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June 8, 1998

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
1919 M. St., NW, Room 222
Washington, D.C. 20554

RE: Ex Parte Presentation – Proxy Cost Models
CC Docket No. 96-45

Dear Ms. Salas:

The attached materials are being provided to the Commission staff members listed on the courtesy copy list below. They will be discussed at a meeting between the HAI Model sponsors and these Commission staff members that will be held on June 9, 1998.

Two copies of this Notice are being submitted to the Secretary of the FCC in accordance with Section 1.1206(a)(2) of the Commission's rules.

Sincerely,

Richard N. Clarke

Richard N. Clarke

Attachments

cc: Gary Biglaiser, Craig Brown, Brian Clopton,
Lisa Gelb, Chuck Keller, Mark Kennet,
Katie King, Bob Loube, Jeff Prisbrey,
Bill Sharkey, Richard Smith, Don Stockdale,
Brad Wimmer, Pat DeGraba, Natalie Wales,
Sheryl Todd (8 copies)

No. of Copies rec'd 0+2
List A B C D E

HAI Model v 5.0a

Why it Engineers the Appropriate Amount of Distribution Plant

AT&T and MCI

June 8, 1998

Overview

- Several parties have suggested that the HAI Model 5.0a (HM) may not engineer lengths of distribution plant sufficient to reach all customers because:
  - PNR cluster configurations do not match sufficiently closely the distribution area (DA) engineered by the HM
  - HM distribution cable lengths are inadequate to reach to the edges of the PNR clusters
- A correctly executed analysis of these issues demonstrates that the HM engineers:
  - Sufficient distribution plant to reach customers in the lowest density zones, where universal service concerns are most acute
  - Slightly excess amounts of distribution plant in the upper density zones, thus overstating unbundled loop costs in these zones

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Overview

- The reasons why these parties' rudimentary analyses may have suggested an opposite conclusion is because their analyses have failed to:
  - account for how PNR customer geocode points are developed
  - account for where these geocode points are located relative to the customer's premises
  - compare HM distribution plant lengths against a correct standard for measuring "sufficient" plant
  - use a comprehensive sample of actual customer locations as the basis for making plant length comparisons -- instead using either:
    - a hand-picked set of clusters, or
    - clusters artificially formed from randomly generated points

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How the HM Engineers Distribution

- PNR develops customer clusters based on geocode data specifying the locations of over 100 million customers
- The cluster information that is reported to the HM includes the latitude and longitude of the cluster centroid, its area, and its N-S/E-W aspect ratio (height/width)
- The HM Distribution Module (DM) then engineers distribution cables to "cover" a rectangle that has the same area, centroid and aspect ratio as the cluster
  - for main clusters, this cable is in backbone and branch (BB&B) configuration
  - in outlier clusters, cable is engineered directly based on the distances between individual customer locations

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Main Cluster BB&B Calculations

Assume:

Area of distribution area = A

Aspect (H/W) ratio of area = r

Width of distribution area = $(A/r)^{1/2}$

Height of distribution area = $(Ar)^{1/2}$

Number of customer locations = N

Lot depth to width ratio = 2:1

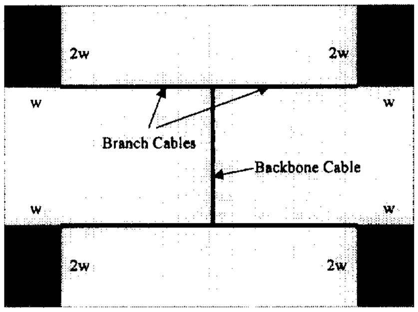
Then:

Area per location = $A/N = w \cdot 2w = 2w^2$

(where w=lot width, and 2w=lot depth)

Lot width = $(A/2N)^{1/2}$

Lot depth = $(2A/N)^{1/2}$



Thus:

Backbone cable length = $(Ar)^{1/2} - 4w$

$2 \times$ Branch cable length = $(A/r)^{1/2} - 2w$

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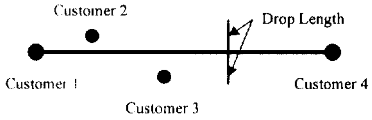
Outlier Cluster Subscriber Road Cable

Customers are within ±1 drop length of being colinear

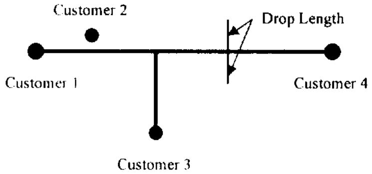
Subscriber road cable length is distance between two locations farthest from each other (major axis of the cluster). Customers 2 and 3 are served by drop wire off of road cable.



Customers are not within ±1 drop length of being colinear

Primary subscriber road cable length is the distance of the major axis of the cluster.

Secondary subscriber road cable are spurs off of the primary with total length equal to the minor axis of the cluster.



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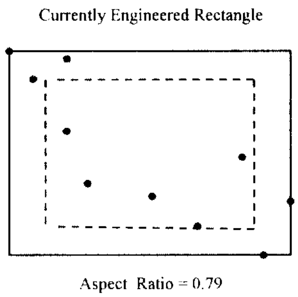
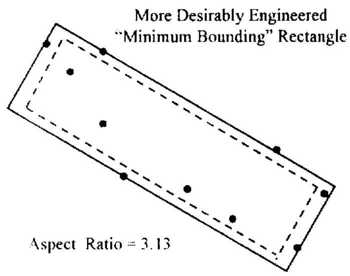
Cluster Configuration Issue

- Because PNR reports only the N-S/E-W aspect ratio of the cluster, the rectangular DAs designed by the HM's DM may differ in configuration from the actual configuration of the cluster





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Cluster Configuration Issue

- The difference between the actual cluster configuration and the engineered rectangle will be largest for clusters that are both:
  - extremely long and thin, *and*
  - rotated maximally away from a N-S/E-W orientation
- PNR will now calculate the aspect ratio of the rotated minimum bounding rectangle (shown on the right in the previous slide)
  - this superior aspect ratio will now be used by the HM's DM, and
  - HM DAs will now match more closely all clusters' actual configurations
- The numerical effect of this adjustment on HM-calculated distribution distances is negligible (see Chart 1)

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Cluster Configuration Issue

- Sprint's focus on this issue is surprising because even the current HM practice of engineering DAs as properly located N-S/E-W rectangles is superior to the BCPM's practice of engineering DAs as arbitrarily located *squares*
- With the engineering of optimally rotated rectangles, the HM's superiority over the BCPM becomes even larger
- Furthermore, because the BCPM makes use no use of actual customer location data, it cannot be improved to have its DAs comport to actual customer clusters

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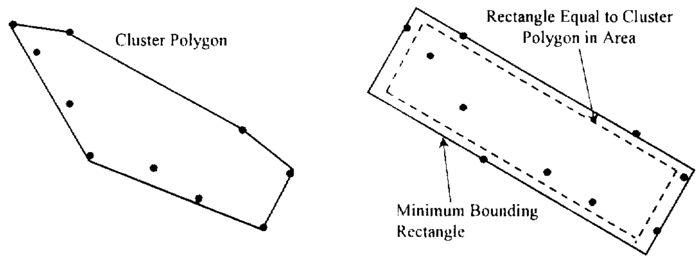
Cable Length Issue

- Sprint suggests that because the HM engineers BB&B cable to cover a rectangular area equal to the cluster polygon's area (which lies within the cluster's minimum bounding rectangle), HM cable lengths may be inadequate to reach customers located at the polygon's vertices



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Cable Length Issue

- While it is theoretically possible for distribution cable lengths not to reach the given polygon's vertices, the HM-engineered cable lengths are adequate, because:
  - PNR clusters are formed from both actual and surrogate geocode points, and
    - surrogate geocode points (which PNR places on the boundary of the customer's Census Block "CB") are likely more dispersed than are the actual customer locations
    - actual geocode points (those whose locations are determined precisely) already are offset by 50 feet from their road centerline towards the customer's house
  - Even within clusters/rectangles engineered by the HM DM, customers are clustered, a characteristic which reduces further actually required cable lengths

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Cable Length Issue

- Sprint appropriately focuses its theoretical concerns over cable lengths to HM main clusters
- In outlier clusters (the most rural clusters considered by the HM), cable already is engineered more directly to link customer locations
- The following analysis will demonstrate that the HM DM engineers adequate distribution plant

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Effect of Surrogate Dispersion

Concept:

- If PNR clusters are larger than real-world clusters due to their inclusion of surrogate geocodes, the amount of distribution plant engineered to serve the PNR cluster may well be adequate to serve all customers in the real-world cluster -- even though this plant may not reach all the way to the PNR cluster's vertices

Demonstration:

- The following empirical analysis determines the amount of excess cable that the HM engineers because it designs to PNR clusters that include surrogate geocode points

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Effect of Surrogate Dispersion

- Compare distribution route distances (DRDs) generated by PNR clusters formed from placing customers at:
  - actual geocode points plus CB-boundary surrogates
  - actual geocode points plus Road surrogates
  - only Road surrogate locations
  - only CB-boundary surrogate locations
- Differences in DRD generated by substituting surrogate points for actual points indicate the magnitude of DRD excess resulting from the HM's use of surrogate points
  (See Chart 2 and Slide 22)

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Effect of Surrogate Dispersion

- This analysis confirms that either surrogate methodology generates points that display less clustering than actual geocode points
- Thus, if all customer locations were based on actual geocodes, roughly 12% less DRD would be required in DZ1 in this real-world situation than is otherwise modeled by the HM DM

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Effect of Actual Geocode Offsets

Concept:

- A loop distribution network should have enough plant so that all customer locations within a cluster may be linked to that DA's Serving Area Interface
- This is accomplished in the HM through an integrated combination of:
  - Backbone cable
  - Branch cable (cable that runs along a street abutting customer's house)
  - Drop cable (cable that connects from the street to the house)

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Effect of Actual Geocode Offsets

- Thus, depending on the particular customer location point mapped to by an alternative cable distance measure, total cable lengths calculated by the HM must be pulled from as many of its cable "budgets" (BB, B and drop) as are appropriate for this cable to reach to the same customer location point
- Any other comparison, such as those performed by Sprint and Prisbrey is "apples to oranges"

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Effect of Actual Geocode Offsets

- If the alternative distance measure maps only to the street abutting the customer's house, the appropriate comparison is against the HM BB&B cable distance
- If the alternative distance measure maps beyond the street and into the customer's lot, then a portion of the HM drop cable sufficient to reach an equivalent distance into the customer's lot needs to be added to the HM BB&B cable distance before making the comparison

  (Alternatively, one could subtract the appropriate drop cable from the alternative distance measure before comparing it to HM BB&B cable distances)

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Effect of Actual Geocode Offsets

Demonstration:

- Because the actual geocode points used by PNR in creating clusters are offset by 50 feet from the road centerline, any alternative distance measure that maps to these geocode points includes an implied 50 feet of drop cable per customer location
- Thus, either 50 feet per actual customer location must be subtracted from the alternative distance measure before comparing it with the HM BB&B cable length, or 50 feet of drop cable length per customer location must be added to the HM BB&B cable length before comparing it with the alternative distance measure

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Effect of Actual Geocode Offsets

- Empirically, the effect of adding 50 feet of drop cable length to HM BB&B cable lengths raises the implied HM DRD by 38.8% overall

  (See Chart 3 for fuller results)

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Effect of Empty Space in Clusters

Concept:

- Because even within clusters, there is further clustering (thus empty space), the HM DM practice of spreading BB&B cables uniformly throughout the engineered rectangle may place unneeded branch cables

Demonstration:

- (See following cluster map as an example)
- Thus, methodologies that assume quasi-uniform distributions of customers within cluster cannot be used as a standard for determining whether all customers are reached

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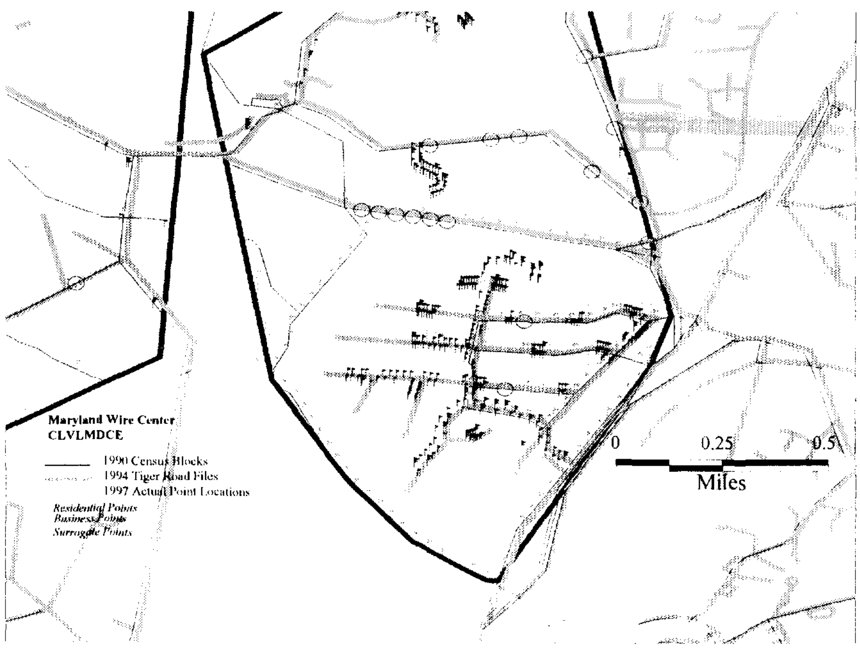

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Sprint's Analysis

- Investigations by Sprint have used a distance concept known as the "minimum spanning tree" (MST) between geocode points to as a distance standard to compare against HM distribution cable lengths
- Sprint claims to find that in many clusters (of its selection), the amount of HM-engineered BB&B cable falls short of the MST distance for that cluster, and concludes that the HM under-engineers distribution plant

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Faults in Sprint's Analysis

- Sprint makes no correction for the excess area that exists within HM clusters because they are formed in part from CB-boundary surrogate points
- Sprint's failure to make such an adjustment is especially curious because the BCPM sponsors have:
  - argued in the past that HM clusters are too large and cover too much of the U.S. geography
  - advocated the use of a "Road" surrogate methodology for the assumed placement of customer locations
  - had PNR placed all surrogate points on roads rather than on CB boundaries, calculated MST distances would have dropped by about 2.6% (see Chart 4)

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Faults in Sprint's Analysis

- Sprint makes no upwards adjustment to HM DRD (or downwards adjustment to its MST lengths) to correct for the fact that the MST includes substantial portions of drop cable (engineered separately by the HM DM) before comparing this distance with the HM BB&B distance

  See following viewgraphs and example numerical effects (Chart 5)

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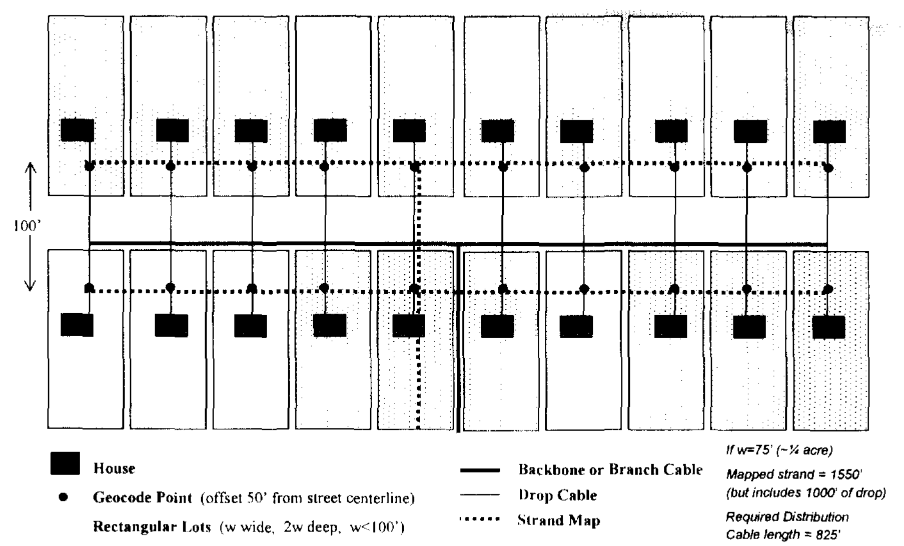
Distribution Cable Lengths vs. Strand Distances

Next-Door House Geocodes Closer than Across-Street House Geocodes



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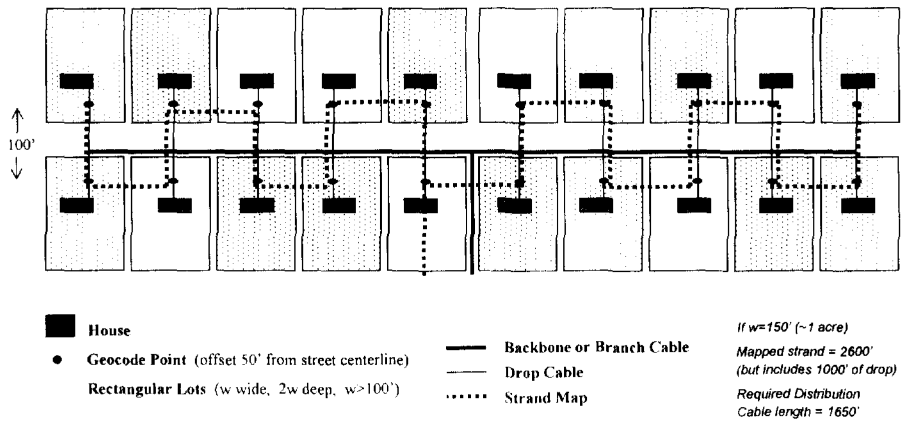
Distribution Cable Lengths vs. Strand Distances

Across-Street House Geocodes Closer than Next-Door House Geocodes



Faults in Sprint's Analysis

- It is especially curious that Sprint chooses to use a theoretical concept like MST as its standard for "correct" cable distances rather than statistically valid empirical data within its control (such as average loop lengths by wire center or plant records describing cable route distances) that could shed a clearer light on:
  - whether on average the HM under- or over-engineers distribution cable lengths, or
  - how frequently the MST is an accurate or useful distance concept, or what its biases might be

Faults in Sprint's Analysis

- In Nevada, the same state for which Sprint has proffered MST examples purporting to show that HM cable lengths are inadequate, Nevada Bell has reported that, on average
  - HM builds loops that exceed Nevada Bell's actual loop lengths, and
  - this over-building is greatest in rural areas
- In Texas, the PUC staff required SWBT to provide its average loop lengths for a specified collection of wire centers
  - HAI loop lengths exceeded SWBT lengths in 14 out of these 16 wire centers, and
  - in the other 2, HAI loop lengths were short by only 4.8%

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Prisbrey's Analysis

- Prisbrey states that his analysis

  "does not attempt to test the accuracy of the distribution or feeder algorithms used in the HAI model. Instead, it attempts to test the accuracy of the preprocessing algorithms used in converting geocoded and surrogate geocoded customer locations into rectangular serving areas"
- Its method of doing this is to use:
  - "a Monte Carlo simulation of a large number of randomly generated customer locations"
  - a particular assumption about how customer lots may be laid out in a uniform checkerboard fashion for distribution engineering by the HM
  - two distance/dispersion measures: the length of the MST and the length of a star network (SN)

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Prisbrey's Analysis

- Although Prisbrey states that his methodology and assumptions do not provide "a test of the adequacy of the distribution plant ... built by the HAI Model," others have interpreted Prisbrey's analysis to suggest that the HM tends to under-build distribution plant everywhere, and that the shortfall is most severe in rural areas
- These parties focus on a statement by Prisbrey that the HM algorithms build:
  - a star network that is 15.4% less in length than exists within his randomly generated clusters of size 25
  - a MST that is 41.5% less in length than exists within his randomly generated clusters of size 25

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Faults With These Conclusions

- Prisbrey's analysis cannot be used to test the adequacy of HM distribution cable lengths because it:
  - assumes a peculiar DA size and shape
  - uses random customer locations rather than PNR actual and surrogate geocoded customer locations
  - fails to recognize that multiple customers frequently have the same geocodes
  - doesn't recognize the use of drop cable to reach geocode points
- Indeed, Prisbrey does not claim that his analysis demonstrates inadequate HM distribution cable lengths
- In fact, if correctly executed, Prisbrey's analysis demonstrates that cable lengths engineered by the HM DM are adequate to reach its customers

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Setting the Analytic Stage

- Rather than limiting the reported comparison of Prisbrey's estimated differences between SN/MST dispersion and HM dispersion to clusters of exactly 25 locations/nodes, it is more useful to display these differences via a graph for all clusters ranging between 5 and 200+ nodes
- The following charts graph SN/HM and MST/HM dispersion ratios as calculated by Prisbrey's algorithms using his selected parameters of:
  - 5 - 200 nodes
  - 18 kft by 18 kft square region

  (See Chart 6)

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Setting the Analytic Stage

- Note that Prisbrey's analysis applies only to HM main clusters with 5 or more lines, and does not apply to the most rural clusters addressed by the HM, outlier clusters which have less than 5 lines
- Note, too, that the average size of main clusters within the HM is:
  - DZ1 (0-5 lines/sq mi): 34 locations/cluster
  - DZ2 (5-100 lines/sq mi): 175 locations/cluster
  - DZ3-DZ9 (100+ lines/sq mi): 560 to 791 locations/cluster

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Correcting for DA Size

- A substantial skewing of Prisbrey's analysis arises because its algorithm's default setting places its randomly-generated customer locations within square areas that always approach 18 kft by 18 kft in size
  - 18 kft x 18 kft (or 11.6 sq mi) is the absolute maximum size that the HM DM will engineer as a DA
  - actual HM main clusters (<200 locations) average 6.3 sq mi in size, and its engineered DAs are even smaller
  - by assuming a maximum size DA, customer lot size is biased upward -- and because the HAI DM places BB&B cables to within one lot depth and width of the the DA's boundaries, this excessive lot size will depress artificially the average DRD calculated by Prisbrey's algorithm

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Correcting for DA Shape

- In addition to the skewing created by modeling only maximally-sized square DAs, a further bias results from modeling only square DAs
  - in a BB&B configuration, it will take slightly more cable to serve a square DA than a rectangular DA of equal size
  - actual HM clusters have an average aspect ratio of 1.8
- When Prisbrey's Monte Carlo algorithm is re-run to generate customer locations in non-square configurations that are smaller than 11.6 sq miles in size, a far closer match between SN/MST dispersion and HM dispersion is obtained

  (See Charts 7 and 8)

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Correcting for Random Locations

- Another significant limitation of Prisbrey's analysis results from its use of randomly-generated (Monte Carlo) customer location points -- rather than actual customer geocode points
- By randomly locating its customers, Prisbrey's algorithm ignores the systematic clustering of customers that exists *within* PNR clusters. Such clustering within clusters:
  - tends to ensure that the actual SNs or MSTs associated with clusters will be significantly shorter than those calculated by Prisbrey's algorithms for random clusters (See Chart 2)
  - makes it likely that there is empty space within a cluster -- which may obviate the need for one or more branch cables

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Correcting for Random Locations

- In fact, Prisbrey's Monte Carlo assumptions tend to create on average a uniform spread of customers across DAs -- an inaccurate modeling assumption that previously has been rejected by the Commission (see, 7/18/97 FNPRM at ¶44)
  - Thus, because cost models' use of uniform customer distributions has been rejected as inaccurate, a set of random points that tend to approximate a uniform distribution should not be used as a reference standard to evaluate the accuracy or "bias" of the HM
- When actual geocoded customer locations from the HM are inserted into Prisbrey's algorithms, even closer matches between SN/MST dispersion and HM dispersion are obtained (See Charts 9 and 10)

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Correcting for Drop Cable

- Prisbrey's analysis also does not includes the upwards adjustment that must be made to HM cable lengths to account for the amounts of drop cable length that are incorporated into Prisbrey's calculations of SN and MST distances
- Performing this adjustment reduces significantly differences between HAI and SN/MST dispersion

  (See Charts 11 and 12)

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Correcting for Surrogate Locations

- In addition, a further adjustment must be inserted to calculated HM distribution cable lengths to account for the fact that HM clusters are oversized due to their inclusion of surrogate geocode points
- As shown earlier, this characteristic causes DZ1 HM DRDs to exceed by about 12% the amount that might be calculated if all customers' geocodes were known precisely

  (See Charts 13 and 14)

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Recognizing Subtending Outliers

- Because analyses that consider only main clusters are partial, distribution cable distances associated with outlier clusters should be added to the cable lengths of their "home" main cluster
- This further increases the amounts of cable associates with rural clusters and reduces and differences between HAI-modeled dispersion and SN/MST dispersion

(See Charts 16 and 17)

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Evaluating the Results

- Finally, it is useful to evaluate these HAI vs. SN/MST dispersion ratios at the average number of locations per HM main cluster in DZ1 and DZ2
- This evaluation indicates that correctly developed dispersion ratios suggest that the HM engineers adequate (or more) cable lengths
- In particular, these dispersion ratios are, roughly,
  - 1 for average size DZ1 main clusters, and
  - substantially above 1 for DZ2 and above main clusters

(See Charts 17 and 18)

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Further Work

- If any adjustments to the HM are indicated by these analyses, they should have the effect of "twisting" the cable length comparison curves to:
  - ensure that even below-average size DZ1 clusters (<34 locations) have correct cable amounts, and
  - reduce the amounts of excess distribution cable engineered in clusters above an average size DZ1 cluster (>34 locations)
- ILECs should be required to provide statistically valid measures of actual plant lengths placed across all zones
  - average loop length by wire center
  - loop cable route distances

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Further Work

- Based on the analyses performed here, HM processes will be adjusted as follows:
  - PNR will report the aspect ratio of minimum bounding rectangle to the HM DM
  - the HM DM will adjust downwards its count of drops to match more closely the number of separate customer locations
- Based on further data to be provided by the ILECs concerning proper targets for DRD, the HM DM also may be adjusted to provide for this "twisting"

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Further Work

- These HM DM adjustments may, variously, include:
  - BB&B cable length adjustments by DZ to:
    - orient BB cable always along the major axis of rectangle
    - push BB&B cable more toward the edges of the cluster
    - ensure a minimum BB cable length
  - Normalize distribution cable lengths to an appropriate statistical measure of inter-customer distance
- Overall evaluation of the accuracy of the model should be consistent with the granularity of the universal service support program

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Chart 1

Revised Aspect Ratio Relative to Baseline:

Percent Change in Monthly Basic Local Service Cost

State	Company	0 - 5	5 - 100	100 - 200	200 - 650	650 - 850	850 - 2,550	2,550 - 5,000	5,000 - 10,000	10,000+	Weighted Average
FL	Central Tel Co Of Florida	-0.89%	-0.09%	-0.20%	0.98%	1.46%	0.52%	-0.08%	-0.01%	-0.12%	0.13%
FL	Gte Floridainc	-1.08%	-0.01%	-0.17%	0.26%	1.00%	-0.07%	0.13%	0.11%	0.08%	0.09%
FL	Southern Bell-Fl	-1.10%	0.32%	0.20%	-0.13%	0.53%	0.07%	0.04%	0.00%	-0.02%	0.07%
FL	United Tel Co Of Florida	-2.01%	0.10%	-0.73%	-0.05%	0.07%	0.13%	0.05%	0.12%	-0.01%	-0.13%
KS	Southwestern Bell-Kansas	-1.73%	-0.01%	1.36%	0.38%	0.05%	0.13%	-0.04%	-0.02%	-0.11%	-0.18%
MN	Contel Of Minnesota Inc Dba Gte Minnesota	-1.28%	0.09%	0.43%	-1.69%	-0.86%	-0.26%	-1.44%	0.05%		-0.61%
MN	Frontier Comm Of Minnesota Inc	-0.66%	-0.37%	-0.28%	0.04%	4.03%	0.07%	0.04%	-0.01%	-0.03%	-0.04%
MN	Northwestern Bell-Minnesota	-0.77%	0.19%	-0.52%	0.11%	0.30%	0.11%	0.13%	0.13%	0.00%	0.01%
MN	United Telephone Co Of Minn	-0.51%	0.07%	0.05%	-0.35%	1.05%	-0.65%	0.01%	0.01%		-0.11%
NV	Central Telephone Company - Nevada	1.96%	1.70%	1.06%	-0.89%	0.02%	-0.99%	-1.26%	-1.35%	-1.53%	-0.84%
NV	Nevada Bell	1.40%	0.65%	0.05%	0.57%	-0.98%	0.74%	-0.04%	0.05%	0.00%	0.57%
IN	Contel Of Indiana Inc Dba Gte - Indiana	-0.53%	0.15%	0.89%	-2.85%	0.16%	-1.23%	-0.29%	0.07%		-0.22%
IN	Gte Of Indiana	-0.09%	-0.49%	0.12%	0.39%	0.08%	0.26%	0.11%	0.42%	-0.02%	-0.02%
IN	Indiana Bell Tel Co	-0.17%	-0.20%	-0.87%	0.14%	-1.17%	-0.21%	-0.10%	-0.14%	-0.19%	-0.21%
IN	United Tel Co Of Indiana Inc	0.79%	-0.14%	0.35%	-0.11%	0.66%	0.19%	-0.07%	0.05%		-0.04%
TN	South Central Bell-Tn	-0.77%	0.18%	-0.57%	-0.19%	-0.02%	-0.29%	-0.32%	-0.31%	-0.53%	-0.18%
TN	United Inter-Mountain Tel Co-Tn		0.47%	-0.42%	-0.45%	3.79%	0.07%	-0.31%	0.30%	0.00%	0.17%
	Weighted Average	-0.90%	0.07%	-0.16%	-0.03%	0.29%	-0.02%	-0.04%	-0.13%	-0.22%	-0.07%