New York State Technology Enterprise Corporation

Presents a

Technical Proposal Exhibit

700-MHz National Pre-Allotment

The Immediate Need, and a Proposed Process for Generation of the Narrowband Spectral Allotments

Submitted to:

The National Public Safety Telecommunications Council

NPSTC
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Introduction

The NYSTEC/SRC team is pleased to present this proposal to the National Public Safety Telecommunications Council (NPSTC). The purpose of the proposal is to illustrate the need for, and the issues relating to, the generation of initial 700-MHz general-pool frequency allotments. It outlines a proposed conceptual methodology for generating these pre-allotments, and identifies areas that may require further discussion with the stakeholders within the process. The NYSTEC/SRC team is uniquely qualified to address these issues through innovative approaches and the application of advanced modeling concepts and tools.

The New York State Technology Enterprise Corporation, NYSTEC[1], is a private not-for-profit technology-engineering company whose mission is to provide systems engineering and technical assistance to government clients on a wide range of information and communication technologies. NYSTEC prides itself on remaining independent from manufacturers and system integrators, which allows it to be an independent trusted partner for its clients. Since its founding in 1995, NYSTEC has developed proven skills in working in diverse, multi-agency environments at the state, local, and federal levels. NYSTEC has a strong focus on the public-safety land-mobile radio market and is well versed in radio propagation measurement and analysis as well as the regulatory aspects. NYSTEC has a staff of about 45 people and is headquartered in Rome, New York.

The other member of the team is NYSTEC's sister company, Syracuse Research Corporation (SRC)[2]. SRC is also a not-for-profit, independent R&D organization serving both government and industry since 1957. The unique expertise of SRC scientists and engineers lies in their ability to analyze complex technological problems and to develop innovative, practical solutions. SRC's approximately 340 staff members hold more than 100 advanced degrees in 40-plus technical disciplines. SRC is headquartered in North Syracuse NY and maintains 10 offices across the US to serve a wide range of federal agencies.

NYSTEC and SRC are affiliates of SRC Management, Inc. (SMI). SMI is a separate not-for-profit corporation that provides general and administrative support services and acts as a holding company for NYSTEC and SRC. The three corporations all share a common Board of Trustees and Corporate Officers, so they are tightly linked together enabling strong partnerships on projects.

As this proposal will discuss, the NYSTEC/SRC team recommends that NPSTC work towards the generation of nationwide geographic pre-allotments for the general-use 700-MHz public-safety spectrum and that these allotments be used to populate the NPSTC pre-coordination database. NYSTEC/SRC have gone through considerable review of this proposed effort with the NPSTC Database Subcommittee, and the methodologies proposed herein reflect the consensus of the subcommittee in regards to this undertaking.

[1] More information can be found at the Web site http://www.nystec.com
[2] More information can be found at the Web site http://www.syrres.com

Pre-Allotment of 700-MHz Spectrum

The 700-MHz spectrum has never before been available for use by land-mobile radio operations. Because of this, it offers many exciting possibilities for creating new paradigms in the way that it is allotted, and used. In particular, the use of more detailed models within the pre-allotment and regulatory realms could allow for a higher level of spectral efficiency than has previously been achievable.

Regulatory and Rule-making procedures for the 700-MHz Public Safety Narrowband spectrum are drawing near completion. Once these processes are completed, many areas of the country will be able to make immediate use of the 700-MHz spectrum (pending equipment availability). In addition to this, state-wide reserve allocations of this spectrum might be made available for licensing later this year. Because of these factors, there is a genuine need for pre-allotment of the spectrum, especially for frequency coordination and Regional Planning purposes. Pre-allotment produces "pools" of channels that may be used in a given area. As actual application data is received from Regional Planning Committees, the process can be run again to re-optimize the "pool" allotments that would remain available within a Planning Region.

The Need for Pre-Allotment

NPSTC has made a pre-allotment database available to all authorized frequency coordinators for the new 700-MHz narrowband public-safety spectrum. In order to maximize the utility of NPSTC's pre-coordination database, and to effectuate its use within frequency coordination and regional planning, it is imperative to completely populate the database as soon as possible. In order to accomplish this, it will be necessary to perform the allotments on a national basis.

This database is in its final stages of acceptance — from both NPSTC and its intended user base — and therefore is nearly ready to be populated with initial "pool" allotments. It was anticipated that the allotments would be provided over time on a regional basis — but with input required from around 55 individual regional planning committees. NYSTEC/SRC propose that the allotments be developed all at once, on a national basis, and without the need for massive collaborative efforts from the individual regional committees – many of which have not yet formed. However, NYSTEC/SRC also propose that actual allotment application data from those 700 MHz Regional Planning committees, which have already been formed, should be solicited early in the pre-allotment process.

Pre-Allotment Boundaries

In general, the geographical structure of the 700-MHz Regional Planning Committees (RPCs) will be based upon state borders, and will be similar to the structure shown in Figure 1 (depicting the 800-MHz National Public Safety Planning boundaries). Note that some large states are broken into multiple regions.

Site-specific parameters are generally not available during the pre-allotment process. However, the spectrum must be allotted based upon <u>some</u> type of bounded area. An obvious choice (and with precedent set from past processes) is to allot the spectrum based upon county-type boundaries. It is the recommendation of the NYSTEC/SRC team that the 700-MHz narrowband spectrum be pre-allotted according to these boundaries — especially since *most* public-safety usage falls naturally into these subdivisions. A map of the suggested county-type divisions is shown as Figure 2. Note that, while the figure mainly depicts county boundaries, many cities that are not incorporated within counties are also depicted. These will be treated as their own individual allocable areas.

700 MHz Structure of RPCs?

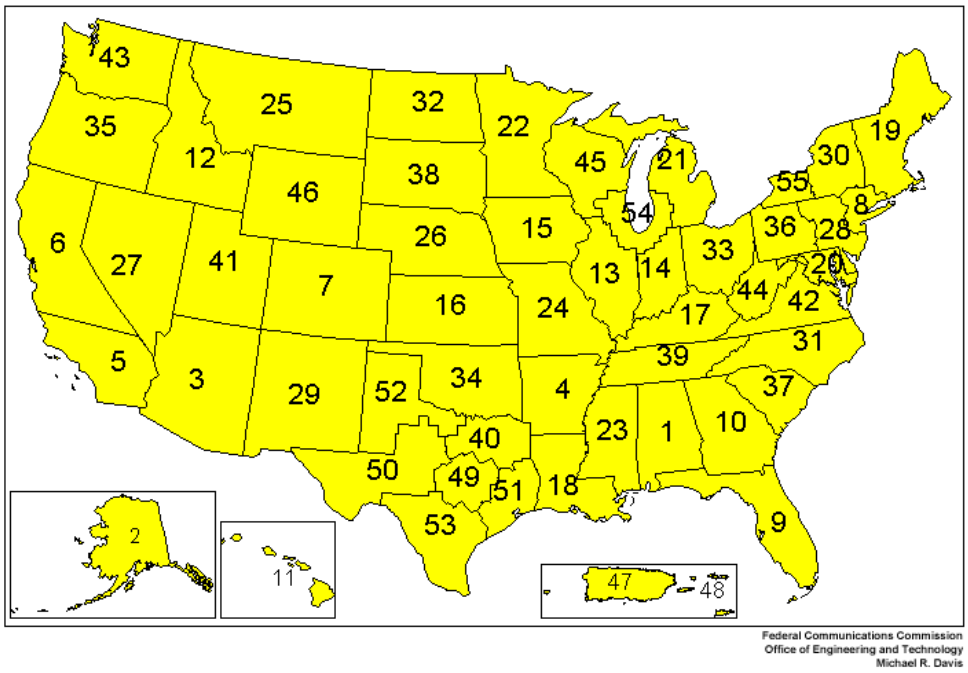

Figure 1, Regional Boundaries

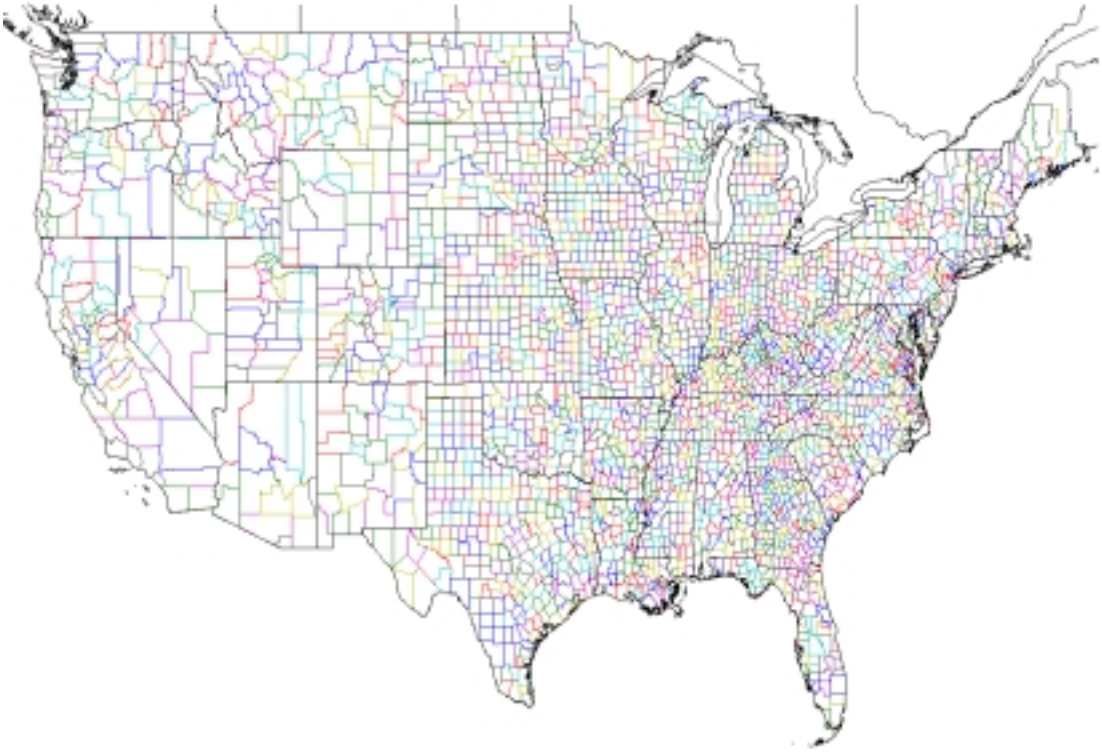

Figure 2, County and Large Municipal Boundaries

Proposed Methodology

It should again be stressed that the opportunity exists for implementing more detailed models and processes when allocating the spectrum. This allows for a higher level of spectral efficiency than has been possible in past efforts of this nature.

Spectral Needs Assessment

Based upon discussions with the NPSTC database subcommittee, it has been decided that each indicated county/area receive some minimum allotment (e.g., three 25 kHz channel pairs for voice, and one 25 kHz channel pair for data - see Allotted Bandwidth Section on pages 8-9), regardless of aggregate capacity needs. Beyond this, the pre-allotment process will provide additional spectrum based upon some measure of individual capacity needs. In the past, this additional capacity assessment was based solely on population. This proposal recommends that the past approach be modified.

In the NYSTEC/SRC team's analysis of public-safety capacity needs within New York, it was found that these needs varied tremendously across the State. It was clear that there was a strong correlation between population and public-safety capacity needs. However, it was also found that, when only considering county populations, a large number of public-safety and public service users were not accurately represented in the rural areas. This is illustrated in Figure 3.

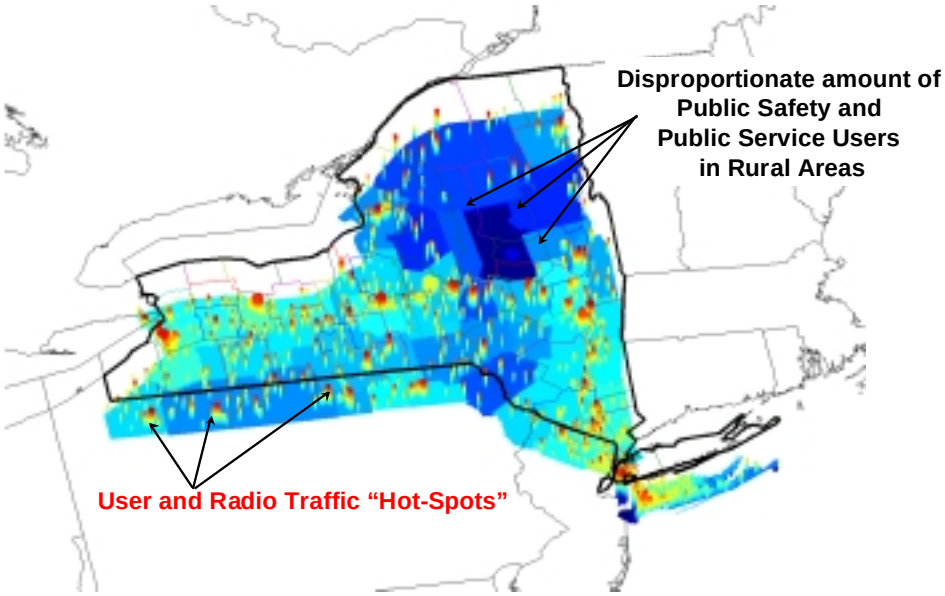

Figure 3, Distribution of Spectral Needs

The NYSTEC/SRC team proposes an approach similar to PSWAC's approach, in which both population and population-density are used to predict the total number of public-safety users within a specific area to be allotted spectrum. The most recent population data available will be used, and can be projected out to a future date (such as 2010). Modifications to PSWAC's models will need to be incorporated — since the original models incorporated little data from rural areas. This algorithm would be submitted for approval to NPSTC. In addition to this, a statewide law-enforcement component must also be integrated into the models. Similar models, developed by SRC/NYSTEC, are shown in Figure 4.

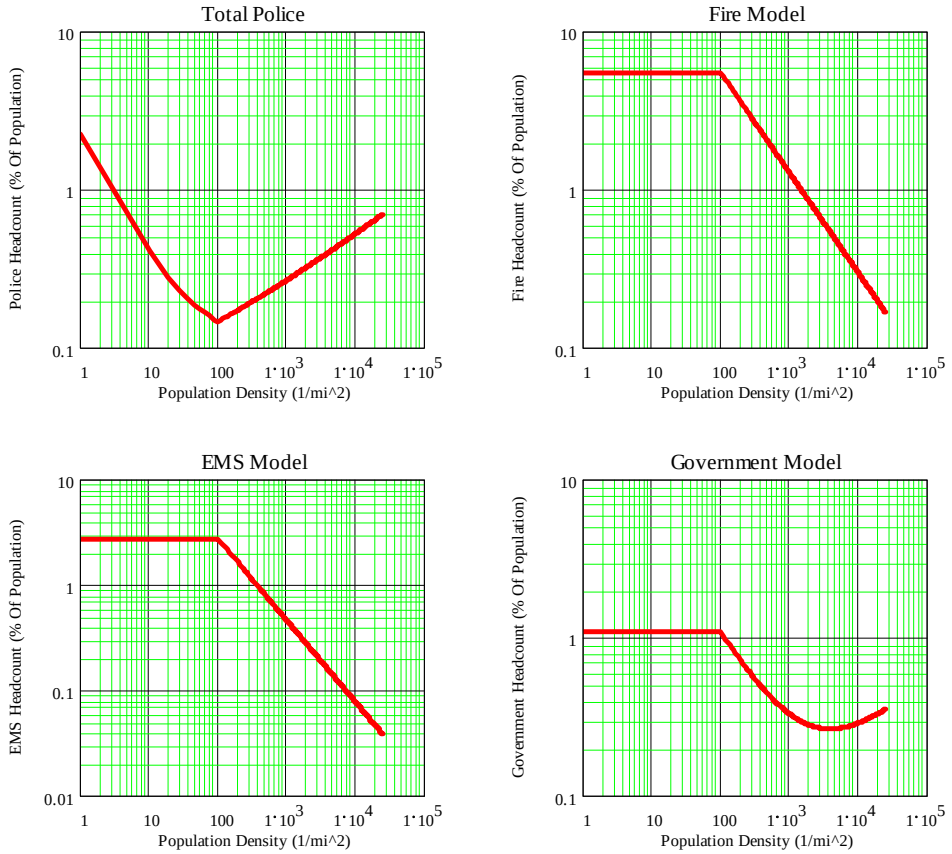

Figure 4, Modified PSWAC User Density Models

Once public-safety and public service user populations are projected for a given area, they will be used to distribute the spectrum pre-allotments, normalized by the total amount of available spectrum (with reuse), and by the total national public-safety user projections.

It should be noted that more detail could be included in the capacity-assessment models by applying service-based usage and voice/data penetration levels to the projected user group populations. By using service-group-based models in summing the resulting Erlang loads, estimates of aggregate capacity needs can created for all of the various user groups. These will then provide Erlang load projections that could be incorporated with traffic models[3] to estimate channel needs.[4] After this process, similar normalization methods would be applied.

Service Area Evaluation and Interference Prediction

It is clear that accurate modeling of coverage and interference effects allows for tighter site/frequency "packing" and greater spectral efficiency. Again, since this frequency band is a new allocation, the ability exists to utilize more accurate methods of assessing these effects during the pre-allotment stages of spectrum planning and plan development. The NYSTEC/SRC team has experience in developing innovative techniques for spectral assignment processes, and continues to work with Telecommunications Industry Association (TIA) TR-8.18's working groups in developing the next generation of coverage- and interference-assessment methodologies.

For the 700 MHz pre-allotments, the service area/contour for each of the counties will be represented by a bounding polygon that extends beyond the county border by 3 to 5 miles. This actual

[3] For example, Erlang-C, or extended-Erlang-B for trunked networks, Erlang-B or Engset/Molina for conventional networks.

[4] This process was followed in New York State, and culminated in the generation of a statewide 250x250-meter resolution traffic-density/capacity grid. Details available upon request.

distance from the county border can be a uniform decision, affecting all service areas, or can be individually based upon population-density metrics (TIA recommendations call for 3 miles for rural areas and 5 miles for urban areas).

There are several possibilities for generating the interference contour(s), all utilizing some measures of local terrain characteristics. From Figure 5 it is apparent that there is a tremendous variance in terrain roughness in the US (Northwest US shown). It is also clear that utilization of terrain features allows for a much more accurate representation of signal propagation and interference prediction, especially when compared to simple "rule-of-thumb" reuse distances.

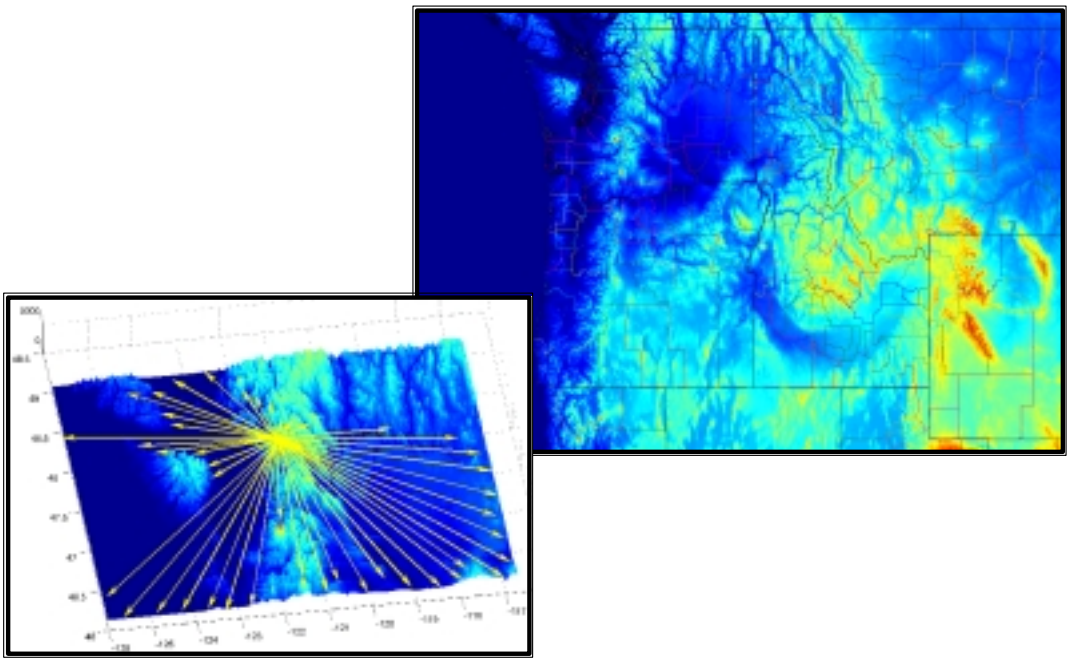

Figure 5, National Terrain Variance and Increased Accuracy through the use of Terrain Features

With no site-specific information available, several options are possible for predicting frequency reuse parameters. An example, shown in Figure 6, places a site location at the highest terrain elevation within a given county, then uses directional height above average terrain (HAAT) calculations to compute the interference range in each direction outward from the site. The model used to compute these distances can be Okumura-Hata-Davidson-based (as in NPSPAC), Carey-based (i.e. R6602, F(50,50)), or new models, such as the "TIA-6602" method (proposed modification to FCC R-6602) under consideration by TR-8.18.[5] Examples of the Okumura-based contours are shown in this figure, with ray-traced radio horizon limits included for reference.

[5] All interference contours utilizing standard values (such as 5 dBu), and with all contours being median levels (i.e. 50,50).

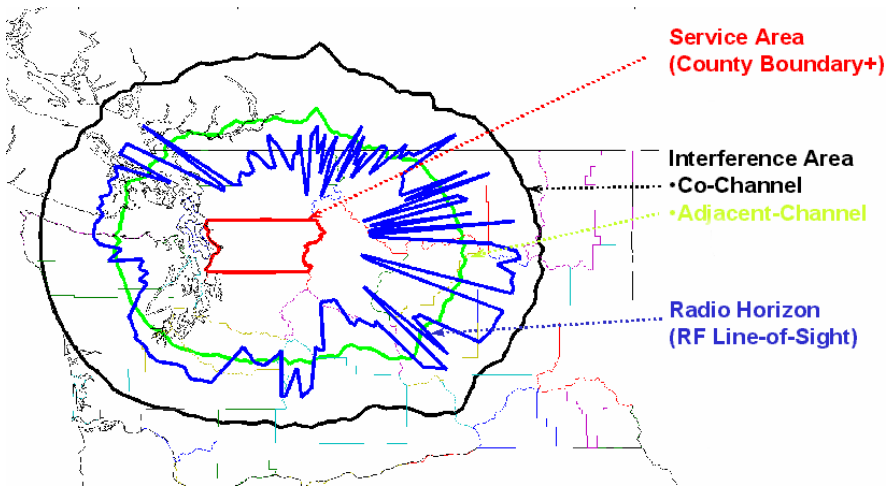

Figure 6, Example of a Possible Contour Methodology

Allotment Approach

NYSTEC and SRC also have experience in generating spectrally efficient frequency assignment methodologies - as evidenced by recent work generating spectrum plans for a statewide wireless network, and generating and proposing alternative Digital Television Transition plans for Canada[6].

Basic Allotment Process

The recommended spectrum-allotment approach is based upon the non-intersection of contours — an approach familiar to regulators and frequency coordinators alike. Specifically it will apply rules within the allotment process that specify that service and interference contours for co-channel frequency allotments cannot intersect. In addition to this, it may specify that adjacent-channel interference contours cannot intersect the service contours on an adjacent-channel examination.[7] The program could iterate, so that, if not enough spectrum is available to meet the recommended levels of any given county, it will spread the load over all counties involved within the allotment process. This ensures that every county reaches a similar level of capacity - relative to its projected needs.

This process provides the ability to pack the spectrum geographically to a very large degree, as illustrated in Figure 8. Note that the NYSTEC/SRC team can also provide periodic re-packing of the spectrum, once site-specific licenses are issued and more detailed models can be applied. Note that, *when* site-specific parameters are available, it is important to populate the database with contours that represent coverage and interference parameters as accurately as possible. For this, a tile-based contouring (such as the NYSTEC/SRC team has proposed to TIA[8]) method is recommended.

[6] These Canadian plans would completely eliminate the need for 700 MHz DTV allotments, and essentially align 700 MHz spectrum on both sides of the US/Canadian border.

[7] TIA's recommendations of 60 dBu contour values for adjacent-channel interference (based upon 65 dB ACCPR into a 6.0 kHz) may render the adjacent-channel consideration within this process unnecessary.

[8] Details available upon request.

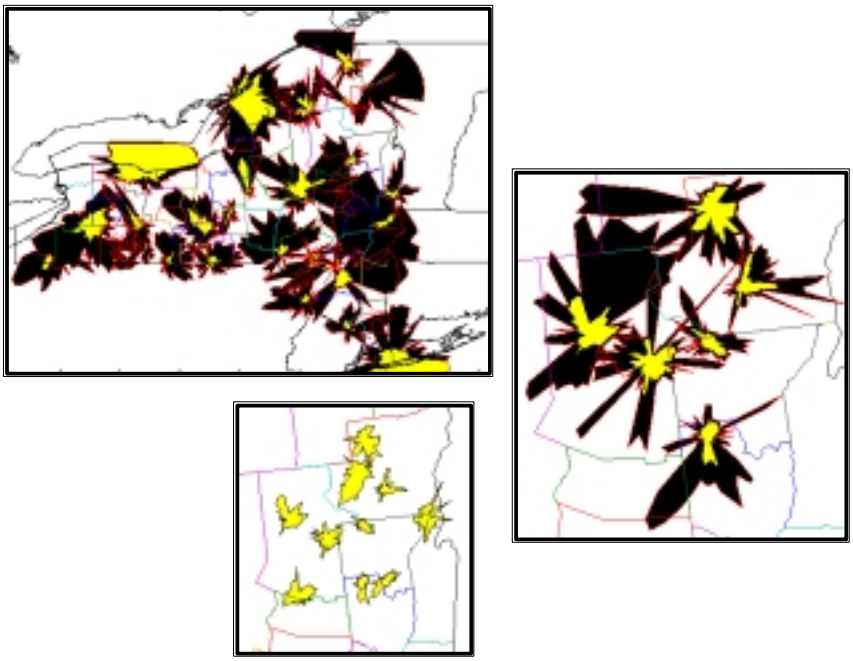

Figure 7, Contour-Intersection Methodologies

Allotted Bandwidth

One very important parameter of the pre-allotment process is the bandwidth of the pre-allotted voice and data channels. This has proved to be a strongly debated topic of discussion.

Figure 8 shows a portion of the 700-MHz narrowband spectral layout. The potential for many diverse technologies within the same spectrum is troublesome in regards to determining the smallest building blocks to allot. It is clear to see that the spectrum may be allotted in either 6.25-kHz (allowing the use of future FDMA technologies) allotments, 12.5-kHz (allowing the use of current FDMA and future TDMA technologies) "bundles", and 25-kHz “blocks” (allowing the use of 25 kHz TDMA technologies). The inherent problem is that allotting anything smaller than 25-kHz blocks precludes the future use of 25-kHz technologies on the pre-allotted channel sets. Presently, no US 25-kHz TDMA technology product is available for operation in this band, although FCC Rules allow such operation.

NPSTC and TIA have previously recommended that 25-kHz blocks be pre-allotted for both voice and data applications. At the May 2001 NCC meeting it was proposed that three (3) 25-kHz voice channels and one (1) 25-kHz data channel would be the minimum default allotments in the absence of actual specific applications for channel allotment. This would permit different technologies to be implemented using 6.25, 12.5, or 25 kHz channel widths at some future date. Therefore, the pre-allotments will be generated based upon aggregating 25-kHz blocks of spectrum.

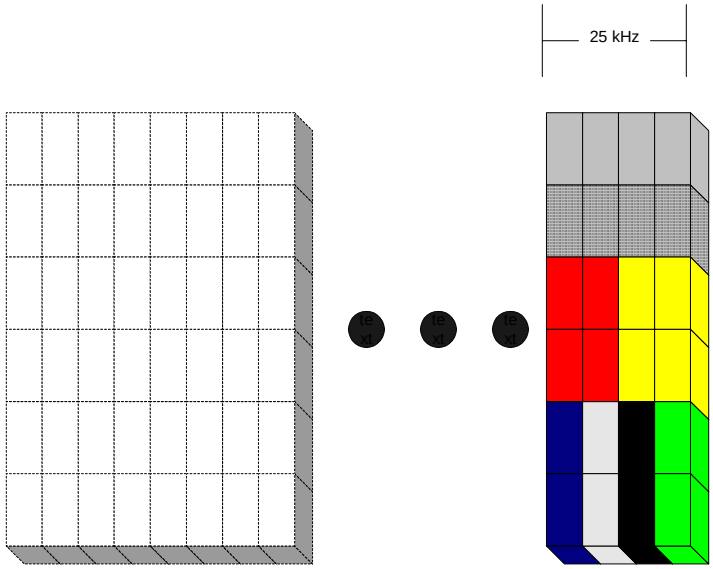

Figure 8, Channel Allotment Possibilities

The pre-allotment process will also account for realistically achievable multi-coupler spacing. For this reason, all-individual pre-allotment channel sets will have an internal separation of no less than 250 kHz.

Geographic Boundaries and Regional Penetration of Pre-allotments

NPSTC has previously recommended that the pre-allotments be performed only along the borders of each region. After discussions with the NYSTEC/SRC team, it was seen that better spectral efficiency could result from allotting all areas of all regions during the pre-allotment process. Pre-allotment of all areas, even within regions, can also result in significantly faster availability of channels to an applicant, since the regional planning process has already taken place. Otherwise one might have to wait for a regional planning process to follow an application.

NYSTEC/SRC proposes that the pre-allotments be performed throughout all of the regions, but that allotments outside of the border areas could be modified without restriction by individual regional planning committees without the need for inter-regional coordination. However, if such change results in an interference contour impact upon any adjacent region, inter-regional concurrence is required.

Treatment of Television Services

There are many additional constraints that can be imposed upon the pre-allotment process; most are based upon the existence of current and future television broadcast services within the 700-MHz band. These include incumbent US analog stations as well as US digital allotments that occur in certain areas of the nation. Aggravating the problem is the uncertainly related to international broadcast services (in particular Canada and Mexico) that may claim protection from, and cause interference to, US operations within the spectrum. An illustration of this is in Figure 9, where the locations of primary-class 700-MHz digital and analog broadcast television services within 400 km of the US/Canadian border are depicted.

While it is possible to alter the allotment process to take all of these broadcast services into account, the final result will not provide the same spectral efficiency that would otherwise be possible. It is also possible that consideration of all of the stations may over-constrain the problem, generating inefficient results for no valid reason. An example of the process of considering these television services is illustrated in Figure 10, where similar tools were used to generate spectrum assignments in New York, while working around existing and proposed television services from both the US and Canada.

The actual selection of allotment criteria and stations to consider during the allotment process depends on many factors — among them US 700-MHz spectrum availability; the DTV transition timelines

of the US, Mexico, and Canada; and international negotiations and treaties. The NYSTEC/SRC team has a firm understanding of these issues, and would be pleased to assist in any discussions regarding their resolution — or in recommending the best course of action to take for the pre-allotment process. However, for the purposes of this proposal, NYSTEC/SRC propose that no consideration be given to allotting spectrum based upon broadcast television services emanating from within the US or abroad.

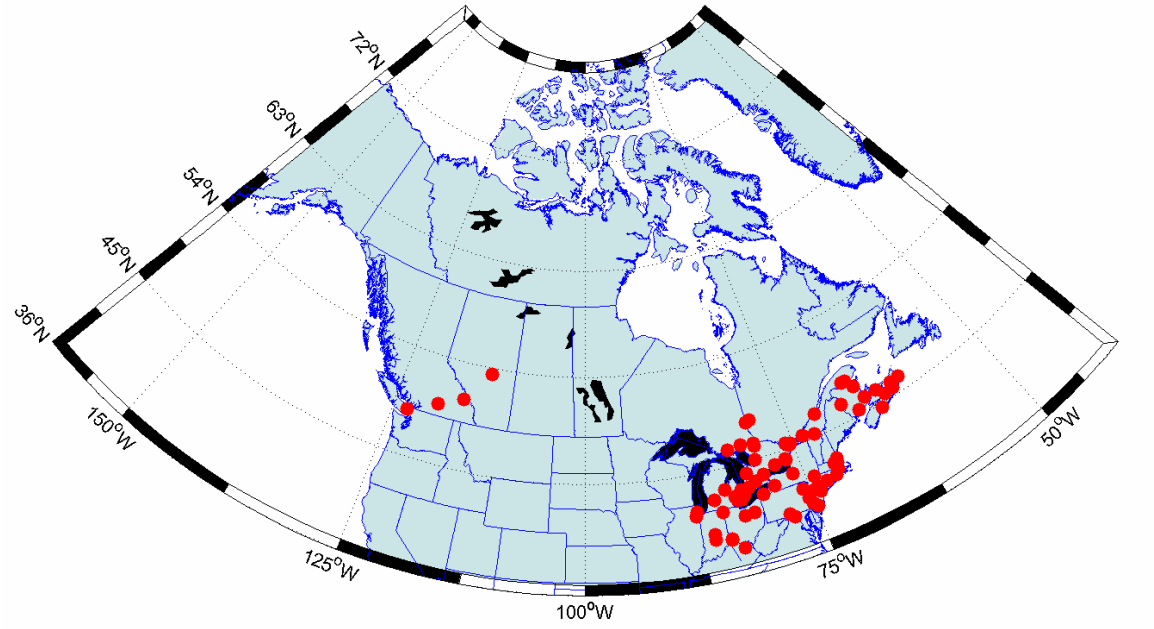

Figure 9, Canadian Border Area Television, Channels 62 through 69

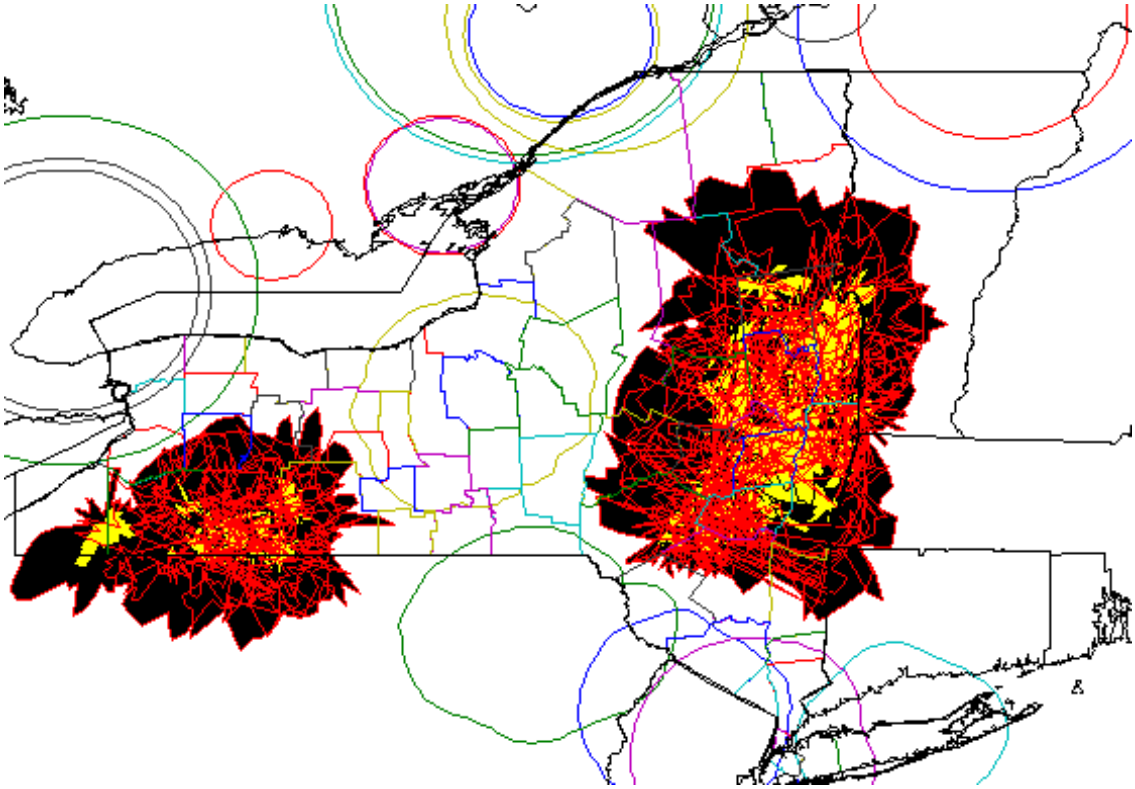

Figure 10, Example of Consideration of Analog and Digital Television Factors

Consideration of Regional Planning Committee Efforts

It must be noted that many 700 MHz regional Planning Committees (RPCs) have now formed and commenced their meetings. Therefore, it is appropriate to solicit input from the 700 MHz Regional Planning committees that have already been formed; and that this should be done at the very beginning of the pre-allotment process.

NYSTEC/SRC will assist NPSTC in the solicitation of this information, and will attempt to utilize any efforts completed by the RPCs. If possible, NYSTEC/SRC will alter the allotment process to better conform to the needs of these individual RPCs. However, note that this may lead to essentially unbounded efforts that cannot be defined at this point. These will need to be carefully considered, and will require further discussion between NPSTC and NYSTEC/SRC to resolve scope and compensatory issues relating to these portions of the re-allotment efforts.

Summary

The NYSTEC/SRC team believes that, in order to maximize the utility of NPSTC's 700-MHz public safety pre-coordination database, and to effectuate its use for regional planning and frequency coordination in a multiple vendor environment, it is imperative to completely populate the database as soon as possible. In order to accomplish this with optimal spectral efficiency, it will be necessary to perform the allotments on a national basis, and to utilize accurate models and spectral assignment strategies.

A summary of the proposed methodologies is as follows:

- Utilize population and population density characteristics in the evaluation of capacity needs. Employ PSWAC-like capacity requirement models to introduce increased accuracy in the modeling process.
- Utilize terrain data for service area evaluation and interference prediction. This will allow greater accuracy in the pre-allotment process, and will result in better reuse of the spectrum.
- Use contour intersections to evaluate the validity of pre-allotment channel sets. Build upon past experience in developing quasi-optimal spectral allotment solutions.
- Solicit input from the 700 MHz Regional Planning committees that have already formed. NYSTEC/SRC will assist NPSTC in the solicitation of this information, and will use Regional Planning Committee allotment application data where available. Such data will specify the channel bandwidth (6.25, 12.5, or 25 kHz)
- Pre-allot "pool" channels in aggregate 25 kHz blocks around any initial Regional Plan allotments. Allow a minimum of four blocks per allotted (county-like) area, three for voice, and one for data. Allot additional spectrum based upon projected need, and normalized by the spectrum available (considering reuse).
- Upon request at a later time, re-run the program in order to update it with additional Regional Planning Committee allotment application data, and revise the "pool" pre-allotments within those regions accordingly.
- Allot all areas. Pre-allotments may be altered without the need for inter-regional coordination as long as adjacent regions are not impacted. Changes that impact adjacent region(s) can only be made with inter-regional concurrence(s).
- When considering allotable spectrum blocks, do <u>not</u> attempt to work around either US or International broadcast-television services. Many of these station assignments are either temporary, or subject to change, and working around them will result in allotment inefficiencies.

NYSTEC/SRC will be pleased to provide NPSTC with a separate Statement of Work and Cost Proposal that addresses the entire scope of this effort.