Application of Google Inc. for Certification to Provide Spectrum Access System and Environmental Sensing Capability Services

GN Docket No. 15-319

Appendix D: Published Wireless Innovation Forum (WinnForum) Standards

Published WinnForum Standards are available at http://groups.winnforum.org/Reports and http://groups.winnforum.org/Specifications. To ease the Commission's review, several standards are attached here.

Appendix D.1 SAS-to-SAS Interface

Interim SAS to SAS Protocol Technical Report-B

Document WINNF-16-P-0003

Version V1.0.0
4 April 2016

Copyright © 2016 The Software Defined Radio Forum Inc. – All Rights Reserved

TERMS, CONDITIONS & NOTICES

This document has been prepared by Working Group 3 of the Spectrum Sharing Committee 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 It may be amended or withdrawn at a later time and it is not binding on any member of the Forum or of the Spectrum Sharing Committee.

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.

The Forum draws attention to the fact that it is claimed that compliance with this specification may involve the use of a patent ("IPR") concerning "Interim SAS to CBSD Protocol Technical Report-A", Document WINNF-15-P-0023, Version V1.0.0, 2 November 2015, referenced in Section 2.1.The Forum takes no position concerning the evidence, validity or scope of this IPR.

The holder of this IPR has assured the Forum that it is willing to license all IPR it owns and any third party IPR it has the right to sublicense which might be infringed by any implementation of this specification to the Forum and those licensees (members and non-members alike) desiring to implement this specification. Information may be obtained from:

QUALCOMM Incorporate
Attn: Thomas Rouse
5775 Morehouse Drive
San Diego, California, 92121
Email: ip.disclosure@qualcomm.com

Attention is also drawn to the possibility that the Forum shall not be responsible for identifying any or all such IPR.

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

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

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

Table of Contents

TERMS, CONDITIONS & NOTICES 1
Contributors 5
1 Introduction 1
2 References 1
2.1 Normative references 1
2.2 Informative references 1
3 Abbreviations 2
4 SAS-SAS Exchange Message Encoding and Transport 2
4.1 Message Encoding 2
4.2 Message Transport 3
5 SAS-SAS Exchange Message Definitions 4
5.1 SAS Administrator record 4
5.2 ESC Administrator record 4
5.3 SAS Implementation record 5
5.4 ESC Implementation record 6
5.5 Domain Proxy record 6
5.6 CBSD Device Type record 6
5.7 CBSD record 7
5.8 Incumbent record 8
5.9 Zone record 8
5.10 CBSD Operator record 9
5.11 Professional Installer record 9
5.12 Coordination Event record 10
6 SAS-SAS Exchange Protocol 11
6.1 Message Flow Overview 11
6.2 Message Methods, Categories and Types 12
6.2.1 Message Methods 12
6.2.2 URL endpoints 12
6.2.3 Message Categories 15
6.2.4 Message Types 16
6.2.5 Time/Date formats 16
6.3 Message Contents Aggregation 16
6.4 Message Definition 16
6.4.1 Definition 16
6.4.2 JSON Representation Examples 19

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

List of Figures

Figure 1 SAS to SAS Exchange Flow 12

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

Contributors

The following individuals made significant contributions to this document:

Editors: James Ni (Federated Wireless), Greg Billock (Google)

Other Member Representatives:

- Alcatel-Lucent: Milind Buddhikot
- AT&T: Neeti Tandon
- Ericsson: Kumar Balachandran, Mark Racek
- Federated Wireless: Masoud Olfat
- Google: Greg Billock
- Key Bridge Global: Jesse Caulfield
- Motorola Solutions: David Gurney
- NIST: Anirudha Sahoo
- Nokia Networks: Anatoly Andrianov, Al Hirsbrunner, Steve Magee, Prakash Moorut
- Qualcomm: Doug Knisely
- Verizon: Max Solondz, Naseem Khan

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

SAS to SAS Exchange Protocol

1 Introduction

This document is a Technical Report describing the protocol by which Spectrum Access Systems (SAS) exchange information as required by the FCC Report and Order 15-47 in order to facilitate access to the band by Citizen's Broadband Radio Service Devices (CBSDs) connected to other SASs, coordinate operations between and among such CBSDs, provide a stable radio frequency environment for Priority Access License (PAL) licensees, and other functions required for orderly spectrum administration and the fulfillment by the SAS of the responsibilities given it under Part 96.

2 References

2.1 Normative references

[N.1]. "Interim SAS to SAS Protocol Technical Report-A", Wireless Innovation Forum Working Document WINNF-15-P-0051.

[N.2]. "The GeoJSON Format Specification 1.0", 16 June 2008.

[N.3]. "SAS to CBSD Protocol Technical Report-B", Wireless Innovation Forum Working Document WINNF-15-P-0062.

2.2 Informative references

[I.1]. "SAS Functional Architecture", Working Document WINNF-15-P-0047, Version V0.3.6, 12 June 2015

[I.2]. "Report and Order and Second Further Notice of Proposed Rulemaking", FCC, FCC 15-47, April 17, 2015.

[I.3]. "CBRS Communications Security Technical Report", Wireless Innovation Forum WINNF-15-P-0065.

[I.4]. "The application/json Media Type for JavaScript Object Notation (JSON)" RFC 4627.

[I.5]. "Interim SAS to CBSD Protocol Technical Report-A", Wireless Innovation Forum Working Document WINNF-15-P-0023.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

3 Abbreviations

Abbreviation	Description
CBSD	*Citizens Broadband Radio Service Device*
ESC	Environmental Sensing Capability
FCC	Federal Communications Commission
FRN	FCC Registration Number
HTTP	Hypertext Transfer Protocol
HTTPS	Secure HTTP (e.g. with TLS)
ID	Identifier
JSON	Javascript Object Notation
PAL	Priority Access License
SAS	Spectrum Access System
TLS	Transport Layer Security
URL	Universal Resource Locator
UTC	Coordinated Universal Time

4 SAS-SAS Exchange Message Encoding and Transport

This section specifies the message encoding and transport methods to be used for all messages specified in section 5 and 6, as well as globally applicable error condition indications and handling.

4.1 Message Encoding

SAS to SAS exchange messages are to be encoded using JSON (JavaScript Object Notation), a widely accepted network data representation and exchange protocol. JSON encoded messages are in the form of human readable single or multiple of “name”/“value” pair(s), where the “name” is typically a self-descriptive unique string tag identifying the information to be represented and the “value” is the information to be carried. JSON allows a “value” be one of the four primitive types (respectively, String, Number, Boolean and Null) and two structured types (JSON object and array). Brief definitions of all above primitive and structured data types are as follows:

- String: a readable string begins and ends with double quotation marks. All Unicode characters can be placed within the quotation marks. Double quotation mark, backslash and control characters must be proceeded by an escape character (\ i.e. backslash).

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

- Number: a signed integer or a floating number. A floating number can be represented using regular decimal format or scientific exponential format.
- Boolean: a Boolean value this indicates either true or false.
- Null: a null value representation of the value of a string or an object or an array type when the required value is not available.
- Object: A self-contained JSON object enclosed in a pair of curly brackets.
- Array: a value array of any one of the String, Number, Boolean, object and array types, enclosed by square brackets.

A JSON representation of the SAS Administration record, for example, is as follows:

```
{
    "ID" : "admin/sas/elgoogSasAdministrator1",
    "name" : "Elgoog Inc. SAS Administrator No.1",
    "contactInformation" : [
        {
            "name" :  "John Dole",
            "phone" : "(202)123-5678",
            "email" : "john.dole@elgoog.com"
        },
        {
            "name" :  "Lisa Dole",
            "phone" : "(202)123-5679",
            "email" : "lisa.dole@elgoog.com"
        }
    ],
    "fccInformation" : {
        "certificationDate" : [
            "12-30-2016 11:10:11 EST",
            "05-30-2016 11:00:00 EST",
            "01-30-2016 11:25:23 EST"
        ]
    }
}
```

4.2 Message Transport

For secure and convenient SAS to SAS information exchange, two essential requirements must be met at the SAS to SAS transport layer. First of all, it must guarantee the transport security requirement as addressed in the WG2 security architecture. Secondly, it needs to satisfy a general purpose requirement that allows broad applications and easy adaption. HTTP over Transport Layer Security (TLS) (HTTPS) is an ideal option that satisfies both the two requirements.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

5 SAS-SAS Exchange Message Definitions

This section will contain detailed field-by-field specifications for the SAS to SAS messages for each of the following exchange record types.

5.1 SAS Administrator record

Field	Data Type	Field Definition
ID	string	• **Format**: admin/sas/$ADMINISTRATOR • **$ADMINISTRATOR**: SAS-CA certified unique SAS administrator identifier
name	string	Human-readable local significant string
contactInformation	object: ContactInformation	Contains various contact information
fccInformation	object: FCCInformation	Contains the FCC certification information

5.2 ESC Administrator record

Field	Data Type	Field Definition
ID	string	• **Format**: admin/esc/$ADMINISTRATOR • **$ADMINISTRATOR**: SAS-CA certified unique ESC administrator identifier
name	string	Human-readable local significant string
contactInformation	object: ContactInformation	Contains various contact information
fccInformation	object: FCCInformation	Contains the FCC certification information

FCCInformation object:

Field	Data Type	Field Definition
certificationId	string	The FCC-issued certification ID
certificationDate	string	Date of certification, in format YYYY-MM-DD
certificationExpiration	string	Date of certification expiration, in format YYYY-MM-DD

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

certificationConditions	string	Human-readable string or reference annotating the certification
FRN	string	The FRN of the certified entity
sasPhase	string	If this is a SAS information object, defines the Phase (“1” or “2”) of certification.
deviceFccId	string	For a device certification, the FCC ID of the device.

ContactInformation object:

This object should be of type jCard (See RFC 7095). (Alternate format: schema.org Person type?)

- Contact name: Human-readable string
- Primary phone number: telephone number string
- Secondary phone number: telephone number string
- Email: email address string
- Alternative email: email address string
- Address: Human-readable address string
- Notes: any descriptive notes
- Should be able to represent multiple contact points and/or methods

5.3 SAS Implementation record

Field	Data Type	Field Definition
ID	string	• **Format**: sas/$ADMINISTRATOR/$IMPLEMENTATION • **$ADMINISTRATOR**: SAS-CA certified unique SAS administrator identifier • **$IMPLEMENTATION**: SAS-CA certified unique SAS implementation instance identifier
name	string	Human-readable local significant string
administrator	string	• **Reference**: SAS Administrator ID
contactInformation	object: ContactInformation	Contains various contact information
publicKey	string	• **Format**: X.509 key
fccInformation	object: FCCInformation	Contains the FCC certification information
escId	array of string	Array of ESC Implementation IDs • **Reference**: each name entry is in references to an ESC implementation instance
url	string	• **Format**: public URL

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

sasToSasUrl	string	• **Format**: Machine-addressable URL
sasToCbsdUrl	string	• **Format**: Machine-addressable URL

5.4 ESC Implementation record

Field	Date Type	Field Definition
ID	string	• **Format**: esc/$ADMINISTRATOR/$IMPLEMENTATION • **$ADMINISTRATOR**: SAS-CA certified unique SAS administrator identifier • **$IMPLEMENTATION**: SAS-CA certified unique ESC implementation instance identifier
name	string	Human-readable local significant string
administrator	string	• **Reference**: ESC Administrator ID
contactInformation	object: ContactInformation	Contains various contact information
publicKey	string	• **Format**: X.509 key
fccInformation	object: FCCInformation	Contains the FCC certification information

5.5 Domain Proxy record

Field	Data Type	Field Definition
ID	string	• **Format**: domain/$DOMAIN_PROXY • **$DOMAIN_PROXY**: SAS-CA certified unique Domain Proxy implementation instance identifier
name	string	Human-readable local significant string
contactInformation	object: ContactInformation	Contains various contact information
publicKey	string	• **Format**: X.509 key
fccInformation	object: FCCInformation	structured object contains the FCC certification information

5.6 CBSD Device Type record

Field	Data Type	Field Definition
ID	string	• **Format**: cbsd-type/$FCC_ID • **$FCC_ID**: the FCC ID assigned to the device type in the FCC equipment authorization process

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

name	string	Human-readable local significant string, e.g. model number
manufacturer	string	Human-readable string. The device manufacturer.
contactInformation	object: ContactInformation	Contains various contact information
fccInformation	object: FCCInformation	Contains the FCC certification information
deviceCharacteristics	object: DeviceCharacteristics	Device parameters for the device type.

DeviceCharacteristics object:

Field	Data Type	Field Definition
airInterface	object: AirInterface (See SAS-CBSD spec)	Air Interface definition of this device
antennaGain	number	Gain of the antenna (in dB)
antennaBeamwidth	number	3 dB horizontal beamwidth of the antenna (in degrees)
antennaVerticalBeamwidth	number	3 dB vertical beamwidth of the antenna (in degrees)

5.7 CBSD record

Field	Data Type	Field Definition
ID	string	• **Format**: cbsd/$FCC_ID/$SerialNumber • **$FCC_ID**: the FCC ID assigned to the device type in the FCC equipment authorization process • **$SerialNumber**: the device manufacturer serial number that is unique within the FCC ID namespace scope
publicKey	string	• **Format**: X.509 key
installationParam	object: InstallationParam (see SAS-CBSD TR-B)	Contains device installation parameters
operationParam	array of OperationParam	Contains the outstanding grants

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

	(see SAS-CBSD TR-B)	

5.8 Incumbent record

Field	Data Type	Field Definition
ID	string	• **Format**: incumbent/$SOURCE/$ID • **$SOURCE**: the source of the incumbent information such as a specific FCC database, e.g. IBFS • **$ID**: the identification of the referenced incumbent such as an FSS station call sign
type	string	• **Format:** enumeration value describing the incumbent class: “FSS”, “Federal”, or “3650”
deploymentParam	Array of DeploymentParam	Contains incumbent deployment parameters

DeploymentParam object:

installationParam	object: InstallationParam (see SAS-CBSD TR-B)	Contains incumbent deployment parameters
operationParam	object: OperationParam (see SAS-CBSD TR-B)	Contains incumbent operating parameters.
protectionContour	string	• **Reference**: ID of a Zone record

5.9 Zone record

Field	Data Type	Field Definition
ID	string	• **Format**: zone/$CREATOR/$ID • **$CREATOR**: SAS Administrator ID or ESC Administrator ID or static government zone definition source ID • **$ID**: the identification of the referenced zone defined by the $CREATOR
name	string	Human-readable local significant string

creator	string	• **Format**: Human-readable string, one of the following:
		  • SAS Administrator record ID
		  • ESC Administrator record ID

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

		• Static government zone definition source ID
usage	string	• **Format:** Enumeration value describing the usage of the zone: • "census tract" • "service area" • "protection contour" • "XdBm contour", e.g. -80dBm, -95dBm, -110dBm • "antenna pattern" • "exclusion zone"
zone	object: GeoJSON ([N.2])	Self-contained geometry description of the addressed zone.

5.10 CBSD Operator record

Field	Data Type	Field Definition
ID	string	• **Format**: operator/$SAS_ADMINISTRATOR/$ID • **$SAS_ADMINISTRATOR**: SAS Administrator ID • **$ID**: Human-readable string, SAS Administrator Assigned CBSD Operator ID
name	string	Human-readable local significant string
contactInformation	object: ContactInformation	Contains various contact information
acknowledgement	string	Human-readable string communicating operator acceptance of interference from federal radars

5.11 Professional Installer record

Field	Data Type	Field Definition
ID	string	• **Format**: installer/$INSTALLER • **$INSTALLER**: SAS-CA certified unique installer identifier
name	string	Human-readable local significant string
publicKey	string	• **Format**: X.509 key

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

contactInformation	object: ContactInformation	Contains various contact information
piCertificationInformation	object: PICertificationInformation	Contains the certification information

PICertificationInformation object:

Field	Data Type	Field Definition
certificationBody	string	Issuer of the Professional Installer certificate
certificationID	string	The certification ID created by the issuer
certificationDate	string	Date of certification, in format YYYY-MM-DD
certificationExpiration	string	Date of certification expiration, in format YYYY-MM-DD
certificationConditions	string	Human-readable string or reference annotating the certification

5.12 Coordination Event record

Field	Data Type	Field Definition
ID	string	• **Format**: coordination/$SAS_ADMINISTRATOR/$ID • **$SAS_ADMINISTRATOR**: SAS Administrator ID • **$ID**: event record ID
name	string	• **Format**: Human-readable local unique reference to the event

creator	string	• **Format**: Human-readable string, one of the following:
		  • SAS Administrator record ID
		  • ESC Administrator record ID
		  • Static government zone definition source ID

creationDate	string	• **Format**: structured object describing time and date
expirationDate	string	• **Format**: structured object describing time and date
description	string	• **Format**: Human-readable description of the coordination event.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

coordinationType	string	• **Format**: Enumerated value indicating the type of event. [TBD]
coordinationDevice	array of string	• **Reference**: ID of the involved device (e.g. a CBSD ID or an incumbent ID)
coordinationZone	array of string	• **Reference**: Array of IDs of the involved zones

coordinationData	object: type is dependent upon the CoordinationType field	• **Format**: Structured object describing the coordination data
		  • Per event specific
		  • (TBD) Extensible anchor for any other metadata needed for automated handling of particular coordination events.

6 SAS-SAS Exchange Protocol

This section specifies in detail the protocol two SASs will use in exchanging messages of the types specified in section 5.

6.1 Message Flow Overview

The message exchanges between two SASs are of the typical client-server request and response flows. The two SASs can symmetrically issue requests to their respective peer SASs independently and the peer SASs respond with either success or error responses. As already specified in the preceding TR-A[I.5], the SAS to SAS information exchanges allows flexible data push and pull for

- a specific data type record instance,
- a bulk of data record instances of a specific type created in a specific time range,
- wildcard retrieval or dump for all data type records in a specific time range and
- full activity retrieval and dump since a specific time.

In terms of message flows and procedures, all above cases are same except the differences in the request and response message contents exchanged between the two SASs, as shown in Figure 1 below.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

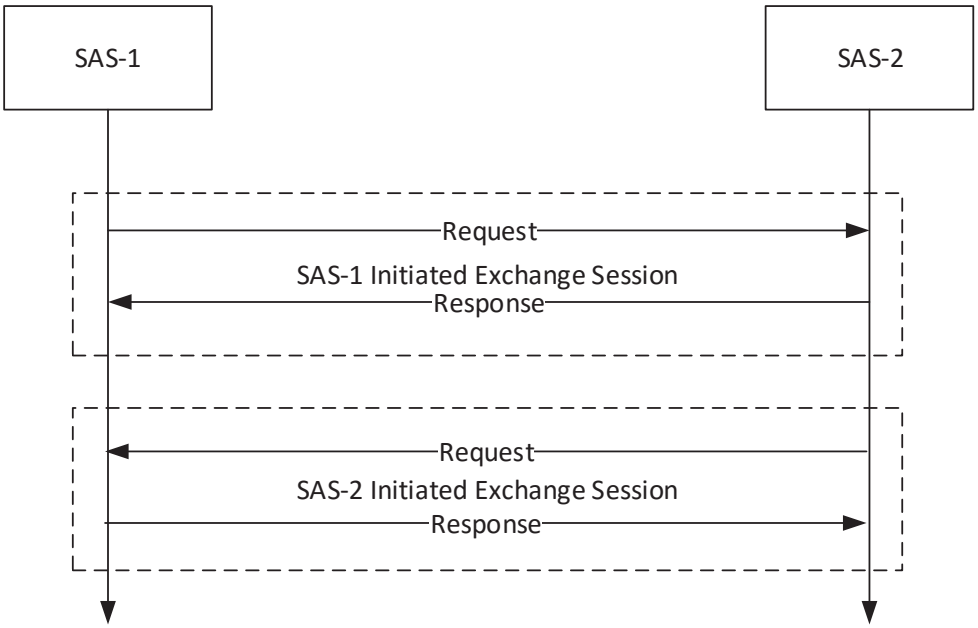


Figure 1 SAS to SAS Exchange Flow

6.2 Message Methods, Categories and Types

6.2.1 Message Methods

Two methods, push and pull, are allowed for SAS to SAS information exchange.

- "Push": used by one SAS to push information to be shared to peer SASs.
- "Pull": used by one SAS to pull wanted information from peer SASs.

"Push" and "Pull" methods are directly mapped to the 'POST/PUT" and "GET" methods respectively defined in the HTTP protocol. No new definition is needed in the SAS to SAS information exchange messages.

6.2.2 URL endpoints

URL endpoints for data exchange should be based on a base URL which is supplied by a SAS implementation, and when path defines the resource to be exchanged (requested or supplied) following this table. (Note this is an adjustment to the table included in TR-A.)

The construction uses the following format convention:

$BASE_URL/$RECORD_TYPE/$ID for single record exchange, where $RECORD_TYPE is the type of record to be exchanged and $ID is the url-escaped ID key for the record to be exchanged.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

$BASE_URL/$RECORD_TYPE:searchByTime?startTime=$START&endTime=$END for time-range requests, where the $RECORD_TYPE is the type of records to be exchanged and the $START and $END parameters are url-escaped ISO 8601 time codes defining time limits for the records exchanged.

Information Element Type	URL construction
SAS Administrators	Individual Records Pull: `GET $BASE_URL/sas_admin/$ID` Push: `POST $BASE_URL/sas_admin/$ID` Time-range records Pull: `GET $BASE_URL/sas_admin:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/sas_admin:searchByTime?start=$T1&end=$T2`
ESC Administrators	Individual Records Pull: `GET $BASE_URL/esc_admin/$ID` Push: `POST $BASE_URL/esc_admin/$ID` Time-range records Pull: `GET $BASE_URL/esc_admin:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/esc_admin:searchByTime?start=$T1&end=$T2`
SAS Implementations	Individual Records Pull: `GET $BASE_URL/sas/$ID` Push: `POST $BASE_URL/sas/$ID` Time-range records Pull: `GET $BASE_URL/sas:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/sas:searchByTime?start=T1&end=$T2`
ESC Implementations	Individual Records Pull: `GET $BASE_URL/esc/$ID` Push: `POST $BASE_URL/esc/$ID` Time-range records

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

	Pull: `GET $BASE_URL/esc:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/esc:searchByTime?start=T1&end=$T2`
CBSD device types	Individual Records Pull: `GET $BASE_URL/cbsd_type/$ID` Push: `POST $BASE_URL/cbsd_type/$ID` Time-range records Pull: `GET $BASE_URL/cbsd_type:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/cbsd_type:searchByTime?start=T1&end=$T2`
CBSDs	Individual Records Pull: `GET $BASE_URL/cbsd/$ID` Push: `POST $BASE_URL/cbsd/$ID` Time-range records Pull: `GET $BASE_URL/cbsd:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/cbsd:searchByTime?start=T1&end=$T2`
Incumbents	Individual Records Pull: `GET $BASE_URL/incumbent/$ID` Push: `POST $BASE_URL/incumbent/$ID` Time-range records Pull: `GET $BASE_URL/incumbent:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/incumbent:searchByTime?start=T1&end=$T2`
Zones	Individual Records Pull: `GET $BASE_URL/zone/$ID` Push: `POST $BASE_URL/zone/$ID` Time-range records Pull: `GET $BASE_URL/zone:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/zone:searchByTime?start=T1&end=$T2`
CBSD operators	Individual Records Pull: `GET $BASE_URL/operator/$ID`

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

	Push: `POST $BASE_URL/operator/$ID` <u>Time-range records</u> Pull: `GET $BASE_URL/operator:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/operator:searchByTime?start=T1&end=$T2`
Domain Proxies	<u>Individual Records</u> Pull: `GET $BASE_URL/domain/$ID` Push: `POST $BASE_URL/domain/$ID` <u>Time-range records</u> Pull: `GET $BASE_URL/domain:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/domain:searchByTime?start=T1&end=$T2`
Wildcard Retrieval for time-range records	<u>Time-range records</u> Pull: `GET $BASE_URL/any:searchByTime?start=$T1&end=$T2` Push: `POST $BASE_URL/any:searchByTime?start=T1&end=$T2`
Full activity dump	Pull: `GET $BASE_URL/dump` Push: `POST $BASE_URL/dump`

6.2.3 Message Categories

All messages used for SAS and SAS information exchanges are of the following categories:

- "Request": request message sent from one SAS to a peer SAS to request a designated action, such as push or pull etc.

- "Response": response message sent from one SAS to a peer SAS in response to a prior received request. A response can be a "success" response indicating the successful processing of the corresponding request and containing the required response results. It can also be an "error" response indicating the unsuccessful handling of the corresponding request either because of errors in the request or required actions cannot be fulfilled. Appropriate error codes shall be contained in "error" responses to indicate the best known cause of the error condition. The format of the error condition data should follow the Error information element defined in the SAS-CBSD Protocol [N.3].

- "Notification": non-acknowledgement-required notification message from one SAS to a peer SAS. This is reserved for future use.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

6.2.4 Message Types

Message types are used to identify the action and results types carried in the request and response messages. In correspondence to the SAS to SAS exchange mechanisms as specified in TR-A[I.5], the following message types are required:

- "Individual": indicates request or response associated with a specific individual data record of a specific data record type.
- "Time-range": indicates request or response associated with a specific type data records created in a specific time range.
- "Wildcard": indicates request or response associated with all types of data records created in a specific time range.
- "Full-dump": indicates request or response associated with all types of data records created after a given time.

6.2.5 Time/Date formats

Date and time references exchanged in the protocol (startTime and endTime fields) should follow ISO 8601 formats as described in RFC 3339 (example format: YYYY-MM-DDThh:mm:ss.ssssZ) and exchange times in UTC.

6.3 Message Contents Aggregation

In order to achieve efficient SAS to SAS exchange, it is allowed to aggregate multiple required data elements into single request and similarly the corresponding response will contain the aggregated data elements found.

6.4 Message Definition

6.4.1 Definition

6.4.1.1 Request message

Field	Definition	
messageType	Message type, choose from: • "Individual" • "Time-range" • "Wildcard" • "Full-dump"	
records	Array of structured object specifying the SAS to SAS exchanged data records required, each structured object contains the following fields	
	recordType	SAS to SAS exchanged data record type, each choose from: • "SAS Administrator"

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

		• "ESC Administrator" • "SAS Implementation" • "ESC Implementation" • "Domain Proxy" • "CBSD Device Type" "CBSD" • "Incumbent" • "Zone" • "CBSD Operator" • "Professional Installer" • "Coordination Event" • "any" – for wildcard type
	recordId	SAS to SAS exchanged data record instance ID, each choose from: • Unique record instance ID as specified in TR-A[I.5]. • "any" – for wildcard type
	startTime	String representation of standard timestamp indicating the start time of the concerned time range, not applicable in "individual" type, indicates the very beginning since server is started if absent.
	endTime	String representation of standard timestamp indicating the end time of the concerned time range, not applicable in "individual" and "full-dump" types, indicates "now" if absent.

6.4.1.2 Response message

Field	Definition	
messageType	Message type, choose from: • "Individual" • "Time-range" • "Wildcard" • "Full-dump"	
records	Array of structured object specifying the SAS to SAS exchanged data records responded, each structured object contains the following fields	
	recordType	SAS to SAS exchanged data record type, each choose from: • "SAS Administrator" • "ESC Administrator" • "SAS Implementation" • "ESC Implementation" • "Domain Proxy" • "CBSD Device Type" "CBSD"

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

		• "Incumbent" • "Zone" • "CBSD Operator" • "Professional Installer" • "Coordination Event" • "any" – for wildcard type
	recordId	SAS to SAS exchanged data record instance ID, each choose from: • Unique record instance ID as specified in TR-A[I.5]. • "any" – for wildcard type
	recordData	Array of structured object contains required record data of the specific type, no "error" response
	error	Response status, defined by the Error information element in SAS-CBSD TR-B [N.3] and associated codes • errorCode, errorData, errorMessage
	startTime	String representation of standard timestamp indicating the start time of the concerned time range, not applicable in "individual" type, indicates the very beginning since server is started if absent.
	endTime	String representation of standard timestamp indicating the end time of the concerned time range, not applicable in "individual" and "full-dump" types, indicates "now" if absent.

6.4.1.2.1 Response error codes

Response error codes are a subset of those 1xx category of general errors found in Section 8.13 of [N.3]. The following Error codes can be present in SAS-SAS responses.

errorCode	Name	Description
0	`SUCCESS`	Request is successfully processed by the receiving SAS
100	`VERSION`	Version information contained in the request is not supported by the receiving SAS
101	`BLACKLISTED`	Requesting SAS is blacklisted by the peer receiving SAS

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

102	MISSING_PARAM	Required parameters missing
103	INVALID_VALUE	One or more parameters have invalid value
105	RECORD_NOT_FOUND	Required record not found

6.4.1.3 Notification message

TBD

6.4.2 JSON Representation Examples

6.4.2.1 Request message (for a push exchange)

Multiple request records can be aggregated in on request message.

```
{
    "messageType" : "individual",
    "records" : [
            {
                "recordType" : "SAS-Administrator"
                "recordId" : "admin/sas/$ADMINISTRATOR-ID"
                "startTime" : "2015-07-16T19:30:27Z",
                "endTime" : "2015-07-17T19:30:27Z"
            },
            {
                "recordType" : "SAS-Administrator"
                "recordId" : "admin/sas/$ADMINISTRATOR-ID"
                "startTime" : "2015-07-21T23:30:27Z",
                "endTime" : "2015-07-25T23:30:27Z"
            },
            {
                // more records to be aggregated in the request if any
                ……
            }
        ]
}
```

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

6.4.2.2 Response message

Response is always on per request record basis, if multiple request records were aggregated into a single request message, a corresponding number of response records will be contained in the response message. And furthermore, “success” and “error” response records are allowed to be in the same response message.

- All success response

```
{
    “messageType” : “individual”,
    “records” : [
                {
                    “recordType” : “SAS-Administrator”
                    “recordId” : “admin/sas/$ADMINISTRATOR-ID”
                    “startTime” : “2015-07-16T19:30:27Z”,
                    “endTime” : “2015-07-17T19:30:27Z”
                    “recordData” : {
                        // record data JSON object
                     },
                     “error” : “OK”,
                },
                {
                    “recordType” : “SAS-Administrator”
                    “recordId” : “admin/sas/$ADMINISTRATOR-ID”
                    “startTime” : “2015-07-21T23:30:27Z”,
                    “endTime” : “2015-07-25T23:30:27Z”
                    “recordData” : {
                        // record data JSON object
                     },
                     “error” : “OK”,
                },
                {
                     // additional records found per corresponding request
                     ……
                 }
               ]
}
```

- Mixed Success and Error response

```
{
    “messageType” : “individual”,
    “records” : [
                {
                    “recordType” : “SAS-Administrator”
                    “recordId” : “admin/sas/$ADMINISTRATOR-ID”
                    “startTime” : “2015-07-16T19:30:27Z”,
```

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

```
                    "endTime" : "2015-07-17T19:30:27Z"
                    "recordData" : null,
                     "error" : {"errorCode": 103, "errorMessage": "required data not found"
                },
                {
                    "recordType" : "SAS-Administrator"
                    "recordId" : "admin/sas/$ADMINISTRATOR-ID"
                    "startTime" : "2015-07-21T23:30:27Z",
                    "endTime" : "2015-07-25T23:30:27Z"
                    "recordData" : {
                        // record data JSON object
                     },
                     "error" : "OK"
                },
                {
                     // additional response records
                     ……
                 }
               ]
}
```


- All Error response


```
{
    "messageType" : "individual",
    "records" : [
                {
                    "recordType" : "SAS-Administrator"
                    "recordId" : "admin/sas/$ADMINISTRATOR-ID"
                    "startTime" : "2015-07-16T19:30:27Z",
                    "endTime" : "2015-07-17T19:30:27Z"
                    "recordData" : null,
                     "error" : {"errorCode": 104, "errorMessage": "required data not found"
                },
                {
                    "recordType" : "SAS-Administrator"
                    "recordId" : "admin/sas/$ADMINISTRATOR-ID"
                    "startTime" : "2015-07-21T23:30:27Z",
                    "endTime" : "2015-07-25T23:30:27Z"
                    "recordData" : null,
                     "error" : {"errorCode": 102, "errorMessage": "xxx parameter is missing"
                },
                {
                     // additional response records
                     ……
                 }
```


Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

```
                    ]
}
```

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Appendix D.2 CBSD-to-SAS Interface

SAS to CBSD Protocol Technical Report-B

Document WINNF-15-P-0062

Version V1.0.0

30 March 2016

Copyright © 2016 The Software Defined Radio Forum Inc. – All Rights Reserved

TERMS, CONDITIONS & NOTICES

This document has been prepared by the SSC Work Group 3 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 3.

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.

The Forum draws attention to the fact that it is claimed that compliance with this specification may involve the use of a patent ("IPR") concerning "Interim SAS to CBSD Protocol Technical Report-A", Document WINNF-15-P-0023, Version V1.0.0, 2 November 2015, referenced in Section 2.1. The Forum takes no position concerning the evidence, validity or scope of this IPR.

The holder of this IPR has assured the Forum that it is willing to license all IPR it owns and any third party IPR it has the right to sublicense which might be infringed by any implementation of this specification to the Forum and those licensees (members and non-members alike) desiring to implement this specification. Information may be obtained from:

QUALCOMM Incorporate
Attn: Thomas Rouse
5775 Morehouse Drive
San Diego, California, 92121
Email: ip.disclosure@qualcomm.com

Attention is also drawn to the possibility that the Forum shall not be responsible for identifying any or all such IPR.

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

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

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

Table of Contents

TERMS, CONDITIONS & NOTICES i
Contributors v
Preface vi
1 Introduction 1
2 Scope 1
3 References 1
3.1 Normative references 1
3.2 Informative references 1
4 Definitions and abbreviations 1
5 Information Flows 1
5.1 SAS Discovery 2
5.1.1 Successful operation 2
5.1.2 Unsuccessful Operation 2
5.2 CBSD Registration 2
5.2.1 Successful operation 2
5.2.2 Unsuccessful Operation 4
5.3 CBSD Spectrum Inquiry 4
5.3.1 Successful operation 5
5.3.2 Unsuccessful Operation 6
5.4 CBSD Grant Request 6
5.4.1 Successful operation 6
5.4.2 Unsuccessful Operation 8
5.5 CBSD Heartbeat Request 8
5.5.1 Successful operation 8
5.5.2 Unsuccessful Operation 10
5.6 CBSD Spectrum Relinquishment 11
5.6.1 Successful operation 11
5.6.2 Unsuccessful Operation 12
6 Message Encoding and Transport 12
6.1 Message Encoding 12
6.2 Message Transport 15
7 Parameters of SAS-CBSD Messages 16
7.1 Registration Request Message: registrationRequest 16
7.1.1 AirInterface data object: 17
7.1.2 InstallationParam data object: 17
7.2 Registration Response message: registrationResponse 19
7.2.1 Error data object: 19
7.3 Spectrum Inquiry Request Message: spectrumInquiryRequest 19
7.3.1 FrequencyRange data object: 20
7.4 Spectrum Inquiry Response Message: spectrumInquiryResponse 20
7.4.1 AvailableChannel data object: 21
7.5 Grant Request Message: grantRequest 21
7.5.1 OperationParam data object: 21

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7.6 Grant Response Message: grantResponse 22
7.7 Heartbeat Request Message: heartbeatRequest 23
7.8 Heartbeat Response Message: heartbeatResponse.....24
7.9 Relinquishment Request Message: relinquishmentRequest 25
7.10 Relinquishment Response Message: relinquishmentResponse 25
7.11 Deregistration Request Message: deregistrationRequest.....25
7.12 Deregistration Response Message: deregistrationResponse.....26
7.13 Error Codes and Data.....26

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Contributors

The following individuals made significant contributions to this document:

Editors: Prakash Moorut & Steve Magee (Nokia), Yi Hsuan (Google), Kumar Balachandran (Ericsson), Masoud Olfat (Federated Wireless), Dave Wright (Ruckus Wireless), Naotaka Sato (Sony Corporation)

Other Member Representatives:

- AT&T: Neeti Tandon
- Federated Wireless: James Ni
- Google: Greg Billock
- Key Bridge Global: Jesse Caulfield
- Motorola Solutions: David Gurney
- NIST: Anirudha Sahoo
- Nokia: Anatoly Andrianov, Al Hirsbrunner
- Qualcomm: Doug Knisely
- Verizon: Max Solondz

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Preface

This Technical Report (TR) describes details on information flows and functional description relating to SAS and CBSD operation. The main goal of this TR is to enable initial testing and trials of CBRS systems. WG3 will use this document, Interim SAS to CBSD Protocol Technical Report-A and any other relevant TRs to develop SAS to CBSD Protocol Technical Specification (TS). The TS will be developed in phases and published according to the work progress.

Note: There are a number of Working Group 1 Task Groups (Registration, Domain Proxy, ESC, Measurements) whose requirements outputs will be processed during the 1st or 2nd iterations of the Technical Specification.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

SAS to CBSD Protocol Technical Report

1 Introduction

2 Scope

This document is a Technical Report on the signaling protocol for the SAS-CBSD (SAS-CBSD) interface.

3 References

3.1 Normative references

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

[n.1] "Interim SAS to CBSD Protocol Technical Report-A", Document WINNF-15-P-0023, Version V1.0.0, 2 November 2015 (http://groups.winnforum.org/d/do/8699)

[n.2] "CBRS Communications Security Technical Report", Working Document WINNF-15-P-0065, Version V0.3.3, 4 December 2015

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.

[i.1] Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650MHz Band, GN Docket No. 12-354, "Report and Order and Second Further Notice of Proposed Rulemaking", adopted April 17, 2015, FCC 15-47.

4 Definitions and abbreviations

Citizens Broadband Radio Service Device (CBSD): Fixed Stations, or networks of such stations, that operate on a Priority Access or General Authorized Access basis in the Citizens Broadband Radio Service consistent with this rule part. For CBSDs which comprise multiple nodes or networks of nodes, CBSD requirements apply to each node even if network management and communication with the SAS is accomplished via a single network interface. End User Devices are not considered CBSDs.[i.1]

Spectrum Access System (SAS): A system that authorizes and manages use of spectrum for the Citizens Broadband Radio Service in accordance with subpart F in [i.1].

5 Information Flows

This section contains detailed information flows describing the transactions over SAS-U. These information flows are intended to show an example of how the messages specified in reference [n.1] are used and how they combined to perform activities.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

5.1 SAS Discovery

This procedure discusses how a CBSD discovers a SAS entity the CBSD can use for registration requests. A Domain Proxy can also discover a SAS on behalf of all CBSDs that it serves.

5.1.1 Successful operation

The CBSD or Domain Proxy shall initiate this procedure whenever needed to identify the SAS, e.g. prior to initiating the registration procedure.

The CBSD or Domain Proxy may use static methods for SAS discovery. For static methods, SAS connection information is provisioned into the CBSD or Domain Proxy. The CBSD or Domain Proxy then uses this provisioned information to establish a secure session with SAS. Once a secure session is successfully established, CBSD Registration may be initiated.

If supported by the network hosting the CBSD/Domain Proxy, dynamic provisioning may be used and leverage existing protocols like Domain Name System (DNS)/ Dynamic Host Control Protocol (DHCP) to determine the SAS connection information. The CBSD or Domain Proxy then uses this information to establish a secure session with SAS. [n.2]

One or more SAS addresses may be provisioned for SAS discovery. The method used to provision the SAS discovery information is outside the scope of this document.

5.1.2 Unsuccessful Operation

SAS discovery may fail due to e.g. SAS URL configuration errors or DNS configuration errors. The CBSD or Domain Proxy sends the failure cause to the appropriate entity for resolution, possibly involving a separate element management system.

5.2 CBSD Registration

This procedure describes how a CBSD registers with a SAS.

5.2.1 Successful operation

This procedure is initiated after the CBSD has successfully discovered the SAS. The CBSD initiates the procedure by performing SAS Authentication. The details of the authentication procedure are found in reference [n.2].

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

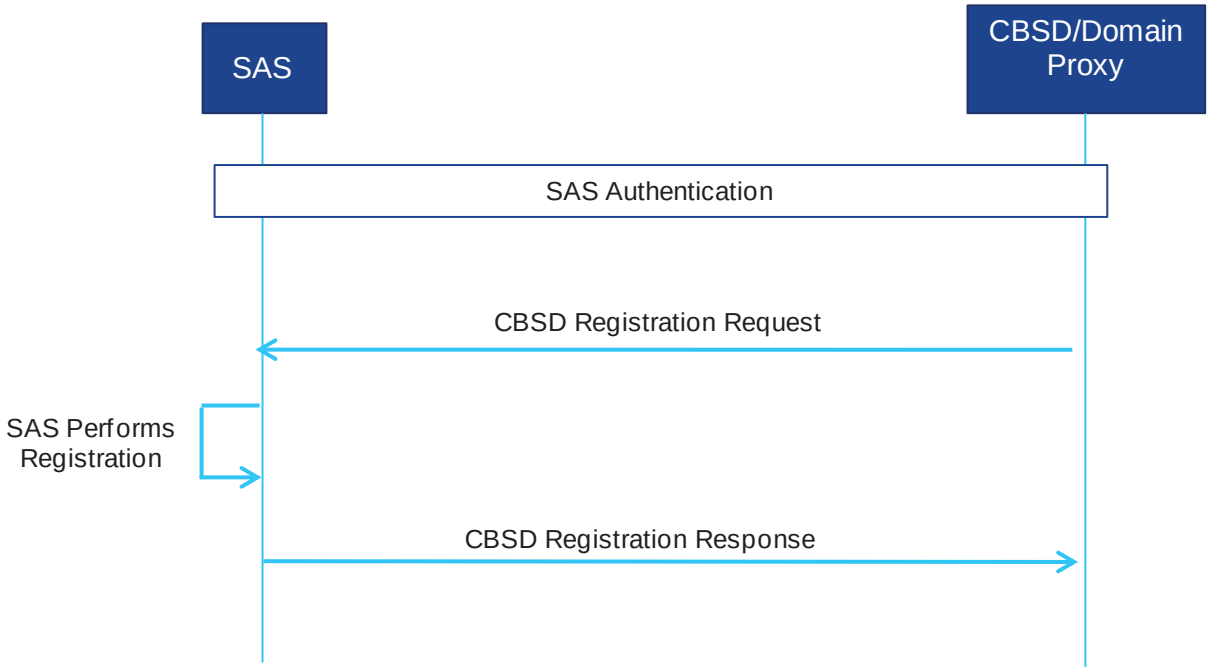


Figure 1: CBSD Registration procedure. Successful operation.

Item for further study: It is to be determined whether authentication details are included in this document or a reference to a WG2 document.

After successful authentication, if there is no Domain Proxy, the CBSD initiates registration by sending a CBSD registrationRequest (fccId, cbsdCategory, callSign, userId, airInterface, cbsdManufacturer, cbsdSerialNumber, maximumGrants, sensingCapability, installationParam) message to SAS. The fccId, callSign, cbsdSerialNumber, and userId identify the CBSD to SAS. The cbsdCategory, airInterface, cbsdManufacturer, sensingCapability and installationParam provide specific information on the CBSD equipment capabilities. The maximumGrants parameter informs the SAS on the maximum number of grants the CBSD can use simultaneously (CBSD capability). Upon reception of the CBSD registrationRequest, SAS initiates the registration of the CBSD. SAS responds to the CBSD with a CBSD registrationResponse containing a *CBSD ID* Information Element (IE) along with an indication whether the registration succeeded or failed. The CBSD uses the *CBSD ID* parameter for all subsequent procedures with SAS. If registration fails, there will be a registrationResponse containing an error code.

If there is a Domain Proxy and the Domain Proxy is performing bulk CBSD registration, the Domain Proxy will aggregate registration information for multiple CBSDs. The Domain Proxy sends a CBSD registrationRequest message to the SAS containing a list of registrationRequest objects which represents the aggregated CBSD registration information. The CBSD registrationRequest contains one instance of CBSD registration parameters per CBSD that the Domain Proxy is registering. Upon reception of the CBSD registrationRequest, SAS initiates the registration for each CBSD. SAS responds with a CBSD registrationResponse containing a

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

CBSD ID IE along with an indication whether the registration succeeded or failed for each registrationRequest and sends the aggregated response list to the Domain Proxy. The Domain Proxy and/or CBSD shall use the registered *CBSD ID* parameter for all subsequent procedures with SAS relative to each registered CBSD. The details of the interaction between the Domain Proxy, the CBSDs, and a possible CBSD element management system are outside the scope of this specification.

Item for further study: The current working assumption is the fccId+cbsdSerialNumber can be used for matching requests and responses in a Domain Proxy list.

5.2.2 Unsuccessful Operation

If SAS determines the registration is incomplete, the SAS returns a *REG_PENDING* error code. The CBSD periodically repeats the registrationRequest until receiving a successful registrationResponse from the SAS.

Item for further study: It is to be determined whether the CBSD implements a retry timer to initiate the Registration Request or receives a notification from the SAS. If a retry timer is implemented, its implementation including retry timer duration is internal to the CBSD.

If SAS determines the CBSD operating privileges have been revoked, SAS returns a *BLACKLISTED* error code. When the CBSD operating privileges are restored, the CBSD may initiate a registrationRequest. How operating privileges are restored to the CBSD is outside the scope of this document. The method used to trigger the CBSD registration is implementation specific.

If SAS determines an error with one of the parameters in the registrationRequest, SAS returns a *Registration Failed* error code along with the faulty parameter(s). The CBSD passes the failure cause to the upper layers for resolution.

If there is a Domain Proxy, the Domain Proxy receives an aggregated list of registrationResponse objects. For each registration that fails, there will be one registrationResponse object per CBSD containing an error code. The Domain Proxy matches the individual responses to the individual requests and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system.

5.3 CBSD Spectrum Inquiry

This procedure describes how a CBSD performs the Spectrum Inquiry procedure with SAS. Spectrum Inquiry allows registered CBSDs to request information on available channels. With SAS providing available channel information, the CBSD can decide operational parameters for a grant request.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

5.3.1 Successful operation

The CBSD initiates this procedure anytime after successfully registering with SAS. Spectrum Inquiry messages may be sent prior to the Grant Request if the CBSD wants SAS to indicate specific information on channels available for the CBSD.

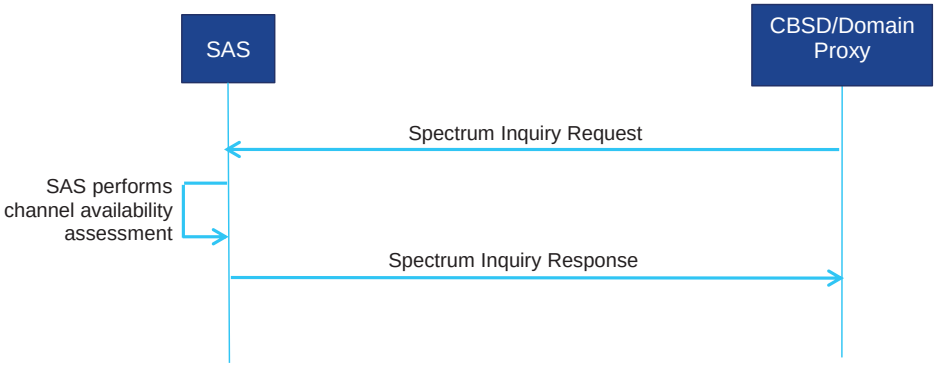


Figure 2: CBSD Spectrum Inquiry. Successful operation.

If there is no Domain Proxy, the CBSD initiates spectrum inquiry by sending a spectrumInquiryRequest (cbsdId, palCredential, inquiredSpectrum) message to SAS. The cbsdId identifies the CBSD to SAS. The palCredential is an optional parameter and is included in spectrumInquiryRequest as described in section 7.3. The inquiredSpectrum is an array of FrequencyRange data objects indicating the frequency range(s) which the CBSD seeks information. The CBSD may request information for one or more frequency ranges as described in section 7.3.

SAS performs an assessment of channel availability for the frequency ranges indicated in the spectrumInquiryRequest. If the request succeeds, SAS sends a spectrumInquiryResponse (cbsdId, availableChannel, error) message to the CBSD with the results of its channel assessment in the availableChannel object. The availableChannel object contains a list of frequency ranges available for the CBSD for grant requests. For each frequency range contained in the availableChannel object, SAS also indicates the channel access type (PAL/GAA) and the regulatory rule SAS used to determine availability. If the parameter cbsdId used in the spectrumInquiryRequest message does not match with the palCredential (e.g. the CBSD location does not match), the SAS fails the request and responds with an error message

SAS does not reserve any channel allocations as part of Spectrum Inquiry nor does SAS guarantee the information in the availableChannel object is still valid when the CBSD initiates a grant request. The CBSD should consider the information in the availableChannel object as an indication of the channels available to the CBSD.

If there is a Domain Proxy and the Domain Proxy is performing bulk Spectrum Inquiry Requests, the Domain Proxy aggregates information related to each applicable CBSD into an array of

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

spectrumInquiryRequest objects as described in section 7. When the Domain Proxy receives the the array of spectrumInquiryResponse objects from SAS, the Domain Proxy matches the individual responses to the individual requests and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system. The details of the interaction between the Domain Proxy, the CBSDs, and a possible CBSD element management system are outside the scope of this specification.

5.3.2 Unsuccessful Operation

If SAS determines an error with one of the parameters in the spectrumInquiryRequest message, SAS returns a spectrumInquiryResponse message with an error code along with the faulty parameter(s). The CBSD passes the failure cause to the upper layers for resolution.

If there is a Domain Proxy, the Domain Proxy receives an aggregated list of spectrumInquiryResponse objects. For each failed request, there will be a failure reason in the *error* object. The Domain Proxy matches the response with the originating request and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system.

5.4 CBSD Grant Request

This procedure describes how a CBSD requests spectrum from SAS. This procedure can only be performed by CBSD after it has successfully registered with the SAS and has obtained its CBSD ID.

5.4.1 Successful operation

This procedure is initiated after the CBSD has successfully registered with the SAS. This procedure moves the CBSD from the Registered state to the Granted state and must be successfully completed prior to the CBSD moving to the Transmission state. Spectrum Inquiry messages may be sent prior to the Grant Request if the CBSD wants SAS to indicate specific information on channels available for the CBSD. Heartbeat is required prior to activating any channels assigned during the grant request.

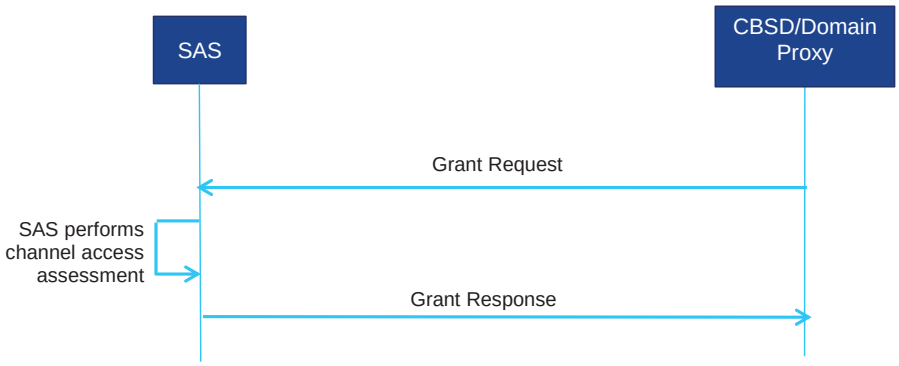


Figure 3: CBSD Grant Request. Successful operation.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Prior to initiating a grant request, the CBSD has to determine the operational parameters used in the grant request. These operational parameters include the frequency range and peak power the CBSD wants to use for operation and whether the CBSD wants to operate this frequency range with PAL access or GAA access. The determination of the specific operational parameters used in the grant request depends on CBSD capabilities, current operation and configuration.

The CBSD initiates a grant request by sending a grantRequest (cbsdId, operationParam) message to SAS. The cbsdId identifies the CBSD to SAS. The operationParam object contains the details of the grant request and contains the PAL credentials, CBSD peak power and the desired frequency range for use as described in section 7.5. The PAL credentials is an optional parameter and must be included if the CBSD is requesting PAL access for the desired frequency range. The CBSD peak power indicates the peak transmission power the CBSD will use during the grant time. The desired frequency range is a contiguous frequency range specified by low and high frequency values.

SAS responds to the CBSD with a grantResponse (cbsdId, grantId, grantExpireTime, heartbeatDuration, measReportConfig, operationParam, error) message. The error parameter indicates whether the request succeeded or failed. If the grantRequest succeeded, SAS shall include the grantExpireTime parameter and the heartbeatDuration parameter. The CBSD uses the value of the grantExpireTime parameter to determine when the CBSD stops transmitting on the assigned spectrum. If the heartbeatDuration parameter is included, the CBSD uses the value as the time interval between two consecutive Heartbeat requests. Since the CBSD can not transition to the Transmission state until completion of the Heatbeat procedure, the CBSD should execute the first Heartbeat procedure as soon as possible after the grantResponse. If the grantRequest failed, the CBSD may issue a new grantRequest and may use the operational parameters included in the operationParam object. In this case, the optional parameter grantId should not be included in the response. The measReportConfig parameter is an optional parameter containing the CBSD measurement report configuration. If the parameter cbsdId used in the grantRequest message does not match with the palCredential (e.g. the CBSD location doesn't match), the SAS fails the request and responds with an error message.

> ***Note: SAS may include operationParam if SAS wants to recommend a frequency range for the CBSD to use in the new grantRequest. It is optional whether SAS includes this object in a failed grantResponse. Whether the CBSD chooses to use the operationParam object in the new grantRequest is left to CBSD implementation.***

If SAS accepts the grantRequest, SAS allocates spectrum according to the parameters in the operationParam object in grantRequest. SAS allocates the spectrum in a frequency range indicated by the lowFrequency and highFrequency parameters in the operationalParam object. The CBSD cannot use that spectrum (e.g. activate its radio) until successfully completing the Heartbeat procedure.

If there is a Domain Proxy and the Domain Proxy is performing bulk Grant Requests, the Domain Proxy aggregates information related to each applicable CBSD into an array of grantRequest objects as described in section 7. When the Domain Proxy receives the array of

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

grantResponse objects from SAS, the Domain Proxy matches the individual responses to the individual requests. If the response indicates the Grant Request succeeded, the Domain Proxy takes the appropriate action, either directly with the CBSD(s) or optionally via a separate CBSD element management system. The details of the interaction between the Domain Proxy, the CBSDs, and a possible CBSD element management system are outside the scope of this specification.

5.4.2 Unsuccessful Operation

If SAS determines an error with one of the parameters in the grantRequest message, SAS returns a grantResponse message with an error code along with the faulty parameter(s). The CBSD passes the failure cause to the upper layers for resolution.

If there is a Domain Proxy, the Domain Proxy receives an aggregated list of grantResponse objects. For each failed request, there will be a failure reason in the *error* object. The Domain Proxy matches the response with the originating request and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system.

5.5 CBSD Heartbeat Request

This procedure describes how a CBSD performs the Heartbeat procedure with SAS. The Heartbeat Request informs SAS that the CBSD is still using the allocated spectrum. It also allows SAS to suspend or terminate the grant. If the grant is suspended or terminated, SAS has the option of reassigning the CBSD to alternative spectrum.

5.5.1 Successful operation

The CBSD initiates this procedure anytime prior to the expiration of the Heartbeat Duration timer. Heartbeat duration is defined as the time interval between two consecutive heartbeats. The timer is reset when the heartbeatRequest is sent to SAS. The Heartbeat Duration timer is included in the grantResponse message and in the heartbeatResponse message. The CBSD should also send the heartbeatRequest as soon as a grant is approved by SAS.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

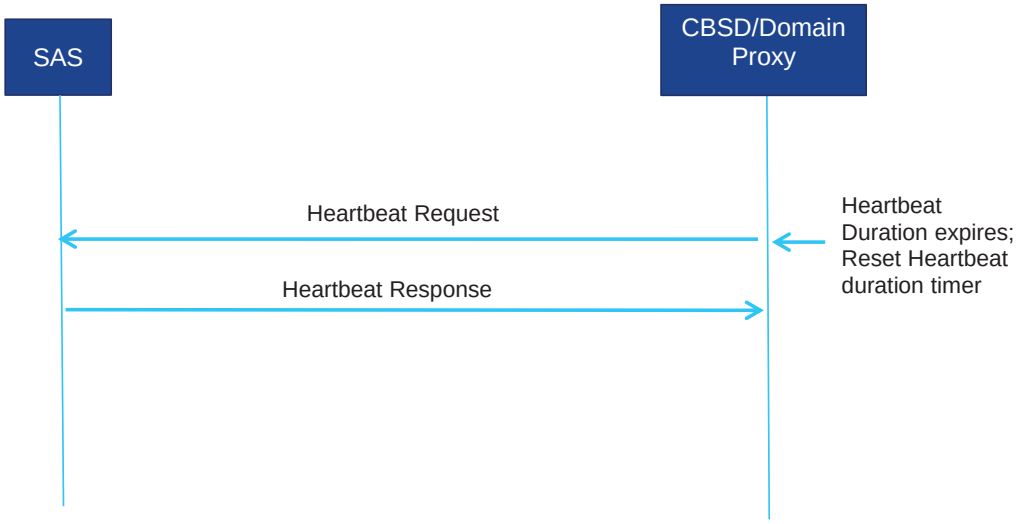


Figure 4: CBSD Heartbeat Request. Successful operation.

If there is no Domain Proxy, the CBSD initiates heartbeat by sending a heartbeatRequest (cbsdId, grantId, operationState, operationParam, measReport) message to SAS. The cbsdId identifies the CBSD to SAS. The grantId provides specific information on the spectrum grant intended for the heartbeat. The operationState and operationParam are optional parameters and are included in Heartbeat Request as described in section 7.7. The measReport parameter is an optional parameter containing the CBSD measurement report.

The CBSD obtains the heartbeat duration value in the grantResponse message or in a previous heartbeatResponse message. SAS responds to the CBSD with a heartbeatResponse (cbsdId, grantId, operationStatusReq, transmitExpireTime, heartbeatDuration, operationParam, measReportConfig, error) message. The error parameter indicates whether the request succeeded or failed. If the request succeeded, SAS includes the transmitExpireTime parameter and may include the heartbeatDuration parameter. The CBSD uses the value of the transmitExpireTime parameter to determine when the CBSD stops transmitting on the assigned spectrum. If the heartbeatDuration parameter is included, the CBSD uses the value as the time interval before the next heartbeatRequest is sent. If the request fails, SAS may include the operationParam parameter. If the operationParam parameter is included, the CBSD interprets the values as a spectrum reassignment. The following text summarizes the CBSD behavior based on errorCode in the error parameter.

```
IF errorCode = SUCCESS
                    Initiate radio transmission if initial heartbeatRequest
                    Update parameters based on heartbeatResponse

                    Continue operation (or resume operation if grant was suspended)
ELSE IF errorCode = SUSPENDED_GRANT
                        Turn off radio transmission (suspend radio operations)
```

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

```
                    Update parameters based on heartbeatResponse
                    Reset heartbeat timer if there are no new operational parameters
                          Resend heartbeatRequest after timer expires
                    Issue  relinquishmentRequest if new operational parameters
                    Issue  grantRequest with new operational parameters
ELSE IF errorCode = TERMINATED_GRANT
                    Turn off radio transmission (terminate radio operations)
                    Issue  relinquishmentRequest if new operational parameters
                    Issue  grantRequest
END
```

The operationStatusReq parameter is an optional parameter informing the CBSD whether operational parameters and operational state are to be included in the next heartbeatRequest. If the operationStatusReq parameter is true, the operationState and operationParam associated with the grantId are included in the next heartbeatRequest. If the operationStatusReq parameter is false, these parameters are not included in the next heartbeatRequest. The measReportConfig parameter is an optional parameter containing the CBSD measurement report configuration.

Item for further study: The specification and inclusion of the measurement report parmeter needs further discussion and agreement.

If there is a Domain Proxy and the Domain Proxy is performing bulk heartbeatRequests, the Domain Proxy aggregates information related to each applicable CBSD into a heartbeatRequest message as described in section 7. When the Domain Proxy receives the heartbeatResponse message from SAS, the Domain Proxy matches the individual responses to the individual requests. If the response indicates the heartbeatRequest succeeded, the Domain Proxy performs the previously described CBSD behavior on behalf of the successful CBSD(s). If this is the initial heartbeatRequest message after a grantResponse message, the Domain Proxy takes the appropriate action to initiate radio transmission, either directly with the CBSD(s) or optionally via a separate CBSD element management system. The details of the interaction between the Domain Proxy, the CBSDs, and a possible CBSD element management system are outside the scope of this specification.

5.5.2 Unsuccessful Operation

If SAS determines an error with one of the parameters in the heartbeatRequest message, SAS returns a heartbeatResponse message with an error code along with the faulty parameter(s). The CBSD passes the failure cause to the upper layers for resolution.

If there is a Domain Proxy, the Domain Proxy receives an aggregated list of heartbeatResponse objects. For each failed request, there will be a failure reason in the *error* object. The Domain Proxy matches the response with the originating request and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system..

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

5.6 CBSD Spectrum Relinquishment

This procedure describes how a CBSD informs SAS if a grant is no longer used by the CBSD.

5.6.1 Successful operation

The CBSD initiates this procedure anytime after the CBSD has successfully completed the Grant Request procedure.

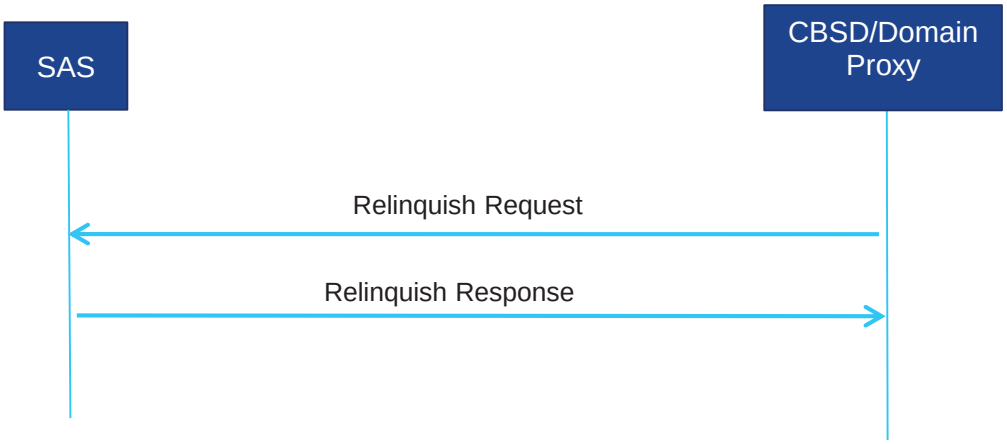


Figure 5: CBSD Spectrum Relinquishment. Successful operation.

If there is no Domain Proxy, the CBSD initiates spectrum relinquishment by sending a relinquishmentRequest (cbsdId, grantId) message to SAS. The cbsdId identifies the CBSD to SAS. The grantId provides specific information on the spectrum grant the CBSD wants to relinquish. The relinquishmentRequest message may be sent while the grant associated with the grantId is valid. Upon reception of the relinquishmentRequest message, SAS relinquishes the spectrum assigned to the CBSD and associated with the grantId. SAS responds to the CBSD with a relinquishmentResponse message containing the cbsdId and grantId Information Elements (IEs) along with an indication whether the request succeeded or failed. If the request succeeded, the CBSD no longer has authorization to use the spectrum associated with the grant and must repeat the CBSD Grant Request procedure. If the request fails, the relinquishmentResponse message will contain an error code.

If there is a Domain Proxy and the Domain Proxy is performing bulk Relinquishment Requests, the Domain Proxy will aggregate relinquishment information for multiple CBSDs. The Domain Proxy aggregates this information into a list of relinquishmentRequest objects and sends a relinquishmentRequest message to SAS. The relinquishmentRequest message contains one instance of the Relinquishment Request parameters per CBSD requesting spectrum relinquishment. Upon reception of the relinquishmentRequest message, SAS initiates the relinquishment process for each CBSD. SAS responds to the CBSD with a relinquishmentResponse message containing the associated cbsdId and grantId along with an

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

indication whether the relinquishment succeeded or failed for each relinquishment request and sends the aggregated response list to the Domain Proxy. The Domain Proxy matches the individual responses to the individual requests and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system. The details of the interaction between the Domain Proxy, the CBSDs, and a possible CBSD element management system are outside the scope of this specification.

5.6.2 Unsuccessful Operation

If SAS determines an error with one of the parameters in the relinquishmentRequest message, SAS returns a relinquishmentResponse message with a failure reason along with the faulty parameter(s). The CBSD passes the failure cause to the upper layers for resolution.

If there is a Domain Proxy, the Domain Proxy receives an aggregated list of relinquishmentResponse objects. For each failed relinquishment request, there will be a failure reason in the *error* object of the relinquishmentResponse for the CBSD(s). The Domain Proxy matches the response with the originating relinquishment request and takes the appropriate action, possibly involving the CBSD(s) and/or a separate CBSD element management system.

6 Message Encoding and Transport

6.1 Message Encoding

SAS-CBSD messages are encoded using JSON, or JavaScript Object Notation. JSON encoded messages are in the form of single or multiple of name/value pairs, where a name, represented as a string, and its value is separated by a colon. A value can be one of four primitive types (strings, numbers, booleans, and null) and two structured types (objects and arrays).

- String: a string begins and ends with quotation marks. All Unicode characters can be placed within the quotation marks except quotation mark, reverse solidus and control characters.
- Number: a signed integer or a floating number belongs to this category. A floating number can contain a fractional part or be represented in exponential form.
- Boolean: a Boolean value can be true or false
- Object: An object is a data structure represented as a pair of curly brackets surrounding zero or more name/value pairs. A SAS-CBSD message is represented as a JSON object. To better organize data in a message, an object can also be created to include a group of name/value pairs that belong to a certain category.
- Array: represented as square brackets surrounding zero or more values, separated by commas. There is no requirement that values in an array are of the same type.

When a domain proxy sends requests to SAS, multiple JSON encoded requests of the same type can be aggregated together in the form of a JSON array and sent in one HTTP request. Similarly

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

SAS can include multiple response messages in a JSON array and send it to a domain proxy. Therefore a JSON encoded message is in an array format that can accommodate one or multiple requests or responses of the same type. Different types of requests or responses should not be included in one JSON-encoded message.

The following example shows the format of a JSON-encoded SAS message. As shown in the example, the message contains two objects in a JSON array, whose name is registrationRequest. Each object denotes a registrationRequest for a CBSD.


```
{
  “registrationRequest”: [
    {
      “fccId”: “abc123”,
      “cbsdCategory”: “B”,
      “callSign”: “KQQQ”,
      “userId”: “John Doe”,
      “airInterface”: {
        “radioTechnology”: “E-UTRA”,
        “supportedSpec”: “LTE-Rel10”
      },
      “cbsdManufacturer”: “Equipment Maker B”,
      “cbsdSerialNumber”: “abcd1234”,
      “maxNumberOfGrant”: 2,
      “sensingCapability”: [
        “signalStrength”,
        “interferenceStrength”
      ],
      “installationParam”: {
        “latitude”: 37.419735,
        “longitude”: -122.072205,
        “height”: 6,
        “indoorDeployment”: true
      }
    },
    {
      “fccId”: “321cba”,
      “cbsdCategory”: “A”,
      “callSign”: “KPPP”,
      “userId”: “John Doe”,
      “airInterface”: {
        “radioTechnology”: “E-UTRA”,
        “supportedSpec”: “LTE-Rel10”
      },
      “cbsdManufacturer”: “Equipment Maker C”,
      “cbsdSerialNumber”: “4321dcba”,
      “maxNumberOfGrant”: 2,
```


Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

```
      "sensingCapability": [
        "signalStrength",
        "interferenceStrength"
      ],
      "installationParam": {
        "latitude": 37.425056,
        "longitude": -122.084113,
        "height": 9.3,
        "indoorDeployment": false,
        "antennaAzimuth": 270.5,
        "antennaDowntiltMech": 3,
        "antennaGain": 16,
        "antennaBeamwidth": 30
      }
    }
  ]
}
```


The name of the outermost array in a JSON-encoded SAS message maps to a SAS-CBSD message defined in Section 7. Mapping of SAS-CBSD messages and the corresponding JSON array names can be found in the following table.

JSON Array Name	Reference	SAS-CBSD Message
registrationRequest	Section 7.1	Registration Request Message
registrationResponse	Section 7.2	Registration Response Message
spectrumInquiryRequest	Section 7.3	Spectrum Inquiry Request Message
spectrumInquiryResponse	Section 7.4	Spectrum Inquiry Response Message
grantRequest	Section 7.5	Grant Request Message
grantResponse	Section 7.6	Grant Response Message
heartbeatRequest	Section 7.7	Heartbeat Request Message
heartbeatResponse	Section 7.8	Heartbeat Response Message
relinquishmentRequest	Section 7.9	Relinquishment Request Message
relinquishmentResponse	Section 7.10	Relinquishment Response Message
deregistrationRequest	Section 7.11	Deregistration Request Message

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

deregistrationResponse	Section 7.12	Deregistration Response Message

6.2 Message Transport

HTTPS (HTTP plus TLS) is used as the transport mechanism for the SAS-CBSD protocol. A HTTP request message sent to SAS has a header like the following.

```
POST /v1.0/registration HTTP/1.1
Host: www.sasproviderapi.com
Content-type: application/json
```

The first line is the request line. POST is a standard HTTP request method that is used for all requests from CBSD to SAS. The string after POST is the URL that the message is sent to. The URL should end with /sas_version_number/sas_method_name to indicate the SAS protocol version and the SAS method included in the message. Each SAS administrator can choose the URL of its SAS service, as long as the end of the URL is in the format defined in this specification. The SAS version number is in the form of vx.y where x is the major release number and y is the minor release number. A SAS method corresponds to a pair of request and response messages defined in Section 7. Valid SAS methods are listed in the table below. HTTP/1.1 indicates that HTTP protocol version 1.1 is used. The second line shows the hostname of the SAS server. The third line indicates JSON as the encoding method for the content in the HTTP message.

SAS Method Name	Request	Response
registration	registrationRequest	registrationResponse
spectrumInquiry	spectrumInquiryRequest	spectrumInquiryResponse
grant	grantRequest	grantResponse
heartbeat	heartbeatRequest	heartbeatResponse
relinquishment	relinquishmentRequest	relinquishmentResponse
deregistration	deregistrationRequest	deregistrationResponse

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7 Parameters of SAS-CBSD Messages

In this section parameters of SAS-CBSD message are described in more details. A parameter value can be one of the primitive JSON data types, i.e., string, number, boolean, array, or object. If a parameter is an object, a name for the object is given and a separate table describes parameters in the object.

A parameter marked as "Required" should always be included when its associated message or object is used, while an "Optional" parameter may not be present. In the registrationRequest, some parameters are marked as "Conditional". These parameters are required by SAS to complete the CBSD registration process but may not be included in a registrationRequest message. For example, some required CBSD registration information could be provided to SAS through the device type registration process or the CBSD installation process.

7.1 Registration Request Message: registrationRequest

Parameter Name	Data Type	Required/ Optional	Description
userId	string	Required	The identifier of a CBSD user.
fccId	string	Required	The FCC certification identifier of the CBSD. It is a string of 19 characters as described in FCC Administration Topics Review.
cbsdSerialNumber	string	Required	A serial number assigned to CBSD by the CBSD device manufacturer.
cbsdManufacturer	string	Conditional	A unique name for the CBSD manufacturer.
callSign	string	Conditional	A device identifier provided by FCC.
cbsdCategory	string	Conditional	Device Category of the CBSD. Allowed values are "A" or "B" as defined in Part 96.
maximumGrants	number	Conditional	The maximum number of grants that the CBSD can use simultaneously.
airInterface	object: AirInterface	Conditional	A data object that includes information on the air interface technology of the CBSD.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

installationParam	object: InstallationParam	Conditional	A data object that includes information on CBSD installation. Installation information may be provided to SAS through a separate interface between SAS and installers.
sensingCapability	array of string	Conditional	The array describes all sensing capabilities of CBSD relevant to SAS operation. Examples of sensing capability include “esc”, “receivedInterferencePower”.

7.1.1 AirInterface data object:

Parameter Name	Data Type	Required/ Optional	Description
radioTechnology	string	Conditional	This field specifies the radio access technology that is going to be used for the CBSD, e.g., “lte”, “hspa”, “wimax”, “wifi”, etc
supportedSpec	string	Optional	This field specifies the latest release supported by CBSD. Examples include “lte-rel10”, “ieee802.11ac”, etc.

7.1.2 InstallationParam data object:

Parameter Name	Data Type	Required/ Optional	Description
latitude	number	Conditional	Latitude of the CBSD antenna location. The allowed range is from -90.000000 to +90.000000
longitude	number	Conditional	Longitude of the CBSD antenna location. The allowed range is from -180.000000 to +180.000000.
height	number	Conditional	CBSD antenna height in meters.
heightType	string	Conditional	The value should be “AGL” or “AMSL”. AGL height is measured

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

			relative to the ground level. AMSL height is measured relative to the mean sea level.
horizontalAccuracy	number	Optional	A positive number in meters to indicate accuracy of CBSD antenna horizontal location if it's smaller than the FCC requirement (50 meters)
verticalAccuracy	number	Optional	A positive number in meters to indicate accuracy of CBSD antenna vertical location if it's smaller than the FCC requirement (3 meters)
indoorDeployment	boolean	Conditional	Whether the CBSD antenna is indoor or not. True: indoor. False: outdoor.
antennaAzimuth	number	Optional / Conditional	Antenna azimuth in degrees. It is optional for Category A CBSD and required for category B CBSD.
antennaDowntiltMech	number	Optional / Conditional	Mechanical antenna downtilt in degrees. It is optional for Category A CBSD and required for category B CBSD.
antennaDowntiltElec	number	Optional / Conditional	Electrical antenna downtilt in degrees. It is only required for category B CBSD capable of electrical antenna downtilt.
antennaGain	number	Optional / Conditional	Peak antenna gain in dBi. It is optional for Category A CBSD and required for category B CBSD.
antennaBeamwidth	number	Optional / Conditional	3 dB antenna beamwidth in degrees. It is optional for Category A CBSD and required for category B CBSD.
antennaModel	string	Optional	If an external antenna is used, the antenna model is optionally provided in this field.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7.2 Registration Response message: registrationResponse

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS. Definition of this ID is FFS.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

7.2.1 Error data object:

Parameter Name	Data Type	Required/ Optional	Description
errorCode	number	Required	An integer to indicate the type of error. 0 means the corresponding CBSD request is approved.
errorMessage	string	Optional	A short description of the error.
errorData	errorCode dependent	Optional	Additional data can be included to help CBSD resolve error. The data type depends on the value of the error code.

Definitions of errorCode and errorData are specified in Section 7.13.

7.3 Spectrum Inquiry Request Message: spectrumInquiryRequest

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
palCredential	array of string	Optional	If the CBSD owner has PAL right, the PAL credential(s) should be included here. Credentials are formatted as an

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

			array of strings. This field is not included if the CBSD has no PAL right.
inquiredSpectrum	array of FrequencyRange	Required	This field describes the spectrum in which CBSD seeks information. The parameter is an array of the FrequencyRange data object.

7.3.1 FrequencyRange data object:

Parameter Name	Data Type	Required/ Optional	Description
lowFrequency	Number	Required	The lowest frequency of the frequency range in Hz.
highFrequency	Number	Required	The highest frequency of the frequency range in Hz.

7.4 Spectrum Inquiry Response Message: spectrumInquiryResponse

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
availableChannel	array of AvailableChannel	Required	This parameter is an array of a data object, AvailableChannel, which describes a channel that is available for the CBSD.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7.4.1 AvailableChannel data object:

Parameter Name	Data Type	Required/ Optional	Description
frequencyRange	FrequencyRange	Required	This parameter is frequency range of the available channel.
channelType	string	Required	"PAL": the channel is a PAL channel based on the credentials provided in the spectrum inquiry request. "GAA": the frequency range is for GAA use.
ruleApplied	string	Required	The regulatory rule used to generate this response, e.g., "FCC Part 96".

7.5 Grant Request Message: grantRequest

A grant request contains operating parameters that CBSD plans to operate with. Operation parameters include a continuous segment of spectrum and the peak transmission power. A CBSD shall present its PAL credentials in the grant request if it requires PAL protection for the grant.

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
operationParam	object: OperationParam	Required	This data object includes operation parameters of the requested grant.

7.5.1 OperationParam data object:

Parameter Name	Data Type	Required/ Optional	Description
palCredential	array of string	Optional	PAL credential(s) shall be provided here if the grant requires

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

			PAL protection. This field is not included if the CBSD does not demand PAL protection for the grant.
peakPower	Number	Required	Peak transmission power to be used in the grant. The peak power is in the unit of dBm/MHz.
operationFrequencyRange	FrequencyRange	Required	This parameter is frequency range of a contiguous segment.

7.6 Grant Response Message: grantResponse

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
grantId	string	Optional	An ID provided by SAS for each approved grant. If the request is rejected, this field must not be included.
grantExpireTime	string	Optional	If the request is approved, SAS shall include this field to indicate the UTC time when the grant expires. It is expressed using the format, YYYY-MM-DDThh:mm:ssZ, as defined by "Date and Time on the Internet: Timestamps" [RFC3339].
heartbeatDuration	number	Optional	If the request is approved, SAS shall include this field to indicate the time interval in seconds between two consecutive heartbeat requests.
measReportConfig	object: MeasReportConfig	Optional	Configuration for CBSD to perform various measurements (interference, incumbent, etc) and report to SAS.
operationParam	object:	Optional	If grant request is disapproved, SAS

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

	OperationParam		can optionally provide a new set of operation parameters for the CBSD.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

7.7 Heartbeat Request Message: heartbeatRequest

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
grantId	string	Required	An ID provided by SAS for each approved grant.
grantRenew	boolean	Optional	If set to True, CBSD asks for renewal of the current grant. SAS should include a grantExpireTime in the following heartbeatResponse.
operationState	string	Optional	If operationStatusReq is True in the previous heartbeat response, CBSD operation state (Transmission or Granted) should be included.
operationParam	object: OperationParam	Optional	If operationStatusReq is True in the previous heartbeat response, operationParam should be included.
measReport	object: MeasReport	Optional	If CBSD is configured to report measurements, this field includes the measurement reports.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7.8 Heartbeat Response Message: heartbeatResponse

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
grantId	string	Required	An ID provided by SAS for each approved grant.
operationStatusReq	boolean	Optional	If True, CBSD should include operation parameters and operation state in the next heartbeat request.
transmitExpireTime	string	Required	If the request is approved, this field indicates the time CBSD can transmit until. It is UTC time expressed in the format, YYYY-MM-DDThh:mm:ssZ
grantExpireTime	string	Optional	If grantRenew is set to True in a heartbeatRequest, SAS should include this field in heartbeatResponse.
heartbeatDuration	number	Optional	SAS can change the future heartbeat duration with this field.
operationParam	OperationParam	Optional	If heartbeat request is disapproved or SAS intends to change CBSD operation parameters, SAS can provide a new set of operation parameters to the CBSD.
measReportConfig	object: MeasReportConfig	Optional	Configuration for CBSD to perform various measurements (interference, incumbent, etc) and report to SAS.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7.9 Relinquishment Request Message: relinquishmentRequest

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
grantId	string	Required	An ID provided by SAS for each approved grant.

7.10 Relinquishment Response Message: relinquishmentResponse

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
grantId	string	Required	An ID provided by SAS for each approved grant.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

7.11 Deregistration Request Message: deregistrationRequest

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7.12 Deregistration Response Message: deregistrationResponse

Parameter Name	Data Type	Required/ Optional	Description
cbsdId	string	Required	This is a globally unique identifier for each CBSD registered to SAS.
error	object: Error	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

7.13 Error Codes and Data

In the error data object of a SAS-CBSD response message, SAS shall include an error code to inform CBSD the status of the corresponding request. The error codes are grouped into the following categories and defined in the following table. The name associated with each error code is not included in the error data object but can be attached to an error code by CBSD or other network entity for logging or human-involved troubleshooting.

0: success

100 – 199: general errors regarding CBSD and protocol

200 – 299: error events related to CBSD registration

300 – 399: error events related to spectrum inquiry

400 – 499: error events related to grant

500 – 599: error events related to heartbeat

errorCode	Name	Description
0	SUCCESS	CBSD request is approved by SAS
100	VERSION	SAS protocol version used by CBSD is not supported by SAS
101	BLACKLISTED	CBSD is blacklisted

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

102	MISSING_PARAM	Required parameters missing
103	INVALID_VALUE	One or more parameters have invalid value
104	PAL_CRED_MISMATCH	The CBSD parameters do not match with the PAL attributes announced through palCredential field.
200	REG_PENDING	Incomplete registration information. The registration process is pending.
201	DUPLICATED_REG	Duplicated registration. Deregister first and re-register.
300	UNSUPPORTED_SPECTRUM	SAS doesn't support the spectrum in the spectrum inquiry request
400	INTERFERENCE	Requested operation parameters cause too much interference to other users
401	GRANT_CONFLICT	Conflict with an existing grant of the same CBSD
402	TOO_MANY_GRANTS	The grant request exceeds the maximum number of grants of a CBSD
500	TERMINATED_GRANT	The grant is terminated
501	SUSPENDED_GRANT	The grant is suspended
502	UNSYNC_OP_PARAM	Operation parameters are out of sync between CBSD and SAS

In the error data object, SAS can optionally include supplemental data (errorData) to help CBSD with further investigation of the error. The following table describes supplemental data to be included with some error codes.

errorCode	Name	errorData Data Type	Description of error data
0	SUCCESS		
100	VERSION	array of string	Protocol versions supported by the SAS administrator

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

101	BLACKLISTED		
102	MISSING_PARAM	array of string	A list of missing parameters
103	INVALID_VALUE	array of string	A list of parameters names with invalid values
104	PAL_CRED_MISMATCH		The CBSD parameters do not match with the PAL attributes announced through palCredential field.
200	REG_PENDING	array of string	A list of missing registration parameters
201	DUPLICATED_REG	string	CBSD ID of the existing registration
300	UNSUPPORTED_SPECTRUM		
400	INTERFERENCE	array of AvailableChannel	A list of available channels CBSD can use
401	GRANT_CONFLICT	string	Grant ID of an existing grant that causes the conflict
402	TOO_MANY_GRANTS	array of string	A list of approved grant IDs
500	TERMINATED_GRANT		
501	SUSPENDED_GRANT		
502	UNSYNC_OP_PARAM		

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Appendix D.3 SAS Functional Architecture

SAS Functional Architecture

Document WINNF-15-P-0047

Version V1.0.0

7 September 2015

Driving the future of radio communications and systems worldwide

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

Terms and Conditions

This document has been prepared by the SSC WG1/WG3 Joint Architecture Task Group 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 WG1/WG3 Joint Architecture Task Group.

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.

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

Intellectual Property Rights

Use this chart in all contributions

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.

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

FCC Illustrative End-to-End CBRS Architecture

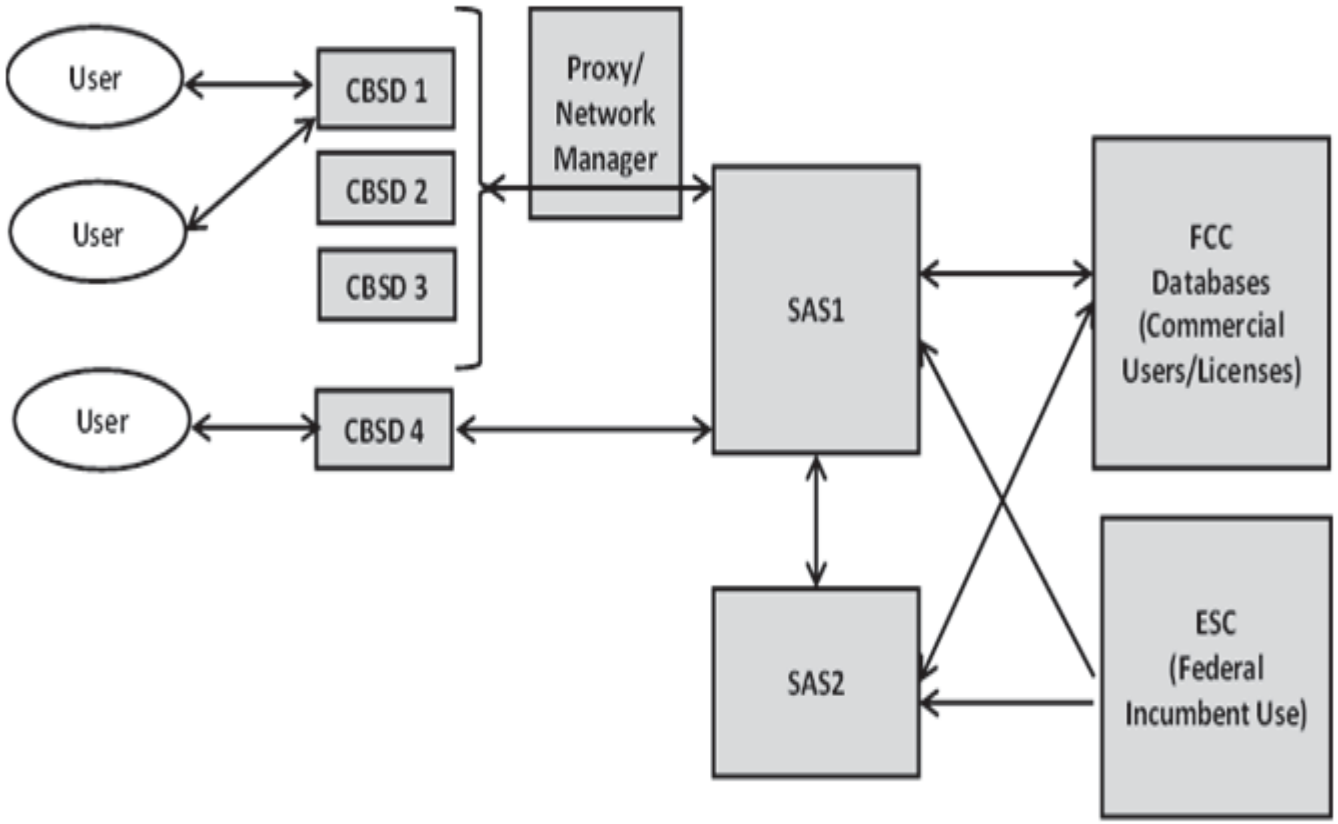
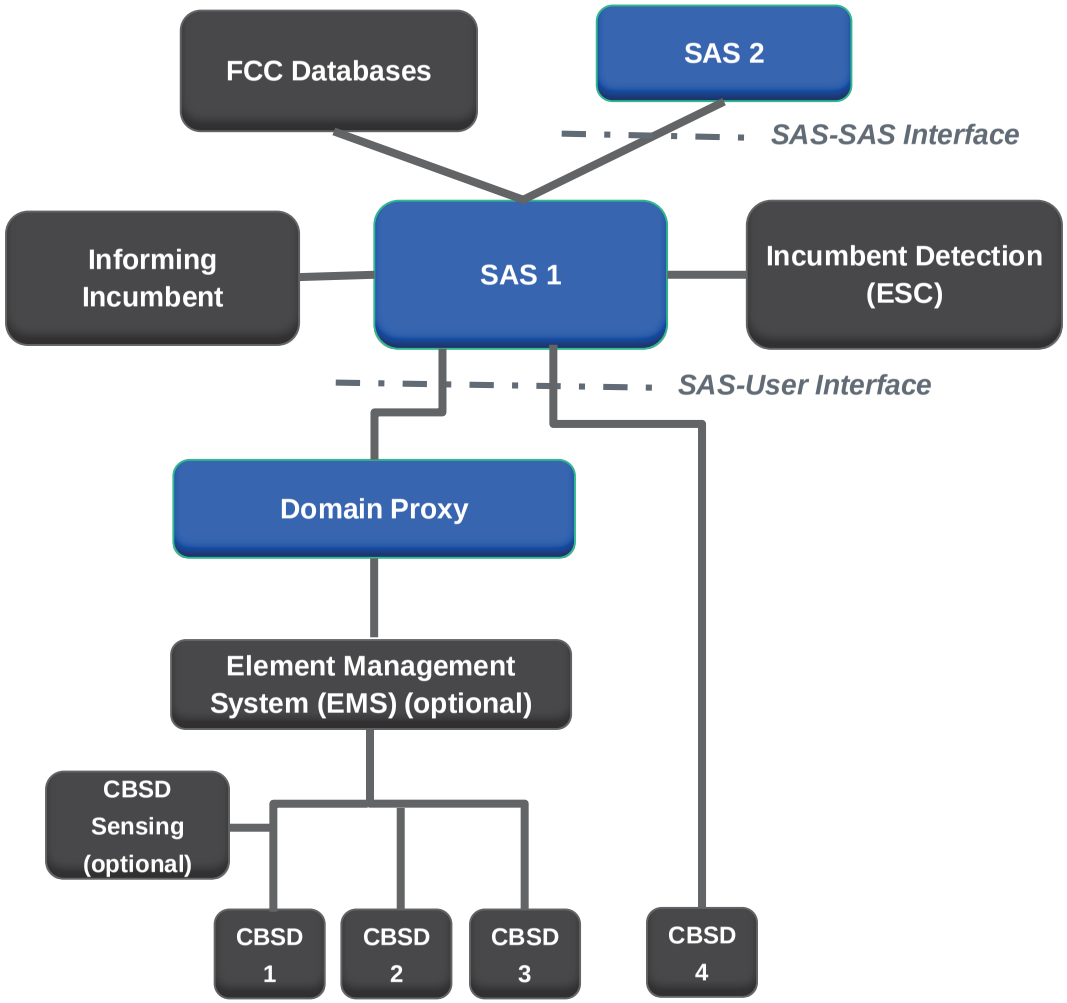


Figure 3, page 95 of 187

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

SAS – Functional Architecture



Acronyms:

ESC: Environmental Sensing Capability
CBSD: Citizens Broadband Radio Service Device
SAS: Spectrum Access System

Notes:

- A SAS may not need to support all interfaces.
- Each CBSD domain may optionally include some sensing capability (including possibly an ESC).

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

Domain Proxy Functionality

A Domain Proxy is a managing intermediary.

A Domain Proxy's function is to:

- Accept a set of one or more available channels and select channels for use by specific CBSDs, or alternatively pass the available channels to the carrier EMS for CBSD channel selection
  - EMS may optionally be co-located with the domain proxy
- Back report selected channels to SAS optionally received via EMS
- Receives confirmation of channel assignment from SAS
- Performs bidirectional bulk CBSD registration and directive processing, optionally through carrier EMS if present.
- Perform bidirectional information processing and routing.
  - E.g. interference reporting, etc.

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

SAS Purpose and Functionality (from FCC R&O, Annex A, 96.53)

- Enact and enforce all policies and procedures developed by the SAS Administrator pursuant to section 96.63.
- Determine and provide to CBSDs the permissible channels or frequencies at their location.
- Determine and provide to CBSDs the maximum permissible transmission power level at their location.
- Retain information on, and enforce, Exclusion Zones and Protection Zones in accordance with sections 96.15 and 96.17.
- Communicate with the ESC to obtain information about federal Incumbent User transmissions and instruct CBSDs to move to another frequency range or cease transmissions.
- Ensure that CBSDs operate in geographic areas and within the maximum power levels required to protect federal Incumbent Users from harmful interference, consistent with the requirements of sections 96.15 and 96.21.
- Register and authenticate the identification information and location of CBSDs.
- Ensure that CBSDs protect non-federal Incumbent Users from harmful interference, consistent with the requirements of section 96.17 and 96.21.
- Protect Priority Access Licensees from interference caused by other PALs and from General Authorized Access Users consistent with section 96.25.
- Facilitate coordination between GAA users operating Category B CBSDs, consistent with section 96.35.
- Resolve conflicting uses of the band while maintaining, as much as possible, a stable radio frequency environment.
- Ensure secure and reliable transmission of information between the SAS and CBSDs.
- Protect Grandfathered Wireless Broadband Licensees consistent with section 90.1307,90.1338, and 96.21.
- Implement the terms of current and future international agreements as they relate to the Citizens Broadband Radio Service.

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

SAS Core Functions (from FCC R&O, Para 320)

- Determine the available frequencies at a given geographic location and assign them to CBSDs;
- Determine the maximum permissible transmission power level for CBSDs at a given location and communicate that information to the CBSDs;
- Register and authenticate the identification information and location of CBSDs;
- Enforce Exclusion and Protection Zones, including any future changes to such Zones, to ensure compatibility between Citizens Broadband Radio Service users and incumbent federal operations;
- Communicate with the ESC and ensure that CBSDs operate in a manner that does not interfere with federal users;
- Ensure that CBSDs protect non-federal incumbent users consistent with the rules;
- Protect Priority Access Licensees from impermissible interference from other Citizens Broadband Radio Service users;
- Facilitate coordination between GAA users to promote a stable spectral environment;
- Ensure secure and reliable transmission of information between the SAS, ESC, and CBSDs;
- Provide an approved ESC with any sensing information reported by CBSDs if available;
- Protect Grandfathered Wireless Broadband Licensees until the end of the grandfather period;
- Facilitate coordination and information exchange between SASs.

Copyright © 2015 Software Defined Radio Forum, Inc. All Rights Reserved

Appendix D.4 CBRS Operational and Functional Requirements

Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band

Document WINNF-15-S-0112

Version V1.0.0

12 May 2016

Copyright © 2016 The Software Defined Radio Forum Inc. – All Rights Reserved

TERMS, CONDITIONS & NOTICES

This document has been prepared by the Spectrum Sharing Committee Work Group 1 (Operational and Functional Requirements) 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 Spectrum Sharing Committee Work Group 1 (Operational and Functional Requirements).

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.

The Forum draws attention to the fact that it is claimed that compliance with this specification may involve the use of a patent ("IPR") concerning Sections 4.1 and 4.6. The Forum takes no position concerning the evidence, validity or scope of this IPR.

The holder of this IPR has assured the Forum that it is willing to license all IPR it owns and any third party IPR it has the right to sublicense which might be infringed by any implementation of this specification to the Forum and those licensees (members and non-members alike) desiring to implement this specification. Information may be obtained from:

QUALCOMM Incorporated
5775 Morehouse Drive
San Diego, CA 92121

Attention is also drawn to the possibility that the Forum shall not be responsible for identifying any or all such IPR.

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.

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

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

Table of Contents

TERMS, CONDITIONS & NOTICES i
Contributors iv
1 Scope 1
2 Definitions and abbreviations 2
2.1 Other Definitions 2
2.2 Abbreviations 2
3 Requirement Organization 2
4 SAS Requirements 3
4.1 SAS General Requirements (SGN) 3
4.2 Incumbent Protection Management (IPM) 7
4.3 SAS Interference Management and Exclusion Zones (IMZ) 10
4.4 SAS Administrators (SAD) 11
4.5 SAS Requirements for PAL Users (SPU) 14
4.6 SAS Requirements for GAA Users (SGU) 14
4.7 Inter-SAS Communication (ISC) 15
5 CBSD Requirements (DEV) 16
6 Domain Proxy Requirements (DPX) 21
7 System Registration Requirements 22
8 Environmental Sensing Capability Requirements (ESC) 26
9 End User Device Requirements (EUD) 30
10 References 30
Appendix B: Revision History 36

List of Figures

Figure 1: SAS Functional Architecture 1

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

Contributors

The following individuals made significant contributions to this document:

Editor: Al Jette, Nokia Networks

Other Member Representatives:

- AT&T: Neeti Tandon
- Ericsson: Kumar Balachandran
- Federated Wireless: Sam MacMullan, Masoud Olfat
- Google: Greg Billock, Andy Clegg
- Key Bridge Global: Jesse Caulfield
- Motorola Solutions: David Gurney
- NIST: Mudumbai Ranganathan, Anirudha Sahoo, Michael Souryal
- Nokia Networks: Milind Buddhikot, Prakash Moorut
- Pathfinder Wireless: Colby Harper
- Ruckus Wireless: Dave Stephenson, Dave Wright
- Qualcomm: Doug Knisely
- Verizon: Max Solondz

Copyright © 2016 The Software Defined Radio Forum Inc
All Rights Reserved

Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band

1 Scope

This document specifies the requirements and technical considerations for commercial operations in the 3550-3700 MHz band in the United States. The requirements are based on Federal Communications Commission (FCC) rules adopted in the 2015 Report and Order in FCC docket GN 12-354, "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band" [1]. The rules themselves are codified in Part 96 of Title 47 the U.S. Code of Federal Regulations [2]. The FCC rules will hereafter be referred to as "the FCC Rules," "the Rules," or "Part 96," and reference to specific items in the rules will be given in the form of, for example, 96.15(a)(1).

The document defines the requirements on the Spectrum Access System (SAS), Citizens Broadband Radio Service Device (CBSD), End User Device (EUD), Priority Access License (PAL), and General Authorized Access (GAA) equipment in order to define the necessary operation and standards interfaces between such equipment to effect a properly functioning spectrum sharing environment in the 3550-3700 MHz band.

To assist the reader, we include below the SAS Functional Architecture with defined interfaces.

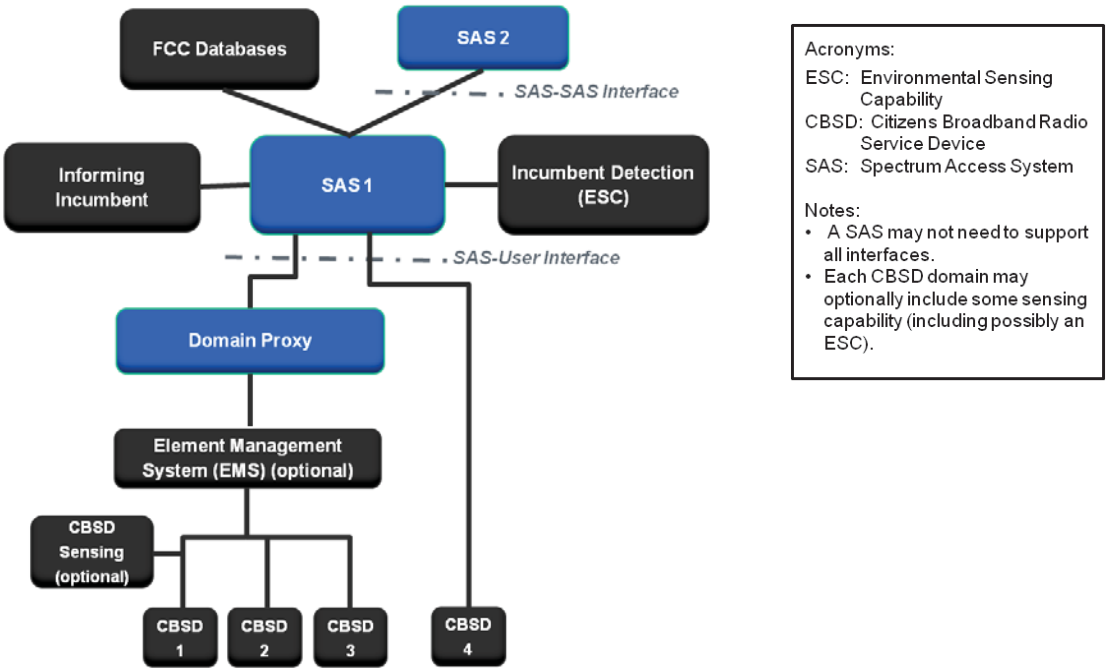


Figure 1: SAS Functional Architecture

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

2 Definitions and abbreviations

2.1 Other Definitions

The Wireless Innovation Forum Spectrum Sharing Committee (SSC) leverages the definitions provided by the FCC from their Title 47 Part 96 rules. These definitions are also available at reference. [3]

Additional definitions:

Domain Proxy: An entity engaging in communications with the SAS on behalf of multiple individual CBSDs or networks of CBSDs. The Domain Proxy can also provide a translational capability to interface legacy radio equipment in the 3650-3700 MHz band with a SAS to ensure compliance with Part 96 rules.

2.2 Abbreviations

3GPP	3rd Generation Partnership Project
CBSD	Citizens Broadband radio Service Device
DoD	U.S. Department of Defense
ESC	Environmental Sensing Capability
EUD	End User Device
FCC	Federal Communications Commission
FFS	For Further Study
FSS	Fixed-Satellite Service
GAA	General Authorized Access
MFCN	Mobile / Fixed Communication Networks
NTIA	National Telecommunications and Information Administration
OA&M	Operations, Administration and Maintenance
PA	Priority Access
PAL	Priority Access License
SAS	Spectrum Access System
WBS	Wireless Broadband Service (FCC Rules Part 90, Subpart Z)
WISP	Wireless Internet Service Provider (operated under WBS)

3 Requirement Organization

Requirements shall be uniquely identified by: R#-<CATEGORY>-<XX>. Where

- R0-: Requirements directly from FCC Rules
  R1-: Requirements derived from FCC Rules
  R2-: Requirements imposed by WINN Forum

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

- <CATEGORY>

Code	Category
SGN	SAS General
IPM	Incumbent Protection Management
IMZ	SAS Interference Management and Exclusion Zones
SAD	SAS Administration
SPU	SAS Requirements for PAL Users
SGU	SAS Requirements for GAA Users
ISC	Inter-SAS Communication
DEV	CBSD Requirements
DPX	Domain Proxy
SRR	System Registration Requirements (includes Owner, CBSD & Certified Professional Installer Registration)
ESC	Environmental Sensing Capability
EUD	End User Device

- <XX>: Unique number to identify the requirement

Requirements taken from the FCC Rules are included as "R0" and we attempted to use the FCC Rules without change. In some instances, the FCC uses "must" or "will" for rules, which we have included below as a requirement; however, we insert [shall] to indicate we consider this as a formal requirement.

The following terms are used within this document and should be interpreted as:

- SHALL is a mandatory requirement (negative is SHALL NOT)
- SHOULD is recommended requirement /best practice (negative is SHOULD NOT)
- MAY is an optional requirement, i.e. something that is allowed (negative is NEED NOT)

4 SAS Requirements

4.1 SAS General Requirements (SGN)

R0-SGN-01: The SAS shall support 3 tiers of service: Incumbent Access, Priority Access (PA) and General Authorized Access (GAA). [Ref-2, 96.1].

Informative Note: The Incumbent Access tier includes authorized federal users, grandfathered FSS earth stations and for a finite period, grandfathered terrestrial wireless operations in the 3650-3700 MHz portion of the band. [Ref-2, para 4]

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R0-SGN-02: The SAS must [shall] support registration of CBSDs prior to CBSD initial service transmission. [Ref-2, 96.39] See CBSD section for what information is required for registration.

R0-SGN-03: The SAS assigns channels for PALs to use. [Ref-2, 96.11, 96.13 & 96.25]

a. The SAS shall authorize 10 MHz channels in the 3550-3650 MHz frequency band to PA users. Note: 10 MHz channels shall be contiguous spectrum unless the PAL licensee agrees to subdivide the spectrum [Ref-2, para 74]
b. The SAS shall not assign more than seven PALs in any given License Areas at any given time.
c. The SAS must [should] assign multiple channels held by the same Priority Access Licensee to contiguous channels in the same License Area, to the extent feasible, and to the extent indicated by the PAL holder and consistent with the other requirements of the SAS.
d. The SAS may temporarily reassign individual PALs to non-contiguous channels to the extent necessary to protect Incumbent Users or if necessary to perform its required functions under subpart F of Section 96 [2].
e. Priority Access Licensees may request a particular channel or frequency range from the SAS but will not be guaranteed a particular assignment.
f.

R0-SGN-04: The SAS shall make unused PAL channels available for assignment for General Authorized Access use. GAA users may operate in the 3550-3700 MHz frequency band. [Ref-2, 96.11 & 96.25]

R0-SGN-05: SAS interface security [Ref-2, 96.61 & 96.39]

a. An SAS must [shall] employ protocols and procedures to ensure that all communications and interactions between the SAS and CBSDs are accurate and secure and that unauthorized parties cannot access or alter the SAS or the information it sends to a CBSD.
b. Communications between CBSDs and an SAS, between an ESC and a SAS, between individual CBSDs, and between different SASs, must [shall] be secure to prevent corruption or unauthorized interception of data. An SAS must be protected from unauthorized data input or alteration of stored data.
c. An SAS must [shall] verify that the FCC identification number supplied by a CBSD is for a certified device and must not provide service to an uncertified device.

R0-SGN-06: SAS The purposes and functionality of the SAS includes [Ref-2, 96.53].

a. To enact and enforce all policies and procedures developed by the SAS Administrator pursuant to section 96.63.
b. To determine and provide to CBSDs the permissible channels or frequencies at their location.
c. To determine and provide to CBSDs the maximum permissible transmission power level at their location.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

d. To register and authenticate the identification information and location of CBSDs.
e. To retain information on, and enforce, Exclusion Zones and Protection Zones in accordance with sections 96.15 and 96.17.
f. To communicate with the ESC to obtain information about federal Incumbent User transmissions and instruct CBSDs to move to another frequency range or cease transmissions.
g. To ensure that CBSDs operate in geographic areas and within the maximum power levels required to protect federal Incumbent Users from harmful interference, consistent with the requirements of sections 96.15 and 96.21.
h. To ensure that CBSDs protect non-federal Incumbent Users from harmful interference, consistent with the requirements of section 96.17 and 96.21 [Ref R0-SGU-01:(b)].
i. To protect Priority Access Licensees from interference caused by other PALs and from General Authorized Access Users consistent with section 96.25 [Ref R0-SGU-01:(b)].
j. To facilitate coordination between GAA users operating Category B CBSDs, consistent with section 96.35.
k. To resolve conflicting uses of the band while maintaining, as much as possible, a stable radio frequency environment.
l. To ensure secure and reliable transmission of information between the SAS and CBSDs.
m. To protect Grandfathered Wireless Broadband Licensees consistent with section 90.1307, 90.1338, and 96.21.
n. To implement the terms of current and future international agreements as they relate to the Citizens Broadband Radio Service.

R0-SGN-07: The SAS shall maintain current information on registered CBSDs, the geographic locations and configuration of protected FSS locations as set forth in section 96.17, and the federal Incumbent User Exclusion Zones and Protection Zones. [Ref-2, 96.55]

a. For registered CBSDs, such information shall include all information required by section 96.39 and 96.45.
b. SAS Administrators must [shall] make all information necessary to effectively coordinate operations between and among CBSDs available to other SAS Administrators.
c. SAS Administrators must [shall] make CBSD registration information available to the general public, but they must obfuscate the identities of the licensees providing the information for any public disclosures.
d. For non-federal Incumbent Users, the SAS shall maintain a record of the location of protected earth stations as well as the all registration information required by section 96.17.

R0-SGN-08: The SAS shall maintain records not pertaining to federal Incumbent User transmissions for at least 60 months. [Ref-2, 96.55]

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R0-SGN-09: The SAS shall only retain records of information or instructions received regarding federal Incumbent User transmissions from the ESC in accordance with information retention policies established as part of the ESC approval process. [Ref-2, 96.55]

R0-SGN-10: The SAS shall be technically capable of directly interfacing with any necessary FCC database containing information required for the proper operation of an SAS. [Ref-2, 96.55]

R0-SGN-11: The SAS shall process and retain acknowledgements by all entities registering CBSDs that they understand the risk of possible interference from federal Incumbent User radar operations in the band. [Ref-2, 96.55]

R0-SGN-12: SAS Registration, Authentication and Authorization of CBRS Devices [Ref-2, 96.57]

a. An SAS must [shall] register, authenticate, and authorize operations of CBSDs consistent with this rule part.
b. CBSDs composed of a network of base and fixed stations may employ a subsystem for aggregating and communicating all required information exchanges between the SAS and CBSDs. [Note: Related to Domain Proxy Requirements & R2-SRR-13 & 14].
c. An SAS must [shall] also verify that the FCC identifier (FCC ID) of any CBSD seeking access to its services is valid prior to authorizing it to begin providing service. A list of devices with valid FCC IDs and the FCC IDs of those devices is to be obtained from the Commission's Equipment Authorization System. [Note: Related to R0-SRR-01 & -02]
d. An SAS must [shall] not authorize operation of CBSDs within Protection Zones except as set forth in section 96.15.

R0-SGN-13: SAS Assignment of Frequencies [Ref-2, 96.13c, 96.59]

a. An SAS must [shall] determine the available and appropriate channels/frequencies for CBSDs at any given location using the information supplied by CBSDs, including location, the authorization status and operating parameters of other CBSDs in the surrounding area, information communicated by the ESC, other SASs, and such other information necessary to ensure effective operations of CBSDs consistent with this part. All such determinations and assignments shall be made in a non-discriminatory manner, consistent with this part.

    i. Upon request from the Commission or a CBSD, an SAS must [shall] confirm whether frequencies are available in a given geographic area.

    ii. Upon request from the Commission, an SAS must [shall] confirm that CBSDs in a given geographic area and frequency band have been shut down or moved to another available frequency range in response to information received from the ESC.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

iii. If an SAS provides a range of available frequencies or channels to a CBSD, it may require that CBSD to confirm which channel or range of frequencies it will utilize.

b. Consistent with the requirements of 96.25, an SAS shall assign geographically contiguous PALs held by the same Priority Access Licensee to the same channels in each geographic area, where feasible. The SAS shall also assign multiple channels held by the same Priority Access Licensee to contiguous frequencies within the same License Area, where feasible.

c. An SAS may temporarily assign PALs to different channels (within the frequency range authorized for Priority Access use) to protect Incumbent Access Users or if necessary to perform its required functions.

R0-SGN-14: We require that the SAS and the ESC must [shall] not have any connectivity to any military or other sensitive federal database or system. Nor shall they store, retain, transmit, or disclose operational information on the movement or position of any federal systems. The SAS shall only retain records of information or instructions received from the ESC in accordance with information retention policies established as part of the ESC approval process. These policies will [shall] include appropriate safeguards for classified and other sensitive data and will be developed by the Commission in coordination with NTIA and DoD. [Ref-2, 96.63n & para 330]

R1-SGN-01: The SAS must [shall] not collect, track, or store information on End User Devices or their users without user consent. [Ref-2, para 333]

4.2 Incumbent Protection Management (IPM)

R0-IPM-01: Protection of Existing FSS Earth Stations in the 3600-3650 MHz Band and 3700-4200 MHz Band [Ref-2, 96.17]

a. CBSDs shall protect the FSS earth stations authorized to operate in the 3600-3650 MHz band listed at fcc.gov/cbrs-protected-fss-sites in accordance with the Commission's rules.

b. CBSDs shall protect the FSS earth stations authorized to operate in the 3700-4200 MHz band listed at fcc.gov/cbrs-protected-fss-sites in accordance with the Commission's rules.

c. These protection criteria will [shall] be enforced by the Spectrum Access System authorized consistent with section 96.53, et seq. below.

d. FSS earth station licensees requesting protection under this Part must [shall] register with the Commission annually, no later than 30 days before the end of the preceding calendar year, or upon making changes to any of the operational parameters listed in this section. Registration information will [shall] be made available to all approved SASs.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

i. Annual registration for each earth station shall include, at a minimum: the earth station's geographic location (Using NAD83 coordinates); antenna gain; azimuth and elevation antenna gain pattern; antenna azimuth relative to true north; and antenna elevation angle.

ii. Such information must [shall] be made available to SAS Administrators and maintained consistent with section 96.55.

e. CBSDs may operate within areas that may cause interference to FSS earth stations provided that the licensee of the FSS earth station and the authorized user of the CBSD mutually agree on such operation and the terms of any such agreement are provided to an SAS Administrator that agrees to enforce them. The terms of any such agreement shall be communicated promptly to all other SAS Administrators.

R0-IPM-02: Protection of Existing Operators in the 3650-3700 MHz Band [Ref-2, 96.21]

a. Grandfathered Wireless Broadband Licensees shall be granted Incumbent User status consistent with sections 90.1307 and 90.1338. Notwithstanding this status, Grandfathered Wireless Broadband Licensees shall not cause harmful interference to federal Incumbent Users and grandfathered FSS earth stations consistent with the rules governing Citizens Broadband Radio Service operators in this part.

i. Incumbent User protections for a Grandfathered Wireless Broadband Licensee shall only apply within its Grandfathered Wireless Protection Zone.

ii. Incumbent User protections for a Grandfathered Wireless Broadband Licensee shall only apply to Grandfathered Wireless Protection Zones around base or fixed stations that are registered in ULS on or before April 17, 2015 and constructed, in service, and fully compliant with the rules in Part 90, subpart Z as of April 17, 2016. Grandfathered Wireless Protection Zones will [shall] be reduced in geographic area and/or applicable frequency range if portions of the protected network fail to meet the above criteria after April 17, 2016. Grandfathered Wireless Protection Zones will [shall] not be defined for subscriber units operated by Grandfathered Wireless Broadband Licensees, regardless of whether they have been registered in ULS.

iii. Grandfathered Wireless Protection Zones must [shall] be registered in the SAS for these protections to apply.

b. Grandfathered Wireless Broadband Licensees may operate within their Grandfathered Wireless Protection Zones and operational frequencies consistent with the technical rules in Part 90, subpart Z, consistent with the transition period set forth in sections 90.1307 and 90.1338.

c. Grandfathered Wireless Broadband Licensees and Citizens Broadband Radio Service users must [shall] protect authorized grandfathered FSS

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

earth stations in the 3650-3700 MHz band, consistent with the existing protection criteria in part 90, subpart Z until the last Grandfathered Wireless Broadband Licensee's license expires within the protection area defined for a particular grandfathered FSS earth station. Thereafter, the protection criteria in section 96.17 applicable to similarly situated facilities shall apply.

R1-IPM-01: Protection of Federal Incumbent Users from CBSDs operating in the 3550-3650 band [Ref-2, 96.15]

a. CBSDs and End User Devices must [shall] not cause harmful interference to and must accept interference from federal Incumbent Users authorized to operate in the 3550-3700 MHz band and below 3550 MHz. Note: the FCC Rules do not explicitly state how far below 3550 MHz that federal Incumbent Users must be protected. However, primary federal allocations extend to 3100 MHz.
b. The SAS shall only authorize the use of CBSDs consistent with information on federal frequency use obtained from an approved ESC, except as provided in this section.
c. For Category A CBSDs, Exclusion Zones shall be maintained along the Coastline, as shown at ntia.doc.gov/category/3550-3650-mhz. Exclusion Zones shall also be maintained around federal radiolocation sites as set forth at ntia.doc.gov/category/3550-3650-mhz. NTIA shall notify the Commission in writing if and when the list of protected federal radiolocation sites is updated. Exclusion Zones shall be maintained and enforced until one or more ESCs are approved and used by at least one SAS, in accordance with section 96.67. Thereafter, Exclusion Zones shall be converted to Protection Zones.
    i. Category A CBSDs may be authorized by an approved SAS in geographic areas outside of Exclusion Zones before an ESC is approved.
    ii. Once an ESC is approved and used by at least one SAS, Category A CBSDs may only be authorized consistent with information on federal frequency use provided to the SAS by an approved ESC.
    iii. Category B CBSDs may only be authorized consistent with information on the presence of a signal from a federal system provided to the SAS by an approved ESC. [Ref-2, 96.45b]
d. Within 60 seconds after the ESC communicates that it has detected a signal from a federal system in a given area, the SAS must [shall] either confirm suspension of the CBSD's operation or its relocation to another unoccupied frequency, if available. Note: the 60 second time period is expected to change with the second report and order.
e. The Commission will, as necessary, add or modify Exclusion Zones or Protection Zones to protect current and future federal Incumbent Users.
f. The Commission may temporarily extend or modify Exclusion Zones and Protection Zones to protect temporary operations by federal Incumbent

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Users. Federal Incumbent Users will [shall] coordinate with the Commission prior to the beginning of any non-emergency operation requiring additional protection. Such modifications will [shall] be communicated to the SAS along with the expiration date and time of any modification.

R1-IPM-02: Protection of Federal Incumbent Users from CBSDs operating in the 3650-3700 band [Ref-2, 96.15]

a. CBSDs and End User Devices must [shall] not cause harmful interference to and must accept interference from federal Incumbent Users.
b. Exclusion Zones shall be maintained for an 80 km radius around the federal radiolocation sites listed in 47 CFR 90.1331 [Ref 4] and 47 CFR 2.106 footnote US 109 [Ref 4]. These Exclusion Zones shall be maintained and enforced until one or more ESCs are approved and used by at least one SAS, in accordance with section 96.67. Thereafter, Exclusion Zones shall be converted to Protection Zones.
c. CBSDs may only be authorized within these Protection Zones consistent with information on the presence of a signal from a federal system provided to the SAS by an approved ESC, in accordance with section 96.67.
d. Within 60 seconds after the ESC communicates that it has detected a signal from a federal system in a given area, the SAS must [shall] either confirm suspension of the CBSD's operation or its relocation to another unoccupied frequency.

R2-IPM-01: Impacts from CBRS activity authorized by all SASs shall be managed to achieve an aggregate interference level at 3550-3650MHz for federal incumbent radars not to exceed an I/N of -6 dB at the incumbent radar system receiver [NTIA Report 15-517 section 4.3].

Note: there is a question in to NTIA regarding the noise level used in Report 15-517. A nominal noise figure of 3 dB was used in the derivation of the R2-ESC-02.

Note: how SAS's manage aggregate interference is left for future study.

4.3 SAS Interference Management and Exclusion Zones (IMZ)

R0-IMZ-01: Citizens Broadband Radio Service operation in the 3550-3700 MHz band is [shall be] subject to current and future international agreements with Mexico and Canada. The terms of these agreements shall be implemented by the SAS. [Ref-2, 96.19]

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

4.4 SAS Administrators (SAD)

R0-SAD-01: SAS Administrators are [shall be] designated by the FCC to provide nationwide service.

Note: The Commission may, at its discretion, permit the functions of an SAS, such as a data repository, registration, and query services, to be divided among multiple entities; however, it shall designate one or more specific entities to be an SAS Administrator responsible for coordinating the overall functioning of an SAS and providing services to operators in the Citizens Broadband Radio Service. [Ref-2, 96.63]

R0-SAD-02: Each SAS Administrator designated by the Commission must [shall]: [Ref-2, 96.63]

a. Maintain a regularly updated database that contains the information described in section 96.55 [2].
b. Establish a process for acquiring and storing in the database necessary and appropriate information from the Commission's databases, including PAL assignments, and synchronizing the database with the current Commission databases at least once a day to include newly licensed facilities or any changes to licensed facilities.
c. Establish and follow protocols and procedures to ensure compliance with the rules set forth in this part, including the SAS functions set forth in section 96.53 [2], et seq.
d. Establish and follow protocols and procedures sufficient to ensure that all communications and interactions between the SAS, ESC, and CBSDs are accurate and secure and that unauthorized parties cannot access or alter the SAS or the information transmitted from the SAS to CBSDs.
e. Provide service for a five-year term. This term may be renewed at the Commission's discretion.
f. Respond in a timely manner to verify, correct or remove, as appropriate, data in the event that the Commission or a party brings a claim of inaccuracies in the SAS to its attention. This requirement applies only to information that the Commission requires to be stored in the SAS.
g. Securely transfer the information in the SAS, along with the IP addresses and URLs used to access the system, and a list of registered CBSDs, to another approved entity in the event it does not continue as the SAS Administrator at the end of its term. It may charge a reasonable price for such conveyance.
h. Cooperate to develop a standardized process for coordinating operations with other SASs, avoiding any conflicting assignments, maximizing shared use of available frequencies, ensuring continuity of service to all registered CBSDs, and providing the data collected pursuant to section 96.55 [2].
i. Coordinate with other SAS Administrators including, to the extent possible, sharing information, facilitating non-interfering use by CBSDs

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

connected to other SASs, maximizing available General Authorized Access frequencies by assigning PALs to similar channels in the same geographic regions, and other functions necessary to ensure that available spectrum is used efficiently consistent with this part.

j. Provide a means to make non-federal non-proprietary information available to the public in a reasonably accessible fashion in conformity with these rules.
k. Ensure that the SAS shall be available at all times to immediately respond to requests from authorized Commission personnel for any and all information stored or retained by the SAS.
l. Establish and follow protocols to respond to instructions from the President of the United States, or another designated Federal government entity, issued pursuant to 47 U.S.C. 606.
m. Establish and follow protocols to comply with enforcement instructions from the Commission.
n. Ensure that the SAS operates without any connectivity to any military or other sensitive federal database or system, except as otherwise required
o. Ensure that the SAS does not store, retain, transmit, or disclose operational information on the movement or position of any federal system or any information that reveals other operational information of any federal system that is not required by this part to effectively operate the SAS.

R0-SAD-03: An SAS Administrator may charge Citizens Broadband Radio Service users a reasonable fee for provision of the services [Ref-2, 96.65]

R1-SAD-01: We require SAS Administrators to [shall] implement protocols to respond to directions from the President of the United States or another designated federal entity to manually discontinue operations of its associated CBSDs in a given area pursuant to 47 U.S.C. § 606. SAS Administrators must [shall] also implement protocols to manually discontinue operations of their associated CBSDs in response to enforcement actions taken by the Commission. [Ref-2, para 268]

R1-SAD-02: SAS Administrators must [shall] develop policies and procedures to ensure CBRS users accept & acknowledge that they may receive potentially harmful interference from federal radar systems as a condition of their authorization. [Ref-2, para 274]

R1-SAD-03: A SAS Administrator shall provide a capability for receiving reports of exceptional circumstances requiring the attention of the Administrator. Such reports shall be able to be received from these entities and/or their designated agents:

1. The Federal Government
2. Operators of incumbent Fixed Satellite Earth Stations
3. Operators of incumbent Wireless Broadband Service stations operating in the 3650-3700MHz band
4. Operators of networks protected by Priority Access licenses

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

5. Operators of network equipment licensed by GAA rules
6. Other SAS Administrators
7. ESC Administrators

Such reports shall support communication to the SAS Administrator of at least the following exceptional circumstances:

1. The report of erroneous data in the SAS database.
2. The report of harmful interference experienced by an incumbent station or Priority Access licensee which is prohibited by Part 96 rules.
3. The report of an alternative interference protection relationship between an incumbent station or group of stations) and CBSDs operating under Part 96.
4. The report of an alternative interference protection relationship between a network operator protected by a Priority Access license and other CBSDs operating under Part 96.
5. The report by the FCC of an enforcement action, including any action taken regarding a particular CBSD or group of CBSDs or regarding a particular CBRS user or group of users.
6. The report by the FCC of a waiver granted to provide an exception to Part 96 rules for CBSDs or other CBRS entities.
7. The report by the FCC of a waiver which has been granted to a non-CBRS entity which impacts CBRS operations.

When in receipt of such a report of exceptional circumstances, a SAS Administrator shall provide the full details of such a report to all other SAS Administrators to whom the report is relevant [Note: it is FFS to define who is "relevant"]:

1. Reports originated by the Federal Government shall always be provided to other SAS Administrators without delay.
2. Reports of alternative interference protection relationships between incumbents and CBSDs or between Priority Access and General Authorized Access users shall always be provided to other SAS Administrators without delay.
3. Reports leading to corrections in the SAS database shall be communicated to other SAS Administrators without delay insofar as the correction will impact previously-communicated information the SAS Administrator has corrected as a result of the report.
4. Reports of harmful interference may be communicated to other SAS Administrators in the process of responding to such a report.

The tools provided by a SAS Administrator for the reporting of harmful interference should provide sufficient information for the reporter of such harmful interference to follow standardized reporting procedures such as OpenSSRF formats and the JSIR process. Such tools shall also inform the user that reports may be acted upon by the FCC.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

A SAS Administrator shall respond in a timely fashion corresponding to the nature of the report of exceptional circumstances, including those of harmful interference.

Note: FCC actions regarding an ad hoc exclusion zone or an emergency reclamation of spectrum are addressed in requirement R2-ISC-01.

[Ref-2, 96.35(e), 96.41(d)(1), 96.41(e)(4), 96.63(f), para. 37, 214, 399]

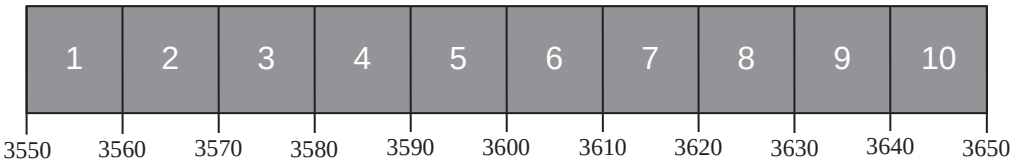
4.5 SAS Requirements for PAL Users (SPU)

R0-SPU-01: Each PAL[shall] consists of a single License Area (Census Tract). [Ref-2, 96.25]

R0-SPU-02: PAL channels must [shall] be assigned by the SAS. Priority Access Licensees may request a particular channel or frequency range from the SAS but will not be guaranteed a particular assignment. Priority Access Users may operate in the 3550-3650 MHz frequency band with assigned 10 MHz channels. [Ref-2, 96.11, 96.12 & 96.25]

R0-SPU-03: Priority Access Licensees may [shall] not aggregate more than four PAL channels in any License Area at any given time. [Ref-2, 96.31]

R2-SPU-01: The following channels are defined for PAL assignments in the 3550-3650 MHz band:



[Reference: FCC 15-47 at paragraph 59]

Informative Note: Future studies will examine the relative utility of each channel for single-carrier and aggregate emissions, in the context of out-of-band emissions limits, fixed-satellite and Part 90 incumbent protections, and other considerations.

4.6 SAS Requirements for GAA Users (SGU)

R0-SGU-01: General Authorized Access Users shall be permitted to use frequencies assigned to PALs when such frequencies are not in use, as determined by the SAS. Frequencies that are available for General Authorized Access Use shall be made available on a shared basis. [Ref-2, 96.35]

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

a. General Authorized Access Users shall have no expectation of interference protection from other General Authorized Access Users operating in accordance with this part.
b. General Authorized Access Users must [shall] not cause harmful interference to and must accept interference from Priority Access Licensees and Incumbent Users in accordance with this part. [Ref R0-SGN-06:(h) and R0-SGN-06:(i)]
c. General Authorized Access Users operating Category B CBSDs must [shall] make every effort to cooperate in the selection and use of available frequencies provided by an SAS to minimize the potential for interference and make the most effective use of the authorized facilities. Such users shall coordinate with an SAS before seeking station authorization, and make every effort to ensure that their CBSDs operate at a location, and with technical parameters, that will minimize the potential to cause and receive interference among CBSDs.
d. Operators of CBSDs suffering from or causing harmful interference are [shall be] expected to cooperate and resolve interference problems through technological solutions or by other mutually satisfactory arrangements.

R0-SGU-02: General Authorized Access Users may operate in the 3550-3700 MHz frequency band. [Ref-2, 96.11]

R0-SGU-03: General Authorized Access CBSDs must [shall] register with the SAS and comply with its instructions. [Ref-2, 96.33]

4.7 Inter-SAS Communication (ISC)

R2-ISC-01: When a SAS Administrator receives instructions from the President of the United States or another designated Federal government entity issued pursuant to 47 U.S.C. 606, or instructions from the FCC pursuant to FCC enforcement actions, that SAS Administrator shall, without delay, inform all other designated SAS Administrators of those instructions.

[Ref-2, 96.63(l & m) & Para 268; Title 47 USC 606]

R2-ISC-02: When a SAS Administrator receives communication that the Commission has temporarily extended or modified an Exclusion Zone or Protection Zone to protect temporary operations by federal incumbent users, that SAS Administrator shall, without delay, inform all other designated SAS Administrators of such communication. This information shall include the nature of the extension or modification as well as any accompanying expiration date and time specified by the Commission. [Ref-2, 96.15(a)(6)]

R2-ISC-03: Sharing of ESC Information between SASs:
a. Sharing of ESC information between SASs is prohibited if each of the SASs receive input from different ESCs.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

b. SASs shall exchange on a timely basis all CBSD data required for each SAS to correctly participate in aggregate federal incumbent radar protection relying on an ESC without reference to the behavior of any other SAS.

   Note: an enumeration of CBSD data to be shared will be the subject of study in the information sharing WG1 Task Group.

c. In addition, SAS administrators shall perform any necessary pre-arrangement of protection behavior needed to ensure the protection of federal incumbent radar activity in any exclusion zone within which CBSD operation is enabled due to the operation of an ESC system.

   Note: The specifics of such pre-arranged responses is expected to be provided by SAS administrators at the time of their application for approval, including a description of how these responses are parameterized by the ESC. Such parameterization may be updated during periodic ESC reviews.

5 CBSD Requirements (DEV)

R0-DEV-01: The Citizens Broadband Radio Service is [shall be] authorized in the 3550-3700 MHz frequency band. General Authorized Access Users may operate in the 3550-3700 MHz frequency band. Priority Access Users may operate in the 3550-3650 MHz frequency band. Grandfathered Wireless Broadband Licensees may continue to use the 3650-3700 MHz band in accordance Ref-2. [Ref-2, 96-11]

R0-DEV-02: All CBSDs must [shall] be able to determine their geographic coordinates (referenced to the North American Datum of 1983 (NAD83)) to an accuracy of ±50 meters horizontal and ±3 meters of elevation. Such geographic coordinates shall be reported to an SAS at the time of first activation from a power-off condition. [Ref-2, 96.39]

a. For professionally installed CBSDs, geographic coordinates to the same accuracy specified above may be determined and reported to the SAS as part of the installation and registration process. Geographic coordinates must [shall] be determined and reported each time the CBSD is moved to a new location.
b. Non-professionally installed CBSD must [shall] check its location and report to the SAS any location changes exceeding 50 meters horizontal and ±3 meters elevation from its last reported location within 60 seconds of such location change.

R0-DEV-03: A CBSD must [shall] register with and be authorized by an SAS prior to its initial service transmission. The CBSD must [shall] provide the SAS upon its registration with its geographic location, antenna height above ground level (in meters), CBSD class (Category A/Category B), requested authorization status (Priority Access or General Authorized Access), FCC identification number, call sign, user contact information, air interface technology, unique

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

manufacturer's serial number, sensing capabilities (if supported), and additional information (see below) [Ref-2, 96.39].

a. CBSD Category-A devices must [shall] also indicate if they are operating indoors or outdoors. [Ref-2, 96.43b]
b. CBSD Category-B devices must [shall] also provide: antenna gain, beamwidth, azimuth, downtilt angle, and antenna height above ground level. [Ref-2, 96.45d]
c. If any of the registration information changes, the CBSD shall update the SAS within 60 seconds of such change, except as otherwise set forth in section 96.39 of Ref-2.
d. All information provided by the CBSD to the SAS must [shall] be true, complete, correct, and made in good faith. [Ref-2, 96.39]

R0-DEV-04: CBSD technical operation [Ref-2, 96.39]

a. All CBSDs must [shall] be capable of two-way operation on any authorized frequency assigned by an SAS. Equipment deployed by Grandfathered Wireless Broadband Licensees during their license term will be exempt from this requirement
b. A CBSD must [shall] operate at or below the maximum power level authorized by an SAS, consistent with its FCC equipment authorization, and within geographic areas permitted by an SAS on the channels or frequencies authorized by an SAS.
c. A CBSD must [shall] receive and comply with any incoming commands from its associated SAS about any changes to power limits and frequency assignments. A CBSD must [shall] cease transmission, move to another frequency range, or change its power level within 60 seconds as instructed by an SAS.
d. A CBSD must [shall] report to an SAS regarding received signal strength in its occupied frequencies and adjacent frequencies, received packet error rates or other common standard metrics of interference for itself and associated End User Devices as directed by an SAS.
e. If directed by the SAS, a CBSD that receives a range of available frequencies or channels from an SAS must [shall] promptly report to the SAS which of the available channels or frequencies it will utilize.
f. CBSDs shall incorporate security measures sufficient to ensure that they are capable of communicating only with SASs operated by approved SAS Administrators, and that communications between CBSDs and SASs, between individual CBSDs, and between CBSDs and End User Devices are secure to prevent corruption or unauthorized interception of data.
g. For purposes of obtaining operational limits and frequency availabilities and their updates, CBSDs shall only contact SASs operated by SAS Administrators approved by the Commission in accordance with subpart F.
h. All communications between CBSDs and SASs must [shall] be transmitted using secure methods that protect the systems from corruption or unauthorized modification of the data.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

i. Communications between a CBSD and its associated End User Devices for purposes of obtaining operational power, location, and frequency assignments shall employ secure methods that protect the system from corruption or unauthorized modification of the data.
j. All CBSDs and End User Devices must [shall] contain security features sufficient to protect against modification of software and firmware by unauthorized parties. Applications for certification of CBSDs and End User Devices must [shall] include an operational description of the technologies and measures that are incorporated in the device to comply with the security requirements of this section. In addition, applications for certification of CBSDs and End User Devices must [shall] identify at least one of the SAS databases operated by an approved SAS Administrator that the device will access for channel/frequency availability and affirm that the device will conform to the communications security methods used by such databases.
k. Airborne operations by CBSDs and End User Devices are [shall be] prohibited.

R0-DEV-05: CBSD and End User Devices General Radio Requirements [Ref-2, 96.41]

a. Systems operating in the CBRS must [shall] use digital modulation techniques
b. Unless otherwise specified in this subsection, the maximum conducted output power, maximum transmit antenna gain, maximum EIRP, and maximum Power Spectral Density (PSD) of any CBSD and End User Device must [shall] comply with the limits shown in the table below:

Device	Geographic Area	Maximum Conducted Output Power (dBm/10 megahertz)**	Maximum EIRP (dBm/10 megahertz)	Maximum Conducted PSD (dBm/MHz)
End User Device	All	n/a	23	n/a
Category A CBSD	All	24	30	14
Category B CBSD*	Non-Rural	24	40	14
Category B CBSD*	Rural	30	47	20

* Category B CBSDs will only be authorized for use after an ESC is approved and commercially deployed consistent with sections 96.15 and 96.67.

c. CBSDs and End User Devices shall limit their operating power to the minimum necessary for successful operations.
    i. CBSDs must [shall] support transmit power control capability and the capability to limit their maximum EIRP and the maximum EIRP of associated End User Devices in response to instructions from an SAS.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

ii. End User Devices shall include transmit power control capability and the capability to limit their maximum EIRP in response to instructions from their associated CBSDs.

d. Received Signal Strength Limits:

i. For both Priority Access and GAA users, CBSD transmissions must [shall] be managed such that the aggregate received signal strength, measured at any location on the Service Area boundary of any co-channel PAL, shall not exceed an average (rms) power level of -80 dBm in any direction when integrated over a 10 megahertz reference bandwidth, with the measurement antenna placed at a height of 1.5 meters above ground level, unless the affected PAL licensees agree to an alternative limit and communicate that to the SAS.

ii. These limits shall not apply for co-channel operations at the boundary between geographically adjacent PALs held by the same Priority Access Licensee.

e. 3.5 GHz Emissions and Interference Limits:

i. General protection levels. Except as otherwise specified below, for channel and frequency assignments made by the SAS to CBSDs, the power of any emission outside the fundamental emission (whether in or outside of the authorized band) shall not exceed -13 dBm/MHz within 0-10 megahertz above the upper SAS-assigned channel edge and within 0-10 megahertz below the lower SAS-assigned channel edge. At all frequencies greater than 10 megahertz above the upper SAS assigned channel edge and less than 10 MHz below the lower SAS assigned channel edge, the power of any emission shall not exceed -25 dBm/MHz. The upper and lower SAS assigned channel edges are the upper and lower limits of any channel assigned to a CBSD by an SAS, or in the case of multiple contiguous channels, the upper and lower limits of the combined contiguous channels.

ii. Additional protection levels. Notwithstanding paragraph (d)(i) of this section, the power of any emissions below 3530 MHz or above 3720 MHz shall not exceed -40dBm/MHz.

iii. Measurement procedure:

Compliance with this provision is [shall be] based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's authorized frequency channel, a resolution bandwidth of no less than one percent of the fundamental emission bandwidth may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full reference bandwidth (i.e., 1 MHz or 1

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

When measuring unwanted emissions to demonstrate compliance with the limits, the CBSD and End User Device nominal carrier frequency/channel shall be adjusted as close to the licensee's authorized frequency block edges, both upper and lower, as the design permits.

Emission power measurements shall be performed with the CBSD and End User Devices operating at their maximum EIRP levels.

Emission power measurements shall be performed with a peak detector in maximum hold.

iv. When an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in this section.

f. Reception Limits: Priority Access Licensees must [shall] accept adjacent channel and in-band blocking interference (emissions from other authorized Priority Access or GAA CBSDs transmitting between 3550 and 3700 MHz) up to a power spectral density level not to exceed -40 dBm in any direction with greater than 99% probability when integrated over a 10 megahertz reference bandwidth, with the measurement antenna placed at a height of 1.5 meters above ground level, unless the affected Priority Access Licensees agree to an alternative limit and communicates that to the SAS.

Note to paragraph (f): Citizens Broadband Radio Service users should be aware that there are Federal Government radar systems in the band and adjacent bands that could adversely affect their operations.

R0-DEV-06: Category A CBSDs shall not be deployed or operated outdoors with antennas exceeding 6 meters height above average terrain. CBSDs deployed or operated outdoors with antennas exceeding 6 meters height above average terrain will be classified as, and subject to, the operational requirements of Category B CBSDs. [Ref-2, 96.43a]

R0-DEV-07: Any CBSD operated at higher power than specified for Category A CBSDs in section 96.41 [R0-DEV-05:] will be classified as, and subject to, the operational requirements of a Category B CBSD. [96.43c]

R0-DEV-08: Category B CBSDs must [shall] be professionally installed. [Ref-2, 96.45a]

Note: See Ref-3 for the definition of a Category B CBSD.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R0-DEV-09: Category B CBSDs are [shall be] limited to outdoor operations. [Ref-2, 96.45c]

R0-DEV-10: Each transmitter used for operation under this part and each transmitter marketed as set forth in section 2.803 [Ref-4, Chapter I, Subchapter A, Part 2] must [shall] be of a type which has been certificated for use under this part.

Any manufacturer of radio transmitting equipment to be used in these services must [shall] request equipment authorization following the procedures set forth in Subpart J [Ref-4, Chapter I, Subchapter A, Part 2]. [Ref-2, 96.49]

Communication between individual CBSDs must [shall] be secure to prevent corruption or unauthorized interception of data. [Ref-2, 96.61]

6 Domain Proxy Requirements (DPX)

The following requirements related to the Domain Proxy

R1-DPX-01: Domain Proxy to CBSD operational requirements: A Domain Proxy must [shall] ensure that all of the CBSD requirements of 96.39 [Ref-2] are met by CBSDs for which the Domain Proxy is communicating to the SAS.

R1-DPX-02: Domain Proxy to SAS interface security [Ref-2, 96.61]

a. A Domain Proxy must [shall] employ protocols and procedures to ensure that all communications and interactions between the Domain Proxy and SAS are accurate and secure and that unauthorized parties cannot access the Domain Proxy via this communication path or alter the information exchanged between the Domain Proxy and the SAS.
b. Communications between a Domain Proxy and an SAS must [shall] be secure to prevent corruption or unauthorized modification of data
c. A Domain Proxy must [shall] incorporate security measures sufficient to ensure that it is capable of communicating only with SASs operated by approved SAS Administrators.

R1-DPX-03: Domain Proxy to CBSD communications security [Ref-2 96.3, 96.61, 96.39(f), R0-SGN-05:]

a. A Domain Proxy must [shall] employ protocols and procedures to ensure that all communications and interactions between the Domain Proxy and CBSDs are accurate and secure and that unauthorized parties cannot access the Domain Proxy via this communication path or alter the information exchanged between the Domain Proxy and the CBSD.
b. Communications between a Domain Proxy and a CBSD must [shall] be secure to prevent corruption or unauthorized modification of data.

R2-DPX-01: Domain Proxy to CBSD communications security implementation: The protocols and procedures to fulfill and enforce Domain Proxy to CBSD security requirements are out of the scope of this document and are not specified.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

7 System Registration Requirements

Registration is a rather complex process and we provide Informative Annex A.1 with information to help explain the process.

R2-SRR-01: Owner Registration Information: The Owner Registration and associated database requires the owner to provide the following information:

a. Owner legal identity (corporate or individual),
b. Owner mailing Address (contact address), or designated agent contact address,
c. Owner's physical address (may or may not correspond to the Mailing Address),
d. Owner's legal Address (may or may not correspond to the Mailing Address),
e. Owner's Email contact address,
f. Owner's Phone Number (contact, or of designated agent),
g. Designated Agent (if applicable)

R2-SRR-02: During the Owner registration process, the system shall provide to the Owner in a secure manner the following:

a. A system wide[1] unique Owner Registration Identity (OR-ID) to identify the Owner,
b. A method to authenticate the Owner when accessing the Owner account (e.g, password)

R2-SRR-03: During the Owner registration process, the SAS shall record:

a. Owner Registration date,
b. Owner Registration expiration or term (tbd),
c. Owner Registration state (valid, expired, pending enforcement, revoked),
d. Registering Agent (FCC, SAS, or other agent),
e. Optional Registration Fee Paid (true of false indication). Note: a credit card transaction for this may help to serve as an identity check and a mailing address check to prevent fraudulent or fictitious registrations and mailing addresses. This credit card transaction may be a separate transaction for the Owner License, or may be the purchase transaction for the CBSD itself.

R1-SRR-01: During registration, the owner shall provide and the SAS shall record:

a. Acknowledgment of part 96 license rules, [Ref-2, 96.55(e) & para 274]
b. Acknowledgement of federal operations risk [Ref-2, 96.55(e) & para 274]

R2-SRR-04: Owner Validation: The owner credentials (whether an individual or business) shall be validated by the SAS to ensure the owner is who they represent and has a valid contact information & address. [Informative note: For an individual, this can include using a credit card to validate name and contact address.]

[1] The scope of System Wide is FFS.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R2-SRR-05: Owner Maintenance of account: The Owner shall be able to update owner information and be able to register or deregister CBSDs associated with their account.

R2-SRR-06: Association of CBSD with Owner: The SAS Administrator and the CBSD Owner shall exchange information that establishes a secure mechanism to identify the CBSD Owner identity and to establish the relationship between the CBSD and its owner. The owner information association shall be established per individual CBSD in such a way that legitimate owners may revoke the owner association.

R2-SRR-07: CBSD ID: The CBSD Registration process shall establish a CBRS-wide unique CBSD ID.

R2-SRR-08: The CBSD ID shall have a one-to-one correspondence with the combination FCC ID + CBSD S/N and may be identical to that combination.

R2-SRR-09: SAS authentication of software & firmware is FFS (along with SAS handling and authentication of software & firmware updates).

R0-SRR-01: Category A CBSD Parameter Set: Prior to the SAS enabling spectrum use by the CBSD, the following Category A CBSD information shall be provided to the SAS. The information shall be uploaded either via the CBSD communicating with the SAS or entered by a Certified Professional Installer via a mechanism provided by the SAS administrator.

a. CBSD Vendor,
b. CBSD Serial number [required by 96.39(c)],
c. FCC Identification number [required by 96.39(c)],
d. Call Sign [required by 96.39(c)],
e. Secure information to associate CBSD with the Owner,
f. Informative Note: this will link a valid Owner with the CBSD [required by 96.39(c)]
g. CBSD Air Interface Technology [required by 96.39(c)],
h. Types include: EUTRA, other values to be defined as appropriate
i. CBSD Sensing capability [required by 96.39(c)],[2]
j. CBSD installation location (Indoor or Outdoor, required for Category A CBSDs) [Ref 2, 96.43(b)],
k. Location information: latitude, longitude, and antenna height above ground level (in meters) [Ref 2, 96.39(c) & para 219],
l. Certified Professional Installer Registration ID (if information provided to the CBSD was manually entered by a Certified Professional Installer)
m. Optional vendor specific information fields. The SAS shall allow CBSDs to provide optional vendor specific information which can be used by the SAS. Examples include: CBSD model number, CBSD HW version

[2] To be defined by the Sensing & Measurement Task Group

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

number, CBSD SW and/or FW version number, hardware characteristics, etc.

R0-SRR-02: Category B CBSD Parameter Set: Prior to the SAS enabling spectrum use by the CBSD, the following Category B CBSD information shall be provided to the SAS. The information shall be uploaded either via the CBSD communicating with the SAS or entered by a Certified Professional Installer via a mechanism provided by the SAS administrator.

a. CBSD Vendor,
b. CBSD Serial number [required by 96.39(c)],
c. FCC Identification number [required by 96.39(c)],
d. Call Sign [required by 96.39(c)],
e. Secure information to associate CBSD with the Owner,
f. Informative Note: this will link a valid Owner with the CBSD [required by 96.39(c)]
g. CBSD Air Interface Technology [required by 96.39(c)],
h. Types include: EUTRA, other values to be defined as appropriate
i. CBSD Sensing capability [required by 96.39(c)],3
j. Location information: latitude, longitude, and antenna height above ground level (in meters) [Ref 2, 96.39(c) & para 219],
k. Certified Professional Installer Registration ID (if information provided to the CBSD was manually entered by a Certified Professional Installer)
l. Antenna Gain [Ref 2, 96.45(d)],
m. Antenna beamwidth [Ref 2, 96.45(d)],
n. Antenna azimuth pointing direction [Ref 2, 96.45(d)],
o. Antenna downtilt angle [Ref 2, 96.45(d)],
p. Optional vendor specific information fields. The SAS shall allow CBSDs to provide optional vendor specific information which can be used by the SAS. Examples include: CBSD model number, CBSD HW version number, CBSD SW and/or FW version number, hardware characteristics, etc.

R1-SRR-02: During the registration process, the SAS shall provide the following information to the registering CBSD:

a. A system wide unique CBSD ID to identify the CBSD,
b. All registration communication shall be done securely (as defined in the WG2 COMSEC standards). Informative note: the mutual authentication in the secure handshake is enough to identify the parties as mutually valid.
c. An indication if the Registration was successful or what additional information is needed to complete the registration process.

This information is required to register the CBSD and to establish a CBSD Registration ID. This CBSD Registration ID shall be linked to a specific owner (an Owner ID), but one owner may register multiple CBSDs. A CBSD

[3] To be defined by the Sensing & Measurement Task Group

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Registration ID corresponds to a single CBSD that can request a spectrum assignment from a SAS.

For a managed network with a Domain Proxy, the Domain Proxy can register on behalf of one or more CBSDs under its control. Each CBSD will still require its own CBSD Registration ID for its own parameters and location.

R2-SRR-10: A SAS shall be able to provide the following information on CBSD registration status to the CBSD Owner, Professional Installer of the CBSD, other SASs or the FCC:

- Whether the CBSD registration is revoked, pending or completed
- Whether the CBSD has been taken out of service (decommissioned)
- Whether the CBSD has any enforcement actions initiated against it or determined to be in effect

R2-SRR-11: Category A CBSDs unable to automatically determine their location to within the requirements set forth by the FCC R&O [include a reference to location accuracy] shall be installed by a Certified Professional Installer. [Ref-2, 96.39 & para 221]

R2-SRR-12: CBSD Group Identifier: While registering a CBSD, a CBSD Group identifier may be specified along with other required device information. If present, this identifier designates a CBSD as a member of a particular group (or network) of CBSDs.

Note: It is anticipated that a system-wide naming convention will be established such that CBSD Group identifiers can be easily selected by entities (such as Domain Proxies). Support for multiple group identifiers is left for further study.

R2-SRR-13: CBSD Group Assignment Indicator: While performing a spectrum inquiry or grant request, a Group Assignment Indicator may be included with the CBSD Group Identifier and other required device information. If present, this value indicates whether all CBSDs in the group prefer or require a common radio frequency assignment, and reassignment when frequency reassignment is necessary.

R2-SRR-14: Domain Proxy Relationship with SAS: The SAS shall ensure that owner information and the credentials for the Domain Proxy are known to, and verified by, the SAS administrator prior to providing service to any CBSD that is subordinate to that Domain Proxy.

R2-SRR-15: Professional Installer information provided to the CBSD: If a professional installer accesses the CBSD to provide additional information for Category A or Category B CBSDs, the professional installer shall provide to the CBSD their associated Certified Professional Installer Registration ID.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R2-SRR-16: Professional Installer information provided to the SAS: When a professional installer provides additional information on Category A or Category B CBSDs via a mechanism provided by the SAS administrator, the professional installer shall provide:

a. The CBSD serial number and FCC ID (to uniquely identify the CBSD),
b. The associated Certified Professional Installer Registration ID

R2-SRR-17: Certified Professional Installer Registration Information: The Certified Professional Installer Registration (CPIR) process requires the Certified Professional Installer to provide the following information to a SAS accessible centralized database:

a. Legal identity (name),
b. Mailing address,
c. Legal address,
d. Email contact,
e. Phone contact,
f. Accredited certification number from a training program,
g. License initiation date, termination date

R2-SRR-18: During the Certified Professional Installer Registration process, the SAS accessible centralized database shall record and maintain the following information for the Certified Professional Installer:

a. A system wide unique Certified Professional Installer Identify,
b. A method to authenticate the Installer when accessing the Certified Professional Installer account

8 Environmental Sensing Capability Requirements (ESC)

Additional background information is provided in Informative Annex A.2.

R0-ESC-01: The following are ESC Requirements as identified in [Ref-2, 96.67]

a. An ESC may only operate after receiving approval by the Commission.
b. An ESC must [shall] be managed and maintained by a non-governmental entity.
c. An ESC must [shall] accurately detect the presence of a signal from a federal system in the 3550-3700 MHz band and adjacent frequencies using approved methodologies that ensure that any CBSDs operating pursuant to ESC will [shall] not cause harmful interference to federal Incumbent Users.
d. An ESC must [shall] communicate information about the presence of a signal from a federal Incumbent User system to one or more approved SASs.
e. An ESC must [shall] maintain security of detected and communicated signal information.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

f. An ESC must [shall] comply with all Commission rules and guidelines governing the construction, operation, and approval of ESCs.
g. An ESC shall be available at all times to immediately respond to requests from authorized Commission personnel for any information collected or communicated by the ESC.
h. An ESC must [shall] operate without any connectivity to any military or other sensitive federal database or system and does not store, retain, transmit, or disclose operational information on the movement or position of any federal system or any information that reveals other operational information of any federal system that is not required by this part to effectively operate the ESC.

R1-ESC-01: The rules governing the ESC are technologically neutral and ESC developers may utilize different sensing techniques that yield the desired result. These sensors shall be deployed in the vicinity of the Exclusion Zones described in section III(G) to ensure that all federal radar use in and adjacent to the 3.5 GHz Band is accurately detected and reported to an SAS. [Ref-2, para 383]

R2-ESC-01: ESC Detection of RADAR Types: An ESC shall be capable of detecting in-band incumbent radar activity that has the following characteristics:

Characteristic	Value	Reference
Polarization	Horizontal or Circular	Ref [6], Table 1
Pulse repetition rate	1 kHz	Ref [6], Figure 6
Pulse width	0.9 us	Ref [6], Table 1 & Fig. 7
Pulse duty cycle:	0.1%	Ref [5], p. 4-57
Antenna rotation period	4 s	Ref [6], Table 1 & Fig. 5
Peak power:	90 dBm	Ref [5], p. 4-57
Average power:	60 dBm	Ref [5], p. 4-57
Antenna gain:	32 dBi	Ref [5], p. 4-57

Periodic review with the U.S. Department of Defense may produce additional radar signal types that must be added to ESC detection capability.

R2-ESC-02: ESC Detection Threshold: An ESC shall be capable of detecting an in-band incumbent radar over a maximum propagation loss from the radar of 184 dB on the coastline and given a sufficiently elevated sensor location (e.g. 25m) with a clear line-of-sight to the horizon.

ESC and SAS administrators shall include in their applications for approval the detection thresholds and corresponding protection mechanisms including an accounting for aggregate interference contributions from Category A and B CBSDs.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R2-ESC-03: ESC Performance Monitoring: An ESC operator shall implement one or more methods to monitor ESC performance and detect ESC faults (including intrusion). Such methods shall be justified in the ESC certification process.

R2-ESC-04: ESC Partial Failure: In the event of a partial failure of the ESC, resulting in an area or frequencies which the ESC is not providing positive incumbent activity monitoring satisfying R2-ESC-02 and R2-ESC-08 requirements, the ESC shall notify any dependent SASs of such an event in the same fashion as a notification of detection of incumbent activity within the area that was being monitored on the frequencies that were being monitored. [Note: this means ESC failures are treated as detections.]

R2-ESC-05: Inland ESC: An ESC may detect the operation of inland in-band ground-based incumbent radars in the same manner as it detects shipborne radar operation in coastal areas.

R2-ESC-06: Detection of out-of-band RADARs: Future periodic reviews with the U.S. Government may establish metrics to detect out-of-band radars operating in the NTIA-defined federal radiolocation sites.

R2-ESC-07: ESC Interference Protection: An ESC operator of a dedicated sensor network may request interference protection of one or more of its sensors. A SAS shall manage CBRS (from CBSDs and EUDs) interference such that the aggregate interference at the antenna output terminal of the protected sensor in 3550-3650 MHz does not exceed 120 dBm/MHz – PL (Path Loss) or a higher level specified by the ESC operator. An ESC operator that requests protection shall provide the location and height of the protected sensor to a SAS. (PL defined as the detection threshold in ref R2-ESC-02). Such requests shall be shared between SASs.

Note: WinnForum will develop appropriate protection definitions and exchange formats to accommodate such protections, as well as requirements on ESC providers to disclose protection requirements.

R2-ESC-08: Figures of Merit: For a signal exceeding the threshold of detection, an ESC shall be capable of detecting in-band incumbent radar activity within 60 s with 99% probability. These time scales and performance characteristics may be adjusted as a consequence of future periodic ESC review.

R2-ESC-09: ESC Data Retention: Full ESC detection records shall not be retained within the ESC system for a time past the cessation of incumbent activity longer than the detection time figure of merit plus any additional randomized deactivation period determined by the ESC. The time period may be subject to periodic review and adjustment. ESC administrators may propose keeping statistical records for the purposes of behavior analysis and reporting during the approval process, but any such record keeping will be subject to DoD review and may be declined.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

R2-ESC-10: Operation in Exclusion Zone areas unmonitored by an ESC: A SAS shall not authorize operation of Category A CBSDs within the frequency ranges and exclusion zones established by NTIA if those areas are not monitored by an ESC network. ESC administrators supporting SASs which authorize CBSDs in the context of a partially-deployed ESC shall include in their applications for approval the method by which they determine the boundary between monitored and unmonitored areas and the resultant Exclusion Zones and Protection Zones around the boundary.

R1-ESC-02: ESC System Failure: For protection of incumbent radar activity in the event of an ESC system failure, a SAS shall fail safely. A SAS which fails to receive expected messages from an ESC network shall behave in the same way as if no ESC was deployed over the relevant exclusion zone.

R2-ESC-11: ESC Periodic Review: ESC network and system requirements are subject to periodic review and modification.

R2-ESC-12: Federal Incumbent Detection Event: Notice from the ESC to the SAS resulting from a detection of federal incumbent activity in the band shall be made expeditiously subsequent to the detection of that activity by the ESC system. Information relevant to federal activity passed from an ESC to a SAS in an incumbent detection event record shall be limited to the following information:

a. A geographical description (or reference) which defines the extent of the federal incumbent activity to be protected. This geographical description shall be limited to the constraints described by [ref: OpSec doc]
b. A frequency range which defines the extent of federal incumbent activity to be protected. This range shall be limited according to any constraints described by [ref: OpSec doc]
c. An activation time for this protection (which may be the current time).
d. A deactivation time for this protection (optional)
e. A retention time for this record within the SAS system, which shall be obeyed by the SAS following notification by the ESC system that the incumbent detection event has expired. This retention time shall be limited to the constraints described by [ref: OpSec doc]
f. A protection level specifier to be enforced by the SAS for this geographical description (if applicable).

Upon cessation of the incumbent detection event, the information passed from an ESC to a SAS relevant to the federal activity shall be limited to the amount necessary to identify which incumbent detection event record is no longer active.

Other information as needed for SAS and ESC operational concerns may also be passed by the ESC to the SAS as required. None of that information shall have any relationship to federal incumbent activity except insofar as it may be derived by either the ESC or the SAS from exactly that information listed in this requirement.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

9 End User Device Requirements (EUD)

R0-EUD-01: End User Device Radios must [shall] also comply with CBSD General Radio Requirements stated above in R0-DEV-05: [Ref-2, 96.41]

R0-EUD-02: End User Devices may [shall] not be used as intermediate service links or provide service over frequencies listed in section 96.11 to other End User Devices or CBSDs. [Ref-2, 96.3]

R0-EUD-03: End User Devices may operate only if they can positively receive and decode an authorization signal transmitted by a CBSD, including the frequencies and power limits for their operation. An End User Device must [shall] discontinue operations, change frequencies, or change its operational power level within 10 seconds of receiving instructions from its associated CBSD.

Any device operated at higher power than specified for End User Devices in section 96.41 [R0-DEV-05:] will [shall] be classified as, and subject to, the operational requirements of a CBSD. [Ref-2, 96.47]

10 References

[1] Federal Communications Commission, "Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band," GN Docket 12-354, FCC 15-47, Report and Order and Second Notice of Proposed Rulemaking, XX FCC Rcd ####, available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-47A1_Rcd.pdf

[2] Title 47, Code of Federal Regulations, Part 96 (2015), available at: www.ecfr.gov.

[3] Wireless Innovation Forum, Spectrum Sharing Committee, "Definitions Related to Commercial Operations in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band" available at: http://www.wirelessinnovation.org/fcc-definitions

[4] Title 47, Code of Federal Regulations (various parts referenced), available at: www.ecfr.gov.

[5] National Telecommunications and Information Administration, "An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands," October 2010 ("Fast Track Report").

[6] National Telecommunications and Information Administration, "Spectrum Occupancy Measurements of the 3550-3650 Megahertz Maritime Radar Band near San Diego, California," Technical Report TR-14-500, January 2014.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Appendix A.1: Registration Overview

Before a CBSD can begin automated channel allocation requests with the SAS, the CBSD must be registered with the SAS. This is a rather complex process where the following separate registrations or enrollments may be required:

- Owner Registration: CBSDs must be associated with an owner, we require the owner to pre-register (enroll) with the system. The owner may be a corporation or an individual.
- Certified Professional Installer Registration (CPIR): Some CBSDs will be installed by a Certified Professional Installer, we require the professional installer to be pre-registered with a Professional Installer certifying body database which the SAS must be able to access. *Note: Category B CBSDs must be setup by a Professional Installer.*
- CBSD Registration (CR): The CBSD must register with the SAS and also provide installation details.
    - Owner installed CBSDs: Category A CBSDs may be installed by an owner or an authorized associate of the owner. Such CBSDs will initiate registration with the SAS. An owner-installed CBSD must be capable of automatically calculating its location (as defined by the FCC Rules) and provide that information as part of the CBSD registration process.
    - Professionally installed CBSDs: All Category B CBSDs must be installed a certified professional installer, while certain Category A CBSDs may be installed by a certified professional installer. Category A CBSDs unable to automatically determine their location to within the FCC Rules must be installed by a certified professional installer, while other Category A CBSDs can be installed professionally (Ref-1 para 208). Category A CBSDs installed by a professional installer may not be capable of automatic determination of their location (either by design or due to disadvantaged placement); such CBSDs will be installed in a fixed location so as to be attached to a permanent structure (e.g. pole, ceiling, or wall), and the location of such a CBSD will be provided by the professional installer.
- PAL License Registration: For CBSDs using PAL spectrum, we require the PAL License and the specific protection area to be pre-registered (enrolled) with the system. This is currently FFS.

Owner Registration / Enrollment with the SAS

The Owner is a person or company who owns and is responsible for one or more CBSDs. Owner registration with a certified SAS is expected to be a manual process (likely via a Web Interface).

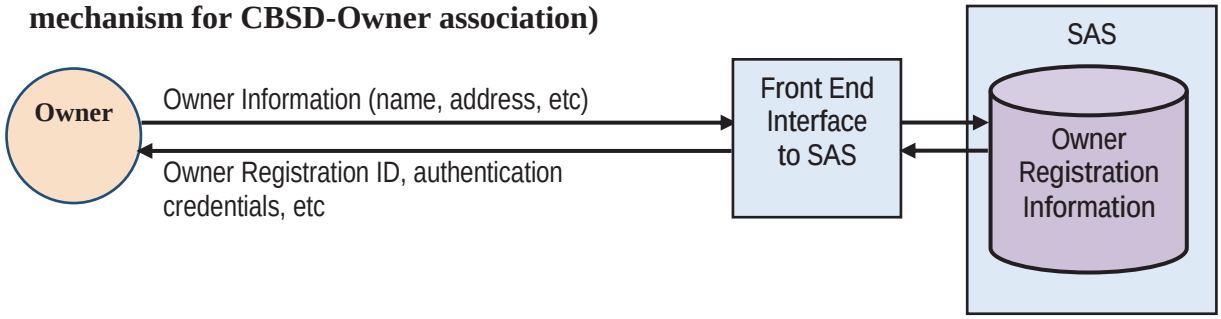
After the owner has provided necessary owner contact information, the system must provide the owner with:

- An Owner Registration Identity (OR-ID),
- A method to authenticate the Owner when accessing the Owner account (e.g, password),

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Information is exchanged between the CBSD owner and the SAS Administrator to establish a secure mechanism to associate CBSD(s) and owner identity. This mechanism will be used to allow the SAS to properly associate a registering CBSD with its owner. This is to ensure the CBSD is linked to a valid owner and to ensure registration occurs with the Owner's permission. The mechanism would allow the owner to create sub-groupings of CBSDs which may be useful for large networks.

Owner Registration Process (includes a secure mechanism for CBSD-Owner association)



CBSD Registration

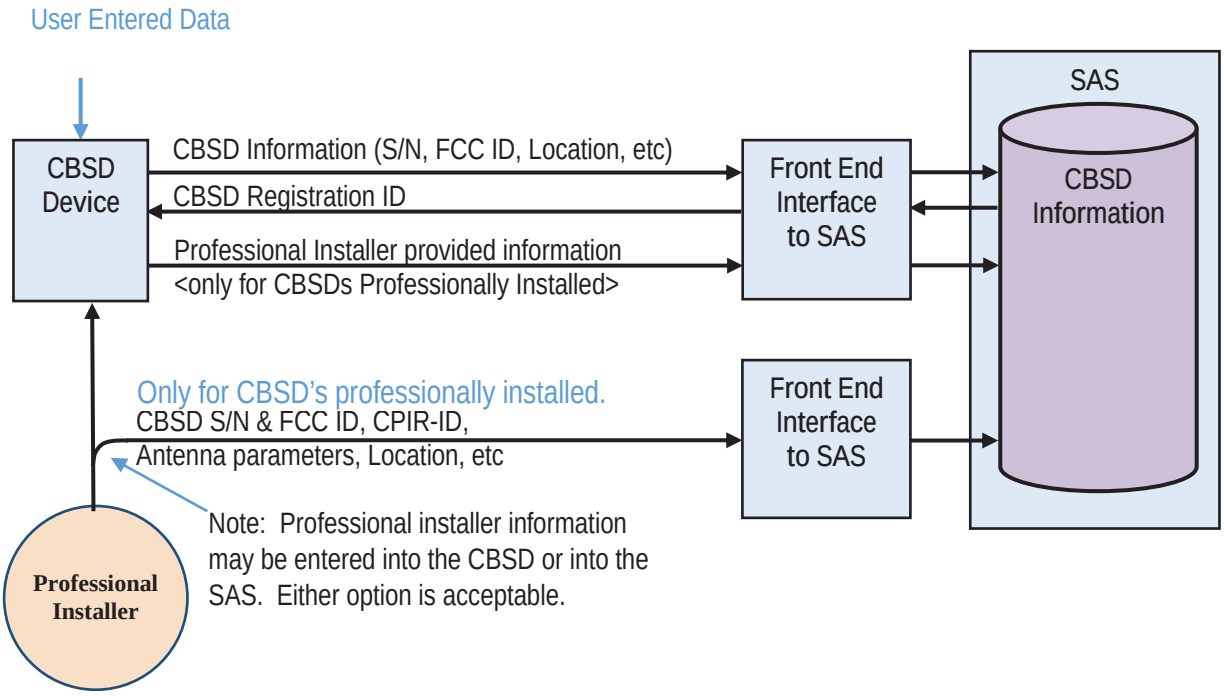
Category B CBSDs are required to be setup by a professional installer and require the professional installer to provide additional information about the CBSD. The information may be entered into the CBSD (to be relayed to the SAS) or entered by a Certified Professional Installer via a mechanism provided by the SAS administrator.

Category A CBSDs which are unable to automatically calculate their location within the FCC requirements need to have their location validated by a certified professional installer.

The information provided by the certified professional installer is site specific.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

CBSD Registration Process

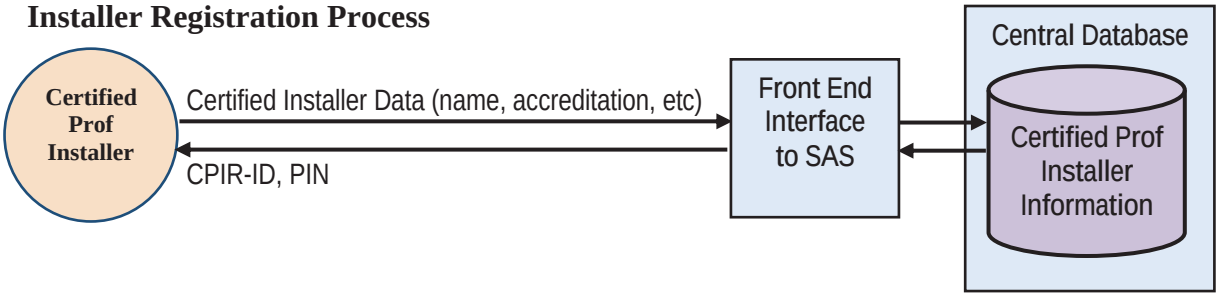


Certified Professional Installer Registration (enrollment)

The FCC Rules require Category B CBSDs must be installed by a certified professional installer, while Category A CBSDs may be installed by a professional installer [Ref-2 96.45 (b)]. The rules also "encourage" an accreditation program for professional installers (para 222).

The Certified Professional Installer must be pre-registered in a centralized database, which is accessible by all SASs, which will provide the installer with a system wide unique Certified Professional Installer Identify and a method to authenticate the Installer when accessing the Certified Professional Installer account. This information will be used by the installer when they enter the Device Installation Record into the CBSD or provide it to the SAS Administrator.

Installer Registration Process



Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Appendix A.2: Additional Information about ESC Requirements

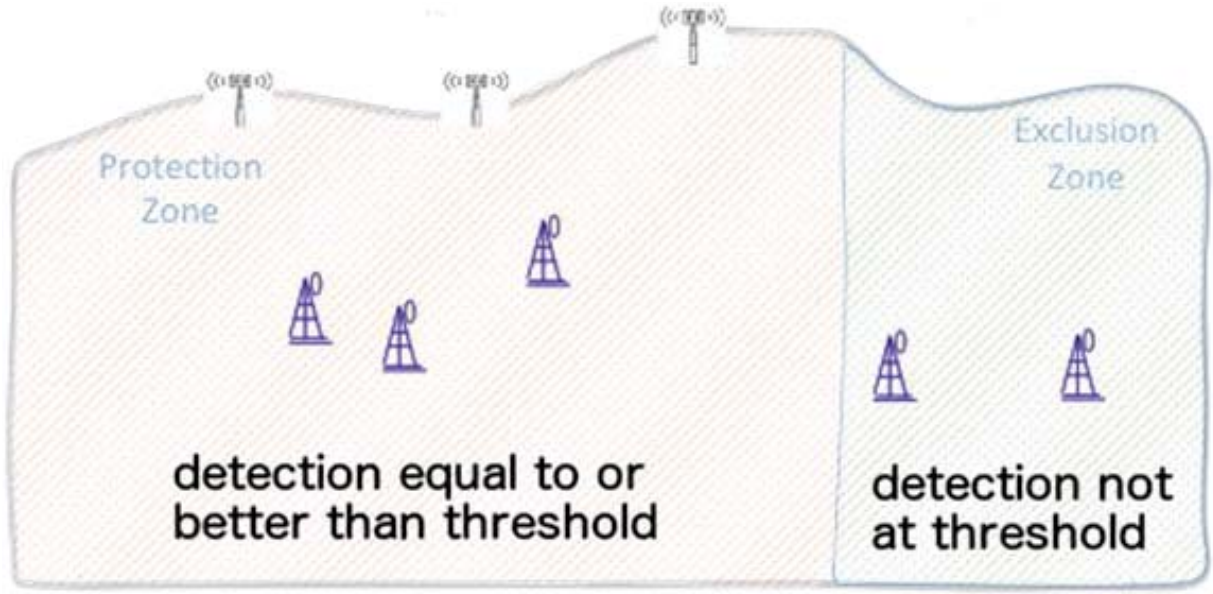
The ESC requirements establish the maximum propagation loss over which an incumbent radar must be detected by an ESC on the coastline. Effectively specifying the required sensitivity of the ESC without multiple complicating factors such as peak vs average detection, integration time, reference bandwidth, maximum distance to radar, etc. Also allowing maximum flexibility in system design.

For reference, the specified maximum propagation loss (184 dB) corresponds to the minimum path loss allowed between an equivalent total emission power of a single Category B rural CBSD on the coastline and the radar receiver such that the interference-to-noise ratio (I/N) in the receiver does not exceed -6 dB. (The calculated loss assumes a radar receiver noise figure of 3 dB, an equivalent noise bandwidth of 1 MHz, and an insertion loss of 2 dB).

In practice, ongoing investigations into the effects of aggregate interference from multiple CBSDs and their locations may need to be taken into account to better establish this figure.

The implementer may choose to interpret this requirement as a received power requirement using a link budget for conversion and the radar antenna gain, transmit power, maximum propagation loss, and appropriate assumptions on the receiver (e.g., antenna gain).

If the ESC is not capable of detecting the equivalent incumbent radar at a particular location on the coastline, a SAS relying on this ESC for incumbent radar detection would need to make use of the static NTIA defined Exclusion Zones.



Note: This figure may be adjusted as a result of future periodic ESC review.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

The ESC provides the only mechanism within CBRS to determine the presence of federal Incumbent Users and ESC designs are limited in their ability to detect federal Incumbent Users due to the presence of interference such as that caused by CBRS device transmissions. CBSDs and EUDs within very close proximity of ESC sensors will prevent ESC from accurate federal Incumbent User detection. Therefore, given that federal Incumbent User protection is one of SAS's highest priorities, SAS must prevent excessive CBRS device interference at ESC sensors. In particular, SAS must prevent CBRS transmissions in close proximity to ESC sensors.

Given the R2-ESC-01 parameters and the path loss defined in R2-ESC-02, the peak radar power received at an ESC sensor antenna is:

PESC = 120 – PL dBm/MHz

Assume an ESC radar signal-to-CBSD interference plus noise power ratio (SINR) of 5 dB is required to satisfy ESC performance requirements and that the ESC antenna gain in the direction of the radar is 5 dB greater than the ESC antenna gain in the direction of each CBSD. Then assuming the CSBD interference greatly exceeds the noise, to achieve SINR = 5 dB implies that the aggregate CBSD power, PCBSD, incident on the ESC antenna is given by

PCBSD = PESC + antenna discrimination - SINR
= 120 – PL + 5 - 5
= 120 – PL dBm/MHz

Thus, the SAS needs to ensure that the aggregate CBSD interference does not exceed 120-PL dBm/MHz so that SINR >= 5 dB.

Note: this analysis does not imply any additional sensitivity requirement on ESC sensors.
Note: SASs will need to coordinate to achieve the protection requirement.

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved

Appendix B: Revision History

Document History		
V1.0.0	May 2016	Forum approval

Copyright © 2016 The Software Defined Radio Forum Inc.
All Rights Reserved