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CostQuest National 5G Model: Methodology

Understanding the costs to deploy and serve unserved areas across the U.S. with 5G mobile broadband

DEVELOPED FOR COMPETITIVE CARRIER ASSOCIATION

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INTRODUCTION

The ever-growing increase in demand for mobile bandwidth, including the development of machine-to-machine and other IOT solutions, will create even greater demand for wireless connectivity. How to meet this demand raises pressing questions regarding 5G deployment. How much more new infrastructure will be needed to provide 5G mobile wireless coverage to unserved areas in the U.S.? What areas should be covered to consider 5G successfully deployed nationwide? How much initial investment will be needed to deploy this network? With these questions in mind, CostQuest Associates (CQA) developed a national 5G network model to estimate the costs to complete the deployment of 5G nationwide. The following represents a high-level summary of CQA's study and findings.

APPROACH FOR ESTIMATION OF COSTS (METHODOLOGY)

CostQuest Associates has developed an efficient approach to estimate the number of cell sites across the United States [1] needed to deploy a 5G Network to all areas currently unserved by 5G mobile wireless. Using this model, CQA is able to determine the count of new cell sites required to serve all currently unserved areas. However, before the count of cell sites could be determined, three fundamental methodological definitions needed to be addressed:

1. The geographic scope of what was uncovered had to be determined. For the purpose of this study, CQA looked at three coverage alternatives: FCC's 477 current 4G coverage, FCC's 477 current 5G coverage, and FCC's LTE coverage from the four largest carriers, released August 2021.
2. The geographic unit of coverage had to be defined. For the purposes of this study, CQA looked at two geographic coverage units: roads and area. For road coverage, this captures both populated and unpopulated areas. For area coverage, CQA captured most areas of the country. However, some extremely remote areas (e.g., areas in the west and in Alaska) were left out.
3. The speeds at which CQA considered an area served is 30/5Mbps.

With these definitions, CQA was able run various scenarios of its model to develop the required count of new cell sites. With the required count of cell sites identified, the next step in the process was to develop the investment for each cell's deployment. A 10-year study period was used that captures the initial capital to deploy a new site or upgrade existing sites along with considering future maintenance capital spend. The model also considers several network requirements in addition to the radio access network (RAN) at the site, including backhaul, edge and core equipment. The results represent an estimate of the total capital nationwide to deploy a 5G network to unserved areas. Below, CQA further explains how the model develops an estimation of costs for these network components.

SCENARIOS

CQA processed the 5G ubiquity cost model for an array of scenarios[2]. The scenarios considered include variations in parameters such as low- and no-demand service areas (serving geography), leased and newly

[1] Includes: Alaska and Hawaii

[2] It should be noted that without a standardized and fully accurate view of current 5G service availability, assumptions were necessary in order to provide a proxy for a basis of coverage. As such, the results represent a best estimate until reliable current coverage data is made available.

built backhaul, inclusion and exclusion on replacement CapEx, and more. In consultation with America's leading association for competitive wireless providers and stakeholders[3], Competitive Carriers Association (CCA), CQA settled on a rational set of assumptions for a number of scenarios in order to give policymakers a view of the range of potential public funding needed.

The scenarios that yielded the highest overall price tags (High Range Scenarios) for ubiquity assumed 5G coverage from the FCC Form 477 maps showing service as of June 2019. At the lower end of the investment range (Low Range Scenarios), the modeling starts with the FCC Form 477 4G LTE coverage and excludes Replacement CapEx and CORE CapEx. The various scenarios results range between a high of $55B and a low of $20B.

THE RAN NETWORK

In the first stage of the modeling effort, the model analysis developed the total counts of tower and cell sites that need to be deployed for those areas that are currently unserved or partially served by 5G wireless service.

As a first step in the process, CQA has gridded up the entire country (including AK and HI) using 5 different Grid sizes with the following estimated serving radii:

- Grid Level1: 8-mile grids
- Grid Level1.5: 4-mile grids
- Grid Level2: 2-mile grids
- Grid Level3: 800m grids
- Grid Level4: 200m MicroGrids

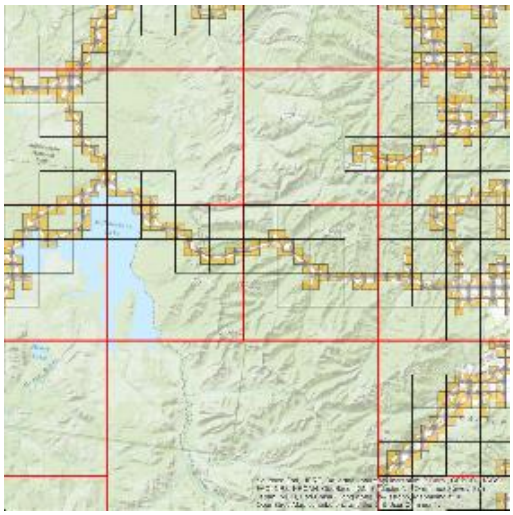

Figure 1: Example of Grid Levels

For each grid, CQA identified the variance in terrain in the area and the type and length of roads within the grid. Those grids without any roads were discarded. Figure 1 shows the populated grids in a sample area from the western U.S.

The next step in the process was to estimate the mobile traffic from every road in the U.S. As a starting point, population and employee counts were extracted from CostQuest's Broadband Serviceable Location Fabric (BSLF) dataset for every census block. Using an assumed monthly total demand, subsequently converted to estimate busy hour traffic, from each person and employee, the busy hour traffic in census block was calculated. This busy hour traffic was then distributed to each road meter within the Census Block Group (CBG), distributing more traffic to major roads than minor roads. Overlaying the grids over this road/demand data, the busy hour traffic in each grid was identified.

[3] Competitive carriers Association. Competitive Carriers Association. (n.d.). https://www.ccamobile.org/#HomePageminiabout.

In the third step, CQA identified census blocks of the country considered not served by 5G. Unserved areas were defined by using the latest coverage data noted above: 477 4G, 477 5G, and LTE coverage from the four largest carriers released by the FCC in August 2021.

As a final step in the determination of tower counts to cover the unserved roads in the U.S., the grids covering the unserved census blocks were pulled. Using the busy hour demand, CQA selected the appropriate grid size based on demand, terrain, and density triggers. Once the grid size was selected, the frequency to be used was assigned. For this study, CQA assumed that low band and mid band spectrum would be used to provide coverage in these unserved areas. CQA only considered Grid Levels 1, 1.5, and 2, which closely align with the serving radii of these spectrum bands.

Once tower counts and sizing were determined and the amount of busy hour traffic was determined, each site was sized for the number of sectors required. Using the counts of towers and sectors, the capital associated with tower deployment (antennas, cabling, power, RF equipment, the tower structure, and the site) was determined. Labor associated with tower deployment was also accounted for. Based on known tower location data, any new 5G sites that could be served using existing towers were identified. These sites were assumed to be colocation sites and as such tower capex was not included. New tower sites assumed full cost of deployment (i.e., new tower structure, siting, etc.). All inputs for equipment and labor are based on the FCC's Widelity costs[4].

Backhaul

The model assumed a variety of backhaul approaches, from new fiber, to microwave, to leasing of assumed existing fiber. As a default, the model assumes fiber deployment for backhaul unless the cost to deploy this fiber to any site exceeds $57,000. If this is the case, deployment of fiber is found to be infeasible and the model switches to using microwave backhaul for these high-cost sites. Backhaul costs are user adjustable and applied to each site location.

Demand/Road Inclusion

Roads are the primary demand point for this study. The table below shows the road types included from the TIGER Road Classification. Roads may be included or excluded based on scenarios chosen.

Table 1: TIGER Road Classification

TIGER RoadType	Description
S1100	Primary Road
s1200	Secondary Road
s1400	Local Neighborhood Road, Rural Road, City Street
s1500	Vehicular Trail (4WD)
s1630	Ramp
s1640	Service Drive usually along a limited access highway
s1730	Alley
s1740	Private Road for service vehicles (logging, oil fields, ranches, etc.)
s1780	Parking Lot Road

[4] (Commission, 2021) "https://docs.fcc.gov/public/attachments/DA-21-355A1.pdf" (2021).(Rep).

RESULTS[5]

The study is intended to provide a range of reasonable estimates of total investment required to deploy nationwide 5G network coverage to support policy analysis, potential legislation, and auction funding programs. Default toggles and descriptions of sensitivity scenarios are described in Appendix A. The results of the study are provided in Appendix B. The assumptions, inputs, and methods included in the methodology present reliable high-level estimates of populations, roads, and total investment necessary to build-out meaningful 5G mobile broadband service.

[5] This study is not an attempt at creating the actual final cost, the precise tower/site count, or the bill of materials to deploy mobile broadband services in any one particular area.

APPENDIX A: TOGGLES

Table 2: Default Toggle Values[6]

Toggle	Value	Unit	Source
AirToRoute	1.2	Multiplier	Standard value
DropCostPerMeter	$ 7.55	dollars	Internal CostQuest based on industry data for buried drop (average of $2.30 per foot)
RoadFiberCostPerMeter	$ 22.97	dollars	Internal CostQuest based on industry data for fiber installed cost on road (average of $7 per foot)
IncludeAreaCells	1		1=Yes, 0=No
BackHaulMonthlyCost	$ 1,550.00	dollars	Per CCA Member
DiscountRate	10%	%	
YearsOfStudy	10	years	
IncludeReplacementCapex	0		1=Yes, 0=No
IncludeEdgeAndCore	0%	%	Adder to RAN Equipment
ToleranceForAreaInclusionSqMi	160	SqMi	160 acres - can be adjusted
IncludeQuietZone	No		Needs to excluded in the Grid model.
ConsiderMicrowave	No		
BackhauMicroWaveCutover	$ 57,000.00	dollars	Per Widelity
RoadConstructionCostPerFt	$ 50.00	dollars	Per Widelity
UseBackHaulFromCAM	1		1=Yes, 0=No
UseBackHaulLEASE	0		1=Yes, 0=No
UseBackHaulMWandFiber	0		1=Yes, 0=No
UseBackHaulDROPOnly	0		1=Yes, 0=No
HelicopterCostCutoverVSRoadConstructio	$ 300,000		Cost to use Helicopters instead of building a road
MaxRoadConstructionMeters	20000	Meters	
IncludePctRankOrder	100%	%	Which towers to include...Area towers are ranked lowest cost per MB to highest (if not 1, turns off area cells)

Table 3: Toggle Analysis Descriptions

Run	Description
Current 5G Coverage	*Uses FCC 477 coverage*
Current 4G Coverage	*Uses FCC 477 coverage*
4G Coverage with Replacement Capex and 10% Core	*Uses FCC 477 coverage with Replacement and CORE capex included.*
NewLTE	*Uses FCC LTE Maps 20210515*
NewLTE_With replacement capex	*Captures need to replace capital over time (uses 10 year life for RAN equipment, 25 for fiber and 30 for towers)*
NewLTE_With 10% core network loading	*Assumes new RAN will trigger capactiy requirements at existing Edge and Core sites*
NewLTE_Backhaul Lease	*This provides cost of simply the 10 year NPV of backhaul lease (No other BH)*
NewLTE_Backhaul New Fiber/MW	*This provides the cost of new Fiber / MW backhaul from EXISTING landline network (uses 477 to find nearest CB with either fiber or cable coverage)*
NewLTE_Backhaul Drop	*This captures the cost of new fiber drop if the FIBER landline network exists*
NewLTE_Exclude Area cells	*These are the cells deployed to cover unserved gaps of land (assuming current coverage and new road based cells)*
NewLTE_Exclude top 2% (Input = 98%)	*Excludes highest cost per MB sites*
NewLTE_Exclude top 10% (Input = 90%)	*Excludes highest cost per MB sites*
NewLTE_Exclude top 25% (Input =75%)	*Excludes highest cost per MB sites*
NewLTE % for Amount to Equal $25B (Input=81.55%)	*Excludes highest cost per MB sites*
NewLTE_with Replacement Capex and 10% Core	*Uses new FCC LTE coverage with Replacement and CORE capex included.*

[6] Cost inputs are derived from CostQuest's experience and, when applicable, the Widelity Supply Chain Reimbursement Program Study (https://docs.fcc.gov/public/attachments/DA-21-355A1.pdf). Widelity input values are set to 75% of the high range value for most components. AK/HI freight premiums were kept at 100%. Some adjustments were made, most notably crane costs at 40%.

Table 4: Sensitivity Scenarios

Modified Toggle Values

Toggle/Run Description	Geographic Coverage	Include Area Cells	Include Replacement Capex	Include Edge And Core	Use Backhaul From CAM	Use Backhaul Lease	Use Backhaul Microwave and Fiber	Use Backhaul Drop Only	Include Pct Rank Order
Unit		Toggle	Toggle	%	Toggle	Toggle	Toggle	Toggle	%
Current 5G Coverage	5G All Carriers	1	0	0%	1	0	0	0	100%
Current 4G Coverage	4G All Carriers	1	0	0%	1	0	0	0	100%
4G Coverage with Replacement Capex and 10% Core	4G All Carriers	1	1	10%	1	0	0	0	100%
NewLTE (Based on FCC LTE Coverage May 2021)	FCC May 2021 LTE	1	0	0%	1	0	0	0	100%
NewLTE with replacement capex	FCC May 2021 LTE	1	1	0%	1	0	0	0	100%
NewLTE with 10% Core Network Loading	FCC May 2021 LTE	1	0	10%	1	0	0	0	100%
NewLTE backhaul LEASE	FCC May 2021 LTE	1	0	0%	0	1	0	0	100%
NewLTE Backhaul New Fiber/MW	FCC May 2021 LTE	1	0	0%	0	0	1	0	100%
NewLTE Backhaul Drop	FCC May 2021 LTE	1	0	0%	0	0	0	1	100%
NewLTE Exclude Area cells	FCC May 2021 LTE	0	0	0%	1	0	0	0	100%
NewLTE Exclude top 2% (Input = 98%)	FCC May 2021 LTE	1	0	0%	1	0	0	0	98%
NewLTE Exclude top 10% (Input = 90%)	FCC May 2021 LTE	1	0	0%	1	0	0	0	90%
NewLTE Exclude top 25% (Input =75%)	FCC May 2021 LTE	1	0	0%	1	0	0	0	75%
NewLTE % for Amount to Equal $25B (Input=81.55%)	FCC May 2021 LTE	1	0	0%	1	0	0	0	82%
NewLTE with Replacement Capex and 10% Core	FCC May 2021 LTE	1	1	10%	1	0	0	0	100%

APPENDIX B: RESULTS

Table 5: Study Results

Run	CellCount	BusyHour MB	RoadMileage	New Towers	Total	Per Tower Site
Current 5G Coverage	59,331	8,085,065	5,447,849,201	55,777	$ 53,139,323,604	$ 895,642
Current 4G Coverage	17,983	40,394	304,620,387	17,111	$ 20,092,482,840	$ 1,117,304
4G Coverage with Replacement Capex and 10% Core	17,983	40,394	304,620,387	17,111	$ 24,562,719,200	$ 1,365,886
NewLTE (Based on FCC LTE Coverage May 2021)	36,983	310,244	990,545,725	35,617	$ 35,837,016,340	$ 969,013
NewLTE with replacement capex	36,983	310,244	990,545,725	35,617	$ 42,510,223,756	$ 1,149,453
NewLTE with 10% Core Network Loading	36,983	310,244	990,545,725	35,617	$ 37,236,840,066	$ 1,006,864
NewLTE backhaul LEASE	36,983	310,244	990,545,725	35,617	$ 31,906,793,828	$ 862,742
NewLTE Backhaul New Fiber/MW	36,983	310,244	990,545,725	35,617	$ 44,922,636,534	$ 1,214,683
NewLTE Backhaul Drop	36,983	310,244	990,545,725	35,617	$ 30,283,825,458	$ 818,858
NewLTE Exclude Area cells	36,174	310,244	990,545,725	34,808	$ 31,652,874,475	$ 875,017
NewLTE Exclude top 2% (Input = 98%)	35,449	310,244	975,914,893	34,838	$ 30,780,964,571	$ 868,317
NewLTE Exclude top 10% (Input = 90%)	32,648	310,173	959,708,269	32,058	$ 27,982,843,603	$ 857,107
NewLTE Exclude top 25% (Input =75%)	27,207	309,360	917,251,990	26,649	$ 22,753,753,720	$ 836,320
NewLTE % for Amount to Equal $25B (Input=81.55%)	29,583	309,843	939,491,662	29,007	$ 24,988,779,489	$ 844,701
NewLTE with Replacement Capex and 10% Core	36,983	310,244	990,545,725	35,617	$ 44,340,113,023	$ 1,198,932