ATTACHMENT F

SPECTRUM ALLOCATION DESIGN:
Objectives, Recommendations and Analysis

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The opinions expressed herein are of the authors and do not necessarily reflect those of the individuals listed above or others who kindly assisted in the writing of this document.

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SECTION I: INTRODUCTION AND OBJECTIVES

This document addresses the following question:

How can the proposed Public Safety Broadband Trust accomplish a fair and efficient reallocation of rights to use spectrum while guaranteeing that a national wireless network achieves the geographic scope essential for public safety use (e.g., maximum terrestrial build-out, even in rural areas assumed to be unprofitable for most commercial operators)?

To answer this question, we studied auction design, competitive strategies of firms, Federal Communication Commission spectrum allocation policy, and spoke with several experts in these fields. Our research, as well as our spectrum rights allocation proposal outlined herein, has been guided by the desire to achieve several goals that we believe to be shared, directly or indirectly, by the Commission. These goals are as follows:

- Maximization of consumer welfare and contribution to a high and rising standard of living;
- Efficient and intense use of valuable electromagnetic spectrum;
- Diversification of spectrum lease rights holders (e.g., entrepreneurs, small businesses, minority owned businesses, etc.);
- Exploitation of network effects through the mass market penetration of advanced, mobile broadband wireless network capabilities;[1]
- Revenue maximization;[2]

[1] Tom Eisenmann and Reed Hundt; *Broadband: The Case for Universal Service.*

[2] Note that revenue maximization is a goal, but one of secondary priority to the others mentioned here. For this private process for assigning lease rights, the primary reason to concentrate on revenue maximization is to support regions of the country that will require subsidies for build-out despite the proposed public/private partnership. More on this topic of subsidies later in this document.

SECTION II: AUCTION MECHANISM DESIGN

Auction Basics

The important features and definitions of the recommended spectrum rights allocation process are outlined below. Two critical rule proposals – the "Population Cap Rule" and the "Negative Bidding Rule" – are introduced in this section but explained in greater depth in Section III.

What is up for bid?

- Lease rights to 30 MHz of spectrum in the 700MHz band ("700 MHz Spectrum") in designated geographic regions covering all of the United States. Subject to eligibility rules, limits will be placed on the total number of geographic regions that can be bid for by one potential commercial operator ("commercial operator");
- Lease rights obligations and benefits will include:
    - Obligation to build out a mobile broadband network in designated geographic area(s) subject to strict technical and timeline requirements of the Public Safety Broadband Trust; ("PSBT")
    - Access to an industry that currently has nearly insurmountable barriers to entry;
    - Access to a national network;
    - An "anchor tenant" in public safety;
    - Obligation to deploy an advanced mobile broadband technology standards, selected by the PSBT, and to operate and maintain the network to meet relevant service level agreement standards for public safety users;
    - Access to potential economies of scale through support from and coordination with PSBT and a manager of the public safety portion of the network;[3]

Who are the bidders?

- Organizations, businesses and entrepreneurs (referred to from here on as "commercial operators")

[3] More on access to economies of scale in Section III.

What is a bid?

- A bid is defined as a short "business plan" or completed questionnaire that may also include a monetary price.
    - The primary purpose of the business plan or completed questionnaire is for potential bidders to prove that they meet all basic FCC qualification requirements and have adequate financial resources and operational capabilities. We recommend, however, that the business plan or questionnaire should not impose a significant barrier to entry for potential lessees. A high number of eligible bidders are critical to the efficiency and success of the spectrum rights allocation process.
- "Negative" or "Subsidy" bids should also be allowed. Negative bidding will allow the process to assign an efficient market price to the spectrum lease rights package in all geographic regions, even those which are considered unprofitable by prospective commercial operators. (An extensive explanation of the "Negative Bidding Rule" as well as details regarding its execution and historical success can be found in Section III.)

Auction Structure

Simultaneous, Ascending, Multiple-Round Auction

- The country will be divided into ____ regions[4]
- Reserve prices (minimum bids) are set for each region based on a low-end estimate of the net present value ("NPV")[5] of region build-out and operation. Less populated regions could have a negative reserve price or subsidy limit. (See below for more information on reserve prices.)
- In each round the participants will make sealed bids for the spectrum lease rights for the geographic regions in which they are interested. At the end of a round the highest standing bid is posted but the identity of the bidder remains hidden. For the next round, the

[4] The question of the region demarcation and the optimal number of regions to divide the country into for this purpose is a challenging one requiring financial analysis that is beyond the scope of this document. Recommendations for this analysis are discussed briefly in Appendix A.

[5] The difference between the present value (in today's dollars) of cash inflows and the present value of cash outflows. "NPV" is used in capital budgeting to analyze the profitability of an investment or project.

minimum bid is the standing high bid plus a predetermined increment (typically 5-10% of the standing high bid). The greater of the highest bid in the previous round and the new highest bid this round becomes the standing high bid.

Maximum Eligibility and Activity Rules

- The "Population Cap Rule" limits maximum eligibility to ____% of the total population up for bid.[6] Outside of this rule proposal, standard regulations used in FCC simultaneous ascending auctions for spectrum allocation should apply. Participants should be required to pay a refundable payment upfront to ensure eligibility.
- Typically an ascending auction has three stages which can consist of multiple rounds. The stage transition occurs when there is little bidding activity in two consecutive rounds Similar to activity rules in previous FCC spectrum auctions, a participant must be active on a predefined fraction (typically 80%, 90% and 98%, depending on the stage) of its current eligibility; otherwise the participant's eligibility moving forward is reduced.
- Activity rules are in place to limit the total time of the auction and to ensure constant activity throughout the process by preventing bidding at the very end of a round. If a participant does not bid their eligibility is reduced or they can use a limited number of activity waivers (typically five).

Auction Stopping Rules

- Traditional stopping rules are suggested here. The auction is closed when no bidder submits a waiver or a new bid on a particular spectrum lease rights package as to which it is not the highest standing bidder.

Reserve Price or Minimum Opening Bid

- The process of arriving at a reserve price should vary somewhat from a traditional simultaneous ascending auction. For the geographic areas which are clearly going to be profitable (positive NPV) and therefore will generate positive auction revenue, reservation prices will be set as they have in previous auctions based on the formula ($x * MHz *

[6] A full explanation of the "Population Cap Rule" can be found in Section III. The question of "Population Cap Rule" eligibility is a challenging one requiring financial analysis that is beyond the scope of this document. Recommendations for this analysis are discussed briefly in Appendix A.

License Area Population). However, for geographic regions which are likely to require subsidies and will therefore generate negative bids, some further analysis must be conducted to estimate both the NPV and the "social NPV"[7] for each subsidized region (see Section III for more analysis of the negative bidding rule as well as the analysis required to find reservation prices for geographic area requiring subsidies for build-out).

Bid Removal and Bid Withdrawal

- Traditional FCC auction bid removal rules and penalties are recommended. A bidder is allowed to withdraw two standing high bids. If a bid is withdrawn the standing high-bid is the previous round's second highest bid. Penalties equal to the difference between the withdrawn bid and the second highest bid are assessed to the bidder.

Build-out Requirements

- Strict build-out requirements and timelines are recommended. Forcing commercial operators to adhere to strict build-out requirements and face penalties for non-compliance will have three potential benefits:
  - (i) Timely completion of the network;[8]
  - (ii) Decreasing the probability of bankruptcies caused by speculative firms bidding beyond their financial means with the sole intention of "flipping" the spectrum lease rights package to another bidder;[9] and
  - (iii) Eliminating the possibility of firms bidding on spectrum lease rights with the intention of "squatting" on them and preventing the timely build-out of a nationwide network.

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[7] A "social net present value" includes the total increase in consumer surplus resulting from the project (which included the external benefits of having a local public telecommunication service available e.g. avoided transportation costs, opportunity cost of time, etc, which effectively reduce the price of a call and increase the potential demand for the service)

[8] Timely build-out is critical for the maximization of consumer welfare. In the calculation of social NPV there is a theoretical discount rate (a "social discount rate") which impacts the present value of consumer welfare. If timely build-out isn't achieved and months/years pass, the social discount rate will have a negative impact on social NPV. (Hazlett, Thomas W., and Munoz, Robert E. "What Really Matters in Spectrum Allocation Design." AEI-Brooking Joint Center for Regulatory Studies, Working Paper 04-16, August 2004, p. 4.)

[9] Speculators will be deterred by the fact that the value of spectrum lease rights will go down as time passes and the risk of incurring significant penalties for build-out delays increases. Still, speculation isn't entirely bad, as long as the spectrum lease rights end up in the possession of the firm that will utilize that asset most efficiently. The only negative aspect of speculation is the delay of network build-out, which will be limited by strict build-out requirements.

Payments

- The payments received from the various winning bidders are placed in an account. These funds could be used to fund the regions which are awarded a subsidy via a final bid that is negative. The payment of these subsidies should occur after the build-out is completed and inspections are conducted.

Buying, Selling and Trading in an After-auction Market

- Buying, selling and trading of spectrum lease rights between authorized firms should be allowed in an after-auction market. An after-market shouldn't be used to correct problems or inefficiencies that could have been solved in the original auction design. Instead, it is an insurance policy of sorts to ensure the spectrum lease rights package ends up in the hands of those who most value it. All rules associated with lease rights should apply to whoever obtains those rights in the aftermarket (i.e. population cap rules and build-out requirements).[10]

SECTION III: CRITICAL RULE PROPOSALS

As referenced in the spectrum lease rights allocation mechanism description above, two non-standard auction rules have been proposed. The negative bidding rule and the population cap rule will be critical to the achievement of the goals stated in Section I, the success of the proposed public/private partnership for public safety network build-out, as well as increased competition and innovation throughout the wireless industry.

[10] There are two specific benefits to an after-auction market: (i) High participation throughout the spectrum lease rights allocation process is critical, and an aftermarket allows firms to participate that may not have entered the original auction. (ii) The population cap rule will force bidders to make tradeoffs during the auction. The winning bidders may want to shift around their allocation and trade spectrum lease rights package after the auction is over (still subject to the restrictions set out in the original auction). This is desired if it in any way puts the spectrum lease rights in the possession of the firm that will utilize them most efficiently. The major problem we see with the aftermarket is that people may try to collude and pay lower prices to obtain spectrum lease rights in the original auction and then sell them for a profit in the aftermarket (this problem could be reduced by having strict build-out requirements, etc.)

The Negative Bidding Rule

The most significant obstacle to building a mobile broadband network for public safety and first responders is the ubiquitous coverage demands of that user community. Emergency wireless communications are needed even in the least populated areas of our nation; however build-out to these areas has proven to be unprofitable.[11] If it is assumed that there are many businesses with the expertise to achieve terrestrial build-out of less populated regions, the challenge becomes simply a matter of price.

A well conceived auction with a sufficient number of bidders will, if nothing else, assign an efficient market price to any item up for bid. But how does an auction assign a market price to a project that might have a negative net present value ("NPV")?[12] The answer: negative bids. Prospective commercial operators should be allowed to place "negative" or subsidy bids in the auction proposed herein. For example, while bidding for spectrum lease rights covering a rural area in which the build-out and operations are assumed to be unprofitable, a prospective commercial operators may bid "negative $50 million" (meaning, a $50 million subsidy would be required by that firm in order for its build-out plan to be profitable). However, if another firm bids "negative $40 million" it would win the spectrum lease rights package for that particular geographic region. Auction revenues earned from the bidding for profitable regions could be distributed in the form of a subsidy to those bidders that "win" an auction in which the final price was a negative number. Quite simply, negative bidding will allow the auction to assign an efficient market price to the spectrum lease rights in all geographic regions.

A Successful Example of Negative Bidding

In conceiving the negative bidding rule, it is informative to draw on thee experience of the Chilean government in effectively extending telecommunications (public telephones in this particular case) services to rural areas in between 1995 and 2000.[13] The sector regulator,

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[11] Coverage maps of today's nationwide wireless carriers show that while 90+% of the nation's population can obtain some level of mobile telecommunications service, there is a large geographic portion of the country that is not covered by their networks.

[12] The difference between the present value (in today's dollars) of cash inflows and the present value of cash outflows. "NPV" is used in capital budgeting to analyze the profitability of an investment or project.

[13] The negative bidding rule was recommended by Harvard Business School Professor Felix Oberholzer-Gee. The summary herein is drawn from an article "Extending Telecommunications Service to Rural Areas- The Chilean

SUBTEL, first conducted a cost-benefit analysis which estimated the subsidy necessary to provide public telephone service to a particular geographic region. In some cases it found that the project had a positive NPV, despite the fact that current operators assumed otherwise. The cost-benefit analysis of other, less populated regions resulted in a negative NPV. In these cases, a "social net present value" was calculated which included the increase in consumer surplus which would result from the project (this included the external benefits of having a local public phone available, e.g. avoided transportation costs, opportunity cost of time, etc, which effectively reduce the price of a call and increase the potential demand for the service). Some projects were deemed to have a positive social net present value but a negative NPV and were therefore not commercially viable. For these regions the maximum subsidy was set to the negative NPV and the projects were ranked by social NPV per unit of maximum subsidy to prioritize which regions would be available for bidding.

Maximum subsidies (negative reservation prices) were set for each region and licenses were awarded to the bidder requiring the lowest subsidy to achieve profitable build-out. The subsidy was paid in a lump sum after the facilities were built out and SUBTEL had conducted inspections. Build-out requirements were set from six to twenty months after the license was granted. The combination of a contractual obligation and a monetary incentive to initiate service quickly worked well in this case. The subsidies were driven down by the competitive nature of the bidding. The bidding process also helped identify demand and willingness to pay in small regions which had not received sufficient attention from incumbent operators. The result was that many bids unexpectedly required zero subsidies. Some call charge caps which existed in cities were also lifted. This combined with the subsidy made regions much more attractive than they originally appeared. Many of the regions with limited competition were awarded the maximum subsidy which indicates that future auctions should incorporate some mechanism to move towards the maximum subsidy rather than start there.

The Chilean public telecommunications auction was considered to be very successful. Sixty two offers were made for forty two of the forty six projects. Sixteen bids were made for a zero subsidy. The rest of the projects were bid at or near the maximum available subsidy.

Experience, Bjorn Wellenius, World Bank Group" and "Closing the Gap in access to rural communications, Chile 1995- 2002", Bjorn Wellenius, World Bank discussion paper no. 430.

Some Analysis is Recommended

Returning to the topic of the proposal for an advanced public safety broadband network, it is highly recommended that further analysis must be conducted to estimate both the NPV and the "Social NPV"[14] for each geographic region that is assumed to generate negative bids and therefore require a subsidy for build-out. There are three reasons why this analysis must be done:

(i) Education is critical for increasing the number of potential bidders. Without analysis and reasonable evidence to support the value of a subsidy required to profitably build-out and operate a portion of the network in a rural area, it is likely that the less attractive regions will only receive bids from local firms, if any at all. This lack of a high number of bidders will result in the region being won for a subsidy that will be inefficiently large. More bidders lead to more competition, a more efficient auction, higher revenues and lower subsidies.

(ii) Build-out costs will vary over time. The PSBT and its advisors will always be in the best position to make an accurate estimate of the efficient subsidy figures. As the technology costs change (e.g. terrestrial build-out vs. use of satellite for coverage), costs of network build-out will change.

(iii) Prepare for a "net-negative" auction result. It is possible that the auction proposed herein is "net negative" – meaning, the total subsidies required exceed the total revenues generated by bidding for profitable regions. In this case, some prioritization of the regions will be required to ensure the limited funds generated in the positive bid regions are used most effectively. The regions should be ranked by the social NPV per unit of maximum subsidy (i.e. the goal is to obtain the most value from each additional subsidy dollar) with the regions having the highest ratio being given priority in the allotment of any additional subsidies.[15]

[14] A "social net present value" includes the total increase in consumer surplus resulting from the project (which included the external benefits of having a local public phone available e.g. avoided transportation costs, opportunity cost of time, etc, which effectively reduce the price of a call and increase the potential demand for the service)

[15] After all potential subsidies are paid out, offering service to the least profitable areas (lowest social NPV per unit of subsidy) will be achieved by other means than a terrestrial network (i.e., satellite, etc.)

The Population Cap Rule

We recommend that a cap be placed on the total population of the geographic regions that a prospective commercial operator can bid for during the auction. Population estimates should be publicized for the designated geographic regions up for bid and an auction mechanism should be created that will not accept any bid which pushes the total outstanding bids of a prospective commercial operator over ___% of the total population.[16] The implementation of a population cap rule within the simultaneous ascending auction will have several specific benefits, namely:

- Maximizing the number of bidders;
- Diversification of spectrum lease rights holders; and
- Rapid, mass-market penetration of mobile broadband wireless capabilities.

Maximizing the Number of Bidders

If there is one critical success factor for the auction design proposed herein (or any auction for that matter), it is the presence of a large number of bidders. A high bidder-to-region ratio will lead to a competitive and efficient auction which generates the maximum possiblevalue. The population cap rule and the enforcement of hidden bidder identities will help this cause. In an auction in which a large player (an incumbent national carrier, for instance) can bid on any and all regions, smaller bidders may simply assume that the larger bidder has more information, more money and more incentive to win. Since there will be a cost of auction entry (if not an up front payment then at least the management hours and other costs to participate) smaller players will most likely not even bother to participate. Thus, the larger player will win the spectrum lease rights packages for the affected region at a discount. Competition, overall auction revenues, and efficiency of spectrum use all are negatively impacted.

Diversification of Spectrum Lease Rights Holders

[16] The question of "Population Cap Rule" eligibility is a challenging one requiring financial analysis that is beyond the scope of this document. Recommendations for this analysis are discussed briefly in Appendix A.

The FCC website lists "The facilitation of innovative service and product offerings, particularly by small businesses and new entrants" as one of its primary goals.[17] We believe that the auction mechanism proposed herein presents an unprecedented opportunity for regional wireless players, small businesses and entrepreneurs to participate in an industry altering wave of innovation. Specifically, the population cap rule will help to achieve goals for diversification in spectrum lease rights holders while avoiding many of the potential financial risks of small to medium sized businesses.

However simply providing an opportunity for small businesses and entrepreneurs to obtain spectrum lease rights covering particular geographic regions is only half the battle. Creating an environment in which these firms can succeed after the spectrum lease rights are awarded is of critical importance. The consolidation occurring within the wireless industry over the last several years highlights the fact that there are significant scale economies in wireless communications. A business model must be created which allows commercial operators to benefit from these economies of scale. While these firms will make their own capital expenditures for network build-out, each should receive access to nationwide roaming agreements, buying power with suppliers and technical assistance ensuring interoperability with other regions through rules adopted by the PSBT or by coordinating the relevant activities, where possible, with the entity managing the public safety network. The result would be a number of businesses with the operational independence of individual units that collectively obtain the economies of scale and market power of a national player. Such a structure is not only crucial to building a viable competitor to major existing incumbents wireless network operators but it is imperative to building and operating an economically viable nationwide public safety network.

Rapid, Mass-Market Penetration of Mobile Broadband Wireless Capabilities

Famed economist Joseph Schumpeter spoke of the need for innovation in competitive markets: "Competition crucially depends upon innovation (the introduction of new products and processes, the creation of new markets, the development of new organizational forms and the search for new sources of supply)."[18] There has been a growing interest in the mobile communications service sector in recent theoretical and empirical studies in industrial

[17] FCC Website: http://wireless.fcc.gov/organization/#goals
[18] Nicoletta Corrocher and Lorenzo Zirulia, *Innovation and Schumpeterian Competition in the Mobile Communications Service Industry*

organization literature. However a majority of the research focuses on purely strategic aspects of mobile service competition. Innovation, in its most general sense, is usually not considered, especially the role of service innovation in affecting competition between firms in the mobile communication industry.[19]

A noteworthy example: Italy represents one of the most developed markets for mobile communications. One of the most relevant determinants of this performance has been technical and service innovations. Increasing competition and the continuous development of service plans and pricing mechanisms have undermined first mover advantages in the maintenance of a large customer base. "The progressive market openness has stimulated the creativity of market leaders, instead of perpetuating a myopic attitude."[20] This is witnessed by the sequence of subsequent innovations developed by TIM and Vodafone-Omnitel in response to the entry of new operators, which have allowed them to preserve their market power. By contrast, in the United States, market power has been maintained without customers benefiting from continuous innovation to the extent that could actually be possible from both a technology and pricing plan perspective.[21]

SECTION IV: CONCLUSION

The unique simultaneous ascending auction process described herein will provide the best opportunity for the proposed public/private partnership to achieve its goal of creating a national wireless broadband network that achieves theexpansive geographic scope essential for public safety use. Two aspects of the auction in particular -- the negative bidding rule and the population cap rule – are critical to the achievement of this goal, as well as the objectives of diversification of spectrum lease rights holders and rapid, mass-market penetration of mobile broadband wireless capabilities. Participation remains the key to the auction. A high bidder to region ratio will result in a competitive auction, efficient valuation of spectrum leasing rights (either positive or negative) and the inevitable increase of consumer welfare.

[19] Corrocher and Zirulia
[20] Corrocher and Zirulia
[21] Corrocher and Zirulia

Appendix A

A Note on the Size of Geographic Regions

The question of how many regions to divide the country into is a challenging one that extends somewhat beyond the scope of this paper. A financial model must be created which estimates the required capital expenditures and pro forma profit and lost estimates for the network build-out and operation of the type of combined public safety/commercial broadband wireless network contemplated here, in various geographic areas. Such a model should be built after technical standards decisions are made by the PSAI and cost of network build-out can be accurately estimated. Assuming that as the geographic size and population of a region grows, the total average cost per unit of area will fall (through economies of scale), eventually flattening out when the marginal benefit of one extra mile of coverage becomes very small. Regions must be made large enough so that the maximum economies of scale from build-out are captured but small enough so that the spectrum lease rights to many regions are feasibly won by small businesses and regional wireless carriers, therefore increasing the total number of bidders in the auction.