Having estimated the total cross section capacity required (per user) for the Task Force objective (100 Mbps for every Alaskan) the second of three technical committee tasks was to develop cost metrics that can be applied to a network extension topography model.

Starting with the assumption that both digital microwave radio systems and fiber optic cable systems would be included, typical costs for construction in rural Alaskan areas were developed. Given the wide variety of terrains and construction environments that might be encountered, the estimates included herein err to the side of conservatism, and are reckoned to be +/- 50% in total.

Since both technologies are constructed with reasonable modularity, the cost models used were developed with capacity increments that represent this modularity. Both the M/W and fiber system costs were developed on a per mile basis, in increments that allow cost per mile to be a function of "downstream" users. That is, the total numbers of users whose internet traffic will be traverse the network segment under consideration. For purposes of this calculation, it is assumed that 100% of the traffic will flow in this fashion (that is, the "local" internet traffic will be negligible.)

Microwave Design Characteristics

For purposes of this exercise, we assumed that we would be extending a current network, this requiring a new tower only at the distant end of each "hop." We allowed for 25 mile hops, so a new tower would be required every 25 miles. The cost per mile was calculated for a 100 mile route, to ensure that this effect is included in the estimate.

Microwave radio systems are composed of single or multiple radio signals, or carriers, several of which can be transmitted through the same antenna. For purposes of our design, we used a common design of 6 such channels with a single hot standby channel, known as 6+1 system. So, we buy and install 7 radio channels to use 6. We have also assumed that a single radio route, or path, could accommodate up to three of these 6+1 systems, and while it is possible that some could share common towers, we have included the cost of new towers for each. This is reasonable inasmuch as there would be significant increased load requirements on the towers, which could be satisfied with a heavy duty tower, or by constructing a separate one. Again, we have chosen a conservative estimate.

Fiber Optic Cable Design Characteristics

While we know that direct burial of fiber cable, or burial of ducts into which the cable is pulled varied significantly based on terrain, enough data exist to use a single number for the average cost. Regulatory and right of way costs are included in this estimate, but offer a good opportunity for savings if ameliorated. This effect, however, is likely within the +/- 50% overall margin of error in these estimates.

We assumed that installations would include one wavelength (10 Gbps) with the capability of adding numerous more wavelengths on the cable either by "lighting" more fibers or utilizing wave-division multiplexing, wherein multiple wavelengths of light are injected into a single fiber pair. Once constructed, then the cost of increasing the capacity is fairly low, up to fairly high increments. At very high capacities, there are significant incremental costs are each terminal and regenerator site, but since our network extensions are for relatively low capacity (in terms of the ultimate capacity of a fiber system) we have not needed to include these costs. We have assumed spacing of regeneration sites of 60 miles.

Resulting Calculations and Their Interpretation

There were two metrics that we sought in this exercise – the cost per mile to construct, and the cost per mile to construct per downstream user. Knowing these two figures for both technologies will allow for straightforward construction cost estimating, as well as providing a basic technology/cost optimizing metric – which technology should be used for which network extension segment.

Within the bounds of our data, then, we following display these results:

Construction cost per mile:

No. of Downstream Users	M/W Cost/Mile	Fiber OpticCost/Mile
15	$26,000	
30	$28,400	
45	$29,600	
60	$30,800	
75	$32,000	
90	$33,200	
105	$59,200	$100,000
120	$61,600	$100,000
135	$62,800	$100,000
150	$64,000	$100,000
165	$65,200	$100,000
180	$66,400	$100,000
195	$92,400	$100,000
210	$94,800	$100,000
225	$96,000	$100,000
240	$97,200	$100,000
255	$98,400	$100,000
270	$99,600	$100,000
300		$100,000
500		$100,000
1000		$100,000
2000		$100,500
3000		$101,000
4000		$101,500
5000		$102,000
6000		$102,500

Note that in our model, the cost to construct for both technologies is about the same for 200-300 downstream users. Clearly this is the range over which the fiber optic option would begin to make much more sense, given the nearly unlimited upside capacity capability for this small number of users!

Translating this to a cost per user per mile provides a slightly different view and allows for a "bottom up" design and cost modeling. The results of this are shown below. Recall that the design requires 100 Mbps for each user (household) with a 10X over subscription rate (that is, the design calls for 10 Mbps for every household.)

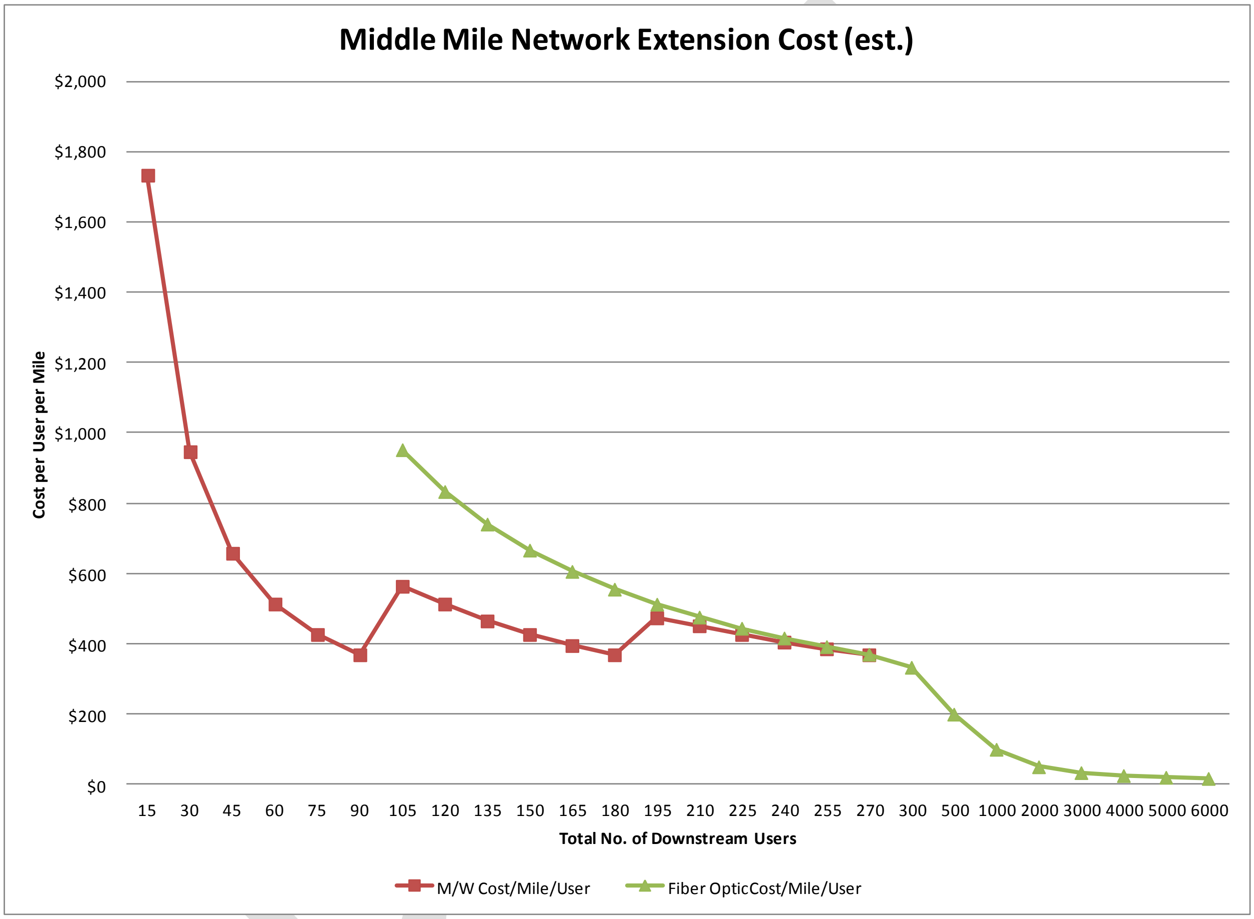

Figure 1 - Estimated Middle Mile Cost to Build

Note that the horizontal scale is not linear. This view reiterates the point made in the table, that from ~200 to ~300 users the costs are similar. What is significant here are the extremes. Costs for 50 or fewer users are >$500 per user per mile while the higher user counts, utilizing fiber optics, are <$20 per mile per user, asymptotically approaching $10!

Next Modeling Steps

To complete the network extension exercise, this data will be applied to a network connectivity map that reflects current infrastructure. Once extended to all the currently satellite-only sites the capacity needs back to the three major hubs will be verified, as current terrestrial networks may not be robust enough to support the design objective.