Value Creation from an Accelerated Clearing of the C-Band Spectrum

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# Table of Contents

Executive Summary ........................................................................................................................... ii

I. Introduction .................................................................................................................................. 1

II. Post-Auction Negotiation Will Not Yield Accelerated Clearing .............................................. 2

III. Mandated Accelerated Clearing Fee Achieves Early Clearing .................................................. 6

IV. Methodology for Valuing Accelerated Clearing ........................................................................ 7
    A. Baseline Clearing ....................................................................................................................... 7
    B. Discounting and Growth Rate ................................................................................................. 8
        a. Growth Rate ......................................................................................................................... 9
        b. Discount Rate .................................................................................................................... 10
    C. How Soon can the Spectrum be Cleared? ............................................................................... 11

V. Quantifying the Increase in Value ............................................................................................... 11

VI. Conclusion ................................................................................................................................ 15
Executive Summary

The foremost policy priority for the FCC is enabling rapid deployment of 5G networks and services, with their associated economic and social benefits. The C-Band, which will satisfy some of the much-needed mid-band spectrum required for robust 5G services, is a key enabler of this policy. Smart policy with the right incentives could see C-Band spectrum start to be repurposed in as few as 18 months, with a full 280 megahertz available for terrestrial uses within 36 months. Such an accelerated transition would create enormous value for terrestrial mobile operators, their customers and society. To create the incentives for satellite operators to accelerate the clearing of the spectrum, to make new investments and abandon their non-interference rights and existing revenue-generating satellite capacity, a mechanism is needed for the licensees of the repurposed spectrum to compensate the incumbent satellite operators.

Just selling rights to the repurposed spectrum and letting the new licensees negotiate with the existing satellite operators, is unlikely to create the benefits of an accelerated transition. This is because the new licensees will likely suffer a coordination problem in bargaining with the satellite operators. Namely, market failures created by free-rider problems among the new terrestrial licensees and holdout problems amongst the non-C-Band Alliance (CBA) satellite operators risks forgoing the accelerated transition and associated benefits. That an accelerated transition is beneficial is in little doubt. Consequently, to overcome these market failures and facilitate an accelerated transition, the FCC could adopt a structure for auction winners to incentivize incumbent satellite operators to repurpose the C-Band spectrum as soon as possible.

A solution would be to set an “accelerated clearing fee” that C-Band auction winners would pay to impacted satellite operators, who would then clear the spectrum within 18 – 36 months. This fee would be paid outside of the auction context and would not directly impact auction receipts. Such a fee should be directly related to the benefits to the new terrestrial licensees created by the accelerated transition. Such benefits of gaining access to a swath of spectrum sooner are, naturally, proportional to the value of spectrum. As the analysis in this paper demonstrates, an accelerated clearing fee, no less than equal to the amount of aggregate winning bids of the C-Band spectrum auction licenses, would reflect a conservative market value estimate of accelerated clearing for those licenses. This is because under reasonable assumptions about how terrestrial licensees value spectrum, an accelerated transition will more than double the value of the C-Band spectrum if it was repurposed under a baseline FCC spectrum reallocation.
I. Introduction

In a seminal paper on the detrimental effects of delaying the introduction new services in the telecommunications space, Hausman (1997) estimated that a 10-year delay in the introduction of cellular telephone services decreased consumer welfare by almost “$100 billion in total, with more than $25 billion lost in a single year.”¹ Fast forward to 2020, and we are on the cusp of a 5G revolution where mid-band spectrum is critical, and the C-Band is a perfect candidate for 5G deployments. Hausman’s older estimate suggests that in the current context, with wireless communications much more valuable than in the early days of cellular phone service, delaying the 5G deployment will cost the US economy even more. Any mechanism to clear this spectrum faster and make it available to terrestrial mobile users will avoid delaying the introduction of new and innovative goods and services, and will avoid significant lost profits, growth, jobs and private sector investment, to the US economy.

In the subsequent sections, we discuss the tradeoff that is inherent in accelerating the C-Band spectrum availability, with the need to be fair to incumbents while incentivizing them to clear the spectrum faster. We discuss why a mandatory post-auction negotiation period is not the best solution for accelerating clearing in this band. We describe a scenario where the FCC could set a baseline number of years for when the spectrum will be cleared after the date of the auction that is consistent with the commercial life of current revenue-generating domestic C-Band satellites. We then discuss market failures that suggest why negotiations inside this timeframe will likely fail and the accelerated clearing is unlikely to happen. With this baseline, we then estimate the value created for auction winners if the incumbent satellite operators clear the spectrum before any potential FCC-mandated timeframe. We provide estimates of the ranges of the increase in value that an auction winner may be willing to pay the satellite incumbent over and above, and outside the actual auction bid, to accelerate clearing the spectrum. We calculate that the net present value of accelerated clearing is at least equal to the aggregate winning auction bids. We then propose that this value be paid by C-Band entrants to incumbents through an “accelerated clearing fee.”

II. Post-Auction Negotiation Will Not Yield Accelerated Clearing

Over the years, the Commission has relied on a reallocation framework that balances “the interest of new licensees seeking early entry into their respective bands in order to deploy new technologies and services with the need to minimize disruption to incumbent operations used to provide service to customers during the transition.” This marries the notion of creating benefits from reallocating spectrum with the idea that losses to incumbents (and their customers) from the transition should be minimized, and that incumbents should be provided with appropriate incentives to cooperate and create value. As Professor Peter Cramton noted in his analysis of the PCS (Personal Communication Service) spectrum reallocation paper, “[W]ithout providing incumbents with a share of the gain from reallocation, the incumbents would have blocked the reallocation of spectrum from fixed microwave to emerging technologies.”

The FCC first applied the concept of post-auction negotiations through its “Emerging Technologies” framework in the 1993 PCS Proceeding when it reallocated the 1850 – 1990 MHz band from private fixed point-to-point licenses to PCS overlay licenses with wide service areas and flexibility in use. In 2002, it applied the same framework when reallocating 90 megahertz of spectrum in the 1710-1755 MHz and 2110-2155 MHz bands from spectrum held by Federal Government entities that was “slated for transfer to non-Federal Government use,” spectrum used by “fixed microwave services and designated for emerging technologies,” and spectrum that was being used by the Multipoint

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Distribution Service, to new Advanced Wireless Services (AWS). A decade later, in 2012, the framework was applied to the 2180-2200 MHz band for AWS-4 under Part 27.

As Professor Cramton points out, in earlier instances, “[W]hen spectrum was reallocated from one use to another, incumbent licensees were given the right to stay, that is, “grandfathered,” for a relatively long period (typically 10 or more years) to allow amortization of their equipment investment.” The satellite incumbents in the C-Band are somewhat different in that the relevant time-periods associated with satellite investments are usually of a much longer duration than typical terrestrial mobile investment. In general, allowing an incumbent licensee to operate in the auctioned band for some period of time minimizes the amount of investment in revenue-generating assets that is stranded by reallocation. Minimizing the impact on these assets is typically accomplished by assuring that current licensees are provided replacement facilities so that they do not suffer any economic loss from investments they made that are rendered unusable in the process of creating social value through spectrum reallocations.

When the FCC introduced the concept of post-auction negotiations, it recognized that spectrum needed to be transitioned faster to reap maximum economic benefits and hence it introduced “the idea of allowing new entrants to compensate incumbents for early relocation.” It did so by permitting new entrants to negotiate accelerated clearing in exchange for “premium payments” – amounts over and above relocation costs. For example, in the PCS context, it further enhanced the potential benefits of the reallocation by allowing the new licensees to pay the incumbent microwave licensees additional money to move faster and by mandating a negotiation period. Consequently, the incumbents were at least compensated for stranded investments (by being guaranteed a transition to comparable facilities on alternative frequencies) and incentivized with additional payments to cooperate with an accelerated transition that created additional value.

The C-Band transition is distinguishable from past uses of post-auction negotiations for at least three reasons. First, such proceedings typically involved transitioning incumbents to equivalent spectrum. In contrast, the C-Band transition involves a reduction of 60% of the band. Not only will

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7 “Efficient Relocation of Spectrum Incumbents,” p. 15.
8 “Efficient Relocation of Spectrum Incumbents,” p. 16.
this strand significant existing revenue-generating investments, but losing the rights to 300 megahertz of spectrum is a large loss in option value for players making use of C-Band, and is not compensated under this framework. Second, the C-Band transition impacts not only the satellite operators whose primary transmission rights would be lost, but also the many C-Band customers and users—each of which will still have important commercial needs. Third, piecemeal geographic clearing through bilateral negotiation, such as between microwave incumbents and PCS entrants, is not feasible in the C-Band. This is because the band is non-exclusively shared by multiple satellite operators that possess nationwide transmission rights.

In the current context, as explained below, mandating a sunset date and a negotiation period will not achieve an accelerated clearing of the C-Band spectrum after the auction. Therefore, there is a strong public interest case to tailor the Emerging Technologies framework for the C-Band to achieve accelerated clearing. We propose that an efficient mechanism, given the complexities of the C-Band, would be through an accelerated clearing fee.

Suppose, initially, the FCC mandates a clearing date for the 280 megahertz of spectrum in the auction, based on precedent and accounting for the length of time needed to consume some reasonable portion of revenue generating stranded investments. Since the incumbents are not being moved to comparable facilities and equivalent spectrum at no costs to them, the way the incumbent satellite operators are allowed to avoid stranded investments is by giving them sufficient remaining time to fully operate their currently commercialized domestic revenue-generating C-Band satellite assets. Then, suppose, the FCC would allow the auction winners to pay the satellite operators to vacate the spectrum ahead of the potential FCC-mandated clearing date. There are two issues with the C-Band that make the negotiation framework an inefficient mechanism for clearing the spectrum faster. We briefly touch on each below and explain why the Emerging Technologies framework needs to be tailored to the C-Band to achieve an accelerated clearing.

The first issue is the well-known holdout problem in the C-Band. Since the property rights of the band are such that it needs agreement amongst all incumbents before anything can be implemented

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in the band, a mandatory negotiation period does not clear the band faster. The primary reason is
the holdout problem that results from overlapping rights.\textsuperscript{10} In general, the problem created by these
overlapping rights is that, to clear any portion of the band at any specific location requires
coordination of all relevant rights holders. For example, among the satellite rights holders currently
delivering revenue-generating service to the continental United States, unanimous agreement
would be required to clear the 100 megahertz in 18 months in the top markets. That is, agreement
among all but one is not sufficient. Any one of the rights holders can refuse to cooperate in an
attempt to capture a disproportionate share of the collective gains generated by the clearing. As a
consequence, value-creating early clearing may not take place, even though doing so could make
everyone involved better off.

The second set of issues is the free-rider and holdout problems among the new terrestrial licensees
that may plague this band and prevent an efficient bargaining outcome. In the context of other
bands, accelerated clearing can be localized and targeted only to the geographies and licenses that
the auction winner wants to pay for. However, for the C-Band such a localized geographic and
piecemeal clearing is not feasible. So the whole structure underlying the bilateral negotiation will
not be effective in clearing spectrum faster. For example, suppose the FCC provides for post-auction
negotiations and a sunset period of 10 years. Suppose further a company wins spectrum in a
meaningful subset of markets and wants to access the spectrum it has won in the auction in an
accelerated timeframe and strikes a deal with satellite operators, and they pay enough to deploy
filters, launch new satellites and deploy the compression technologies that will make this clearing
feasible. As explained earlier, the C band cannot only be cleared in just the winning bidder’s specific
frequencies and markets, as use in those markets will affect satellite reception in adjacent markets.
Thus, as a practical matter, the satellite operators will have to clear on a nationwide basis. If other
bidders won this spectrum in other markets, they could reap the benefits of this accelerated clearing
without having to pay for it. They, too, will be able to operate sooner than a hypothetical sunset
date, but possibly without having contributed to the costs of the early clearing. True willingness to
pay may not be expressed and the free-rider/holdout problem will create the wrong signals of value
from early clearing, jeopardizing the prospect of early clearing.

\textsuperscript{10} Overlapping rights in the C-Band were an efficient solution to facilitate use of the band for satellite-
based services. The holdout problem only emerges in the context of trying to repurpose portions of the
29, 2018.

\url{https://ecfsapi.fcc.gov/file/102980223165/Intel_Intelsat_SES_Joint_NPRM_Comments%20Final%2010-29.pdf},
(”Maximizing the Value of the C-Band”).
III. Mandated Accelerated Clearing Fee Achieves Early Clearing

An accelerated clearing fee mandated by the FCC would solve both the holdout and the free-rider problems and bring the C-Band spectrum to market faster than would post-auction negotiations. If the FCC set a mandatory accelerated clearing fee, a clearing coordinator could solve the holdout problem on the satellite operator side. All that is needed is for the impacted satellite companies to accept the accelerated clearing fee in exchange for participating in the transition. An accelerated clearing fee, with associated fair and transparent rules on distributing the fee to the satellite operators, imposed by the FCC, and accepted by the satellite operators, would solve the holdout and coordination problems on the satellite operator side.

In addition, as explained above, the free-rider problem creates incorrect signals for the value of early clearing and may jeopardize the prospect of early clearing. Since we have strong *ex ante* reasons to believe that an accelerated transition would create enormous social benefit, any solution that fails to provide for this outcome would not maximize the benefits from repurposing C-Band spectrum.

An accelerated clearing fee also solves market failures on the terrestrial licensee side. As briefly alluded to earlier, with a number of terrestrial providers attempting to negotiate clearing with the satellite providers there is a free-rider problem, where some terrestrial providers may want to free-ride on the efforts of the early movers amongst the terrestrial providers. This itself may dampen any effort to accelerate the clearing of the spectrum. With a mandated clearing fee, there is certainty about the payment and all auction winners have to pay their part. The cost sharing could be as simple as being proportional to the amount of each licensees’ winning bids.

An added benefit from a mandated accelerated transition fee is that by creating certainty in an accelerated clearing scenario, winning bids in an FCC-run auction for the terrestrial rights to C-
Band spectrum will likely be higher than otherwise.\textsuperscript{12} The satellite operators have already revealed a substantial amount of information about their ability to accelerate a transition. This has already created significant value by doing the hard work of showing that a value-creating reallocation is possible. An accelerated clearing fee will build on this work, reduce uncertainty, eliminate the potential for further market failures, and increase the expected proceeds to the U.S. Treasury of a C-Band auction.

\section*{IV. Methodology for Valuing Accelerated Clearing}

In this section, we describe a baseline clearing case (assuming a hypothetical sunset period) and then estimate the value of an accelerated transition compared to that baseline.

\subsection*{A. Baseline Clearing}

In the 1993 PCS Proceeding discussed above, the Commission established a ten-year sunset for Fixed Service microwave incumbents because most incumbents’ equipment would be “would be completely amortized or need replacement by the time the period expired.”\textsuperscript{13} This 10-year sunset has been used as the baseline in subsequent reallocation proceedings using the Emerging Technologies framework.\textsuperscript{14} As noted above, the economic life of satellite investments are substantially longer than that of typical terrestrial mobile infrastructure. Consequently, assuming

\begin{itemize}
  \item \textsuperscript{12} Of course, a fee set too high could divert funds from the Treasury. As discussed below, a fee set in relation to the value created avoids this problem.
  \item \textsuperscript{14} FCC, “Amendment of Section 2.106 of the Commission’s Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service,” Second Report and Order and Second Memorandum Opinion and Order, ET Docket No. 95-18, FCC No. # 00-233, ¶ 52, adopted June 27, 2000 (“We believe that an appropriate sunset date is ten years after the beginning of the negotiation period. This is the period we currently use for relocation of FS microwave licensees. We have been presented with no persuasive reason to adopt a different sunset date in the case of BAS incumbents.”).
\end{itemize}
the FCC will adopt the customary period of 10 years may be very conservative. This conservatism is illustrated by examining the in-orbit commercial life of the current fleet of satellites using the C-Band. Based on data provided by the C-Band Alliance, Intelsat and SES together currently operate 40 revenue-generating CONUS C-Band satellites. Assuming a March 2020 FCC Order, the CBA calculates these 40 satellites would have an average of 155 months (12 years, 11 months) in commercial life remaining. 22 of these 40 satellites would have a commercial life in excess of 10 years following a March 2020 order.\textsuperscript{15}

From these data, the CBA finds that 75\% of the current investment in these satellites will be used within 15.7 years and 95\% within 24.6 years. On the one hand, if the satellite operators were given sufficient time to fully utilize their existing revenue generating assets, the last few years of such an unaccelerated transition would require delaying the repurposing of the entire band to protect a declining portion of the total investment. On the other hand, assuming the FCC’s 10-year baseline transition precedent, the percentage of stranded satellite investments would be approximately around 55\%; that is, with a 10-year transition, the satellite operators would strand (waste) over half their investment in their current revenue generating satellites. Of course, allowing these currently commercialized revenue-generating CONUS C-Band assets to fully operate until their planned end of commercial life would significantly extend the sunset period and further increase the value of an accelerated transition. Consequently, the 10-year baseline transition precedent is very conservative. Nonetheless, in our analysis below we use this 10-year sunset as a baseline against which to value an accelerated transition.

B. Discounting and Growth Rate

Delay in availability inherently decreases the market value of the good being delayed. That is, a good that is marketed today is more valuable than the same good marketed in the future, all else equal, due to the time value of money. The current value of a band of spectrum is the present value of the stream of future expected cash flows generated from the spectrum band.\textsuperscript{16} Hence, there are two components that can separately affect the market value of a good: future expected cash flows or profits and the discount rate.

\begin{itemize}
\item Number of months in commercial life until potential decommission is calculated based on an effective order date of March 15, 2020, and end of commercial life to account for inclined-orbit operation. End of commercial life is defined as the end of maneuver life plus 4.5 years for station-kept assets or the end of maneuver life for inclined assets.
\end{itemize}
In our analysis, we do not need to assume a specific value of the C-Band spectrum, which will ultimately be decided by the auction. We can estimate the value of accelerating the availability of that spectrum by simply modeling the value of spectrum as the present value of an unknown, but steady stream of cash flows. All we need to know is how that stream of cash flows grows over time and what discount rate to use to express the future values in today’s dollars. With a discount and growth rate, we can calculate the value of that stream of cash flows starting any arbitrary number of years sooner than under the FCC baseline.\(^\text{17}\)

\[\text{a. Growth Rate}\]

The growth rate in profits of the mobile terrestrial operators will affect the present value of an expected profit stream. We are interested in the general expected growth in profits well into the future from deploying radio spectrum to provide mobile broadband services.\(^\text{18}\) Given this is a mature industry, it is customary to model the longer term growth rate as the growth rate of the economy in general; any other assumption would be predicting a significant change in the wireless sector relative to the overall economy – a prediction we don’t have a basis for making. According to the Organisation for Economic Co-operation and Development (OECD), the average annual real GDP growth rate in the U.S. from 2021 to 2031 is projected to be 1.67%.\(^\text{19}\) We convert this real growth rate to a nominal one using the forecasted long-term inflation rate (2.1%) for the same period.\(^\text{20}\) Based on these data, we model the nominal growth rate of value from deploying the C-Band spectrum at 3.75% and provide a conservative sensitivity of 2.1% nominal growth in value, i.e. a 0% real growth rate.

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\(^{17}\) We model everything in nominal terms.

\(^{18}\) Although we don’t know who will end up purchasing the spectrum or exactly how they will deploy it and generate future profits from it, we can reasonably assume that they will be mobile broadband players with an interest in multiple spectrum bands. Consequently, even if the specific profits from the use of the C Band spectrum were higher or growing more quickly, to the extent they would be cannibalizing other spectrum-based streams of profits, it is appropriate to look at the industry-wide growth in profits to assess the growth rate of C-Band profits because this will represent the opportunity cost of the owners of the C-Band.


b. Discount Rate

The discount rate represents the extent to which society values a dollar today relative to a dollar in the future. An appropriate discount rate should reflect the expected return on investments in an industry, plus any added uncertainty of the future profits for terrestrial mobile operators from the specific investment being analyzed. For a base value, we use the median industry weighted cost of capital (WACC) of 7.9% from 2018 for the telecommunications sector (SIC 48) to discount the stream of profits.21

Although the WACC reflects the overall returns required by a firm or industry, in practice they are likely to use a higher discount rate when evaluating a specific investment in C-Band spectrum, whether in the baseline or accelerated scenarios. Most firms use hurdle rates to evaluate investments that are higher than their WACC. This can be for a number of reasons including principal-agent concerns related to overly optimistic financial projections as well as accounting for project-specific risks. It is also reasonable to believe firms would want to increase their enterprise value in exchange for undertaking investment risk and, therefore, require some margin above breakeven (the WACC).

Project-specific risks are likely very relevant for investments in repurposed C-Band spectrum. Under the baseline reallocation, the new licensee will experience significant delays between the time of bidding for spectrum and that spectrum becoming available. As noted in Bazelon (2012), long delays can introduce significant regulatory risk and such “uncertainty implies that some previously profitable projects will no longer be undertaken” leading to significant loss of value.22 Project specific risks in either the baseline or accelerated scenarios represent the possibility of operational, technical, marketplace or other developments that significantly change the value of a specific investment in C-Band spectrum. Given these risks, it is appropriate to use a higher discount rate that includes an added premium for specific risk associated with C-Band spectrum. The premium will certainly be greater than zero, but specifying it is precisely is beyond the scope of the current analysis. To illustrate this impact, we assume an additional 1% to 5% discount rate that is


reflective of additional risk. A more precise estimate of a risk premium would require significant additional analysis and is beyond the scope of the current analysis. Nevertheless, given past analyses it is reasonable to use a placeholder for the costs of added risks in this range. Thus we use an aggregate discount rate that varies between 8.9% and 12.9%.

C. How Soon can the Spectrum be Cleared?

With the right incentives, the CBA is committed to clearing a total of 300 megahertz of spectrum (280 megahertz and a 20 megahertz guard band) within 18 to 36 months. Of this, 100 megahertz of spectrum will become available within 18 months in 46 of the top 50 PEAs and the entire 280 megahertz of spectrum will be available throughout the continental U.S. within 36 months from the date of an auction. In the analysis below, the expected auction receipts are based on the spectrum becoming available in 10 years, i.e. the customary potential sunset date set by the FCC. The incentive payments then, account for the time saved considering the differential clearing timing discussed above and the clearing time mandated by the FCC.

V. Quantifying the Increase in Value

To estimate the increase in value from an accelerated clearing schedule, we estimate the impact of shifting a stream of cash flows forward in time. That is, we model the value of accelerating the availability of spectrum as the difference between two streams of cash flows where the only difference between them is the timing of when the cash flows start. Since the value of spectrum is the discounted present value of future cash flows, the value created by accelerating the availability


24 “Implications of Regulatory Inefficiency for Innovative Wireless Investments.”


26 “CBA 300 MHz Ex Parte,” 2019.
of C-Band spectrum is measured as the difference in the present value of a baseline and accelerated stream of cash flows.

Projecting specific year-by-year cash flows would require a significant amount of information; we can use a much simpler model of spectrum value that greatly streamlines our analysis. We recognize that the cash flows associated with any spectrum investment start off negative and turn positive as networks are deployed and customers use them. A convenient modeling convention used in prior analysis recognizes that after the initial negative cash flows and a period of subsequent positive cash flows, there will be a point in time when the present value of cash flows returns to zero, before growing positive. Prior research has found that the zero point in the net present value of cash flows for typical new mobile telecom networks likely happens between 6–8 years. However long it takes to get to the zero point, it is reasonable to assume that from that point forward, the annual cash flows are in an equilibrium or steady state. At this point, the technology is deployed and the customer base is built up. Going forward the cash flows may grow over time, more in line with overall growth of the wireless sector rather than for idiosyncratic reasons related to the specific band of spectrum.

The value of a band of spectrum is the net present value of cash flows from using the spectrum. With the above modeling convention that recognizes that the present value of the first number of years of cash flows sums to zero, spectrum value is then the present value of positive cash flows from the zero point onward. As also noted above, those cash flows after the zero point are ‘smooth’ in that they are in their longer run steady state and can be modeled with an appropriate growth rate. We are interested in how value changes from accelerating the transition, rather than in the absolute value of the spectrum, which will be revealed in an auction. Our variable of interest is the percentage change in the present value of these cash flows caused by accelerating the availability of C-Band spectrum. That percentage change is invariant to whatever level we start the steady state cash flows. Consequently, we can assume the steady state cash flows start at $1 per year and grow at the specified growth rate.

In the current context, we are modeling the impact on the value of accelerating the availability of C-Band spectrum from a baseline of 10 years to 18 and 36 months for 100 megahertz and 180 megahertz, respectively. In the baseline specification, the steady state of cash flows is assumed to

28 For the purposes of the analysis presented below, the conclusions are not sensitive to the specific time it takes to reach the zero point in the present value of cash flows.
29 This is similar to being able to simply calculate a terminal value.
start 15 years after an auction. In the accelerated specification, the steady state of cash flows is assumed to start 7 and 8 years after the auction.

To estimate the present discounted value of this stream, we discount the expected stream of profits of mobile terrestrial operators based on two factors – a discount factor, including project specific risk adjustments, and a growth rate in profits in line with expected economic growth, and an alternative sensitivity of no growth. As discussed above, the discount factor used is the median weighted average nominal cost of capital of 7.9% plus an additional 1% to 5% added to reflect operational, technical, marketplace and other related risks. We also report the risk premium that causes the value of an accelerated clearing to just equal the baseline value of spectrum (the amount an auction would raise absent an accelerated clearing) under the current assumptions. The stream of profits being discounted grow at a nominal rate of 3.75%, with a sensitivity of a 2.1% nominal growth rate. As discussed earlier, in the accelerated scenario we assume that 100 megahertz of the spectrum can be cleared in 18 months and the next 180 megahertz in 36 months. Using these specifications, we calculate the net present value of the profit stream if the spectrum in cleared in 18-36 months versus in 10 years as in the FCC baseline for a transition. The value created is expressed as a percentage of the value of spectrum under baseline availability assumptions. Table 1 shows the ranges of value created under the varying assumptions and sensitivities.

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30 15 years is the 10-year baseline availability of the spectrum plus 5 years to reach the zero point in the present value of cash flows. We use 5 years for the following reason. We start with a 7-year zero point (the mid-point of the range of 6-8 years) and then subtract 2 years as the typical amount of time a carrier would take from starting to spend money on a network until spectrum was deployed. This period of time covers the period of radio network design and infrastructure deployment, up to the point where spectrum is ‘turned on’.

31 6.5 years is the assumed positive cash flow point for the earlier tranche of spectrum (and the first trance becomes available 18 months after the auction). 8 years for the second tranche of spectrum recognizes that 36 months is just one year beyond the customary two-year ramp up period.

32 Calculation = Present Discounted Value of Potential Lost Profit Stream/Value of a Delayed Perpetuity that starts in 10 years, where: PDV of Lost Profit Stream=Σ(C * ((1+g)^m))/((1+r)^n) where m goes from 0 to t and n goes from i to t. i is the year when the cash flow turns positive. PDV of a Delayed Perpetuity = ((C/(r-g))/(1+r)^t-1)), where C is the profit stream, r is the discount rate, g is the growth rate and t is the time the perpetuity start paying out.
Table 1
Range of Value Created as a Percentage of Auction Winning Bids

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>8.90% (7.9% + 1%)</th>
<th>10.05% (7.9%+2.15%)</th>
<th>11.10% (7.9%+3.2%)</th>
<th>11.90% (7.9%+4%)</th>
<th>12.90% (7.9%+5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Term Growth Rate 2.1%</td>
<td>83%</td>
<td>100%</td>
<td>131%</td>
<td>149%</td>
<td></td>
</tr>
<tr>
<td>Long Term Growth Rate 3.75%</td>
<td>66%</td>
<td>100%</td>
<td>114%</td>
<td>132%</td>
<td></td>
</tr>
</tbody>
</table>

Sources:

Note:
The nominal long term growth rate of 2.1% corresponds to the forecasted inflation rate for the next decade. Thus a 2.1% nominal growth rate corresponds to a 0% real long term growth rate.
The nominal long term growth rate of 3.75% corresponds to the sum of the forecasted real growth rate and inflation rate for the next decade.
Cleared spectrum is available 10 years from the close of the auction under a potential FCC mandated sunset date of 10 years.

Table 1, above, shows that under most assumptions and sensitivities the value created through acceleration is in excess of 100% of the value of the spectrum under baseline clearing. The actual value created from an accelerated transition is likely to be at the upper end of this range due to the likely risk premium assumed by potential bidders and their desire to earn a return on C-band investments in excess of their WACC. In fact, any premium for risk above about 2-3% (a modest premium) suggests that the value created by an accelerated transition exceeds the baseline value the U.S. Treasury would receive without an accelerated transition. Based on the estimates presented
in Table 1, and the discussion above, setting an accelerated clearing fee at 100% of the auction winning bids conservatively reflects the value created from an accelerated clearing.\textsuperscript{33}

VI. Conclusion

It is well accepted that the C-Band will be a critical part of meeting the mid-band needs of U.S. mobile network operators, and earlier availability of this spectrum will help the U.S. emerge as a global 5G leader. As with auctioning other spectrum bands with incumbents, the fundamental tradeoff in the C-Band is balancing the need for a faster availability of the spectrum for the terrestrial mobile operators, with the stranded revenue-generating investment and fair treatment of the incumbents. In the past, the FCC has applied the flexible Emerging Technologies framework, with a combination of sunset dates, cost sharing and mandatory negotiation periods. However, the likely market failures in the C-Band noted above, such as holdout and free-rider problems, make post-auction negotiations unworkable, and unlikely to create the benefits of an accelerated transition. We propose that a mandatory accelerated clearing fee where the FCC mandates that the auction winners pay the impacted satellite operators a fixed percentage of the auction winning bids to accelerate the clearing of spectrum after the auction closes, will fairly and appropriately incentivize the incumbents to make spectrum available within the 18 – 36 month timeframe. We provide estimates to show that under the customary 10-year sunset assumption (that for satellite operators would still leave considerable revenue-generating investment stranded) a fee that is set at

\textsuperscript{33} An accelerated clearing fee equal to auction bids is also consistent with an alternative approach to modeling the fee. If market failures could be overcome and a bargaining model was used, the incumbent satellite operators and new terrestrial spectrum licensees could be expected to split the surplus gained from an early clearing. Such a surplus would be the value of the accelerated transition to the terrestrial operators, less hard transition costs. Under the accelerated clearing fee, the hard costs of the transition are paid for out of the fee, with the satellite operators only benefiting from the portion of fees above clearing costs. Given that the value created from an accelerated clearing is likely more than the value of the spectrum without the accelerated clearing, a fee equal to 100% of the auction proceeds may approximate this bargaining solution. To illustrate the point, suppose the value of the spectrum under a baseline transition was $10 and under an accelerated clearing was $25, an increase in value of $15 or 150%. If the hard transition costs were $5, then $10 of net economic value is created by an accelerate clearing. ($15 of value, less $5 of costs to realize that value.) Under a symmetric Nash bargaining game, the $10 in value would be split between the satellite and terrestrial operators. In this case, the satellite operators would receive $10 ($5 in hard transition costs plus $5 in the shared value created) or an amount equal to 100% of the net winning auction bids of $10 for the spectrum without the accelerated clearing.
100% of the auction winning bids is a conservative and highly defensible level. Such a mandatory clearing fee will accomplish the fastest clearing and to the extent acceleration more than doubles value (which is likely), it will only increase U.S. Treasury receipts as that additional value increases auction bids.