Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules with	)	
Regard to Commercial Operations in the 3550-	)	GN Docket No. 12-354
3650 MHz Band	)	

T-MOBILE USA, INC. PAPER ON THE PROPOSED SPECTRUM ACCESS SYSTEM

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T-Mobile USA, Inc. ("T-Mobile")[1/] submits the following in response to the November 18, 2013, Public Notice issued by the Wireless Telecommunications Bureau and Office of Engineering and Technology (the "Bureaus") in the above-referenced proceeding,[2/] soliciting papers on the technical aspects of the Spectrum Access System ("SAS") for the use of the 3550-3650 MHz band ("3.5 GHz Band") in advance of the January 14, 2014, workshop the Bureaus will conduct on this topic.[3/] The workshop follows the Commission's release of a Notice of Proposed Rulemaking ("*NPRM*") and a separate Public Notice seeking comment on licensing models and technical requirements ("Revised Framework") in this proceeding.[4/]

[1/] T-Mobile USA, Inc. is a wholly-owned subsidiary of T-Mobile US, Inc., a publicly traded company.

[2/] *See Wireless Telecommunications Bureau and Office of Engineering and Technology Call for Papers on the Proposed Spectrum Access System for the 3.5 GHz Band*, Public Notice, GN Docket No. 12-354, DA 13-2213 (rel. Nov. 18, 2013).

[3/] *See Wireless Telecommunications Bureau and Office of Engineering and Technology Announce Workshop on the Proposed Spectrum Access System for the 3.5 GHz Band*, Public Notice, GN Docket No. 12-354, DA 13-2018 (rel. Sept. 30, 2013) (announcing the original workshop date of December 11, 2013); *Wireless Telecommunications Bureau and Office of Engineering and Technology Announce Date Change for Workshop on the Proposed Spectrum Access System for the 3.5 GHz Band*, Public Notice, GN Docket No. 12-354, DA 13-2152 (rel. Nov. 8, 2013) (announcing that the workshop date will be changed to January 14, 2014). The SAS would be one or more third parties that would control access to the 3.5 GHz Band, building on the TV White Spaces database concept.

[4/] *See Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Notice of Proposed Rulemaking, 12 FCC Rcd 15594 (2012) ("*NPRM*"); *Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band*, Public Notice, GN Docket No. 12-354, FCC 13-144 (rel. Nov. 1, 2013) ("*Public Notice*").

I. SUMMARY

T-Mobile has been an active participant in this proceeding. It submitted comments and reply comments in response to the *NPRM* and in response to the *Public Notice*.[5/] T-Mobile supports the FCC's efforts to make additional spectrum, including the 3.5 GHz Band, available for small cell technologies that will operate with mobile broadband networks and appreciates the proposed Revised Framework for the band. In order to exploit the full potential of the 3.5 GHz Band, however, the Commission should ensure that the Revised Framework provides a clear and stable regulatory environment for all entities that encourages investment and results in the development of a robust equipment market.

One of the key aspects of the Revised Framework is the interaction between the SAS and 3.5 GHz Band networks. Careful planning of that interaction, including functional requirements and SAS evolution will promote more intense use of the 3.5 GHz Band. In contrast, the wrong architecture and functional requirements may severely limit the utility of the SAS by making it overly cumbersome, or greatly reduce the ability of operators to maximize use of the spectrum by allowing the SAS to control network operations.

In particular, we recommend that the means by which interference is mitigated should be left to the network operator, rather than have the SAS directly control different aspects of the network. This will help facilitate the development, adoption and maintenance of the 3.5 GHz Band and avoid unnecessary complexity and the exchange of an excessive amount of information between the SAS and the operator's network. In other words, from a practical

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[5/] *See* Comments of T-Mobile USA, Inc., GN Docket No. 12-354 (filed Feb. 20, 2013) ("T-Mobile Comments"); Reply Comments of T-Mobile USA, Inc., GN Docket No. 12-354 (filed April 5, 2013) ("T-Mobile Reply Comments"); Comments of T-Mobile USA, Inc., GN Docket No. 12-354 (filed Dec. 5, 2013) ("T-Mobile Supplemental Comments"); Reply Comments of T-Mobile USA, Inc., GN Docket No. 12-354 (filed Dec. 20, 2013) ("T-Mobile Supplemental Reply Comments").

perspective, simpler is better. Simpler does not mean poor functionality; it is possible to design a simple system that has the ability to evolve to include more complex interaction between the SAS and the network as experience is gained. However, the evolution of the SAS should be fully considered and planned before more complex interaction is introduced.

II. FOCUS AREA A: GENERAL RESPONSIBILITIES AND COMPOSITION OF THE SAS

T-Mobile continues to be interested in the 3.5 GHz Band in order to support the growth of its network. As T-Mobile pointed out in its response to the *NPRM*, the 3.5 GHz Band holds great potential for small cell applications, such as offloading, and carriers' backhaul needs.[6/] In addition, the 3.5 GHz Band can be used as a component of mobile broadband providers' heterogeneous access networks, which use a mix of technologies, frequencies, and cell sizes to address the coverage and capacity needs of providers' networks.[7/]

The 3.5 GHz Band holds particularly great potential for 3rd Generation Partnership Project ("3GPP") Long Term Evolution ("LTE") small cell technology.[8/] 3GPP LTE is the most advanced mobile broadband technology to date. It has been built with high spectral efficiency and robust multipath operation, significantly increasing higher end user data rates. Its power-control feature makes it capable of self-adjusting transmit power to meet interference requirements. In addition, 3GPP has developed a range of small cell features that further enhance spectral efficiency. The Commission should therefore leverage 3GPP LTE technology as it is and should not allow the SAS to change LTE base station transmit power. When operators roll-out LTE networks, they carefully plan their networks, in accordance with LTE

6/ *See* T-Mobile Comments at 4-5.

7/ *See* T-Mobile Reply Comments at 2-3.

8/ *See* T-Mobile Comments at 9-10; T-Mobile Reply Comments at 7.

technical parameters, to meet coverage and capacity demands. If the Commission allows the SAS to change LTE base station transmit power, it will not only negatively impact LTE system performance, but also impact operator network planning and disrupt services.

Similarly, the Commission should not allow the SAS to re-assign spectrum blocks on a real-time basis because it will cause base station "down time" and disrupt service continuity.[9/] Re-tuning cellular networks from one frequency to another requires intensive planning and careful executing, and it requires the base stations to be taken off-air for the re-tune. Additionally, some network elements such as base station power amplifiers can only support a relatively narrow "instantaneous bandwidth." If the new frequency is not in the vicinity of the original frequency, re-tuning may require change of the base station hardware before it can perform adequately at a new frequency outside of the current "instantaneous bandwidth." In order to keep service disruption to a minimum, operators typically only perform network re-tuning during low-activity "maintenance hours."

In addition to LTE small cells, the 3.5 GHz Band holds potential for wireless backhaul. Wireless backhaul is a point-to-point application, typically with directional antennas aimed and aligned between hops. Its transmit power and EIRP may be different from those of LTE small cells, and potentially different from those of other possible technologies that may be permitted in the 3.5 GHz Band. A point-to-point application like wireless backhaul can be deployed in a way to make it less likely to cause interference to other systems; also, the transmit power is typically not able to change according to interference requirements as an LTE base station can. Allowing the SAS to change wireless backhaul transmit power would therefore not be possible (because of the usual inability of a backhaul link to change power) or even necessary (because the link is not

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9/ *See* T-Mobile Supplemental Comments at 10; T-Mobile Supplemental Reply Comments at 10-11.

likely to cause interference if correctly deployed). Because different applications will have different technical parameters, whatever level of control the SAS has over systems will not be equally appropriate for all systems.

Finally, allowing the SAS to change LTE base station transmit power could impact vendors' LTE systems differently. This is because 3GPP LTE standards leave significant implementation freedom to equipment vendors to include varying features and designs. Proprietary algorithms are commonly found in LTE systems, especially in the area of scheduler, radio resource allocation, modulation scheme assignment, and power control algorithms. If the Commission allows the SAS to change LTE base station transmit power, it may unfairly adversely impact one vendor's LTE system performance more than others' or have unintended consequences that severely degrade system performance.

The role of the SAS should therefore be limited to identifying when spectrum is available for use by operators and transmitting applicable protection requirements to operator networks. The SAS should not be allowed to change operator network parameters, such as changing LTE base station transmit power or re-assigning spectrum blocks. Any attempt to do so will add unnecessary complexity to the SAS and will impede technology innovation and deployment. Also, the interface between the SAS and operator networks, including communication protocols and information exchanged, must be clearly defined and preferably standardized so that operators can prepare their networks accordingly to interact properly with the SAS.

The Commission proposes a three-tiered approach, with General Authorized Access ("GAA") and Priority Access Licenses ("PALs") having access to the spectrum when it is not used by incumbent operations.[10/] The SAS should only allow GAA use of Priority Access

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[10/] *See NPRM* ¶¶ 53-57; *see also Public Notice* ¶ 28.

spectrum when it is unassigned or affirmatively unused. The SAS must not be able to allow GAA operations on assigned and operational PAL channels. Determining if Priority Access spectrum is *assigned* will be straightforward. However, to determine whether spectrum covered by a PAL is actually *in use*, the SAS should be able to query whether a construction or performance notification has been submitted by the PAL user. If such a notification has been submitted, the PAL spectrum should not be available for GAA use.

III. FOCUS AREA B: KEY SAS FUNCTIONAL REQUIREMENTS

There are many possible architecture alternatives for a system supporting dynamic spectrum sharing. However, a complex design approach and an excessive amount of information exchange between operators and nodes could render the system unpractical, jeopardizing the overall goal of unlocking under-utilized spectrum. In other words, from a practical perspective, simpler is better. Nevertheless, it also is possible to design a simple system that has the ability to become more complex over time.

The three key aspects to ensure simplicity, as well as the ability to evolve over time are:

1. The system requirements should leverage existing technologies "as is", without the need for further standardization at the network element levels or below.
2. Clear establishment of boundaries between the SAS and operator network. The SAS should limit its scope to a single operator entity rather than trying to control individual nodes.
3. The amount of information exchanged between these systems should be kept to a minimum. In practical terms, the overall data transfer volume between both systems should be in the Mbps range rather than Gbps.

The first aspect would enable a fast implementation of the system since it would rely on software-based solutions rather than on additional hardware research, development and standardization efforts that would require a longer time-frame.

The second aspect is crucial to ensure that the system will ultimately work once it is integrated. Clearly defined boundaries between the SAS and the operator entity will facilitate

parallel development on both sides, as well as testing for compliance. Otherwise, particularly if the SAS is complex, and the system does not work properly once integrated, it will be hard to identify which entity is not performing properly.

Finally, the amount of information transferred between the systems is very important, as it has implications for capital and operational costs, both for hardware (number of servers required) and transport, as well as maintenance of the system: the more information is exchanged, the larger the hardware footprint, and the harder to troubleshoot should any problem arise.

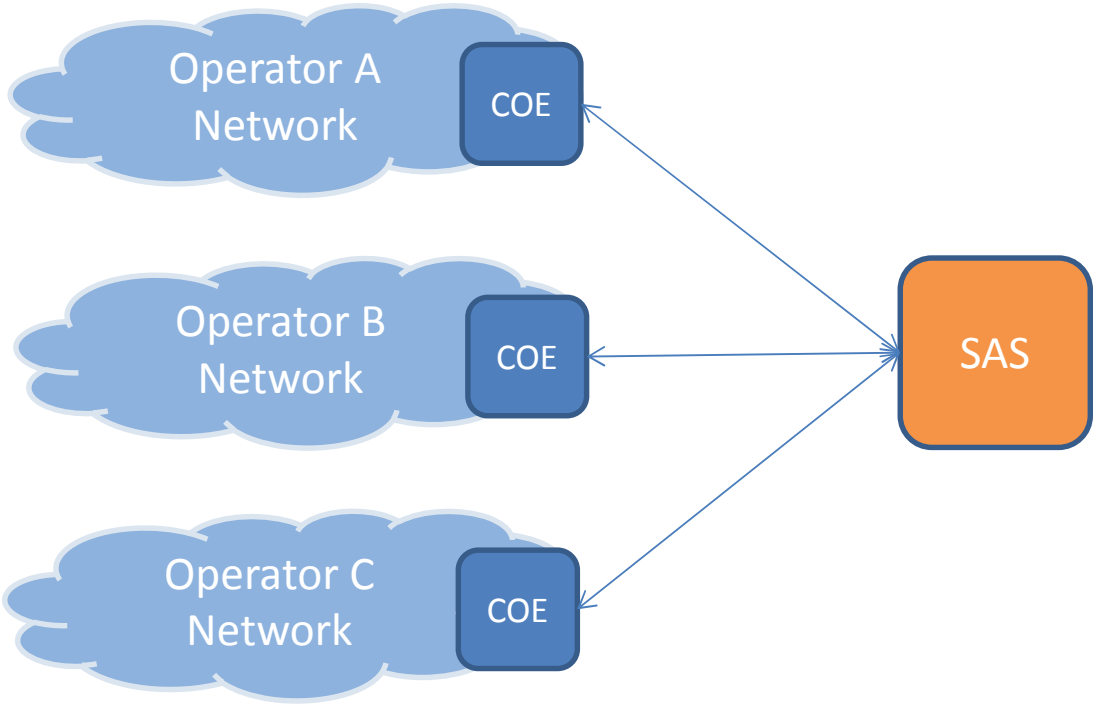
With these premises in mind, we propose a centralized SAS that communicates with a single Centralized Operator Entity ("COE"), rather than with each individual node in the network. The key aspects of the COE would be:

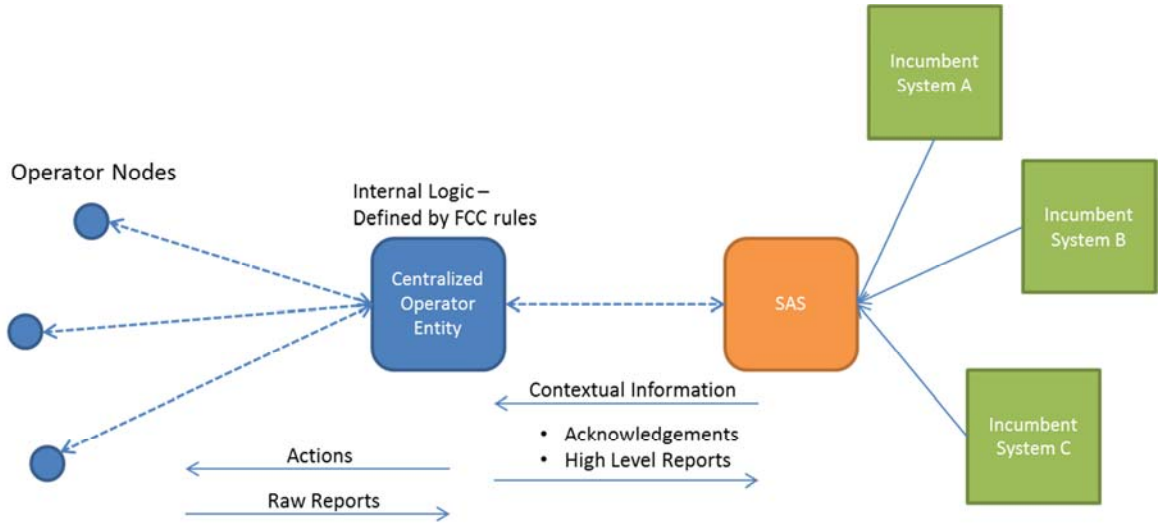
- A software-based system that provides a central point of communication with the SAS and facilitates evolution over time.
- Communication between the SAS and the COE would be based on standard protocols – HTTP for instance.
- The capability to enforce safe transmit power levels in areas with active incumbents, following the rules defined by the FCC.
- A fast response time to SAS requests – real-time acknowledgement of requests (in seconds) and fast execution (less than one hour) of the required network changes.
- Ability to report high-level activity to the SAS, including a summary of protective measures taken to protect incumbents.

The main advantages of this approach would be:

- Light-weight SAS deployment – enables a centralized, instead of distributed, deployment of the SAS, since it only needs to communicate with one element in the operator network.
- Simplified interfaces – only one element in the operator network needs to comply with the requirements, which will facilitate the definition of the interfaces and interaction between units.
- Simplified control – only one element in the operator network needs to comply with the rules dictated by the FCC, instead of having to certify the compliance of many elements.
- Ability to perform complex operations with data – a centralized entity can combine input from multiple data elements and provide meaningful information about the network.
- Support a phased deployment, with simpler rules first and more complex rules possible as the system evolves.

The figures below show a high-level overview of the main system components and interactions:





As shown above, the SAS gathers information from the incumbent systems and shares some contextual information with the operator in real-time that the operator can use to define the actions to take. The information provided by the SAS could be, for example:

- Specific part of the spectrum being utilized.
- Period of time when the protective measures should be in effect.

- Location information of the incumbent transceiver – there could be two levels of location information, fine (latitude and longitude of a given point) and gross (center and radius), depending on security requirements of the incumbent system.
- Safe interference levels for the incumbent system beyond which there is service degradation. It is important that the SAS provide metrics that the COE can act upon, for example, defining the maximum allowed Received Total Wideband Power ("RTWP") in the channel at a certain distance from the location or area. This will permit the operator to calculate ahead of time the required transmit powers, instead of engaging in a continuous cycle of power adjustments based on real-time measurements.

The COE would acknowledge the receipt of the request and decide the set of actions that need to occur in the network to comply with the rules defined by the FCC. It would then communicate with the network nodes to enforce such actions and verify that they have taken place.

Once the actions are verified, the COE would send a report back to the SAS with a high-level summary of the actions taken on the operator side. This report could include, for example, the node locations that have been turned off, or required to reduce power. In future stages, this report could become more complex to facilitate troubleshooting efforts by the SAS, such as identifying external sources of interference in the system that may be affecting the incumbent systems.

To facilitate development, the communication protocol between the SAS and the COE could be implemented using a Web Services Application Programming Interface ("API"), which provides a reliable transport with options for security features using HTTPS. One of the most popular web services style today is Representational State Transfer ("ReST"). ReST relies on a stateless, client-server, cacheable communications protocol and enables the creation of light-weight, customizable APIs that can easily evolve over time. Below are some of the characteristics of this protocol choice:

- Ease of development.
- Simple protocol stack, based on TCP/IP, guaranteed in order and reliable transmissions.
- Optional security (ciphering) can be enabled.
- Ability to provide service calls using URLs.

- Provides GET, PUT, DELETE, POST, HEAD operations (POST can be used for notifications, GET and PUT to exchange further details like, for example, interference level reports).

Such a system is possible with technologies supported by network operators today and would not require changes in hardware units, which may otherwise require over two years of development and testing efforts. T-Mobile, for example, would be able to quickly build a demonstration prototype in a production environment if such an approach is implemented.

IV. FOCUS AREA C: SAS MONITORING AND MANAGEMENT OF SPECTRUM USE

LTE systems provide a set of mechanisms to help control power levels and traffic access to the network, which could be leveraged by the control architecture. Some actions that are possible with today's network equipment include:

- Lock sector – This action stops any active transmissions on the sector and turns off any network broadcasting. Locking a sector will impact the current customers since it causes the calls to drop; after dropping, the devices will camp in a different sector that is still active. For this reason, sector locking actions are typically performed during maintenance windows (*i.e.*, at nights, when traffic volumes are low).
- Cell re-selection procedures and inter-frequency handovers – This action can move devices, idle and active, to another frequency band.
- Reduce maximum transmit power – It is possible to remotely control the total amount of power transmitted by a sector; in many vendor implementations, this may require a locking of the sector. LTE standards also allow controlling maximum output power of devices.
- Soft-lock of sector – Performs a gradual offloading of active calls away from the sector, either by targeted actions (*e.g.*, handover to a different layer) or implicitly by reducing the power until no transmission is possible. The soft-locking feature is not provided by all infrastructure vendors.
- Access Class Barring – Prevents access from users that have a different access class than the access class specified by the operator. Access class barring can be used as an effective way to offload traffic from a sector over time, since the active calls will not be allowed back in the sector once they leave.
- Remote Electrical Antenna Tilt ("RET") – Many of today's antennas support RET, which permits the operator to remotely adjust the antenna footprint; this can be an effective measure to limit interference in a particular geographical area without having to disconnect the sector.

A sample interaction scenario might be as follows:

- The operator receives a notification that an incumbent needs to use Channel X within the next hour, for five consecutive hours. The location of the incumbent is known (as latitude and longitude). A max RTWP level of Y dBm is allowed within a 10 mile radius of the incumbent.
- The operator identifies the sectors that are transmitting on that channel in the nearby areas and calculates a safe maximum transmit power for each sector individually, based on distance to the incumbent.
- All of the affected sectors in that area are cell barred for all classes, which will effectively offload Channel X over time. After 45 minutes, the sectors will be locked and the new corresponding safe transmit power will be assigned.
- After five hours, the network will be reverted to the original state.

V. FOCUS AREA D: ISSUES RELATED TO INITIAL LAUNCH AND EVOLUTION OF THE SAS AND BAND PLANNING

The goal of this proposal is to offer a practical solution to the proposed dynamic spectrum management system that will minimize the complexity of the SAS and the required number of interfaces between the SAS and the operator's network. We therefore recommend avoiding direct interaction between the SAS and individual network nodes and instead contemplate interaction with a COE, which resides in the operator's network. The COE would take the responsibility of interacting with the individual network nodes and making sure that the expected power levels and resulting interference levels meet the requirements. This way, the SAS would be relieved of the responsibility to interact with a myriad of operators' network nodes. As a result, the functions of the SAS would be limited to the following:

1. Interaction with incumbent licensees and Priority Access users to come up with up-to-the-minute information about available spectrum for GAA users at any time and geographic location.
2. Assignment of the available spectrum at different geographic locations and time to appropriate GAA users.
3. Interface with a COE to exchange the above information.
4. Receive COE reports on an operator's use of assigned spectrum and measures taken by the operator to control interference.

SAS functionalities, though simplified, still can evolve over time. It is possible to design a simple system that has the ability to become more complex. We envision three stages of evolution:

1. At launch, communication between the SAS and the COE should be kept to a minimum and be based mainly on very short and simple queries about the availability of spectrum, with short "yes"- or "no"-type responses. The instructions from the SAS to the COE would be based on large scale measures, such as the part of the spectrum to use or avoid in a given location. This level of simplicity is necessary at launch to get the system up and running without having to go through lengthy troubleshooting of the interface between the SAS and different operators' COEs.
2. Once the system becomes stable and different stakeholders become confident in the basic functions of the SAS, more detailed information can be exchanged over the interface between the SAS and COEs. These could introduce some degree of dynamic spectrum assignment capability into the system and allow more granular spectrum assignments (assignments of spectrum over given periods of time and geography). At this stage, both the SAS and COEs should have evolved to the point where the SAS is capable of more frequent updates of its database and the COEs have the ability to act on more localized and real-time orders of the SAS about the use of spectrum.
3. Finally, as more knowledge is gained, the SAS can evolve towards a fully dynamic system that allows sharing of unused and vacant spectrum among multiple users that are approximately collocated. In this stage, the SAS would be able to indicate availability of spectrum in real-time or almost real-time in a given geographic location.

As the SAS evolves and more dynamic capabilities are incorporated into its functions, it is critical to ensure all vendors of the SAS not only follow the same standard interfaces between the SAS and COEs, but also have the same implementation capabilities. This would help minimize or avoid often lengthy inter-operation testing between the SAS and different operators' COEs. This SAS framework would provide benefits in governance, planning and roadmapping of future functionalities to ensure backwards compatibility and managed evolution of the system.

VI. CONCLUSION

Shifting the responsibility of direct interaction with network nodes from the SAS to COEs standardizes the function of the SAS regardless of the type of network nodes (low-power small cells, backhaul, higher-power rural uses, etc.) or wireless technologies a 3.5 GHz Band

network uses. It is not anticipated that the basic functionalities of the SAS, as proposed here, will change over time. Although wireless networks may evolve and new wireless technologies may be deployed in the operator's network, as long as the communication protocols between the SAS and COEs stay the same, there is no need to make any changes to the SAS's basic functionalities because of wireless network or wireless technology evolution.

Evolution of the SAS to accommodate more sophisticated data information gathering or agile response time would be mainly internal to the SAS and may only change the parameter settings sent to COEs, but would have no impact on how the COE works or controls the operator's network nodes.

Accordingly, by introducing COEs, a "garden wall" between the SAS and operators' networks would exist in such a way that the two can change and evolve without almost any impact on the expected outcome of the dynamic spectrum assignment process.

Respectfully submitted,

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