Nebraska Captial Projects Fund (CPF)

Quick Current-Nebraksa LLC

February 2023

Quick Current-Nebraksa LLC is a partnership company between The Omaha Tribe of Nebraska and Evolve Cellular Inc.

Network Design Certification

We the undersigned, certify that the proposed network will be designed and constructed to deliver the broadband service to all premises in the proposed service area as indicated below:

__X__ 100 Mbps downstream and 100 Mbps upstream

Moreover, the network, as designed, can meet the proposed build-out timeline, milestones and construction schedule within the costs specified in the application.

24 Feb 2023
Date

Certifying Engineer's Signature

PROFESSIONAL ELECTRICAL AND COMPUTER ENGINEER
EVERETT LIONELL KINGREY
E-16238
STATE OF NEBRASKA

Everett Lionell Kingrey
Certifying Engineer's Name (Printed)

Registration Number: E-16238

State of Registration: Nebraska

ENGINEERING COMPANY (If applicable):

Date

President's Signature

President's Name (Printed)

Name of Engineering Company

Capital Projects Fund

- Standards Based Solutions
- 100X100 Symmetric Broadband minimum

- 13.2 Fiber Miles Constructed
- 2 new tower facilities to be built*
- BB connected via fixed wireless service using licensed Band 41 spectrum
- 3GPP Compliant Core for operations of wireless network
- O-Ran compliant radio access network

*There may be an opportunity to lease space on an existing tower in Tekamah in which case only one tower will need to be built.

Network Design Narrative

The following slides document the detailed network design of a new fixed wireless access network divided into two Proposed Funded Service Areas (PFSAs) . The network is designed to supply 100 Mbps symmetrical service to all covered households simultaneously, subject to standard network design practices, in order to meet the CPF program requirements.

The network design can be stand alone in that it allows for, with a few minor fiber builds, connectivity to existing 3rd party middle mile backhaul fiber to Quick Current-Nebraska's Data Center in Walthill. However, should the Omaha Tribe, majority owners of Quick Current – Nebraska, be awarded the NTIA Middle Mile NTIA-MMG-2022 (Application #: GRN-001447), those minor fiber builds will go from 13.2 miles down to 6 miles of fiber construction.

The center of our network is an existing building in Walthill, Nebraska where we will deploy a Standards Based 3GPP Compliant Core and will house our personnel and equipment to service each of the mid-haul and end user locations on our network.

Each of the Fixed Wireless Access (FWA) base stations will O-Ran compliant from the F-Node back to the core and thus will be controlled via our core via industry best practices. To connect end users, we will deploy FWA user equipment to subscriber households. The activity required to implement the proposed network design falls under NEPA categorical exclusions which “do not normally require applicants to submit detailed environmental documentation with their applications.”

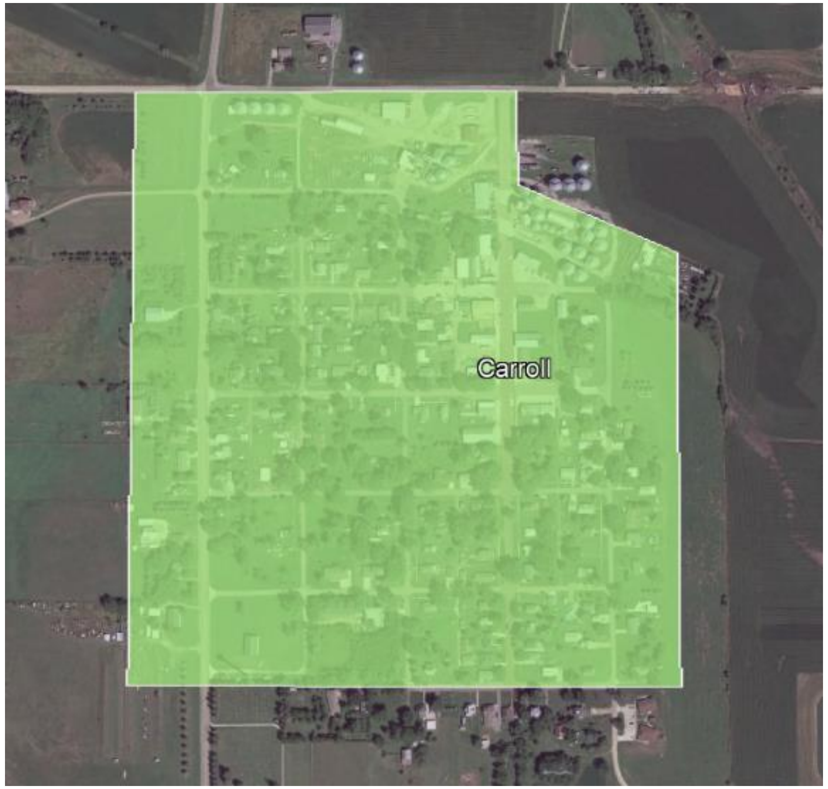
The tower assets will be deployed onto newly constructed towers on land purchased near planned Middle Mile fiber builds. Should there be opportunity to place equipment on existing towers near the planned tower sites and at the same engineered heights, Quick-Current - Nebraska will utilize those facilities instead of constructing new towers.

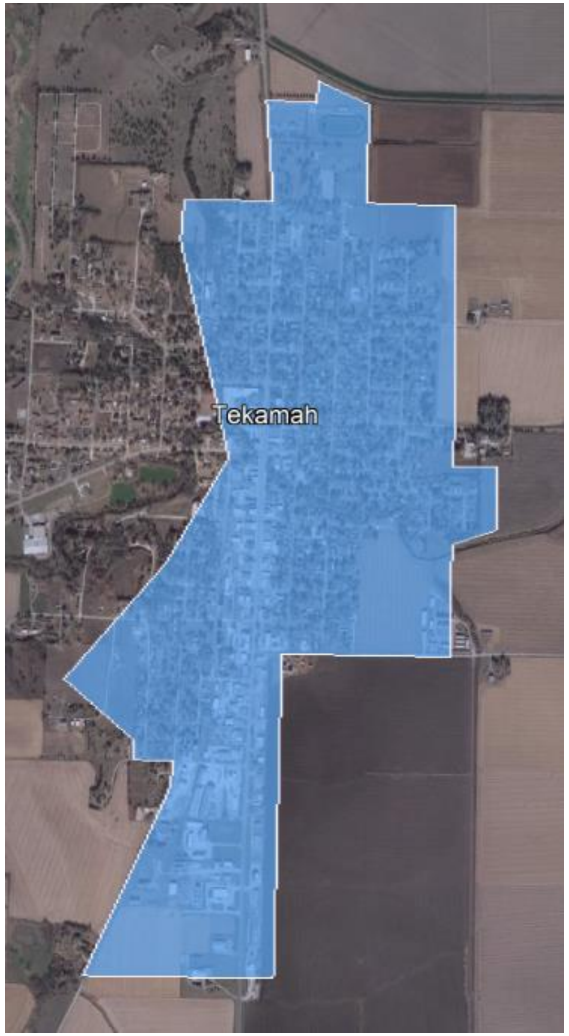
This document focuses on the technical network design.

The proposed network design, with capital costs projected at under $5 MM, provides to build and service areas within the Omaha Tribe of Nebraska (Tribe)'s Licensed Spectrum Area. The applicant, Quick Current-Nebraska LLC is a tribally owned entity, that commits to service adequate speeds as required by the Capital Projects Fund to the specific geographic areas that are within the Licensed Spectrum Area.

Network Design – Proposed Funded Service Areas (PFSAs)

We will build last-mile broadband infrastructure to support the PFSAs indicated below. These areas are mostly (i) where there is insufficient access to broadband, (ii) where no broadband infrastructure would be built out otherwise, and (iii) lacking adequate broadband speeds.





Towers

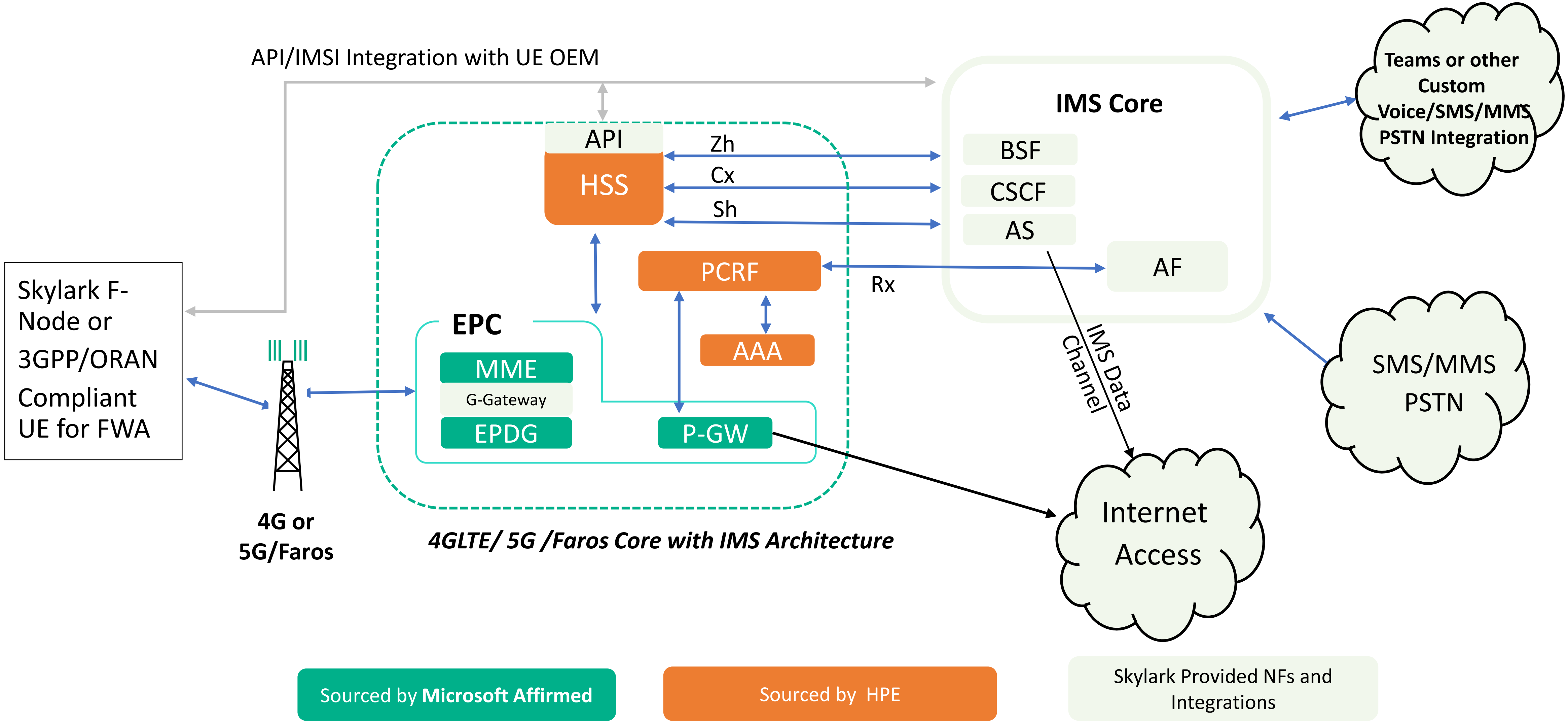
- 2 Tower Locations*

Tower Name	Latitude	Longitude	Equipment Height
Carroll Tower	42.29311	-97.1938	85 ft
Temakah Tower	41.76109	-96.2239	85 ft

*Tekamah Tower location is that of an existing tower. If leasing space on this tower is not an option, land will be purchased near this tower and new tower facilities will be built on that property.

Equipment Description & Capacity Calculations

4GLTE/5G Core and IMS Architecture
(EF&I at Walthill Data Center)

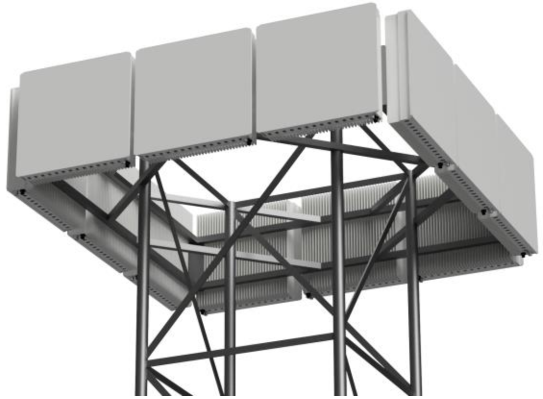


Acronyms Used in 4GLTE/5G Core and IMS Architecture Slide

Acronym	Long Version
3GPP	3rd Generation Partnership Project
ORAN	Open Radio Access Network
UE	User Equipment
OEM	Original Equipment Manufacturer
EPC	Evolved Packet Core
MME	Mobility Management Entity
EPDG	Evolved Packet Data Gateway
P-GW	Packet Data Network Gateway
API	Application Programming Interface
HSS	Home Subscriber Server
PCRF	Policy Charging Rules Function
AAA	Authentication, Authorization, and Accounting
IMS	IP Multimedia Subsystem
BSF	Binding Support Function
CSCF	Call Session Control Function
AS	Application Server
AF	Application Function
SMS	Short Message Service
MMS	Multimedia Messaging Service
PSTN	Public Switched Telephone Network
NF	Network Function

FWA Base Station Description

The last-mile architecture of this project utilizes a Fixed Wireless Access (FWA) topology utilizing dedicated "Faros" Massive MIMO systems from Skylark Wireless, LLC. An O-Ran compliant FWA base station, controllable by the core, with multiple coverage sectors of 90-degree (up to 4 sectors as needed) 3 dB horizontal beamwidth, is installed at a design height unique to each commercial cellular tower* or appropriate building. This FWA base station communicates via Point-to-Multi-Point (PtMP), Non-Line-of-Sight (NLoS) wireless channels to dedicated FWA Customer Premises Equipment (CPEs) installed on-premises at a subscriber's household or business. The class of service is controlled by the 3GPP Standard Core.



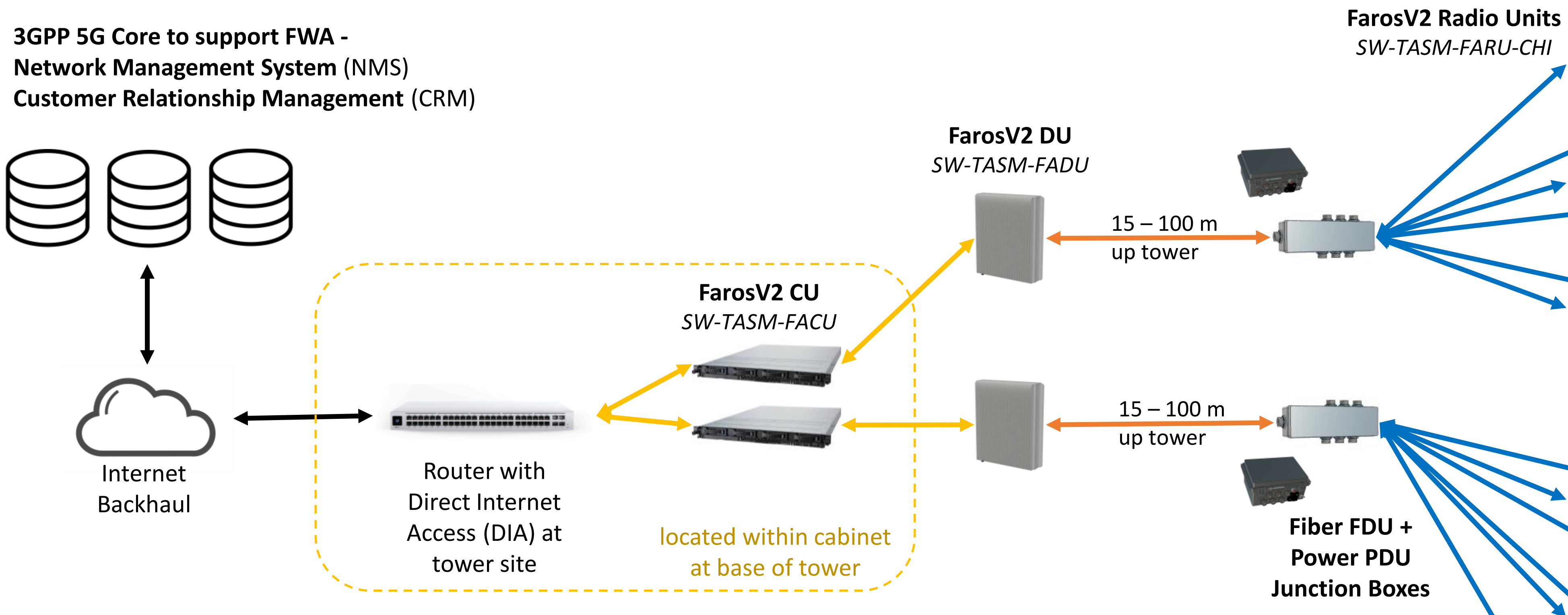
12 coherent Faros 14T x 14R radio units shown in 4-sector configuration with 100% frequency reuse as anticipated in the planned network design.

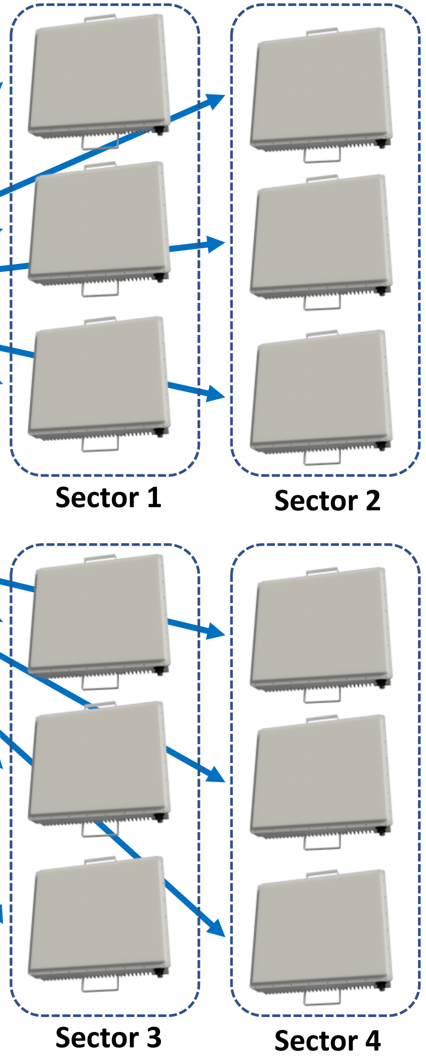
The Faros system utilizes a scaled, multi-user beamforming technology called Massive MIMO (mMIMO) in a modular form factor providing up to 252T x 252R topologies with up to 32 spatial streams (i.e. 32-layer) operating at mid-band frequencies. The system does NOT provide mobile wireless service.

We plan to deploy this system in four sectors of approximately 90-degree horizontal bandwidth with 42T x 42R configuration per sector, with each sector supporting 21 spatial streams on average. The deployed system will utilize BRS Licensed spectrum between 2.5-2.55 GHz, as determined to be available in the designed regions. This proprietary physical layer utilizes a Global Positioning System (GPS) synchronized Time Division Duplexing (TDD) scheduled Media Access Controller (MAC) implementing Orthogonal Frequency Division Multiple Access (OFDMA) in a coherent "no-sector" topology with 100% frequency reuse. The system supports dynamic Modulation and Coding Scheme (MCS) selections with rates between ½ BPSK and ¾ 256QAM and Automatic Repeat Request (ARQ) for low-latency loss recovery.

*design height detailed for each tower on the individual PFSA map pages.

FWA Tower Installation Diagram





- Not within scope of Skylark design
- LC Duplex patch cable, 2-count fiber, OM4
- IP67 jacketed MTP F/F 12-count fiber, OM4
- IP67 jacketed LC Duplex 2-count fiber, OM4

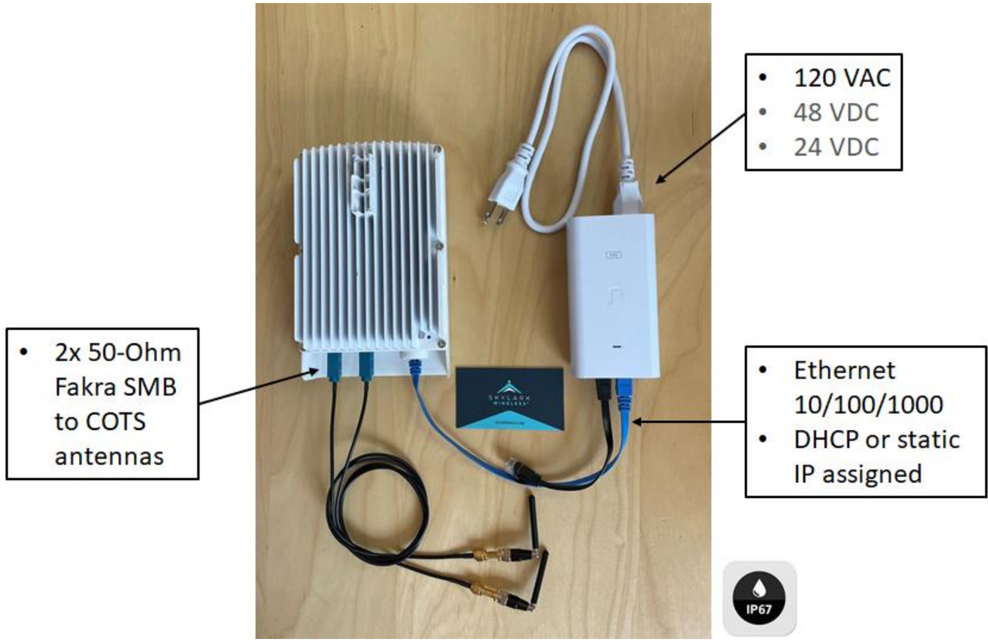
The CU performs Layer 1 and 2 digital signal processing and user management and communicates to the DU over standard fiber interfaces. The DU communicates over standard fiber interfaces to multiple trunked RUs on the tower, providing data backhaul, timing, and synchronization information. The total bandwidth required for each segment of fiber does not exceed the total instantaneous user data rate, which itself does not exceed 10 Gbps.
Each tower site is provided a maximum 10 Gbps connection at the cell site router by the transport network provider, utilizing existing dark fiber at each site.

Customer Premises Equipment (CPE) Description

The installation of service at a subscriber premises utilizes a 2T x 2R MIMO transceiver, with an external, directional antenna permanently mounted on a pole (distant sites) or side of the home (near sites) and pointed at the nearest base station location. Each outdoor CPE unit provides an IP-rated 10/100/1000 Ethernet port for the LAN and implements 802.3at standard 25W power-over-ethernet (PoE+).

CPE units contain active GPS receivers that enable the network operator to know the installation location of CPE units for the purpose of complying with 47 CFR Part 96 emissions regulations.

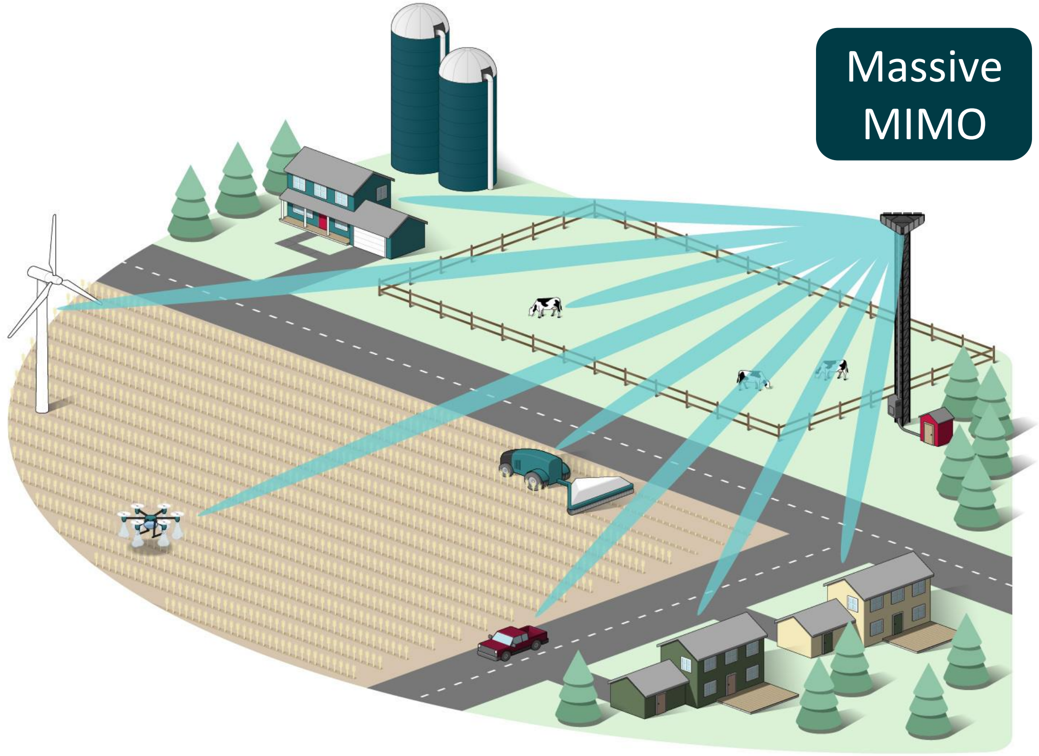
For this design, an active 10/100/1000 Ethernet connection via an RJ-45 jack will be provided to each household where the 100-symmetric service may be accessed and may be further routed around the household as desired by the subscriber. Wi-Fi 6 routers will be made available for purchase at the time of installation, but their procurement is outside the scope of this network design.



Single Faros 2T x 2R CPE units shown with power supply, and indoor COTS test antennas affixed.

Massive MIMO Beamforming

100 Mbps per 20 MHz channel
5 bps/Hz



100 x 16* = 1600 Mbps per 20 MHz channel
80 bps/Hz**

Massive MIMO beamforming serves up to 16x more users at longer range. The proposed system is the system located on the right.

*each "beam" pictured contains two spatial streams with H and V polarization, respectively
**in ideal, fully backlogged conditions; real-world performance will vary

Link Budget Calculations

Downlink

BS Transmit Power per Radio	27 dBm
BS Total Transmit Power (per polarization)	40 dBm
BS Antenna Gain	14 dBi
BS Cable and Connector Loss	<1 dB
BS Beamforming Gain (21 Radios per polarization)	13 dBi
BS EIRP (Regulation Limited)	53 dBm
Maximum Path Loss	138.5 dB
CPE Cable and Connector Loss	<1 dB
CPE Antenna Gain	24 dBi
Received Signal Power	-62.5 dBm
Noise Floor (40 MHz)	-95 dBm
Fade Margin	10 dB
Signal to Noise Ratio (SNR)	22.5 dB
Modulation and Coding Rate	64-QAM 5/6 dual spatial streams
Throughput	104 Mbps

Uplink

CPE Transmit Power	27 dBm
CPE Antenna Gain	24 dBi
CPE Cable and Connector Loss	<1 dB
CPE EIRP	50 dBm
Maximum Path Loss	138.5 dB
BS Antenna Gain	14 dBi
BS Cable and Connector Loss	<1 dB
Received Signal Power per Radio	-75.5 dBm
BS Beamforming Gain (21 Radios per polarization)	13 dBi
Received Signal Power	-62.5 dBm
Noise Floor (40 MHz)	-95 dBm
Fade Margin	10 dB
Signal to Noise Ratio (SNR)	22.5 dB
Modulation and Coding Rate	64-QAM 5/6 dual spatial streams
Uplink Throughput	104 Mbps

Capital Projects Fund mandates that facilities proposed to be constructed with award funds must be capable of delivering 100 Mbps symmetrical service to every premise in the proposed funded service area (PFSA). The considered base station design utilizes Faros 14T x 14R RUs on each sector and antenna elements, evenly split between perpendicular polarizations (+45 and -45 degrees).

The above tables provide our link budget calculations showing that under fully-loaded conditions, the designed network is capable of providing the required level of service at the PFSA cell edges, meeting the Nebraska CPF program requirements. Households at closer distances than the cell edge will be able to achieve higher throughput with higher modulation rates and will provide additional performance margin for this network design.

In this deployment each sector is initially provisioned with Faros RUs, providing radios. This configuration enables an output power of up to 42 dBm per sector, with an EIRP of up to 67 dBm including antenna and beamforming gains (limited to 53 dBm by regulation). In the uplink, the antenna array provides 13 dB of additional beamforming gain per polarization. On the cell edge CPEs utilize high-gain 24 dBi dual-polarized KP Performance KP-35PD2-N antennas, enabling up to 50 dBm EIRP after connector and cable losses. Customer premise equipment is deployed on masts up to 15 m in height at the cell edge, and a path loss of up to 138.5 dB is allowed, with an additional fade margin of 10 dB. Faros MIMO CPE units provide 2 radios, each with 27 dBm power output.

Last-mile service is provided directly from fiber-fed towers with sufficient backhaul capacity to ensure 100/100 Mbps symmetric service is also low-latency, ensuring high user satisfaction and support for modern broadband applications. We have shown that this designed network meets or exceeds the Nebraska CPF program requirements, ensuring that funds are spent on “future-proof” infrastructure.

Aggregate Network Capacity Calculations

	Variable	Equation	Downlink	Unit	Uplink	Unit
Channel Bandwidth	**A**	parameter	49.5	MHz	49.5	MHz
Percent Channel Time	**B**	parameter	50%	percent	50%	percent
Spectral Efficiency per Stream	**C**	parameter	2.8	bps/Hz	2.5	bps/Hz
Number of Spatial Streams	**D**	parameter	21	streams	21	streams
Total Throughput of Sector	**E**	A*B*C*D	1455.3	Mbps	1299.4	Mbps
Maximum Individual Throughput	**F**	A*B*C*2	138.6	Mbps	123.8	Mbps
Target Individual Throughput	**G**		100	Mbps	100	Mbps
Max Users @ 1:1 Oversubscription	**H**	E/G	14.6	users	12.99375	users
Max Users @ 1:12 Oversubscription	**K**	H*12	174.6	users	155.9	users
Number of Sectors per Tower	**L**	parameter	4	sectors	4	sectors
Simultaneous Users per Tower	**M**	L*K	**698.5**	**users**	**623.7**	**users**

Capital Projects Fund mandates that facilities proposed to be constructed with award funds must be capable of delivering 100 Mbps symmetrical service to every premise in the proposed funded service area (PFSA). The previous Link Budget Calculation demonstrated that we will meet the received power requirements in the designed network to support minimum 64 QAM, 5/6 coding rate at all PFSA locations. In this section, we demonstrate that a maximum number of 756 subscribers may be served by each tower in the network design while meeting the performance requirements of the Nebraska CPF program.

All wireless base stations and customer premise equipment operate under FCC Part 96 (BRS) as Category B CBSDs (BRS Devices) that are professionally installed. These devices are allowed to transmit up to 47 dBm/10 MHz EIRP. The deployed network will utilize up to 60 MHz of spectrum in some locations, enabling up to 50 dBm transmit EIRP. The considered base station design utilizes three Faros 14T x 14R Rus in each sector such that each sector contains 42 radios and antenna elements (T), evenly split between perpendicular polarizations (+45 and -45 degrees). We conservatively support 21 spatial streams (D = T/2) in the capacity design, and assume a low 12:1 oversubscription factor, well below industry norms, to account for the statistical variation in network usage even when 100% of PFSA households are actively utilizing their 100 Mbps symmetric service. Towers utilize a frequency-1 reuse factor (100% reuse) between the designed coherent sectors.

The network design is uplink-limited; no more than 756 users are served may be served by any single tower location while meeting Nebraska CPF program performance requirements under the given conservative assumptions, thus the maximum number of symmetric 100/100 Mbps clients that may be supported by the network design for a single tower is 756.

Network Loading Calculations

No tower serves more than 765 subscribers, which would consume 7.7 Gbps of traffic in each downlink and uplink direction assuming 100% of households had backlogged bidirectional traffic and a 12:1 oversubscription ratio.

Each tower has Direct Internet Access (DIA) of up to 10 Gbps provided at the router at the base of the tower since it is directly fed by fiber. This provides sufficient capacity to meet the Nebraska CPF program requirements.

By designing a network that leverages new Massive MIMO beamforming technology to efficiently provide last-mile connectivity from existing fiber and tower infrastructure, we can rapidly deploy and service a large, high-speed broadband user base that currently has insufficient broadband access.

Tower Location	Estimated Housing Units	Number of Towers	Estimated HH Served
Carroll	161	1	80
Tekamah	809	1	404