

NTIA requested the Key Characteristics Subcommittee to:

Develop a methodology to help assess federal bands for potential sharing, using key characteristics identified previously (above) to assess industry desirability of a frequency band. This methodology will be considered and potentially incorporated into the interagency process to identify and prioritize bands for repurposing.

Background

In November 2017, CSMAC approved the Key Characteristics subcommittee [report](#) (November 2017 Report) identifying the Key Characteristics that commercial industry considers when evaluating the desirability of a particular frequency band as a candidate for exclusive or shared licensed or unlicensed spectrum. The characteristics are:

- Propagation and coverage;
- Capacity;
- Contiguity;
- International harmonization; and
- Incumbency.

The November 2017 report noted that various frequency ranges have attributes that influence these key characteristics. In general, as one moves up the continuum from low band spectrum to high band spectrum:

- Propagation and coverage decrease – lower frequencies provide for greater propagation and coverage.
- Capacity – higher frequencies not only provide for greater capacity but also enough bandwidth to provide for multiple competitors.
- Contiguity – adjacency to similar or complementary uses and the ability to provide contiguity will be band specific. Contiguity is much more difficult in the low and medium low bands of spectrum (less available spectrum, more densely used).
- International harmonization – will generally be frequency/band specific. Although some spectrum alignment is needed for harmonization, technological advances have provided some flexibility for harmonization. Rather than requiring the *exact* spectrum band be available for the same service throughout the world, in some cases, operators can benefit from economies of scale when the equipment is designed to operate over a range of frequencies. In addition, on occasion, the United States has not waited for direction from the international community, and has sought to domestically implement first certain frequency bands, such as 600 MHz, 700 MHz, 5 GHz, 12.2-12.7 GHz, and 28 GHz.
- Incumbency – will also generally be frequency/band specific but does have some parallels with contiguity. Incumbency issues will be critical to any sharing methodology in order for federal government and commercial uses to coexist.

The November 2017 report also reached the conclusion that no single spectrum band will meet every requirement for a particular use, given the diversity of industry requirements and use cases. It also concluded that the relative priority for each of these characteristics is likely to vary based on industry and even on use cases within a single industry. For example, satellite operators have different spectrum priorities, depending on the type of service they provide, whether they wholesale to other communications providers or provide service directly to consumers, and whether the service would be fixed or mobile. For terrestrial wireless operators, relative interest in one spectrum band versus another is not only related to which use cases an operator intends to pursue, it is also related to its current spectrum holdings.

While advances in technology and probable use cases provide the foundation for evaluating particular bands, as technology and demand change so too will interest in a particular spectrum band. As an example, a few years ago, terrestrial operators had little interest in millimeter wave spectrum and how to integrate it into LTE networks. That has changed with advances in technology – both at the radio edge and in the network core. As a result, terrestrial mobile operators will launch commercial service this year in millimeter wave frequencies, which to date had been used primarily by global broadband satellite systems. Also of note is that as broadcasters moved from analog to digital broadcasting, they valued UHF spectrum more than VHF spectrum due to the improved performance for mobile services at the higher frequencies and the sensitivity of digital broadcasts to the increased noise floor in the VHF spectrum.

Recommendation 1:

Given the lack of a homogenous “industry” interested in offering the same or similar spectrum-based services, the subcommittee determined that it would be quite difficult, if not impossible to develop a strict methodology or a “matrix” that some have suggested to identify with great accuracy specific federal government frequencies most promising for sharing.¹ However, even though it is not possible to recommend a specific one-size-fits-all methodology, we believe NTIA can inform its decisions by mapping the frequencies in the various bands in accordance with these characteristics.

Mapping Key Characteristics: we recommend that NTIA approach the question by using the map of the key characteristics that CSMAC identified previously to assess industry desirability of a frequency band against the attributes of the various frequencies bands.

- **Low frequency bands (below 1 GHz)** – propagation and coverage is the key characteristic of the band. Finding enough bandwidth and contiguity will be challenging. Here NTIA’s methodology should start with contiguity – like services or fairly easy relocation of dissimilar services. Note: it is unlikely that the federal government will have much, if anything, to consider in this range of frequencies.

¹ The original committee assignment was to identify what commercial industry considers as the key characteristics in evaluating the desirability of a particular frequency band for *both* shared and exclusive use. Key characteristics would be similar for both types of use, with the possible exception of incumbency and contiguity (at least as defined above – like or similar services). The type and the contiguity of incumbent operations will affect how well parties can share and the rules required to ensure coexistence and mitigate interference. For example, an aeronautical mobile incumbent use is extremely difficult to share with other uses – while it would be simpler to design a sharing etiquette with a relatively fixed service in an isolated geographic area.

- **Medium-low (1-3 GHz)** – propagation and coverage are good. Also, propagation characteristics in this range make it well suited for a variety of sharing techniques. There likely is an opportunity for larger bandwidths and greater capacity with contiguity to existing commercial operations. As such, contiguity and incumbency are likely the most important key characteristics, particularly in a sharing environment. Bandwidth will follow in importance.
- **Medium (3-6 GHz)** – propagation and coverage are better than higher bands, but not as good as low and medium-low bands. There may be opportunities for greater bandwidth. As with medium-low, NTIA’s methodology in examining medium spectrum should start with contiguity and incumbency. It should be followed by bandwidth.
- **Medium-high band and high band (>6 GHz)** – We’ve combined the medium-high and high band frequencies because propagation and coverage are less of a concern and capacity becomes the most important trait. The NTIA’s procedure should ensure that there is adequate bandwidth (including for multiple competitors), followed by contiguity and incumbency. For many services in this band, such as satellite services, international harmonization is very important.

A series of questions (or maybe a decision tree) could be informative and lend itself to relocation or sharing options. As shown below, these questions could be asked in the order below for each spectrum band to drive some prioritization of spectrum bands under consideration:

- What is the frequency range?
 - Low (ask the same questions for each frequency range, medium-low, medium, and medium-high and high band, but with reference to specific priority of the key characteristics for each band, as noted in the descriptions above. For example, in medium-low spectrum, we suggest that contiguity and incumbency are the most important factors, followed by bandwidth.)
 - Is it contiguous with existing commercial services?
 - How much spectrum would be available?
 - How much contiguous spectrum would be available?
 - What type of incumbent use?
 - Can incumbent use be relocated to comparable spectrum?
 - If it cannot be relocated, does the incumbent use readily allow for sharing (difficult sharing would be aeronautical mobile for example versus simpler sharing of a fixed service in an isolated area)?
 - What is the future usage for the incumbent (static or growing)?
 - Is the band identified internationally for commercial services?

In general, a good band to study would be one that contains a significant amount of spectrum (what constitutes “significant” will vary based on the frequency range and will increase as the frequency range increases), is contiguous to commercial services, is either totally or partially globally harmonized, and has static federal use that can be relocated. Even if incumbents cannot be relocated, given the other positive features, it would be worth exploring

different sharing methods. However, given the reality of different business models across and within industries, and the likelihood of finding this perfect match, CSMAC recommends that NTIA adopt general guidelines for assessing federal bands for potential sharing, using key characteristics identified above to assess industry desirability of a frequency band. These general guidelines are presented in the following table.

Table 1. General Guidelines for Assessing Industry Desirability of Federal Bands

| Key Characteristics | Band | | | |
|-----------------------------|--------------------------------|----------------------|------------------|------------------|
| | Low (<1 GHz) | Medium low (1-3 GHz) | Medium (3-6 GHz) | High (>6 GHz) |
| Propagation and coverage | | | | |
| Capacity | | | | |
| Contiguity | | | | |
| International harmonization | <i>Generally band specific</i> | | | <i>satellite</i> |
| Incumbency | | | | |

| Relative Importance | Key |
|---------------------|-----|
| High | |
| Medium | |
| Low | |

Recommendation 2:

The subcommittee recommends that NTIA develop and maintain a written “technology radar” for commercial wireless technologies that are most likely to need access to federal spectrum. Many organizations maintain technology radars in a variety of contexts to feed into strategic planning. On a periodic basis, NTIA should conduct a spectrum technology assessment with vendors providing technology to the market. The goal of the technology assessment is to inform NTIA with respect to changing or advancing silicon and/or radio capabilities servicing the commercial sector.

Various forms of technology radar presentations are readily available on the web, but generally consist of a circle, with technologies near the center ready for market, and technologies near the edge in a longer development cycle. The circle could be divided in pie slices to represent different types of technologies, and often these similar types are color coded. As a result, the output is quite literally one page. Additional text can accompany the chart, but only to the extent NTIA finds additional text helpful and useful.

NTIA should focus on collecting information that is in the public domain, as opposed to proprietary data, and should choose methods of receiving information – perhaps something as simple as an interview – that is efficient and enables NTIA to understand vendors’ views of future wireless technology. Examples of information in the public domain include standards organization work and company press releases highlighting new developments. In addition,

NTIA could decide that such a process would benefit from a public comment round, to enable full public participation.

In this way, NTIA would have a regularized process to provide it insight into the work ongoing in the vendor community. Had this process been in place five years ago, for example, NTIA would have uncovered insights into millimeter wave developments that will make it possible to use those frequencies for terrestrial mobile services. In today's environment, such a process would be useful to understand how the vendor community is looking at spectrum above 100 GHz, further development of the 3GPP 5G specification, and eventually, 6G.

Recommendation 3:

The subcommittee recommends that NTIA seek input from the private sector, in accordance with the law, on the characteristics of a band being considered for reallocation for relocation or sharing. As an example, NTIA could obtain input from industry at various critical points of the investigation: (1) at the beginning of the process when considering the types of services that may be interested in this band along with the incumbencies, (2) in the middle of the process when more information is known about the incumbencies and the possibilities of relocation or sharing, and, (3) prior to or upon the release of the final analysis. NTIA may desire to target the 3450-3550 MHz band for this process as a test case.