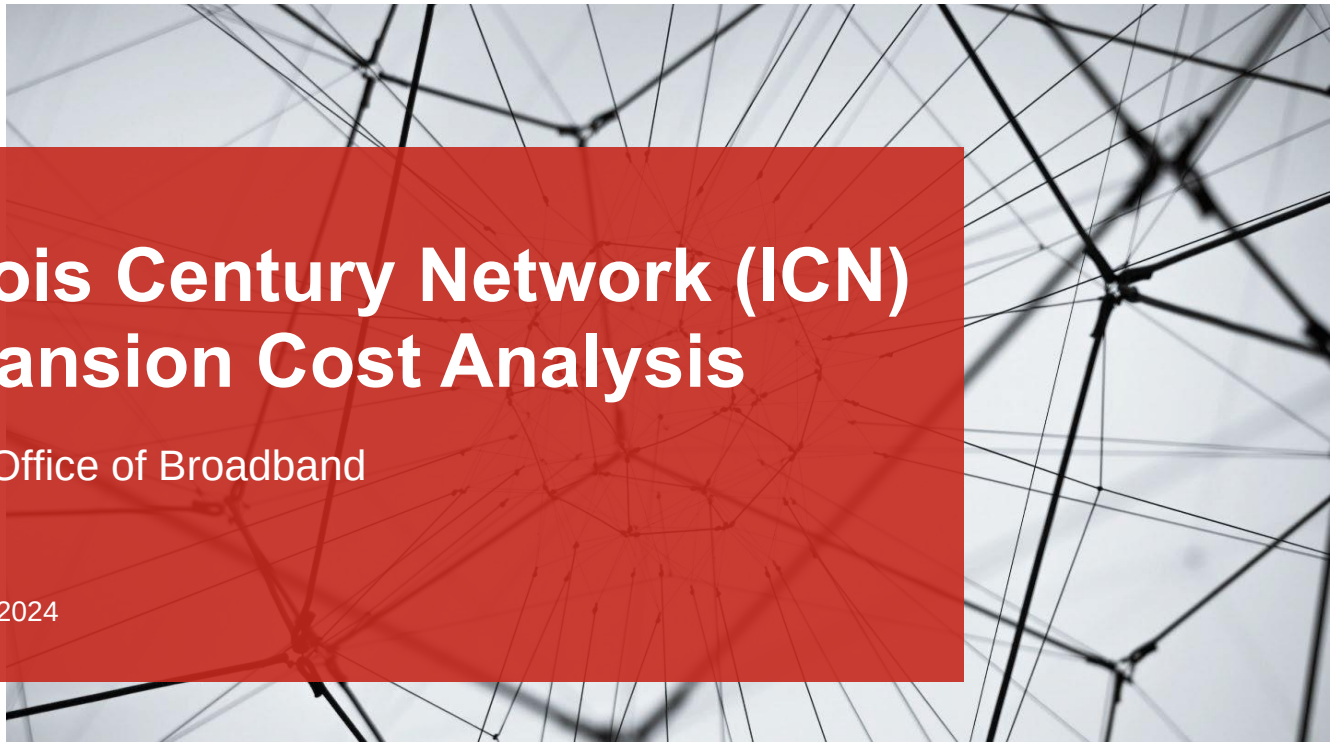

# Illinois Century Network (ICN) Expansion Cost Analysis

Illinois Office of Broadband

January 1, 2024

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# 1. Executive Summary

## 1.1 Context

Per Senate Bill 851 and interest within the Illinois General Assembly, the Illinois Office of Broadband is investigating costs associated with potential expansion of the Illinois Century Network (ICN) to connect all Illinois public schools, public libraries, and state-owned correctional institutions or facilities. To assess the cost of the potential expansion, the Illinois Broadband Lab collaboration between the Illinois Office of Broadband (IOB, Office) and the University of Illinois System assembled a research team to conduct geospatial analysis to identify three feasible route options and to estimate cost ranges by comparing two scenarios: (1) ICN expansion to support last-mile connectivity to these facilities by internet service providers (ISPs) or (2) ICN expansion directly to such facilities. The research team further assessed the cost range of increasing headcount to support the expanded network, based on interviews with experts from similar municipal middle-mile networks.

The list of priority[1] Community Anchor Institutions (CAIs) within the scope of this analysis includes:

1. 852 school districts
2. 813 libraries from 641 library districts
3. 50 correctional institutions or facilities

The Office of Broadband has complied a full list of priority CAIs, available upon request.

## 1.2 Approach of the analysis

The research team has conducted an analysis representing a point-in-time[2], outside-in view that is based on specific cost assumptions and high-level, middle-mile modeling principles. The analysis considers ICN's existing network, locations of high-priority CAIs, and road networks in Illinois as of Q1 2023. The analysis does not account for any topography or right-of-way constraints. **The document is not intended to be a precise estimate of the cost of ICN expansion nor to prescribe the exact route of expansion.**

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[1] Prioritization of CAIs decided by Illinois General Assembly (SB0851) and data collected by the state based on analysis (Oct 2023)

[2] Analysis conducted Q4 2023.

The research team has formulated point-in-time estimates in this analysis using the following data sources:

- Publicly available information on the locations of Illinois public schools, public libraries, and state-owned correctional institutions or facilities as of Q4 2023
- Information from ICN on the ICN footprint, including routes that ICN owns or leases as of Q1 2023
- Information from ICN on the expansion's cost per mile as of Q4 2023
- Interviews with experts (N = 7) conducted in Q4 2023 from municipal and commercial networks, both inside and outside of Illinois.

## 1.3 Key assumptions

The research team estimated the cost of expansion under two scenarios. Key assumptions for Scenario 1 (ICN expansion to support last-mile connectivity through ISPs) include:

1. 60% of prioritized schools are already connected to ICN network and are projected to require no additional funding for capital expenditure. All prioritized libraries and correctional facilities are assumed to require connection.

2. The current ICN middle-mile network has adequate capacity to support additional last-mile connections.

3. The cost of connecting prioritized CAIs includes last-mile circuit cost ($6,200/year per location for 1Gbps symmetrical and $15,500/year per location for 10Gbps symmetrical), ICN bandwidth cost ($4,800/year for 1Gps symmetrical circuit and $12,000/year for 10Gbps symmetrical circuit), and customer premise equipment cost ($2,000 for 1Gbps symmetrical equipment and $15,000 for 10Gbps symmetrical equipment).

4. The State of Illinois (State) may consider leveraging the E-Rate subsidy for all schools and majority of the libraries if applicable.

Key assumptions for Scenario 2 (ICN expansion to directly connect CAIs) include:

1. The overall fiber network uses the road structure of Illinois to identify fiber pathways.

2. Initial investment cost includes middle mile expansion ($150,000 per mile), last mile expansion ($150,000 per mile), point-of-presence locations ($500,000 per location), splice points ($500 per location), and customer premise equipment cost ($2,000 for 1Gbps symmetrical equipment and $15,000 for 10Gbps symmetrical equipment).

3. When optimizing between middle and last mile, the length of last mile is assumed to be at most 5 miles to 10 miles to reduce optical signal loss.

For both scenarios, the research team conducted analysis for 1G, 10G, and a mix of 1G and 10G bandwidth service offerings. The mix of 1G and 10G offering assumes 80% of schools and correctional facilities and 13% of libraries will receive 10Gbps symmetrical service.

See section 2 for the full list of assumptions and sources.

## 1.4 Summary of findings

Under Scenario 1, expanding the ICN to support last-mile connectivity through ISPs, the analysis estimates $7.9 million in upfront capital expenditure and $22.3 million in annual ongoing expenditure to connect all prioritized CAIs, assuming 80% of schools and correctional facilities and 13% of libraries receive 10Gbps symmetrical.

Under Scenario 2, expanding the ICN directly, geospatial analysis estimates between $1.4 billion to $1.5 billion in upfront capital expenditure to cover middle-mile expansion, last-mile expansion, POPs, split points, and CPEs, and $14.2 million in annual expenditure, assuming 80% of schools and correctional facilities and 13% of libraries receive 10Gbps symmetrical. While annual expenditure is slightly lower in Scenario 2 because fees to last-mile providers are eliminated, the projected initial investment is larger than that of Scenario 1.

The research team also projected full-time equivalents (FTEs) potentially needed for ICN based on interviews with peer networks. Under Scenario 1, ICN could manage an approximately 2,000 miles of additional middle mile network, potentially requiring additional FTE. Under Scenario 2, ICN could manage approximately 8,000 miles of additional middle mile network, likely requiring 25 or more new FTE.

# 2. Cost analysis to connect prioritized CAIs

## 2.1 Scenario 1: ICN expansion to support last-mile connectivity by internet service providers (ISPs)

Scenario 1 assumes that ICN will use commercial providers engaged through a competitive bidding process to reach all prioritized CAIs.

The main assumptions of the scenario are:

1. **60% of prioritized schools are already connected to ICN network,** and hence no further capital expenditure is assumed to be needed for these 60% of schools.[3] All prioritized libraries and correctional facilities are projected to need connections.
2. **The current ICN middle-mile network has adequate capacity to support additional last-mile connections**. At present, ICN has approximately 2,600 directly connected customers. The 1,204 additions (all libraries, all correctional facilities, and 40% of schools) represent an approximately 45% increase in connected anchor institutions. Based on interviews with ICN, the current middle-mile network has sufficient capacity to support the additional CAIs; therefore, middle-mile capacity is not projected to require augmentation.[4]
3. **No middle-mile expansion is needed to connect all prioritized CAIs** by combining the ICN and commercial networks. ICN's current customer footprint is statewide. As ICN can already source last-mile providers to connect statewide customers to ICN, no expansion is necessary to connect the additional CAIs.[5]
4. **The cost of connecting prioritized CAIs** includes last-mile circuit cost, customer premise equipment cost, and ICN bandwidth cost:[6]

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[3] Based on interview with ICN.

[4] Based on customer list shared by ICN, as of July 2023.

[5] Based on customer list shared by ICN, as of July 2023. A visual representation of ICN customer locations is not included in this memo to protect the confidentiality of ICN's customers.

[6] ICN bandwidth cost and CPE cost based on expansion cost-modeling shared by ICN. Last-mile circuit cost based on average price by vendor shared by ICN on 12/19/2023.

a. **Last-mile circuit cost**, which includes all costs paid to the third-party provider (bandwidth, maintenance, fees), is estimated at $6,200/year for 1Gbps symmetrical and $15,500/year for 10Gbps symmetrical.

b. **ICN bandwidth cost**, which includes all relevant costs to maintain the middle-mile network, is estimated at $4,800/year for 1Gps symmetrical circuit and $12,000/year for 10Gbps symmetrical circuit.

c. **Customer premise equipment cost** is estimated at $2,000 for equipment to support 1Gbps symmetrical service and $15,000 to support 10Gbps symmetrical service.

5. **An E-rate subsidy (65% discount)** for all schools and 70% of the libraries. The state is assuming a 70% E-Rate participation rate for libraries in anticipation of selective libraries not willing to comply with E-Rate's content filtering requirements.[7] E-Rate subsidy is not assumed to apply to correctional facilities.

6. **Analysis for 1G, 10G, and a mix of 1G and 10G bandwidth service offerings**. The mix of 1G and 10G offering assumes 80% of schools and correctional facilities and 13% of libraries are projected to receive 10Gbps symmetrical service. The share of libraries receiving 10Gbps symmetrical service is projected based on the size of the population the library district serves.[8] The share of schools and correctional facilities receiving 10Gbps symmetrical is assumed based on the state's goal to provide future-proof connections to these entities.

The research team took a three-step approach to estimating the cost:

**Step 1. Calculate total last-mile circuit cost (recurring)**

The following formula is used to estimate the total last-mile circuit cost:

$$Total\ last\ mile\ circuit\ cost\ (\$) = (A)\ Number\ of\ eligible\ CAIs\ \times (B)\ Average\ price\ for\ PTP\ last\ mile\ circuit$$

For (A), the number of eligible CAIs is 1,715, which contains 852 schools, 813 libraries, and 50 correctional facilities. For (B), the last-mile circuit cost is assumed to be $6,200/year for 1Gbps symmetrical and $15,500/year for 10Gbps symmetrical per location.[9] The last-mile circuit cost per year for all 1,715 institutions is estimated at $10.7 million assuming 1Gbps and $26.6 million assuming 10Gbps symmetrical,

[7] Insights based on ICN interview.

[8] Libraries in districts with over 100,000 in population will receive 10Gbps symmetrical.

[9] Cost estimation based on expansion cost-modeling shared by ICN.

before applying the E-Rate subsidy. The last-mile circuit cost is estimated $4.9 million for 1Gbps symmetrical and $12.3 million for 10Gbps symmetrical after applying the E-rate subsidy.

Assuming 80% of schools and correctional facilities and 13% of libraries receive 10Gbps symmetrical and the rest 1Gbps symmetrical, the last-mile circuit cost is estimated at $8.1 million after applying the E-Rate subsidy.

**Step 2. Calculate middle-mile bandwidth cost per building (recurring)**

The following formula has been used to estimate the total last-mile circuit cost:

$$Total\ ICN\ bandwidth\ cost\ \ (\$)\ = (A)\ Number\ of\ eligible\ CAIs \times (B)\ ICN\ bandwidth\ cost\ per\ building$$

For (A), the number of eligible CAIs is 1,751.

For (B) The bandwidth cost is assumed to be $4,800/year per location equipped with 1Gbps symmetrical bandwidth and $12,000/year per location equipped with 10Gbps symmetrical bandwidth.[10] The total bandwidth cost per year is estimated at $8.2 million assuming 1Gbps symmetrical and $20.6 million assuming 10Gbps symmetrical.

Assuming 80% of schools and correctional facilities and 13% of libraries receive 10Gbps symmetrical and the rest 1Gbps symmetrical, the middle-mile bandwidth cost is estimated at $14.2 million.

**Step 3: Calculate customer premise equipment price (one-time capital expenditure)**

The following formula has been used to estimate the total customer premise equipment (CPE) price:

$$\begin{aligned} Total\ customer\ premise\ equipment\ cost\ \ (\$) \\ = (A)\ Number\ of\ unserved\ and\ underserved\ CAIs \\ \times (B)\ Customer\ premise\ equipment\ per\ building \end{aligned}$$

For (A), the number of eligible CAIs without CPE is 1,204, which includes 341 schools (40% of the schools not yet connected with ICN), 813 libraries and 50 correctional facilities.

For (B), the CPE cost is assumed to be $2,000 per building equipped with 1Gbps symmetrical bandwidth and $15,000 per building equipped with 10Gbps symmetrical bandwidth.[11] The total consumer premise

[10] Cost estimation based on expansion cost-modeling shared by ICN.

[11] Cost estimation based on expansion cost-modeling shared by ICN.

equipment cost for all 1,204 institutions is estimated at $2.4 million assuming 1Gbps symmetrical and $18.1 million assuming 10Gbps symmetrical.

Assuming 80% of schools and correctional facilities and 13% of libraries receive 10Gbps symmetrical and the rest 1Gbps symmetrical, the CPE cost is estimated at $7.9 million.

**Overall cost estimation**

The estimated costs to connect all prioritized CAIs under scenario 1 are thus the three costs (last-mile circuit, bandwidth, customer premise equipment) added together. Accounting for E-rate, the estimated cost to connect all prioritized CAIs with 1Gbps symmetrical is approximately $2.4 million in upfront capital expenditure and $13.2 million in ongoing annual expenditure. The estimated cost to connect all prioritized CAIs with 10Gpbs symmetrical is approximately $18.1 million in upfront capital expenditure and $32.8 million in ongoing annual expenditure. Assuming 80% of schools and correctional facilities and 13% of libraries receive 10Gbps symmetrical and the rest 1Gbps symmetrical, the cost estimation will be $7.9 million in upfront capital expenditure and $22.3 million in ongoing annual expenditure. See Table 1 through 3 for summary calculations.

Table 1: Scenario 1 cost estimates for 1Gbps symmetrical service, data as of Q4 2023

| **CAIs** | | **Annual recurring costs estimated** | | | | **Capital expenditure estimated** |
|---|---|---|---|---|---|---|
| Type | Number of CAIs | Last-mile circuit cost | Last-mile circuit cost post E-Rate | Middle-mile bandwidth cost | Annual total cost post E-Rate | Customer premise equipment cost |
| Schools | 852 | $5.3M | $1.9M | $4.1M | $5.9M | $680K |
| Libraries | 813 | $5.1M | $2.8M | $3.9M | $6.7M | $1.6M |
| Correctional facilities | 50 | $310K | $310K | $240K | $550K | $100K |
| **Total** | **1,715** | **$10.7M** | **$4.9M** | **$8.2M** | **$13.2M** | **$2.4M** |

Table 2: Scenario 1 cost estimates for 10Gbps symmetrical service, data as of Q4 2023

| CAIs | | Annual recurring cost estimated | | | | Capital expenditure estimated |
|---|---|---|---|---|---|---|
| Type | Number of CAIs | Last-mile circuit cost | Last-mile circuit cost post E-Rate | Middle-mile bandwidth cost | Annual total cost post E-Rate | Customer premise equipment cost |
| Schools | 852 | $13.2M | $4.6M | $10.2M | $14.8M | $5.1M |
| Libraries | 813 | $12.6M | $6.9M | $9.8M | $16.6M | $12.2M |
| Correctional facilities | 50 | $780K | $780K | $600K | $1.4M | $750K |
| **Total** | **1,715** | **$26.6M** | **$12.3M** | **$20.6M** | **$32.8M** | **$18.1M** |

Table 3: Scenario 1 cost estimates for 10Gbps symmetrical to 80% of schools and correctional facilities and 13% of libraries, data as of Q4 2023

| CAIs | | Annual recurring cost estimated | | | | Capital expenditure estimated |
|---|---|---|---|---|---|---|
| Type | Number of CAIs | Last-mile circuit cost | Last-mile circuit cost post E-Rate | Middle-mile bandwidth cost | Annual total cost post E-Rate | Customer premise equipment cost |
| Schools | 852 | $11.6M | $4.1M | $9.0M | $13.1M | $4.2M |
| Libraries | 813 | $6.1M | $3.3M | $4.7M | $8.0M | $3.0M |
| Correctional facilities | 50 | $680K | $680K | $528K | $1.2M | $620K |
| **Total** | **1,715** | **$23.4M** | **$10.8M** | **$18.1M** | **$22.3M** | **$7.9M** |

## 2.2 Scenario 2: Direct-to-customer model

Scenario 2 assumes that the ICN will own and operate the end-to-end network. This model projects ICN to expand the existing ICN middle-mile network of approximately 2,000 miles and build a last-mile network to reach the prioritized CAIs.[12]

**Cost assumptions**

The cost assumption in this model is based on interviews the research team has conducted with experts with prior experience and leadership in designing and planning middle-mile networks[13]. These experts have previous experience in developing middle-mile networks in both the public and private sectors that ranged in size from 120 miles to 15,000 miles.

Experts estimated that the cost of expanding the middle-mile network could range between $80,000 and $120,000 per mile[14]. Last-mile costs could be less expensive than middle-mile costs if the ICN can easily access pre-existing aerial infrastructure (that is, utility poles); however, these cost savings were seen as unlikely in Illinois based on experts' prior experience in advising on middle-mile expansion in Illinois.[15] Consequently, the conservative estimates in this document assume the same costs for last-mile and middle-mile builds. Additionally, previous analysis that the Office has conducted on the cost of constructing broadband infrastructure shows that the cost per mile in Illinois could be up to 50 percent higher than the national average due to prevailing wage and apprenticeship requirements in Illinois.[16] Thus, the research team applied a 1.5x multiplier to the middle-mile and last-mile costs to account for potentially higher labor cost in Illinois. Here is a summary of the cost assumptions used in this modeling[17]:

- Middle-mile cost, which includes material and labor: estimated at $100,000/mile nationally, and $150,000/mile after adjusting for the labor rate in Illinois.

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[12] Based on ICN interviews and size of network includes network both owned and leased segments.

[13] Seven experts were interviewed in Q4 2023.

[14] Costs are estimates as of 2023 and are point-in-time analyses. They do not account for inflation or future changes in labor or material costs.

[15] CTC Technology Consulting experts.

[16] Based on previous analysis of cost of labor for key roles related to broadband, including construction laborer, locator/communication electrician, and foreman. National rate based on U.S. Bureau of Labor Statistics' May 2022 Occupational Employment and Wage Statistics (OEWS) estimates released on April 25, 2023 (https://www.bls.gov/oes/current/oes_nat.htm). Illinois wage rate based on prevailing wage rates required to be paid for work performed on or after August 15, 2023, on public works projects in each county (https://labor.illinois.gov/laws-rules/conmed/current-prevailing-rates.html). The 1.5x multiplier is further validated by (1) comparing the ICN's middle-mile construction cost ($150,000/mile) to insights gained from expert interviews (~$100,000/mile) and (2) labor costs in established via the Connect Illinois Broadband Grant Program.

[17] All cost assumptions based on expert interviews.

- Last-mile cost, which includes material and labor: estimated at $100,000/mile nationally, and $150,000/mile after adjusting for the labor rate in Illinois.
- Point of presence (POP) locations, which includes active electronics and facility/cabinet costs: estimated at $500,000 per POP.
- Splice points (SP), which includes passive electronics and splice enclosure costs: estimated at $500 per SP.

**High-level principles guiding network design**

The following principles guided the design for the network expansion:

1. **Choice of route.** The overall fiber network uses the road structure of Illinois to identify fiber pathways. This reduces resistance to construction efforts, as roads already provide the State with right of way.
2. **Maximal length of the last-mile connection**. Last-mile connections between the middle mile and CAIs are constrained to five to ten miles to reduce optical signal loss. The research team modeled both scenarios, assuming a maximal last-mile length of five or ten miles.
3. **Structure of the last-mile network.** Last-mile connections in the model either use a *direct* or *daisy-chain* architecture. Direct architectures ensure a direct last-mile connection between the middle-mile splitter/POP and the CAI, with no intermediary stops. Daisy-chain architectures reduce the total amount of last-mile fiber projected by connecting CAIs sequentially via the last mile, thus reducing build costs. Both connection architectures were used in the optimization algorithm, and the most cost-efficient one was chosen.
4. **Structure of middle-mile network.** To ensure that a middle-mile network has sufficient resiliency, it could include redundancy to ensure network resilience if POPs or individual segments become inoperable. *Ring structures* were incorporated into the design of the middle-mile network whenever feasible, providing multiple pathways across the network.
5. **Placement of POP:** POPs are placed in the junctures of the middle-mile network, approximately 50 miles apart, to maximize the network's reach and to support potential future expansion.

**Geospatial optimization**

The research team developed a road-based geospatial analysis to determine the minimal cost of expansion. The research team modeled two scenarios: (A) assumes that maximal last-mile length cannot exceed five miles, and (B) assumes that maximal last-mile length cannot exceed 10 miles.

**Step 1: Middle-mile extension**

The goal of Step 1 is to identify the optimal routes for extending the middle-mile network to reach the prioritized CAIs while minimizing costs. To achieve this goal, the research team took the following steps:

1. All prioritized CAIs were overlaid onto the ICN network to identify CAIs that could be connected using the ICN's existing middle-mile network (i.e., within 5 miles or 10 miles of the existing network).
2. To connect each CAI that could not be mapped to the existing ICN middle-mile network, the nearest road within a pre-set distance (5 or 10 miles) was identified, prioritizing for motorways, trunk roads, primary roads, and secondary/tertiary roads.[18] The nearest point the CAI could be connected to the road was identified. This point is called a "proxy point" below.
3. A shortest-path route-optimization algorithm, which allows the State to reduce overall cost, was used to connect all proxy points, considering the pre-existing ICN network and the same order of road prioritization used in step 2.
4. Manual cleaning and checks were conducted to ensure that (1) middle-mile expansion does not overlap with current network (e.g., removing expansions where existing networks were sufficient), and (2) CAIs that are not within the pre-set distance of any major roads are connected to the network (i.e., manually adding expansion through secondary road structure.)
5. Middle-mile routes were manually added along road segments to build in network redundancy.[19]

The geospatial optimization model identified approximately 6,100 miles of middle-mile expansion in Scenario A, where last-mile length cannot exceed five miles, and approximately 4,900 miles in Scenario B, where last-mile length cannot exceed 10 miles.

**Step 2: Last-mile extension**

The goal of Step 2 is to design last-mile routes that connect all prioritized CAIs to the expanded middle-mile footprint. To achieve this goal, the research team took the following steps:

1. Using the overall middle-mile network constructed in Step 1 and all prioritized CAIs, a shortest-path route-optimization algorithm, which allows the State to reduce overall cost, was applied to connect all prioritized CAIs to the middle-mile network.

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[18] Prioritization of roads based on the composition of existing ICN middle-mile network is located.

[19] As the shortest path is to use the road network to route through points, some redundant paths were created between these points, resulting in ring structures.

2. Intersections between the middle-mile and last-mile network were designated as splice points.
3. Manual cleaning and checks were conducted to ensure that last-mile connections were correctly formatted (e.g., removing last-mile connections close and parallel to the middle-mile network).

The research team's analysis identifies approximately 3,100 miles of last-mile expansion in Scenario A and 5,100 miles in Scenario B. Scenario B shows a much stronger need for last-mile expansion since CAIs are farther away from the middle mile by design. The design resulted in approximately 1,300 (Scenario A) to 1,500 (Scenario B) new splice points.

**Step 3: POP locations**

The goal of Step 3 is to place POPs throughout the middle-mile network in a way that covers the network with the least number of POPs. To achieve this goal, the research team took the following steps:

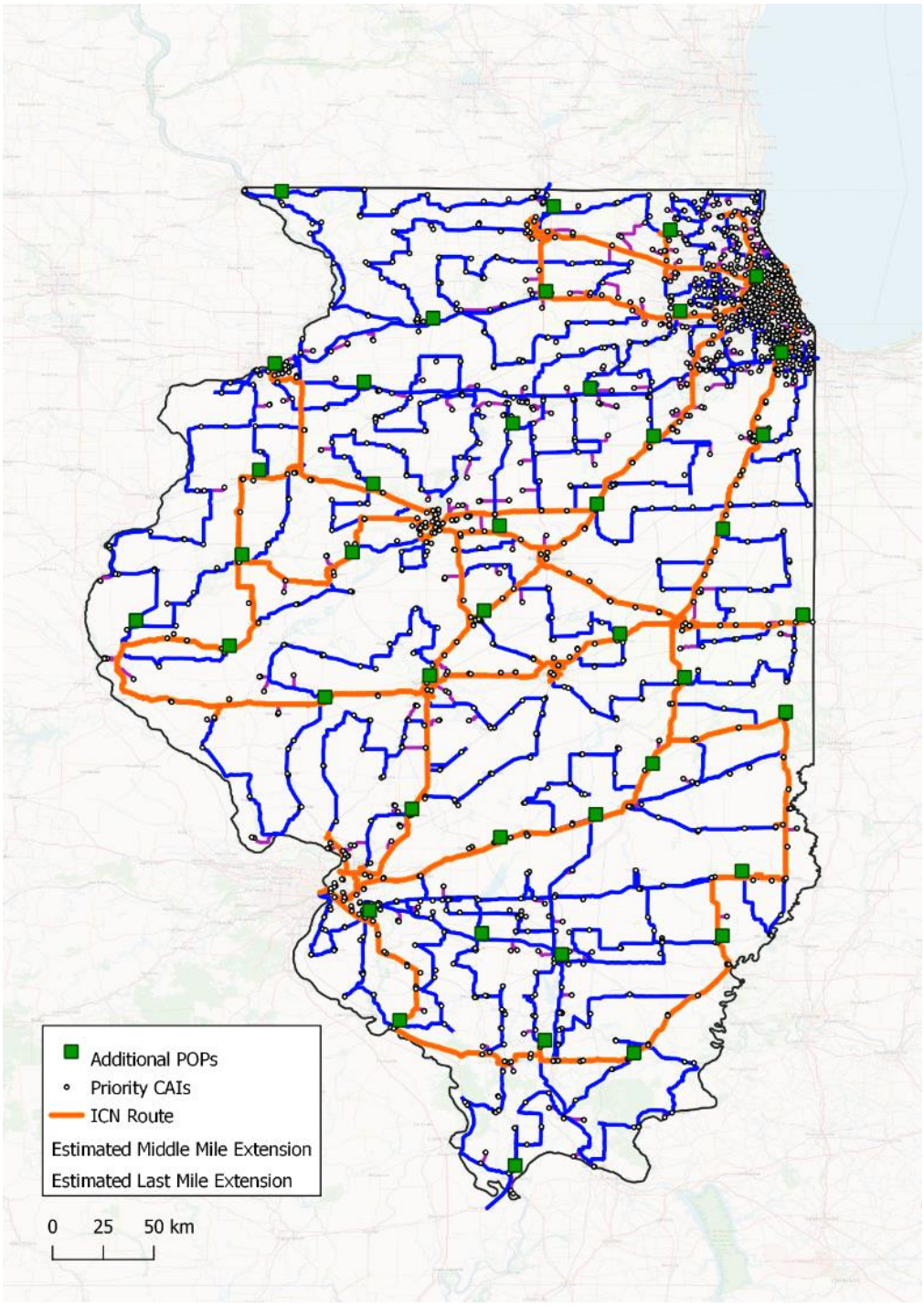
1. All road junctures of the middle-mile network were analyzed, and each juncture was ranked based on the number of segments it connected to other parts of the network.[20]
2. An iterative selection algorithm was used to identify POPs by selecting the juncture with the most segments and checking if it can be a POP.
    a. A POP covers a range of about 20-40 miles in radius. The algorithm checks whether the potential juncture's range would overlap with other selected POPs in more than 50 percent of the middle-mile routes it connects. If it does, then the algorithm will eliminate the juncture in future iterations and never consider it as a POP. If not, the algorithm declares the juncture a POP and removes it from future iterations.
    b. This algorithm continues until every point in the expanded network is within 20-40 miles of a POP.
3. To validate the results of the algorithm, manual checks were performed to ensure full coverage of the network (i.e., adding POP locations to segments of mile networks where there are no junctures.)

The research team's analysis identified the potential placement of approximately 40 POPs in both scenarios.

[20] An example of a road juncture is a T-intersection, which has three potential pathways from the juncture.

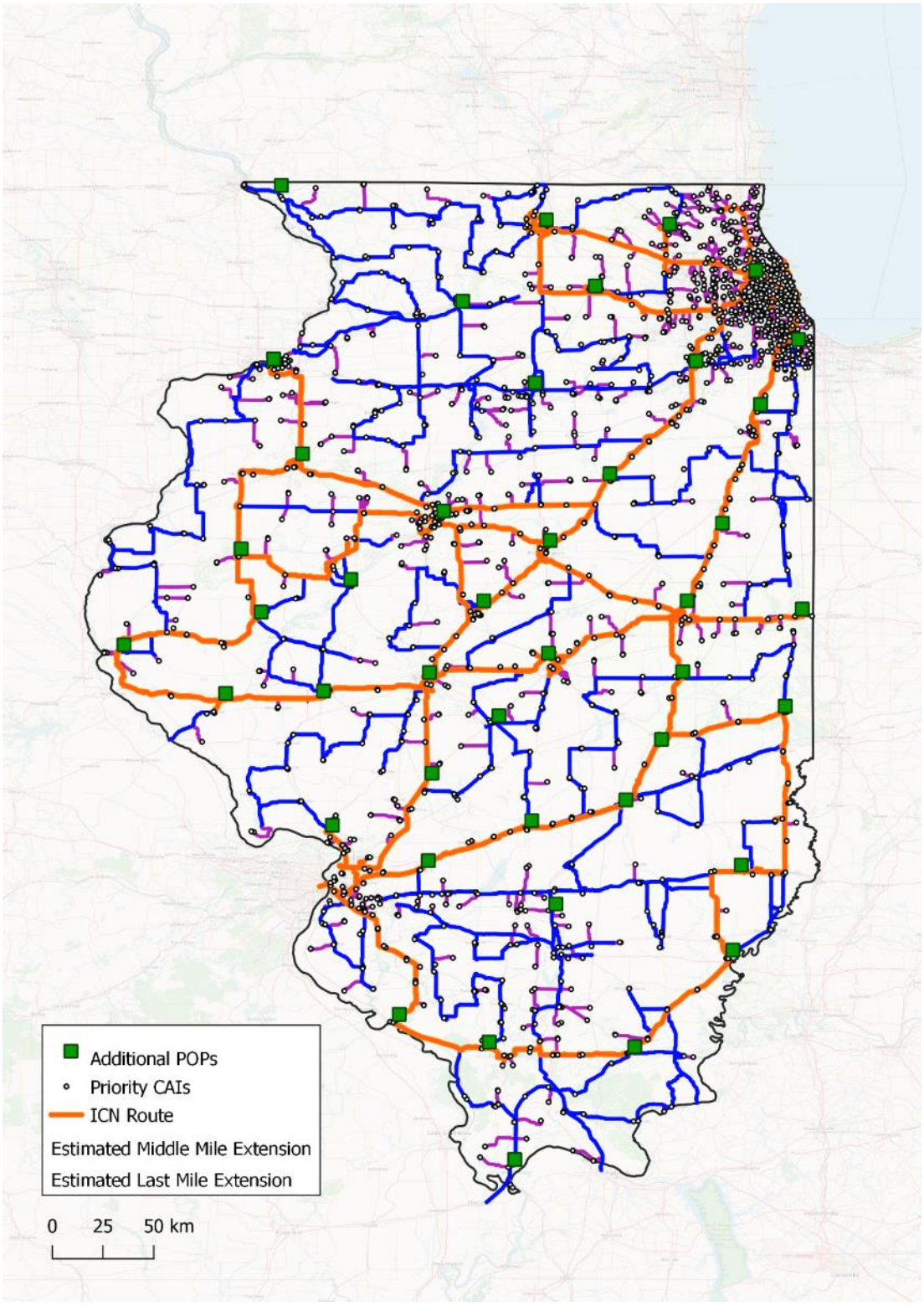
Illustrative networks are shown below:

*Figure 1: Scenario 2 (A): ICN expansion to directly connect all priority CAIs, assuming a maximum five miles of last-mile distance*




*Figures are illustrative and not designed to prescribe specific action.*

*Figure 2: Scenario 2 (B): ICN expansion to directly connect all prioritized CAIs, assuming a maximum ten miles of last-mile distance*




*Figures are illustrative and not designed to prescribe specific action.*

**Cost estimation**

The network structure's components and estimated cost are summarized in Table 4 for Scenario 2(A):

Table 4: Scenario 2(A) estimated cost breakdown, data as of Q4 2023

| Category | Component | Quantity | Cost estimated |
|---|---|---|---|
| One-time CAPEX investment | Middle-mile fiber expansion | 6.1K miles | $919M |
| | Last-mile fiber expansion | 2.9K miles | $464M |
| | POPs | 43 | $22M |
| | Splice points | 1450 | $725K |
| | Customer premise equipment[21] | 1204 | $8M |
| | **Total** | | **$1.4B** |
| Annual expenditure | ICN bandwidth cost[22] | | $14M |

[21] Includes CPE for 40% of schools that are not yet connected, all libraries, and all correctional facilities. Estimation assumes 80% of schools and correctional facilities and 13% libraries receive 10Gbps symmetrical, and the rest receives 1Gbps symmetrical.

[22] Estimation assumes 80% of schools and correctional facilities and 13% libraries receive 10Gbps symmetrical, and the rest receives 1Gbps symmetrical.

The network structure's components and estimated cost are summarized in Table 5 for Scenario 2(B):

Table 5: Scenario 2(B) estimated cost breakdown data as of Q4 2023

| Category | Component | Quantity | Cost estimated |
|---|---|---|---|
| One-time CAPEX investment | Middle-mile fiber expansion | 4.9K miles | $739M |
| | Last-mile fiber expansion | 5.1K miles | $771M |
| | POPs | 39 | $20M |
| | Splice points | 1340 | $670K |
| | Customer premise equipment[23] | 1204 | $8M |
| | **Total** | | **$1.5B** |
| Annual exp. | ICN bandwidth cost[24] | | $14M |

[23] Includes CPE for 40% of schools that are not yet connected, all libraries, and all correctional facilities. Estimation assumes 80% of schools and correctional facilities and 13% libraries receive 10Gbps symmetrical, and the rest receives 1Gbps symmetrical.

[24] Estimation assumes 80% of schools and correctional facilities and 13% libraries receive 10Gbps symmetrical, and the rest receives 1Gbps symmetrical.

# 3. FTE implications for the ICN

## 3.1 Analysis overview

To undertake this analysis, the research team conducted expert interviews with individuals with prior experience and leadership roles in non-profit and private-sector middle-mile networks[25]. The experts have experience in middle-mile networks that provide services to a range of community anchor institutions (such as educational institutions, municipal and local government entities, hospitals, prisons, etc.). The surveyed networks range in size from 120 miles to 15,000 miles and serve between 150 and 2,700+ institutions.

Multiple surveyed networks offer dark-fiber leasing services. Larger networks tend to offer a wider range of services including, but not limited to, lit fiber, cell carrier transport, colocation, consulting, cybersecurity, data centers, dark wave, mapping, software-defined networking, and enterprise services.

The surveyed networks' organizational structure primarily includes the following functions:

1. Operations (see 3.2 for further detail)
2. Marketing and sales (see 3.3 for further detail)
3. Regulatory affairs (see 3.4 for further detail)
4. Administrative functions (see 3.5 for further detail).

Based on the interviews, peer networks potentially have an average of 0.5 to 1.2 operations FTE per 100 miles of middle-mile network served, and 55 to 85 non-operations FTEs per network. The ranges observed may be attributed to varying degrees of efficiencies of scale, and differences in services offered. Based on these averages, Table 6 below outlines the projected FTE headcount for both scenarios described in Sections 2.1 and 2.2.

[25] 5 experts were interviewed in Q4 2023.

Table 6: Projected FTE headcounts for Scenario 1 and 2

| | Scenario 1: ICN expansion to support last-mile connectivity through ISPs | Scenario 2: Direct-to-customer model |
|---|---|---|
| Size of middle-mile network | 2,000 miles | 7,900-8,100 miles |
| Projected FTE headcount | 65-110 FTEs | 95-180 FTEs |
| Current FTE headcount | 70 FTEs | 70 FTEs |
| Estimated FTE needed | 0-40 FTEs | 25-110 FTEs |

Note that the projected headcount is based on an outside-in analysis, not accounting for the current organizational structure of the ICN and potential reorganization or scale efficiencies. ICN currently has 70 FTE, 80% of which are operations-related and 20% are administration related, which broadly is in line with the projection above.[26] Current ICN organizational structure, capacity, and/or potential may reduce significantly additional estimated FTE needed under Scenario 1 and Scenario 2.

## 3.2 Operations

Based on interviews, Peer[27] companies' FTE investments largely seem to be concentrated in the development of operations teams, which, on average, make up about roughly half of peer organizations' total FTE headcount. Typical operations team generally includes team members with expertise and experience in permitting, construction, engineering/customer service, and GIS for expanding and supporting middle-mile networks.

Peer networks employ more operations employees than any other function, with on average about 0.5 to 1.2 operations FTE per 100 miles of middle-mile network served, based on expert estimates[28]:

The main roles in operational functions include, but are not limited to, network managers, network operations center (NOC) managers, customer service representatives (responsible for monitoring outages and dispatching maintenance crews), maintenance associates, network engineers (responsible for maintenance of routers, switches, and optical platforms), and innovation associates (responsible for upgrading platforms, new construction, and implementation).

[26] Based on interview with ICN.

[27] Peer companies are defined as other middle mile network providers

[28] FTE ranges were sourced from interviews with former network employees from similar providers. Current FTE counts may vary. Numbers are not exact and are approximated for the purpose of this analysis.

## 3.3 Marketing and sales roles

The responsibilities of marketing and sales roles in middle-mile networks include management of external communication channels. Marketing associates and sales representatives/coordinators (sometimes referred to by non-profit networks as “member” or “client engagement” representatives) are typically responsible for coordinating community outreach and communication channels (website, social media, etc.).[29]

Investment in sales and marketing teams may be a relatively low priority for municipal/government-operated networks. Team sizes may vary depending on the range of network services offered. For networks with dark-fiber leasing services, a small team of two to five people dedicated to marketing and customer engagement may be standard.

## 3.4 Regulatory affairs roles

Beyond investment in operations and marketing/sales functions, the State may consider team members with experience in regulatory affairs and government program processes to liaise between the FCC and other government offices and stakeholders. These members sometimes are included in the larger operations teams, or they may have their own, separate function.

These roles will be responsible for managing relationships with key government stakeholders and for supporting the procurement of government funding for network development.[30]

## 3.5 Administrative functions

Second to operations, administrative functions like executive leadership teams, human resources, and finance/accounting may support FTE investment to handle back-office support, executive team support, onboarding of new FTEs, and other such activities.

These roles generally include executive and leadership roles (such as directors and chief officers), their supporting teams (such as administrative assistants and secretaries), HR representatives (recruiters and general HR associates, for example), and accounting teams (such as chief financial officers, payroll managers, accounting specialists, and purchasing specialists).[31]

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[29] Sourced from expert interviews. Team sizes vary depending on services offered and size of the network.

[30] *Ibid.*

[31] *Ibid.*