Exhibit C

Interstate Telecommunications Cooperative, Inc.

RDOF Long Form 683 Technical Submission

Date: 2/10/2021
Applicant: Interstate Telecommunications Cooperative, Inc.
FRN: 0003741550
State(s): Minnesota; and South Dakota
Performance Tier(s): Gigabit Performance Tier

GENERAL GUIDANCE:

- The use of this template is optional and voluntary.
- This template does not supersede or modify any of the orders, public notices, rules, or policies that have been or will be adopted by the Commission for the Rural Digital Opportunity Fund and Auction 904.[1] See the Commission's Auction 904 website for more information, including a tutorial regarding the Stage II detailed technical submission: https://www.fcc.gov/auction/904.
- The long-form is meant to be detailed in nature and approaches an LLD (Low Level Design).
- This is a document submitted from one engineer to another engineer.
- We encourage the use of technically valid TERMINOLOGY.
- We encourage the use of precision language for technical terms.
    - Do not say priority or QoS; Use terms such as: DSCP, Diff Serv, TOS, etc.
    - Do not say routing protocols; Use terms such as: OSPF, IS-IS, EIGRP, BGP, etc.
    - Do not say traffic engineering; Use terms such as: MPLS, VPLS, VLANs, etc.
- This is a forward-looking – future-oriented document for the 10-year span of this program.
- Our questions are asking for the minimum. You can add more.
- Each question must be answered completely. There will be portions of your answers that may be repetitious and may have been used as part of an answer to other questions. This is expected. Answer each question completely where it is asked.
- **The spacing between questions below DOES NOT INDICATE THE DESIRED LENGTH OF YOUR ANSWER. Indeed, the blank lines merely represent a placeholder. LONGER ANSWERS ARE EXPECTED.**
- If an answer encompasses multiple technologies – please use separate paragraphs in your answers below to differentiate between how separate technologies or network designs are to be implemented. For example, one paragraph for fiber, a second for Cable and a third for fixed wireless when answering question 1a) for last-mile. Separate paragraphs could also be done if there are variations in the network due to differences such as state(s) in question 1c).
- Please add equipment and software vendor names for most answers that use equipment and software. Not every minor vendor name but the major or significant vendors.

[1] Commission decisions adopting rules and policies for the Rural Digital Opportunity Fund and Auction 904, as well as detailed public notices outlining the procedures, terms, and conditions for the auction control and can be found on the Auction 904 website and through the FCC's Electronic Document Management System (EDOCs) database.

1. ***<u>Overall Network Design</u>. A long-form applicant, regardless of the technology (or technologies) it proposes to use, is expected to:***

   a) ***Describe the proposed last mile architecture(s), design, and technologies[2].***

Interstate Telecommunications Cooperative, Inc. (ITC) will build a fiber to the premises (FTTP) architecture to serve the respective locations within the eligible census blocks of the awarded RDOF awarded census block groups (CBG). ITC has completed the network planning for these awarded areas. As a result of this network planning, ITC decided to construct the fiber optic cable to the RDOF eligible locations using the combination of a “home-run” (or dedicated fiber) design and a centralized splitter design. The “home-run” architecture dedicates fiber from the FTTP optical line terminal (OLT) electronics to the customer premises, and it is the most technology agnostic architecture. The centralized splitter design uses field splitter cabinets, and shared fiber is used from the FTTP OLT electronics to the field splitters and dedicated fiber is deployed from the field splitter cabinet to the customer premises. ITC intends to utilize field splitter cabinets in specific portions of the overall RDOF deployment in order to better leverage existing fiber optic cable assets.

In addition to the “home-run” and centralized splitter fiber design, ITC has selected industry standard Gigabit Passive Optical Network (GPON) technology to serve the locations within the eligible census blocks. The GPON access technology is standardized by the International Telecommunications Union in the ITU-T G.984 standard and provides shared data streams of 2.4 Gbps downstream and 1.2 Gbps upstream per PON port. Subscribers that reside on the same PON port in the central office will share this bandwidth. ITC intends to deploy 32-way splitters on the GPON network to serve up to 32 end users from a single PON port. This technology and network design will allow ITC to provision data rates of 1 Gbps downstream and 500 Mbps upstream to each customer location with a reasonable level of oversubscription, which meets the requirements of the performance tier in which ITC has committed to deliver. The network design being deployed by ITC allows oversubscription to be reduced by implementing some minor changes, if necessary. One of those methods would be to change the splitters from a 32-way split to a 16-way split.

ITC intends to leverage as much existing infrastructure as possible to maintain an efficient network deployment. Specifically, ITC will utilize existing FTTP electronics equipment and fiber optic cable whenever possible to minimize the cost of deployment. The network design involves constructing new fiber to extend from the end of the existing fiber routes to the customer premises locations within the RDOF eligible census blocks. Depending on the customer density for the respective areas, ITC may elect to place the PON splitters in the central office location or in centralized splitter cabinets in the field. The fiber optic cable will be sized to ensure that dedicated fiber strands are available to connect from the splitter location

[2] Architectures include, for example, wireless licensed or unlicensed, fiber, coaxial cable, satellite, digital subscriber line, hybrids, etc. Protocols encompass a wide variety of use categories and standards organizations to include: routing, e.g., OSPF, IS-IS, iBGP, BGP, eBG; traffic engineering, e.g., MPLS, PBB, VPLS; Quality of Service, e.g., DSCP, DiffServ, RSVP, IntServ, ToS, 802.1Q; last-mile, e.g., DOCSIS, Active Ethernet, GPON/PON, VDSL, ADSL, LTE, WiMAX, 5G-NR, and 802.11 variants; voice services, e.g., TDM, SIP, H.323, VoLTE, H.248, MGCP, and RTP. Design includes the links/connectivity in the network, including link speeds, redundancy, load-balancing, fail-over, and associated protocols, topologies, and technologies. Technologies include traffic-engineering, QoS (Quality of Service), or both methods that aid in the performance of its network. Generally, methods of traffic engineering include, but are not limited to, MPLS, PBB, VPLS, SD-WAN. Methods of Quality of Service (QoS) include, but are not limited to, DSCP, DiffServ, RSVP, IntServ, ToS, and 802.1Q.

to each potential subscriber location in the eligible census blocks. This overall OSP architecture will support GPON and future PON-based technologies such as XGS-PON and NG-PON2.

ITC will make incremental additions to its existing Calix E7 FTTP central office electronics to support the GPON based FTTP service to the RDOF locations. These existing FTTP electronics have redundant 10 Gbps uplink connectivity to ITC's existing redundant middle-mile transport network and ultimately its existing core data network. In addition, the existing FTTP electronics utilize redundant uplink connectivity to ITC's existing voice switching network. The incremental additions to the existing FTTP nodes may include card cages, GPON-8 circuit cards, and optical interface modules (OIM). ITC also intends to deploy Calix GigaCenters and GigaSpires at the customer premises to terminate the broadband service and provide the necessary customer interfaces and data rates.

b) Describe the proposed middle mile/backhaul topology,[3] architecture, design, and technologies.

For middle mile connectivity, ITC has an existing dense wavelength division multiplexing (DWDM) system using reconfigurable optical add drop multiplexer (ROADM) technology. This system will support up to 40 individual wavelengths, each of which can transport 10 Gbps or 100 Gbps of traffic. The DWDM system is deployed in a ring architecture with diverse fiber routes for carrier-grade redundancy and resiliency.

Over the top of its DWDM network, ITC has dedicated 10 Gbps wavelengths to each of its broadband central offices to support voice and broadband data services. In addition, it has separate wavelengths deployed on the middle mile backbone to support video and private line services. Each of these wavelengths is served using a Layer 2 Ethernet transponder. This network implementation provides for two-rate, three-color traffic policing, 802.1p prioritization, and protection switching via PBB-TE and G.8032 on each respective wavelength.

For its SST Ring (where DWDM has not been deployed), ITC has an existing 10 Gbps transport ring to backhaul traffic from its broadband central offices. This ring uses diversely route fiber cable to connect the sites of Gary, Milbank, Revillo, South Shore, and Stockholm to the core data aggregation site at Clear Lake. This network uses multi-protocol label switching (MPLS) to provide loop prevention and protection switching on the middle mile ring. ITC is currently evaluating options to upgrade its SST ring to a ROADM-based DWDM platform or a 100 Gbps Ethernet ring.

The existing FTTP electronics at each broadband central office uplink to the middle mile transport electronics using two 10 Gbps connections in a link aggregation group (LAG). In addition, the middle mile transport network electronics uplink four 10 Gbps interfaces in a LAG to the core data routers at Brookings and Clear Lake, South Dakota, as an aggregate uplink for the dedicated wavelengths that serve the respective broadband central offices.

The existing middle mile network has ample capacity to support the additional customers from the RDOF CBGs, but it is also able to be equipped for expanding the existing data throughput, if required. Any middle

[3] For example, describe its network topologies (the layout pattern of interconnections between node devices in a network). There are many different types of network topologies, including point-to-point, linear, daisy-chain, bus, tree, star, ring, dual-ring, mesh (partial & full), and hybrid. There are also technology-specific topologies such as FTTH, FTTN, HFC, PTP, PTMP, and ERPS.

mile expansion will use the current technology deployed and will be incremental additions to the existing network deployment.

c) ***Describe the proposed interconnection architecture, design, and technologies solution to connect to the Internet. This will include the likely service providers,[4] link data-rate/size, locations, dual-homing, and multi-homing characteristics.***

ITC's core data network was designed for current and future capacity, allowing ITC to grow when needed due to increased capacity because of additional subscribers or increased bandwidth demands. The existing middle mile network uplinks to existing Cisco ASR9000 border routers in Brookings and Clear Lake, South Dakota, via redundant 10 Gbps interfaces utilizing LAG for resiliency/redundancy. The ASR9000 platform is capable of multiple 100G connections making large increases in capacity available with changes to optics and line cards.

Each of those routers has multiple 10 Gbps connections to the middle mile transport for terminating the traffic from the respective FTTP electronics nodes. The respective border routers also have four 10 Gbps connections to SDN Communications, the upstream ISP, for a bandwidth of 40 Gbps per connection to SDN Communications. The two border routers for ITC connect to separate SDN Communications data centers for geodiversity. In addition, the 40 Gbps connection from each border router to SDN Communications is sufficient to handle all customer Internet traffic for ITC. Border gateway protocol (BGP) is used for traffic optimization, load balancing, rerouting of traffic in the event of a failure. ITC monitors the bandwidth utilization to its upstream ISP daily, and the connections can burst to two times the configured capacity to prevent any traffic blockages due to bandwidth constraints. When necessary, ITC can increase its capacity on the uplinks to SDN Communications in 10 Gbps increments with the addition of optics and/or circuit interface cards in its existing router.

d) ***Describe the proposed architecture that will be used to provide voice service.[5] Describe whether the proposed voice services will: 1) be internally provided, 2) use a managed voice service provider, 3) use a voice over the top service, or 4) use another type of voice service.[6]***

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[4] This includes selected transient or Internet service provider names and IXP location names or at a minimum city and state location.

[5] If the long-form applicant obtains these or other voice service functions as services from another provider or providers (for example, an over-the-top VoIP provider, or an incumbent or competitive local exchange carrier), the description should so indicate. Voice solutions are a collection of integrated sub-systems dependent on selected architecture and design implementation. These architectures can include items such as: SIP, H.323, and MGCP; internal trunking, e.g., SIP trunks; quality of service protocols and use; connectivity to the PSTN and other VoIP providers; associated internal traffic-engineering to support voice quality; and more. If the applicant is using a hosted or Managed Service Provider (MSP) for its voice solution it must provide and sufficiently describe its infrastructure support. Such network infrastructure support solutions may include Quality of Service (QoS), voice paths setup by traffic-engineering protocols, trunking, and other methods, e.g., when using a voice MSP (Managed Service Provider).

[6] *See Rural Digital Opportunity Fund Phase I Auction Scheduled for October 29, 2020; Notice and Filing Requirements and Other Procedures for Auction 904*, AU Docket No. 20-34 et al., Public Notice, 35 FCC Rcd 6077, 6127-29, paras. 135-39 (2020) (*Auction 904 Procedures Public Notice*). (describing how an ETC must offer qualifying voice service using its own facilities, at least in part).

ITC plans to use an internally designed and operated system to provide voice services for the RDOF CBGs. ITC will utilize one of its existing, redundantly configured, Ribbon C15 Class 5 softswitches to provide voice services in the proposed RDOF areas. ITC currently has Ribbon C15 softswitches deployed in its broadband central offices in Brookings, Clark, Clear Lake, and Webster, South Dakota. ITC will determine which existing softswitch will most effectively serve the various awarded RDOF areas based on geographic location of the RDOF areas.

Similar to its current implementation, ITC will utilize H.248 as the control protocol that facilitates communication between the Ribbon C15 softswitch and the FTTP ONTs. ITC has extensive experience deploying voices services between its Ribbon C15 softswitch and its FTTP electronics that serve the existing service areas.

The proposed FTTP electronics will uplink to the existing middle mile transport network using redundant 10 Gbps interfaces. Voice communications will be transported over the geo-diverse, carrier-grade, packet-optical transport system to connect it to one of the existing Ribbon C15 softswitches. Voice communications will be prioritized on the transport backbone to ensure quality of service. Redundant circuit interfaces are utilized between the middle mile transport electronics and the existing Ribbon C15 softswitches to eliminate single points of failure. Each transport and access network element is engineered and configured with the appropriate level of redundancy to ensure a highly-reliable, carrier-class voice service.

For its proposed RDOF network implementation, ITC will utilize the existing SIP trunks to its centralized equal access (CEA) provider, SDN Communications, who provides connectivity to other carriers on the public switching telephone network. In RDOF awarded areas in South Dakota, ITC will utilize its existing local interconnection trunks to support voice services in the respective areas. For its RDOF awarded areas in Minnesota, ITC will utilize its existing connections to Inteliquent to exchange traffic for local interconnection services.

e) Describe the network's scalability to support customer growth and network data usage growth to account for: 1) ever increasing application requirements, 2) increasing quality demands, and 3) lower response/latency demands for ever increasing usage of highly interactive applications.

The network that ITC intends to deploy to serve the locations within eligible census blocks for its awarded RDOF areas is scalable in numerous ways. In order to provide for ever increasing application requirements and increasing quality demands, it is imperative that the broadband network is scalable from the perspective of the maximum supported data rates. With respect to the last mile portion of the network, the proposed GPON network deployment will enable Gigabit services to be offered to every location within the funded census blocks. This technology implemented via the Calix E7 platform enables ITC to provision peak data speeds to individual users in increments of 1 Mbps or less. This results in ITC's ability to provide a wide variety of data rates up to 1 Gbps (including raw data and Ethernet overheads).

The fiber optic cable network for the last-mile infrastructure is designed to allow other future, next-gen FTTP technologies to be implemented. If ITC needs to increase the bandwidth to the customers in the RDOF area, they could implement technologies such as XGS-PON or NG-PON 2 in the future, without requiring a redesign of the fiber infrastructure. This provides a path to scale Internet services to up to 10 Gbps to customers.

ITC's existing middle mile transport network utilizes ring architectures with diversely routed fiber optic cable to facilitate the automatic failover of traffic with no single point of failure. The middle mile transport electronics platforms implemented by ITC use a variety protocols including, but not limited to, ITU-T G.8032 Ethernet ring protection switching (ERPS), PBB-TE, MPLS, and LAG to ensure redundancy and resiliency in the event of a hardware failure. ITC will leverage its existing DWDM transport system with an Ethernet transport overlay to serve as the core middle mile backhaul system. The DWDM platform will specifically be used to provide middle mile service delivery to the broadband central offices of Hayti, Hendricks, and Lake Benton, which will provide service to RDOF funded locations in Hamlin County (SD) and Lincoln County (MN). In addition, ITC will utilize its existing 10 Gbps Ethernet transport network on the SST ring to provide middle mile backhaul of service to the RDOF funded census blocks in Grant County (SD).

The existing middle mile electronics use redundant 10 Gbps interfaces with LAG groups configured to connect to FTTP electronics and to the core router equipment. The use of multiple interfaces in a LAG group provides redundancy and resiliency of the network. ITC can incrementally add more 10 Gbps interfaces to the existing LAG groups, as necessary, to increase the data throughput from the middle mile network to the access network electronics and/or core data network. In addition, ITC can incrementally add new wavelengths to the existing DWDM network to deliver additional capacity to those broadband central offices that require more data throughput.

For Internet connectivity, ITC will utilize the existing pair of Cisco ASR9000 core routers which are located in geo-diverse broadband offices at Brookings and Clear Lake, South Dakota. These routers use BGP for traffic optimization, load balancing, rerouting of traffic in the event of a failure. ITC has established a 40 Gbps connection (via four 10 Gbps interfaces) from each of its border routers to its upstream ISP, SDN Communications. These 40 Gbps connections terminate at geo-diverse points of presence within the SDN Communications network. If one of the border routers or its 40 Gbps connection to SDN Communications were to fail, the other router can support the entire bandwidth utilized by ITC's customers. ITC monitors the bandwidth utilization to its upstream ISP daily, and the connections can burst to two times the configured capacity to prevent any traffic blockages due to bandwidth constraints. When necessary, ITC can increase its capacity on the uplinks to it upstream ISP in 10 Gbps increments with the addition of optics and/or circuit interface cards in its existing router.

The customers served by ITC in the RDOF funded census blocks will be served via fiber optic cable infrastructure from the customer premises to the Internet content source. This data will travel at the speed of light through fiber, and there is no way to increase this speed. ITC's middle mile transport network is configured to prefer the shortest path from the end user to the edge routers located in Brookings and Clear Lake, SD, which reduce the distance that the data packets will travel during normal operations. In addition, ITC has access to caching services via its upstream Internet service provider, SDN Communications, that brings the content source closer to the end users. This use of caching helps to decrease the distance in which the data packets travel, which decreases the latency of the service. ITC will continue to investigate other opportunities to connect to Internet content sources that are closer to its edge router locations to help further reduce the minimal latency its customers experience on their broadband service.

f) Describe the design and features that it proposes to implement that will: improve reliability (such as redundancy) for equipment, links and software; dual homing; and multi-homing connectivity.

ITC intends to implement a variety of features and functionality as part of its overall design to maximize the network reliability. For the last mile access network, ITC intends to utilize multiple GPON line cards that will serve the end users. The use of multiple line cards allows for ITC to separate the uplinks to the middle mile transport network across two separate circuit cards. This diversity in hardware ensures that the integrity of the uplinks will be intact in the event of the failure of a single circuit card. ITC will utilize LAG for the uplink interfaces being fed from separate circuit cards to maximize the redundancy and resiliency of this portion of the network.

For the middle mile portion of the network, ITC has deployed a ROADM-based DWDM network with embedded Layer 2 Ethernet switching functionality for its primary transport backbone. This middle mile transport network is deployed in a ring architecture that utilizes diversely routed fiber optic cable to ensure that a single fiber cut does not isolate traffic on the network. ITC has dedicated a 10 Gbps wavelength from each broadband central office to its core data aggregation sites of Brookings and Clear Lake, South Dakota, to transport voice and broadband Internet traffic. These dedicated wavelengths use LAG over two 10 Gbps to uplink to the FTTP electronics at the broadband central office. The use of LAG provides an additional layer of redundancy and resiliency that mitigates the possibility of a single interface failure disrupting traffic. In addition, by dedicating a 10 Gbps wavelength to each broadband central office, ITC has isolated the traffic for each broadband central office from the other sites. Separating this traffic by wavelength effectively prevents a network anomaly at one location from impacting customers served from another broadband central office. In addition, redundant circuit interface cards have been deployed in the DWDM transport network nodes to provide additional layers of protection and to eliminate single points of failure.

For its core data network, ITC has established geo-redundant core router sites at Brookings and Clear Lake, South Dakota. The routers include redundancy power supplies, processors/switch fabric, and circuit interface cards to ensure no single point of failure. These routers use BGP for traffic optimization, load balancing, rerouting of traffic in the event of a failure. ITC has established a 40 Gbps connection (via four 10 Gbps interfaces) from each of its border routers to its upstream ISP, SDN Communications. These 40 Gbps connections terminate at geo-diverse points of presence within the SDN Communications network. If one of the border routers or its 40 Gbps connection to SDN Communications were to fail, the other router can support the entire bandwidth utilized by ITC's customers.

ITC will also utilize redundant uplinks from the proposed FTTP aggregation points to its existing Ribbon C15 to provide voice services. The Ribbon C15 softswitch is configured with redundant processors, call agents, and other components to ensure highly reliable voice services. ITC utilizes standards-based protocols for both IP voice services and TDM trunks that flow through this softswitch.

g) Describe network infrastructure ownership. Indicate which parts of the network will use the long-form applicant's or another party's existing network facilities, including both non-wireless and wireless facilities extending from the network to customers' locations. For non-wireless facilities that do not yet exist, the description should indicate whether the new facilities will be aerial, buried, or underground. This includes leased lines, transit services, rented tower space for radios, etc.

All portions of the last-mile network that will be used to serve FTTP to the awarded RDOF census blocks will be owned by ITC. This will include a combination of existing and new infrastructure. ITC will construct new, buried fiber optic cable to extend from the existing fiber optic cable infrastructure to the customer premises. The existing fiber optic cable connects back to the broadband central office, which houses the existing FTTP electronics and miscellaneous infrastructure that will be used to provide broadband services. ITC will utilize buried construction for all new fiber optic cable.

For the middle mile network, ITC will utilize its existing DWDM network with dedicated 10 Gbps wavelengths to each broadband central office to backhaul the various services. In addition, it will use its existing 10 Gbps Ethernet transport system for the SST transport ring. The middle mile electronics and fiber optic cable used to connect the broadband central offices for middle mile transport are owned by ITC.

The core data network electronics for aggregating the Internet traffic is existing and owned by ITC. This includes core/edge routers, Ethernet switches, various servers, firewalls, and other miscellaneous equipment.

ITC has two existing connections to its upstream ISP, SDN Communications. The connections terminate at separate data centers owned by SDN Communications for geo-diversity.