing
- configuration control

⁴ If an ESC interface is standardized, then this should also be supported to allow testing of the behavior when incumbent activity changes.

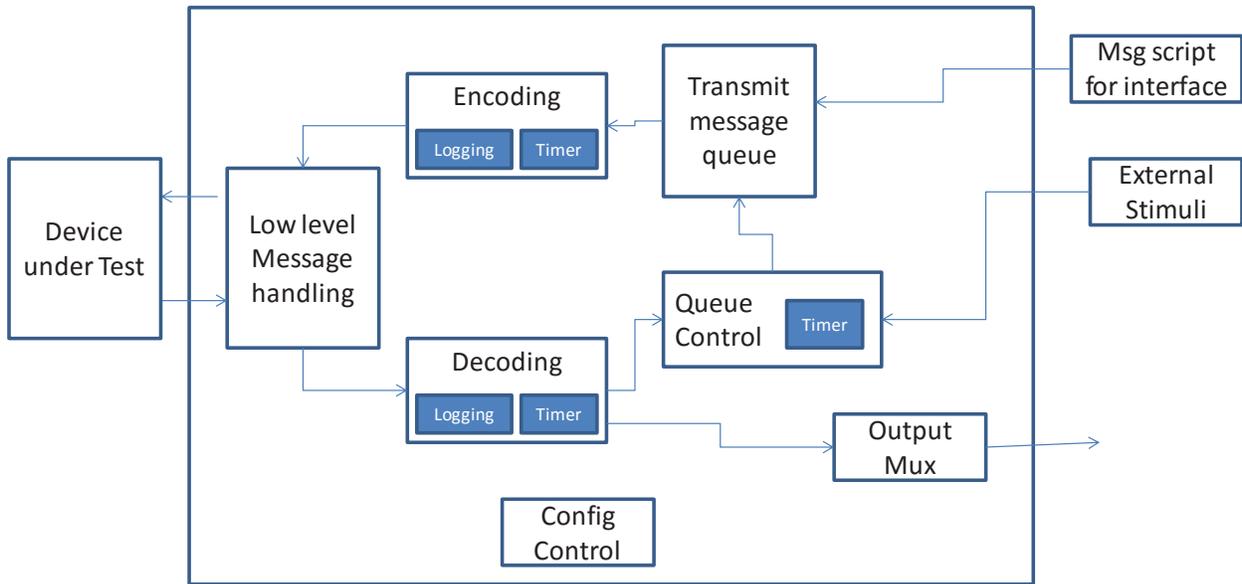


Figure 6-1 The Interface Module implements a single interface (e.g., SAS to SAS) by sending sequences of messages defined in the test script to the device under test.

It is anticipated that code implementing the various needed functionality for these components will be developed by Forum members.

The behavior of the test harness would be determined via externally generated test scripts defined in the test cases developed by WG4.

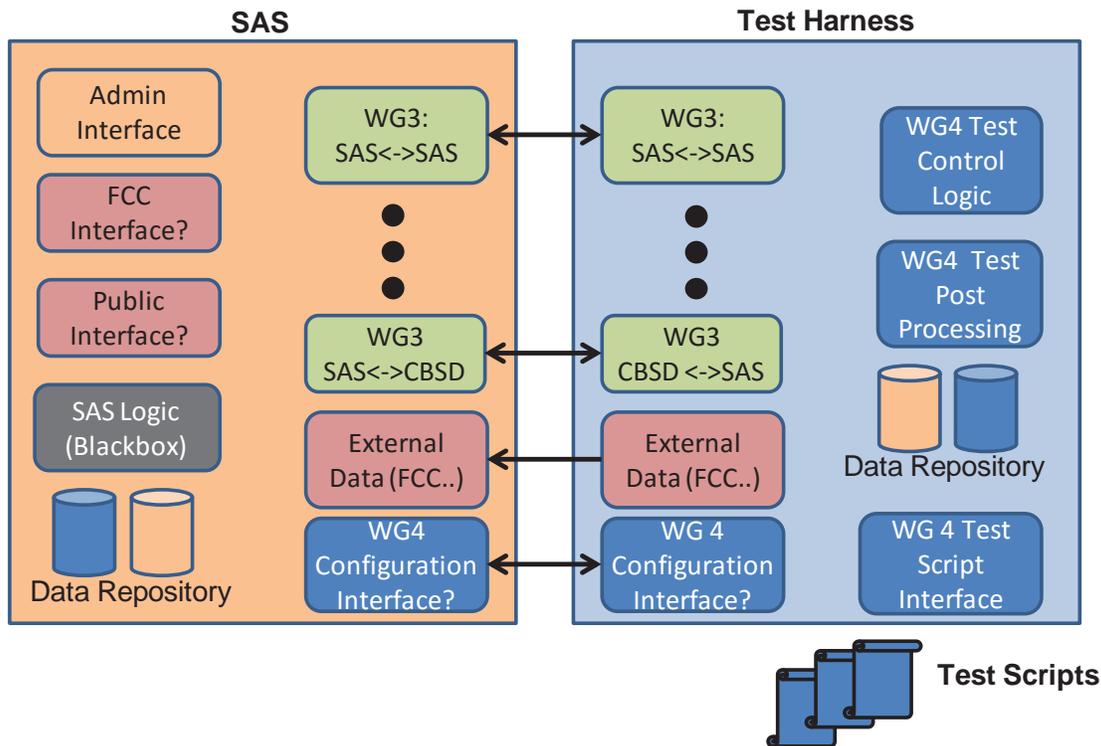


Figure 6-2: Connections of test harness to a test SAS. Items in green implement protocols defined in WG3. Items in red implement protocols defined outside of the WINNF. Items in blue are defined in WG4. Items in black are not directly accessible to the test harness. Items in peach are defined by the SAS administrator (the peach and blue data repositories reflect the mirroring / synchronization of data repositories).

6.4 Test Example: Exclusion Zone Enforcement

The following is an example of a test case envisioned by WG4, the specific details of this test case are still under development and are provide here for illustration.

To verify SAS implementation of the Ground Based Radar Exclusion Zones [5], a scripted sequence of simulated CBSD registrations and channel requests from carefully crafted locations are sent to the SAS under test via the SAS's CBSD / user interface from the Test Harness. The SAS's replies to the requests (also over the SAS to CBSD interface) are compared against known correct results and tabulated by the test harness to assess accuracy.

The test supports both manually specified locations (to allow the tester to evaluate particular points of interest) and randomly generated locations (to minimize the possibility of "building to the test" and to limit human bias in test location selection). Both points inside and outside of each exclusion zone are generated with extra emphasis placed on locations close to the boundaries of the exclusion zone as these are where implementation errors are more likely to arise. For every exclusion zone (i.e., ground-based radar sites, radiolocation sites, and shoreline exclusion zones), default parameters for test location generation are defined (e.g., test point density, distribution along edges, and distribution of points in the interior of exclusion zones).

6.5 Testing Approach for WINNF-Defined Messaging Protocols

To verify correct implementation of WINNF-Defined Messaging Protocols (e.g., SAS-CBSD and SAS-SAS), a scripted sequence of messages are presented to the system under test (e.g., SAS, CBSD, or CBSD proxy) via the associated interface under test. The system's replies to these messages (also over the interface under test) are compared against known correct results (messages) and tabulated by the test harness to assess accuracy.

6.6 Handling Sensitive Test Functionality

Because the test and certification process provides an external actor the capability to set a SAS or device under test into arbitrary states, certain test functions exposed to the Internet would thereby introduce a security risk. As such, some important test functions could be implemented via an interface other than through the WG3-defined public interfaces. This will enable a test facility to operate a system under test in a “safe” mode where it can be controlled in ways impossible in production deployment in order to verify compliance.

6.7 Process for Verifying Test Code Implements Test Specification

The following describes the process for verifying test code as envisioned by WG4, the specific details of the test code verification process is under development.

After at least two member organizations verify that a test specification is fully and correctly implemented in the WG4 test code repository, the test code implementation and verification results will be submitted as a contribution to WG4 for review and comment.

This process is intended to serve two purposes:

- Permit individual code contributions and developmental reviews to proceed in parallel to reduce test development time
- Ensure that broader multi-stakeholder community represented in WG4, some of whom may not have the time or expertise to participate in the "nuts and bolts" development of the test code for each individual test, can verify that the test scripts correctly implement the test specifications

The development status of test code for a test specification will be tracked using GitHub as follows:

- Member organization verification will be performed via a pull request to a development branch of the code
- After successful member organization verification, a pull request containing the new test code is issued to the main code branch, with the pull request used to track feedback from the broader WG4 community.
- After WG4 approval, the test code is added to the main branch.

7 Notional Test Case Development Schedule

The following shows the notional development schedule for WG4 Test Cases for starting and completing the test specifications and test code for various areas of tests. Note that the schedule depends on the availability of requirements from other groups in the Wireless Innovation Forum (e.g., SAS-SAS) and the FCC (e.g., FSS protections).

Test Area	2015						2016												
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Exclusion Zone	◇								◆										
SAS-CBSD						◇			◆										
SAS-SAS								◇				◆							
PAL Protections									◇					◆					
FSS Protections												◇			◆				
Grandfathered Wireless Systems														◇	◆				
ESC System Response														◇	◆				

8 History

Document history		
V0.0.1	January 4 th 2016	Outline for WG Review
V0.3.0	January 19 th 2016	Draft for WG Review
V0.4.0	January 27 th 2016	Draft for WG Review at Face-to-Face
V0.5.0	February 8 th 2016	Draft for SG Review
V0.6.0	February 16 th 2016	Additional edits following SG approval for release