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NTN-ND: CONNECTED TO THE GLOBAL ADVANCED TECHNOLOGY COMMUNITY

The value proposition for national and regional research and education (R&E) networks is most frequently and readily compared to that of the commercial Internet Service Provider (ISP). While the technical differences between the two continue to evolve, the core values held by the R&E community are the foundation that support the innovation and development of advanced network technologies serving the research and academics at higher education institutions around the world. According to Stephen Wolff, former principal scientist at Internet2, the differences between the R&E network community and commercial ISP are key to our ability to serve the needs of faculty, researchers and students as they engage in global scholarship. Powerful and enduring examples of these key differences include the following:

- R&E networks serve scholarly purposes; ISPs serve commercial purposes
- The environment for R&E is collegial; for ISPs it is proprietary.
- R&E’s are collaborative, ISPs are competitive.

Wolff, for Internet2 (2015)

According to a recent report by the Center for Digital Education, today’s global community increasingly looks to higher education to facilitate and perform leading-edge scientific research. Universities investing in advanced technology research infrastructures receive more funding, are more competitive at recruiting top talent and are often at the forefront of some of the most impactful scientific breakthroughs. Much of the important research conducted at universities today depends on the ability to process, store and share massive volumes of data. Across the country, and in this region of the upper Midwest and Pacific Northwest, regional technology networks serve as arms of the national R&E technology network interoperating to form a larger whole, the U.S. national R&E backbone, Internet2.

As a member-owned organization whose mission is to operate an advanced technology network intended for research and academic activities of its membership, Internet2 provides services to more than 90,000 community anchor institutions, 305 U.S. universities, 70 government agencies, 42 regional and state education networks, 84 leading corporations working with our community and over 65 national R&E networking partners representing more than 100 countries. The technology that creates regional networks and the larger interoperable network fabric encircling the globe is the foundation for distributed education and research activities across the higher education community.

For North Dakota, access to and responsibility for the connection to this national and global resource is achieved through the state-owned segment referred to as Northern Tier Network – North Dakota (NTN-ND).
FY17 NORTHERN TIER NETWORK – NORTH DAKOTA ANNUAL REPORT

This report provides an update for fiscal year 2017 (FY17) on the operations and maintenance of the Northern Tier Network – North Dakota (NTN-ND), a state-owned segment of the larger Northern Tier Network Consortium and part of the national R&E network community. Contents of this report include a description of the functions of the network and its service to the research and education activities in North Dakota, along with its role in the larger regional, national and global R&E network community.

Included in this report are highlights of current activities, the FY17 financial report and the list of NTN-ND partners. The report’s appendix provides a detailed synopsis of the history of NTN-ND funding and responsibilities, and Legislative action and segments of the state Century Code relevant to NTN-ND.

This report is intended to inform NTN-ND stakeholders across North Dakota, especially those beneficiaries of the exemplary resources that connection to this global community provides. These include students, faculty and staff located at higher education institutions and Tribal Colleges, and the K-12 community.

This document is available in a printable format at www.ndsu.edu/ypit/ntn.
The Northern Tier Network Consortium (NTNC) serves as a primary regional technology network in our region, partnering with other networks to collectively interconnect with each other and the national backbone of Internet2. The NTNC benefits from the continued growth and expansion of its members. A shared attitude across the membership aligns to the philosophy that what helps one, helps all. In FY17, the NTNC membership grew with the addition of the Network for Education and Research in Oregon (NERO). This brings state memberships to 13 (Figure 1) and includes entities in each state such as higher education, public and private K-12 school districts, research laboratories, libraries, municipalities, hospitals and state networks across the NTNC footprint. Each state engages in the larger NTNC while abiding by its own state-specific laws and infrastructure requirements.

Figure 1. FY17 NTNC network map. Not shown-Alaska.
Northern Tier Network – North Dakota (NTN-ND) is North Dakota’s state-owned segment of the NTNC. NTN-ND plays a key role in the partnerships, collaborative planning and implementation of the larger NTNC, demonstrating the commitment to support our member institutions as they engage in current and future trends for research and academics.

This state connection to the national and global R&E network community depends upon North Dakota’s state government and education network (STAGEnet) to connect public higher education institutions, Tribal Colleges and public K-12 schools. NTN-ND is an example of a state network segment contributing to the 43 regional R&E networks³ that are the foundation of Internet2. While Internet2 serves as the national R&E network backbone, it could not function without the operations and innovations realized across the collective local R&E community.

True to its original vision, NTN-ND has positioned itself to serve as an upper Midwest crossroads for R&E traffic, leveraging the capacity enabled through partnerships with neighboring states and regional networks.

NTN-ND continues to enjoy the engaged support of its three state-level partners: the Information Technology Department (ITD), North Dakota State University (NDSU) and the University of North Dakota (UND), all of whom are collectively responsible for oversight and visioning the future direction of this valuable resource. On behalf of this partnership, NDSU serves as the fiscal agent and supervises operations and maintenance activities.
FY 2017 STRATEGIC ACTIVITIES

Activities of NTN-ND in FY17 were similar to those across several NTNC member states, focusing primarily on exploring opportunities for upgrades to NTN-ND, keeping the NTN moving forward as a whole to support the advanced technology needs of academics and research.

Highlights: Preparing for Next Generation applications

• NTN-ND’s collegial partnership with neighboring regional R&E networks includes visioning for current and future needs of academics and research. With the initial build completed in 2007-2009, and as NTN-ND moves into the next generation at 100G capacity, North Dakota affirms its role as an upper Midwest crossroads for national and international R&E high speed internet traffic.

• Network technology continues to advance. Even as NTN-ND was completing its build at a capacity of 10G, initial tests were being conducted on upgrades to 100G fiber optic networks. Neighboring state and regional networks who have completed or are also planning to complete network upgrades to 100G include South Dakota, Montana, Broadband Optical Research, Education and Sciences Network (BOREASnet)/MN, Merit/MI, and the Great Plains Network in the central plains. NTN-ND is in the process of finalizing plans for similar upgrades. Neighboring networks depend on NTN-ND to advance toward this level to ensure both seamless capacity and redundancy across the footprint of the upper Midwest and northwest. Significant benefits are realized through Consortium alliances, allowing all to leverage the collective pool of resources to the advantage of all partners and the greater R&E community.

• The benefits of partnering with and situating NTN-ND in parallel with neighboring regional and global optical networks allow students and faculty at all institutions to advance at the same level and ensures continued collaboration on research and academics regardless of where institutions are located.

• As a result of action by the North Dakota University System following the 2017 North Dakota Legislative Assembly, legislated funding will no longer be provided to support NTN-ND operations and maintenance or upgrades beginning in FY18 and going forward. This reduction includes funding from the university system previously designated to connectivity. As a result, the NTN-ND partners agreed to withhold funds from FY17 operations and maintenance designated for depreciation, capital refresh and replacement. This will enable the partners to cover the cost of operations and maintenance for FY18 with currently available funds. Going forward, responsibility for annual operations and maintenance, along with allocations for depreciation and capital repair and replacement will be assumed by NTN-ND partners.
Preparing for Upgrades: Fiber Lease Renewal

Motivation to found the NTNC in 2003 was driven by northern states along the northwestern U.S. and Canada border looking to engage in the build-out of broadband networking for use by the research and education community, placing this region on the national map of institutions and regional networks that support advanced research, education and technology-based economic development.

Those early years witnessed exponential growth in required bandwidth and the constantly changing scenarios for collaborative research required to support the higher education and research community. A critical first step was to find a more cost-effective, flexible and agile solution than the legacy system which had been based on traditional lit fiber services agreements. Part of the solution to this challenge came in 2007, when North Dakota arranged to enter into an agreement with the Pacific Northwest GigaPoP (PNWGP) in Seattle and participate in a grant from AT&T, under the terms of the Southeastern Universities Research Association (SURA). The grant provided a 20-year indefeasible right to use (IRU) fiber lease at no initial cost, and only annual operations and maintenance for hardware along the path would be the responsibility of the lessee. Through the agreement with PNWGP, optical fiber between Glendive, Montana, and Minneapolis traversing North Dakota from east to west, could be acquired for use by the State’s R&E community. This agreement was an initial step in providing cost-effective east-west connectivity by universities and research centers in North Dakota to peer institutions between Seattle and Chicago and beyond. Other states in the NTNC entered into a similar agreement with PNWGP at this time with each participating state responsible for deployment of the fiber segment crossing their state, and interconnecting with the larger network span.

As anticipated since the initial planning and deployment, NTN-ND is advancing toward end-of-life and end-of-support challenges as the network segment approaches the end of its first decade. Efforts to set aside funding for necessary upgrades and repair have been a focus of each annual budget. Funds for this purpose have been secured from grant awards, and through budget allotments to depreciation and capital refresh and replacement during the years from FY12 through FY16.

Multiple variables serve as factors in determining budgets for lifecycles of transport technology. These include equipment reliability, vendor support and advancing technology for features such as capacity (i.e. 100 megabits per second to 1 gigabits per second, to 10 gigabits per second to 100 gigabits per second) and security, where hardware and software are evolving quickly. On average, the industry standard for the refresh cycle of optical transport long-distance equipment is an average of seven years. IRUs for fiber lease renewal and replacement costs depend on the market for dark fiber at the time of renewal or replacement. Operations and maintenance costs can fluctuate significantly during the life of an IRU unless specifically restricted in the lease agreement.

As the fiscal agent for NTN-ND, NDSU must account for capital improvement projects: (1) to maintain accurate reporting for the State Board of Higher Education, (2) meet audit requirements for financial reporting purposes and (3) for NDSU management information purposes. Protocol for determining end-of-life and capital repair and replacement schedules of NTN-ND align to NDSU guidelines for proper accounting for capital improvement projects.

Successful completion of the amended agreement between PNWGP and NTN asset holders ensures continuation of the existing and economical PNWGP fiber lease for NTNC through the end of the original 20-year lease agreement. At the same time, the amendment also results in a much-needed upgrade to 100GbE capacity across this span, ensuring that all hardware and software is 100GbE capable and can support contemporary research data requirements for capacity, speed, low-latency and security.
Neighbors depending on neighbors …

As budgets for higher education across many states continue to tighten, it is in the best interest of all stakeholders to move forward in tandem exploring opportunities to leverage collective resources in order to achieve cost savings, critical upgrades and network redundancy that will ensure the necessary requirements for all segments. Across the NTN path, partners have identified strategies which allow for these upgrades. Due to the nature of transport technology, the ability of individual segments across the full NTN path to deploy upgrades at the same time ensures: compatibility and capacity among interconnections of new hardware, software and optical transport technology; secures redundant paths within the region; and boosts capacity and research data security requirements from 10 to 100 times the original equipment.

Along with North Dakota, the universities in Montana have completed similar agreements with PNWGP, resulting in a significant annual savings for the member institutions and the state R&E community as a whole. In 2015 the University of Montana, located in Missoula, completed the process to become an Internet2 Connector site7. Network connectivity is key to education and economic development activities in this rural state where, as in North Dakota, communities are separated by vast distances. The University of Montana, Missoula, connects a portion of Montana’s higher education institutions, including four-year, two-year and tribal colleges, as well as the U.S. Forest Service. The new 100GbE connection provides an opportunity to expand connectivity to more higher education institutions, to the K-12 community, health care facilities, libraries and research laboratories across Montana.

South Dakota’s Research, Education and Economic Development (REED) state network was first implemented in 2008 and includes connections to six public universities and several state entities, including two national research centers, all of which create a significant demand on network capacity. As an example of increasing demands, the United States Geological Survey Earth Resources Observation and Science Center (USGS/EROS) has witnessed the demand for their data increase from an amount similar in size of the entire Library of Congress every nine days in 2011, to that same amount of data being requested every six hours in 2016. Google is a primary user of EROS data. The Sanford Underground Research Facility (SURF), a deep underground and dark matter research laboratory located near Lead, South Dakota, has seen similar increases in data transfer requirements. Groundbreaking in 2017 for a new Long-Baseline Neutrino Facility there will house several large particle detectors. Access to data generated by this facility for research and discovery includes more than 200 scientists located around the world. For all of these users, increased capacity and security of research data, and path redundancy are critical in the expectations SD REED shares with its neighboring state and regional networks.

The Broadband Optical Research Education and Science Network (BOREAS-Net) is a collaboration of four major research institutions in the upper Midwest: Iowa State University, the University of Iowa, the University of Minnesota and the University of Wisconsin-Madison. Regional Optical Network (RON) to service the advanced production and experimental network requirements of the research and education institutions in our region. Founded at about the same time as the NTNC, BOREAS-Net considers itself the eastern segment of the NTNC.
BENEFITS REALIZED

**BENEFIT:** The partnership between PNWGP and NTN asset holders in the current and intended fiber lease agreement remains the most efficient in achieving the best possible economy of scale. This benefit is due in large part to the cost effectiveness of implementing a solution for 100GbE upgrade by using existing wavelengths and hardware initially built by NTNC partners. As a primary route across the northern tier of states, critical services and resources are enabled to partners that would otherwise be unavailable. As an example, these paths are used extensively by Internet2, U.S. Department of Energy’s Energy Sciences Network (ESnet), the United States Geological Survey, Google, PNWGP, and the Corporation for Education Network Initiatives in California (CENIC).

**BENEFIT:** The cost of upgrades to the NTN segments on the PNWGP/ATT fiber resulting from the successfully amended lease agreement will be the responsibility of PNWGP and their vendor partner to complete. Upgrades will advance capacity across the span to a minimum of 100GbE, thereby improving data transfer speed, reducing latency and enhancing security for research data transfer.

**BENEFIT:** Upgrades will focus on key points of connectivity across the span in locations including Spokane, Bozeman, Fargo and Minneapolis. Once the upgrade is completed and coexistence of legacy and newly upgraded equipment is assured, the legacy 10GbE services will be disabled.

**BENEFIT:** Successful negotiation of the operating agreement will result in an annual cost savings of more than $130,000 for NTN-ND. Additional savings will be realized as legacy NTN-ND equipment is exchanged for updated equipment at the expense of the new lessee. NTN-ND will have the option to keep the equipment as spares if possible, or surplus the equipment removing the burden from NTN-ND to cover the cost of annual operations and maintenance, or replacement costs.

**BENEFIT:** Currently, multiple 10GbE circuits across the NTN provide layer two and three services, and institutions needing a single 100GbE capacity wave to ensure long-distance reach have begun exploring solutions to solve this issue, some of which could leave continuation of the 20-year IRU with its affordability and service flexibility in jeopardy. Enabling the upgrade of the existing network to 100GbE assures institutions that their growing need for capacity and data integrity will continue to be afforded by this infrastructure. This upgrade will ensure continuance of the long-term PNWGP lease which provides a direct path going west from Fargo and gives institutions and research centers access to primary and redundant R&E connectivity. Access to this path impacts not only North Dakota institutions, but also R&E partners in Idaho, Iowa, Michigan, Minnesota, Montana, Nebraska, Oregon, South Dakota, Washington and Wisconsin, who all depend on NTN-ND as an upper Midwest R&E crossroad, providing data transfer and network redundancy as part of the larger NTN and national R&E path.
BENEFIT: At the regional, national and international level, engagement in the global R&E community by UND and NDSU benefits higher education in North Dakota across several areas, including: impacting the ability of universities and colleges to retain and attract premier researchers, faculty and students; expanding opportunities for strategic partnerships with research laboratories worldwide; and strengthening the state’s ability to be engaged in discussions on visioning and planning for cyberinfrastructure in support of advanced technology initiatives occur at the regional and national levels.

BENEFIT: At the state level, benefits realized through membership in the Internet2 and R&E community result in immediate positive impact on the ability of the research institutions, and by association all public higher education including Tribal Colleges in the state, to respond to North Dakota’s new Envision 2030 and NexusND initiatives. Described in detail later in this report, the success of both initiatives is decidedly contingent on the agility, competitiveness and overall capability of higher education institutions to address each identified challenge and objective.

BENEFIT: Also critical, engagement in Internet2 and R&E community membership is a significant factor in the ability of the institutions to obtain research grants. Prime examples are evidenced by the National Science Foundation (NSF) where 78 percent of support for research and education programs in FY15 was to colleges, universities and academic consortia. Specifically, the NSF annually expends a significant portion of its funding on awards that are allocated for cyberinfrastructure where concentrated investment is on R&E infrastructure at the institution, campus or regional level. In addition to this is the volume of dollars now devoted to Big Data Initiatives. In each case, UND, NDSU, and NTN-ND have been recipients of awards from these programs. Awards are secured based in part upon the required connection to a regional R&E network infrastructure. Capacity at the institutional and state level alone does not guarantee adequate capacity beyond state boundaries, where a majority of contemporary university discovery and innovation occurs through global collaborations.
NTN-ND – CRITICAL TO NORTH DAKOTA’S VISION FOR THE FUTURE

ND’S ENVISION 2030 Efforts to anticipate the evolution of higher education in the state motivated the State Board of Higher Education and the North Dakota University System to host an educational summit in May 2016 to study this issue further. The executive summary of Envision 2030 highlights challenges and goals for higher education based on results of the summit’s breakout sessions on nine specific topics. While key ideas identified in each of the nine areas are all supported by the resources available from the global connections made possible through the national R&E community, the findings of the breakout session on technology were most noteworthy. In this discussion, key topics focused on unmanned aerial systems (UAS), cybersecurity and high-performance computing. All of these areas are critically dependent on the R&E network community to support innovation and expansion at the national and global level. Examples of current initiatives in UAS and high-performance computing in North Dakota are both described in the Use Cases section that follows.

NEXUSND The same three technology-based topics highlighted in Envision2030 also take center stage in NexusND, a new interdisciplinary research and education initiative for North Dakota’s institutions of postsecondary education. Led by North Dakota University System Chancellor Mark Hagerott, the goal of this initiative is to develop research, education, workforce training and economic development agendas highly attuned to developing North Dakota’s economy in three sustainable and high-growth sectors: unmanned aerial systems (UAS), cybersecurity and high-performance computing/big data.

As an example, included in the summary on Advanced Computing for NexusND, the emphasis on North Dakota’s ability to step up to current and future demands for research and workforce are clearly stated.

As described on the next page, in the 2017 Legislature Final Report, testimony presented by the North Dakota State University System on the value of North Dakota’s engagement in the national R&E community is critical. The ability of the Red River Valley to become a national nexus in industries across a wide spectrum of disciplines cannot happen in a vacuum. The interoperability and interconnectedness of the advanced R&E networks in the region, nation and world are dependent on a strong collegial and collaborative community, all of which NTN-ND has envisioned as it took its place at the table on these discussions over the last two decades.

Ultimately, NexusND is about creating immediately practical research and producing a workforce with the skills needed to develop the cybersecurity and high-performance computing/Big Data infrastructures that will make the Red River Valley the national nexus of the UAS, healthcare, energy, agriculture and other industries, leading to significant economic development.

MARK HAGEROTT, CHANCELLOR NORTH DAKOTA UNIVERSITY SYSTEM (2016)
MIDWEST BIG DATA HUB

The UND serves as one of the five founding institutions (the others being Iowa State University, Indiana University, University of Michigan and University of Illinois Urbana-Champaign) of the Midwest Big Data Hub (MBDH). As one of the four regional Big Data Innovation Hubs established through funding provided by the National Science Foundation, MBDH represents a diverse and committed network of partners to address increasing challenges in collecting, managing, serving, mining and analyzing rapidly growing and increasingly complex data and information collections to create actionable knowledge and guide decision-making. MBDH captures special opportunities, interests and resources unique to the Midwest. As part of this initiative, UND provides one of the five permanent members of the MBDH steering committee, and is a key partner in the creation and implementation of state and regional public/private partnerships.

Priority areas of interest for the MWBDH initiative include Society, Natural and Built Environments, Digital Agriculture, and Health Care and Biomedical Research. More specifically, big data topics critical to these priority areas that are highly dependent on a stable and robust advanced network infrastructure include the following:

- Data science, education and workforce development
- Data: methods, tools, cyberinfrastructure and services
- Data policy
- Unmanned systems, robotics and sensors

PRECISION AGRICULTURE – UNMANNED AERIAL SYSTEMS

Collaborative research projects between the Agriculture and Biosystems Engineering Department at NDSU and private sector partners involve collection, management and analyses of local producer’s crop digital data.

During the growing season, unmanned aerial systems regularly collect digital crop data in the form of high-resolution imagery, delivering real-time information to producers that can be used for strategic in-season and future years’ crop production decisions. The research has been presented at several state and national conferences, including the annual 2017 Internet2 Global Summit and Tech Exchange Conferences in April and October, 2017, respectively, initiating several new international partnerships.

2017 LEGISLATURE FINAL REPORT

CYBERSECURITY AND HIGH-PERFORMANCE COMPUTING

Testimony from a representative of the North Dakota University System indicated the management of data from UAS requires the creation of technology and patents, the control of the technology and cybersecurity, and the creation of policy and law. NexusND is intended to ensure the technological capabilities and workforce of the state are equipped to deal with UAS, cybersecurity and big data issues.

Testimony from a representative of UND indicated high-performance computing enhances the research activity of North Dakota universities. Establishing enhanced high-performance computing resources for the state has involved the establishment of the Northern Tier Network-North Dakota, a joint network effort between the Information Technology Department, North Dakota State University (NDSU), and the University of North Dakota (UND) to connect North Dakota to the nation’s research and education network in 2007.

High-performance computing supports storage, analysis and processing of data from UAS in a variety of contexts, including emergency search and rescue. Because some UAS have the capability to capture and send up to 500,000 images per day, high-performance computing data centers are necessary to handle that amount of data.
FY17 FINANCIAL REPORT

The annual budget for NTN-ND includes revenue acquired through state support, and reimbursements from the North Dakota University System and the state of South Dakota. Expenses are incurred across five categories: equipment, fiber, network operations center, Internet2 and NTNC dues, and other operating. Additional expenses for depreciation and capital refresh and replacement were not deducted for FY17 due to anticipated funding cuts in FY18.

Since completing the full build for this path in 2009, NTN-ND has remained fiscally healthy. No money is used to fund staff of NTN-ND partners ITD, UND or NDSU.

The FY17 report reflects a 4.05 percent budget reduction to the state's general fund as directed by the Governor in February of 2016. It is important to note that the 4.05 percent reduction for FY16 was posted to accounts in FY17. A mandate for an additional 2.5 percent cut to budgets in FY17 further reduced revenue to this fund. The total 6.55 percent reduction is reflected in FY17 revenue.

Going into the next biennium, the North Dakota University System has indicated that beginning with FY18, neither appropriated funds nor North Dakota University System reimbursements will be distributed to NTN-ND to cover annual costs for operations and maintenance. The reduction includes long-standing support from the university system designated for connectivity for all institutions in the system. This decision removes approximately 74 percent of NTN-ND revenue used to cover expenses for annual operations and maintenance, required depreciation and funds for capital refresh and replacement. Based on this information, NTN-ND partners agreed to withhold excess funds from FY17 operations and maintenance designated for depreciation and capital refresh and replacement in order to cover FY18 expenses and planned network upgrades.

For fiscal year 2017, remaining revenue that would have been allocated for depreciation and the cost of future equipment replacement will instead be used to cover FY18 annual operations and maintenance. NTN-ND partners anticipate that current fund balances will be adequate to cover the cost of operations and maintenance for FY18, including additional expenses incurred from planned network upgrades. Beyond 2018, NTN-ND will be challenged to defer funds toward depreciation and capital refresh and replacement.

A delay or abandonment of upgrades to North Dakota’s segment of the Northern Tier Network span that are critical to continued peering with adjoining networks in the region has the potential to create a bottleneck or a complete disconnect in the network. This scenario will obstruct access to R&E resources by institutions in North Dakota, as well as the research and education community across the partners of the NTNC.

Network upgrades by individual networks across the NTNC carry the expectation that collaboration with the neighboring NTN-ND will continue, ensuring redundancy and back-up paths to Internet2 connector locations. Similarly, NTN-ND holds the same expectation for others. The potential inability of any single state or network segment to provide the fiber, hardware and software capacity that ensures interoperability across the multiple networks results in gaps in service to the region and most critically, to the local institutions served by all members.

A variety of state, regional and national colleagues partner with NTN-ND to contribute to the collaborative environment where US research and education organizations solve common technology challenges and develop innovative solutions in support of their educational, research and community service missions.
NTN-ND ANNUAL EXPENDITURES OCCUR IN FIVE MAIN CATEGORIES:

- **Equipment**: Costs related to equipment acquisition and maintenance fees
- **Fiber**: Operations and maintenance fees on fiber, and rack and power required to house equipment in space provided by the vendor
- **Network Operations Center (NOC)**: Management of network equipment, including troubleshooting and response coordination for unplanned outages
- **Internet2/NTNC dues and participation fees**: Annual Internet2 participation and connectivity fees, NTNC membership dues, sponsored participant fees and costs for Internet2 to accept and route traffic to and from NTN-ND. Internet2 membership dues and fees continue to change as the organizational structure for Internet2 and their member community evolves to address the needs of current research and academics.
- **Other operating**: Includes travel expenses for NTN-related meetings by NTN-ND partners, insurance, minor supplies, printing and shipping costs. Beginning in FY18, NTN-ND partners will cover all of their own travel and per diem expenses relevant to R&E activities.
# NTN-ND Partners

<table>
<thead>
<tr>
<th>Partner</th>
<th>Website</th>
<th>Relationship</th>
</tr>
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<tbody>
<tr>
<td>Broadband Optical Research, Education and Sciences Network (BOREAS)</td>
<td>boreas.net</td>
<td>BOREAS is a Regional Optical Network (RON) providing services to the advanced production and experimental network requirements of the research and education institutions in this region. BOREAS is a collaboration of four major research institutions in the upper Midwest: Iowa State University, the University of Iowa, the University of Minnesota and the University of Wisconsin-Madison. BOREAS members are part of the NTNC.</td>
</tr>
<tr>
<td>Internet2</td>
<td><a href="http://www.internet2.edu">www.internet2.edu</a></td>
<td>The primary provider and operator of the nation’s research and education network</td>
</tr>
<tr>
<td>North Dakota Information Technology Department / Statewide Technology Access for Government and Education Network (STAGEnet)</td>
<td><a href="http://www.nd.gov/itd/">www.nd.gov/itd/</a> <a href="http://www.stagenet.nd.gov">www.stagenet.nd.gov</a></td>
<td>The statewide Wide Area Network provides gateway services to the public internet and to Internet2 for designated sites. STAGEnet is operated by the State Information Technology Department, which is one of three NTN-ND partners. ITD is a member of the NTNC.</td>
</tr>
<tr>
<td>North Dakota State University (NDSU)</td>
<td><a href="http://www.ndsu.edu">www.ndsu.edu</a></td>
<td>One of three NTN-ND partners that, along with the University of North Dakota, has been an Internet2 member for North Dakota since 1996. Together NDSU and UND provide Internet2 sponsorship for the other nine North Dakota University System institutions, the ND Tribal Colleges and the public K-12 schools. NDSU is a member of the NTNC.</td>
</tr>
<tr>
<td>Northern Lights Gigapop, University of Minnesota</td>
<td><a href="http://www.northernlights.gigapop.net">www.northernlights.gigapop.net</a> <a href="http://www.umn.edu">www.umn.edu</a></td>
<td>Connects NTN-ND to Internet2. The University of Minnesota is a member of the NTNC.</td>
</tr>
<tr>
<td>Northern Tier Network Consortium (NTNC)</td>
<td><a href="http://www.ntnc.org">www.ntnc.org</a></td>
<td>The NTNC consists of member states that represent the collective interests of their institutions in activities related to networking and network infrastructure.</td>
</tr>
<tr>
<td>Pacific Northwest Gigapop (PNWGP)</td>
<td><a href="http://www.pnwgp.net">www.pnwgp.net</a></td>
<td>Interconnect hub in Seattle, Wash., providing connections between the Northern Wave and other national and international R&amp;E networks. PNWGP and the state of Washington are members of the NTNC.</td>
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<tr>
<td>PARTNER</td>
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<td>RELATIONSHIP</td>
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<tr>
<td>South Dakota High Speed Research, Education and Economic Development Network (SD REED) / South Dakota Board of Regents</td>
<td><a href="http://www.sdstate.edu/information-technology/university-networking-and-research-computing">www.sdstate.edu/information-technology/university-networking-and-research-computing</a> <a href="http://www.sdbor.edu">www.sdbor.edu</a></td>
<td>Provides high-speed connectivity for six South Dakota public universities to Internet2 and regional networks and inter-connect sites including the NTN, GPN, the Northern Lights Gigapop and ESnet. Several institutions and research centers in the state are members of the NTNC.</td>
</tr>
<tr>
<td>University of Montana / Montana State University</td>
<td><a href="http://www.umt.edu">www.umt.edu</a> <a href="http://www.montana.edu">www.montana.edu</a></td>
<td>Partners in the NTN, the University of Montana became an Internet2 Network connector site in 2015, connecting to the Internet2 network with a 100G fiber connection in Missoula and manages operations of the NTN segment for Montana. UMT connects a portion of Montana’s higher education institutions and tribal colleges, as well as the U.S. Forest Service. Both universities are members of the NTNC.</td>
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<tr>
<td>University of North Dakota (UND)</td>
<td><a href="http://www.und.edu">www.und.edu</a></td>
<td>One of three NTN-ND partners that, along with NDSU, has been an Internet2 member for North Dakota since 1996. Together UND and NDSU provide Internet2 sponsorship for the other nine NDUS institutions, the ND Tribal Colleges and the public K-12 schools. Member of the NTNC. UND is a member of NTNC.</td>
</tr>
<tr>
<td>University of Wisconsin, Madison</td>
<td><a href="http://www.wisc.edu">www.wisc.edu</a></td>
<td>Provides network operations center (NOC) services for NTN-ND and is a member of the NTNC.</td>
</tr>
</tbody>
</table>

REFERENCES/ CITATIONS
**NTN-ND FOUNDATIONS**

**PIONEERING THE INTERNET IN NORTH DAKOTA**

A history of North Dakota's dedication to supporting its campuses in their efforts to ensure advanced and stable connectivity among institutions in the state, as well as connections across the country and around the world is evidenced by a consistent vision and actions toward these purposes across almost five decades.

**1970s through 1999**

Dedicated technology support for North Dakota's 11 higher education campuses claims its beginnings in a 1969-1970 interim legislative study. The North Dakota Higher Education Computer Network (HECN) was funded at three institutions and later extended to all institutions of higher education under the State Board of Higher Education (ND Information Technology Legislative Interim Report 1999). This served to establish a host site for administrative computing at the University of North Dakota in Grand Forks, and a host site for academic computing at North Dakota State University in Fargo. Initial responsibilities for these host sites focused on providing mainframe computing and networking for all of the higher education campuses, the North Dakota University System Chancellor's Office, as well as distributed organizations associated with UND and NDSU, including Medical Center Rehabilitation Hospital, NDSU Extension Service, and North Dakota Agricultural Experiment Station (GFA Strategic Plan, 1996, p. 10).

In those early years HECN furnished connection to the statewide network, and in turn, the Internet and World Wide Web (WWW) using T-1 connections of 1.5Mbps. Communication from the statewide network to the campus router was furnished by HECN via the North Dakota Information Network (NDIN). HECN paid for the networking bill for the statewide backbone. This was shared 50-50 between UND and NDSU. The two institutions had joint responsibility for HECN network services (GFA Strategic Plan, 1996, p. 18).

The fiscal year of 1985-1986 will be remembered as the year the HECN joined BITNET. Predecessor to the Internet, BITNET provided electronic transfer of files, mail and messages. The link to BITNET became a reality when a leased line was installed between Fargo and St. Paul, Minn., the nearest BITNET site. BITNET served as a national network of over 500 computers at more than 200 Universities throughout the nation. Through interconnections with other networks, described as ‘bridges’ at that time, it enabled North Dakota campuses to link to other networks in Canada, Europe, and the far east. (1985-1986 NDSU University Computer Center Annual Report, p. 7).

By 1988, the link to Northwest Net (NWNET) was complete and North Dakota was added to the list of charter members of this new consortium. NWNET was a regional data communications network that was developed by a consortium of six states in the upper northwest United States, including Alaska, Washington, Oregon, Idaho, Montana and North Dakota. The purpose of NWNET was to provide advanced scientific computing resources to its membership and other research interests in the region, facilitating better communication between universities and developing a synergy for issues such as supercomputing access and support. NWNET served as North Dakota's first connection to the young Internet and to the National Science Foundation's network, NSFNet. It was the hope of these early network pioneers that NWNET would contribute to the advancement of science and economic development of the region. Representatives from North Dakota’s State Board of Higher Education, NDSU and UND served on several NWNET operational committees. Continued upgrades to campus computing infrastructure combined with the establishment of a communications link to NWNET substantially increased local and remote facilities available to HECN users, opening the door for HECN to strengthen its commitment to supercomputing. (1987-1988 NDSU University Computer Center Annual Report, pp. 6, 8; 1993-1995 NDSU Computer Center Strategic Plan, p. 8)

By 1991 NODAKnet was reporting significant growth in number of network connections, rating consistently as one of the top 100 (of 3,000) networks on the NSFNET in terms of number of packets sent to the Internet (1990-1991 NDSU University Computer Center Annual Report, p. 15).

HECN Biennial Budgets consistently included funding requests for network upgrades and HECN dedicated staff at NDSU and UND, both of whom served as HECN host sites for North Dakota Network. The budgets also provide evidence of continued state support for membership and network participation activities with NWNET, as indicated in the budget numbers requested for the host sites. (North Dakota Higher Education Computer Network Biennial Budgets).
Continuing through the 1990s, efforts continued to support the growing needs of individual universities and the university system as a whole. A strategic plan for the North Dakota Higher Education Computer Network was completed in 1996 and provided recommendations for a model that would focus on highly reliable services based on networked resources available to all students, faculty, staff, and management for all the campuses (GFA Strategic Plan, 1996). The strategic plan also served as a framework for development of a technology plan required by HB 1034 passed in the 55th Regular Legislative Session in 1997. Also in 1996, NDSU and UND joined the new Internet2 national research and education network. Notification was received that NDSU would become part of the Great Plains Network, a six-state consortium that received NSF/EPSCoR funds to install a high-speed network for its educational and research community. This further supported the momentum for NDSU to install a high-performance computing facility.

REFERENCES:
North Dakota Fifty-fifth Legislative Assembly, State of North Dakota, begun in the Capitol in the City of Bismarck, on Monday, the sixth day of January, one thousand nine hundred and ninety-seven, House Bill NO. 1034. Retrieved online www.legis.nd.gov/assembly/55-1997/bill-text/HACH0800.pdf
## History of Funding and Responsibilities

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NTN-ND STATUS</th>
<th>FUNDS AND FUNDING SOURCE</th>
<th>PRIMARY USE OF FUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>The completion of the state’s new statewide network provided faster Internet connectivity and bandwidth. In addition, the Internet2 / Abilene traffic for NDSU and UND had a dedicated 45 Mbps DS3 link to the Northern Lights gigaPOP Abilene connector at the University of Minnesota. HECN staff at NDSU continually monitored network performance and traffic patterns both within North Dakota and with the Great Plains Network, commodity Internet and Internet2. (NDSU IT annual report 2000-2001. Online: <a href="http://www.ndsu.edu/fileadmin/45">www.ndsu.edu/fileadmin/45</a> Mbps DS3 link to the Northern Lights gigapop Abilene connector at the University of Minnesota. HECN staff at NDSU continually monitored network performance and traffic patterns both within North Dakota and with the Great Plains Network, commodity Internet and Internet2. (NDSU IT annual report 2000-2001. Online: <a href="http://www.ndsu.edu/fileadmin/www.its.ndsu.edu/mpd/annual_reports/ITSAnnualReportFY2000-2001.pdf">www.ndsu.edu/fileadmin/www.its.ndsu.edu/mpd/annual_reports/ITSAnnualReportFY2000-2001.pdf</a>)</td>
<td>Partnership formed among seven states to explore the potential of building a robust research network connection for institutions and federal research laboratories in the upper northwest.</td>
<td>Source: Northern Tier Network-North Dakota Annual Report (2009). Published by NTN-ND by the North Dakota State University Information Technology Division.</td>
</tr>
<tr>
<td>2003</td>
<td>Northern Tier Network Consortium is created.</td>
<td>$200,000 one-time Funding source: National Science Foundation Planning grant obtained by North Dakota, South Dakota, Montana and Idaho.</td>
<td>Funded a consultant to develop a network engineering plan that provided the basis for the NTN footprint across the four states.</td>
</tr>
<tr>
<td>2006</td>
<td>Build</td>
<td>$2.773,800 one-time appropriation Funding source: ND Permanent Oil Tax Trust Fund for the Common information services pool of the Higher Education budget.</td>
<td>Remainder of funds needed to cover initial build and start-up costs. Funding was used to complete and begin operations of the segments from Montana to Minneapolis, Minnesota, and from Fargo to Grand Forks.</td>
</tr>
<tr>
<td>2007</td>
<td>Build</td>
<td>$751,244 Funding source: National Science Foundation: American Recovery and Reinvestment Act 2009</td>
<td>The State Information Technology Department (ITD), NDSU and UND partner in an effort to formalize management of this joint project. NDSU serves as fiscal agent and primary contact, supervising operations and management.</td>
</tr>
<tr>
<td>2008</td>
<td>NTN-ND partnership formed</td>
<td>Carroyer funds ($1,000,000) from the 2007-2009 appropriation for the North Dakota University System base funding budget are used to cover operations and maintenance expenses for the first year of the 2009-2011 biennium. NTN-ND partners plan to pursue federal stimulus funding to complete planned north/south routes to South Dakota and Canada.</td>
<td>Expenses for annual operations and maintenance begin. Remaining carry over funds from 2007-2009 biennium intended for completing the build north/south are retained and used to cover annual operating expenses. No funds are allotted to depreciation of capital repair and replacement until the end of FY12.</td>
</tr>
<tr>
<td>2009</td>
<td>NTN-ND goes live April 2009</td>
<td>NTN-ND pursues federal Stimulus funding. Grants are implemented in FY2011. Completes planned connection to South Dakota and the Northern Wave. Plans to complete a connection to Canada are placed on hold due to a delay in available funding for the Canada segment.</td>
<td>NDSU sponsors NSF funded grant award to link North Dakota and South Dakota’s NTN segments (NTN-ND and NTN-SD). Grant project completes connection of South Dakota network to the Northern Tier Network in Fargo.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NTN-ND STATUS</th>
<th>FUNDS AND FUNDING SOURCE</th>
<th>PRIMARY USE OF FUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-2016</td>
<td>NTN-ND in full operation</td>
<td>$935,000/per year</td>
<td>Annual operations and maintenance, depreciation and capital refresh and replacement.</td>
</tr>
<tr>
<td>2017</td>
<td>NTN-ND in full operation</td>
<td>$935,000</td>
<td>Annual operations and maintenance. Funds designated for capital reserves at the end of FY17 were withheld in order to cover FY18 operations and maintenance. No capital reserves or depreciation funds transferred (see details below).</td>
</tr>
<tr>
<td>2018</td>
<td>NTN-ND in full operation</td>
<td>State appropriated funding is withdrawn. NTN-ND partners undertake alternative options for maintaining current funding levels in order to maintain annual operations and maintenance.</td>
<td>Per the North Dakota University System, neither appropriated funds or North Dakota University System reimbursements will be used to cover annual costs or operations and maintenance. Based on this decision, NTN-ND partners agreed to withhold funds from the FY17 budget designated for depreciation and capital refresh and replacement in order to cover annual operations in FY18. Source: • North Dakota Legislature Session Laws Online <a href="http://www.legis.nd.gov/assembly/65-2017/session-laws/documents/APPRO.pdf#CHAPTER28">www.legis.nd.gov/assembly/65-2017/session-laws/documents/APPRO.pdf#CHAPTER28</a> • Final Legislative Budget State Budget Actions; June 2017; North Dakota University System Office / Budget No. 215 / Senate Bill Nos. 2003 and 2244 / 2017-2019 legislative appropriations. Online <a href="http://www.legis.nd.gov/files/fiscal/2017-19/docs/215.pdf">www.legis.nd.gov/files/fiscal/2017-19/docs/215.pdf</a> p. F-17 • Per verbal and email communication between North Dakota State University Vice President for Information Technology Marc Wallman and North Dakota University System Chief of Staff Lisa Feldner, dated June 16, 2017. At the time of this report, NTN-ND partners are exploring available options for self-funding operations and maintenance going forward, in addition to leveraging partnerships with neighboring networks to complete necessary upgrades.</td>
</tr>
</tbody>
</table>
NTN-ND HISTORY OF LEGISLATIVE ACTION AND CENTURY CODE

Anticipated annual costs projected at the time of project completion were projected to be $1M per year. During the 2007-2009 biennium and the initial years of full operation, NTN-ND partners agreed not to set aside funds for budgeted hardware replacement so early operations and maintenance costs would be covered. During the 2009 Legislative session, it was apparent that NTN-ND was not going to receive ongoing funds, NTN-ND partners decided to use capital reserves to pay ongoing operating costs. To preserve additional funds for ongoing operations, NTN-ND pursued external grant funding in order to complete additional routes north and south to connect to Canada’s network, Canadian Network for the Advancement of Research, Industry and Education (CANARIE), and to the South Dakota’s Research, Education & Economic Development (REED) network. As a result of NTN-ND expansion achieved through grant awards in 2010, the North Dakota University System revised its 2011-2013 budget request for NTN-ND operations from $1,691,399 to $1,572,200. (Source: ND Legislative Management Final Report 2011. Online www.legis.nd.gov/files/resource/61-2009/legislative-management-final-reports/2011finalreport.pdf)

The 62nd Legislative Assembly for the State of North Dakota convened in 2011 and passed Senate Concurrent Resolution No. 4003 in support of the Northern Tier Network Technology Initiative, its private enterprise partners and the related activities of the Legislative Management’s interim Information Technology Committee. Funds for annual operations and maintenance are appropriated beginning with FY12 as part of the North Dakota University System’s System information technology services budget. As a result, funds for both depreciation and capital refresh and replacement were instituted beginning in FY12 and continued through FY16.

At the close of the 2017 Legislative session, the NTN-ND partners were informed by the NDUS that neither appropriated funds nor North Dakota University System reimbursements will be used to cover annual costs or operations and maintenance. This information was received via verbal and email communication between North Dakota State University Vice President for Information Technology Marc Wallman and North Dakota University System Chief of Staff Lisa Feldner, dated June 16, 2017. As a result, NTN-ND partners agreed that no capital reserves or depreciation funds would be set aside at the end of FY17 in order to ensure those funds could be used to cover annual operations and maintenance for FY18. (Source: Analysis of 2017-19 Executive Budget. Supplement to the Report of the Legislative Management Budget Section. 65th Legislative Assembly. January 2017. Online www.legis.nd.gov/files/fiscal/2017-19/docs/2017-19%20executive%20budget%20analysis%20book.pdf)

RELATIONSHIP BETWEEN STAGENET AND NTN-ND

In its first comprehensive report to the Legislature in 2009, the relationship between STAGEnet and NTN-ND was clarified. www.ndsu.edu/fileadmin/vpit.ndsu.edu/NTN/2009Jan-NTN-ND-Booklet-webversion.pdf

Upon completion of the network, NTN-ND is a backbone only network. It does not and will not provide connectivity beyond the points-of-presence (POP) at designated sites across North Dakota. When fully operational, NTN-ND took the place of the North Dakota University System’s current Internet2 transport link. This link with connectivity from Fargo to Minneapolis had been in place since 2000. Prior to that, Internet2 research transport was accommodated by the Great Plains Network with a link from Fargo to Kansas City (1997-2000). Institutions not directly connected to a NTN-ND POP, such as the remaining North Dakota University System institutions, now would need to have their Internet2-bound data – destined for out-of-state locations – transported over STAGEnet to the nearest NTN-ND POP.

North Dakota Century Code
Chapter 15-10
The State Board of Higher Education
Available online www.legis.nd.gov/cencode/t15c10.pdf

§ 15-10-45 Telecommunications and information services competition prohibited.
1. The northern tier network, part of a national research network infrastructure, serves entities within and outside this state. The North Dakota university system may use the northern tier network infrastructure only for the purpose of supporting the research and education missions of the North Dakota university system. The North Dakota university system may not use the northern tier network infrastructure for traditional internet, voice, video or other telecommunications services beyond those required for research networks.
2. The North Dakota university system or any entity associated with the university system may not resell any portion of the northern tier network infrastructure to non-university entities other than research collaborators.
3. The northern tier network may not replace any wide area network services to any city, county or school district which are provided by the information technology department under section 54-59-08.

North Dakota Century Code
Chapter 54-98
Information Technology Department
Available online www.legis.nd.gov/cencode/t54c98.pdf

§ 54-98-05 Powers and duties of department. The department:
13. May provide wide area network services to a state agency, city, county, school district or other political subdivision of this state. The information technology department may not provide wide area network service to any private, charitable or nonprofit entity except the information technology department may continue to provide the wide area network service the department provided to the private, charitable and nonprofit entities receiving services from the department on January 1, 2003.
14. Shall assure proper measures for security, firewalls and Internet protocol addressing at the state’s interface with other facilities.
15. Notwithstanding subsection 13, may provide wide area network services for a period not to exceed four years to an occupant of a technology park associated with an institution of higher education or to a business located in a business incubator associated with an institution of higher education.
§ 54-59-08. Required use of wide area network services.
Each state agency and institution that desires access to wide area network services and each county, city and school district that desires access to wide area network services to transmit voice, data or video outside that county, city or school district shall obtain those services from the department. The chief information officer may exempt from the application of this section a county, city or school district that demonstrates its current wide area network services are more cost-effective for or more appropriate for the specific needs of that county, city or school district than wide area network services available from the department.

Sixtieth Legislative Assembly of North Dakota (2007)
In Regular Session Commencing Wednesday, January 3, 2007
House Bill No. 1003
(Appropriations Committee)
(At the request of the Governor)

SECTION 19. ONE-TIME FUNDING - EFFECT ON BASE BUDGET - REPORT TO SIXTY-FIRST LEGISLATIVE ASSEMBLY.
The grand total appropriation in section 3 of this Act includes $28,382,068 from the general fund and $7,583,315 from the permanent oil tax trust fund for one-time funding items identified in this section. This amount is not part of the institutions' base budgets to be used in preparing the 2009-2011 executive budget. The North Dakota university system shall report to the appropriations committees of the sixty-first legislative assembly on the use of this one-time funding for the biennium beginning July 1, 2007, and ending June 30, 2009.

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern tier network infrastructure from permanent oil tax trust fund</td>
<td>$2,773,800</td>
</tr>
<tr>
<td>ConnectND system support</td>
<td>$2,300,000</td>
</tr>
<tr>
<td>Common information system pool parity funding</td>
<td>$420,000</td>
</tr>
<tr>
<td>Deferred maintenance</td>
<td>$10,893,033</td>
</tr>
<tr>
<td>Capital projects</td>
<td>$13,808,235</td>
</tr>
<tr>
<td>Capital projects from permanent oil tax trust fund</td>
<td>$4,809,515</td>
</tr>
<tr>
<td>Campus initiatives</td>
<td>$960,800</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$35,965,383</strong></td>
</tr>
</tbody>
</table>

SECTION 21. LEGISLATIVE INTENT - NORTHERN TIER NETWORK.
It is the intent of the sixtieth legislative assembly that higher education institutions utilizing the northern tier network be responsible for funding the related ongoing maintenance costs for the network.

Sixty-second Legislative Assembly of North Dakota (2011)
2011 North Dakota Legislative Management Bill and Resolution Summaries

Senate Concurrent Resolution No. 4003 - Northern Tier Network Technology Initiative. This concurrent resolution supports the Northern Tier Network Technology Initiative and the related activities of the Legislative Management’s Information Technology Committee. (Workforce Committee).

Sixty-fifth Legislative Assembly of North Dakota (2017)
Enrolled Senate Bill No. 2003 – Sixty-fifth Legislative Assembly of North Dakota – LC Number 17.0511.06000

SECTION 33. RESEARCH NETWORKS - REPORT TO THE LEGISLATIVE MANAGEMENT.
During the biennium beginning July 1, 2017, and ending June 30, 2019, the state board of higher education, in association with the research institutions under its control, shall consider opportunities for collaboration on high-performance computing, data analytics, and connectivity to Minnesota research networks to improve access, increase capacity, and create efficiencies. The board may utilize appropriations and reserves designated for the northern tier network to accommodate continued use of existing research networks and to expand network capabilities. The board shall consider developing policies and procedures to authorize private entities to utilize the research network. During the 2017-18 interim, the state board of higher education shall provide a report to the legislative management regarding the status of efforts to collaborate with Minnesota entities for research network purposes.

Sixty-fifth Legislative Assembly State Budget Actions for the 2017-2019 Biennium Including Supplemental and Statistical Information
Regarding the State Budget. Prepared by the Legislative Council, State Capitol, Bismarck, North Dakota June 2017.

Research networks – Section 33 provides for the State Board of Higher Education to consider collaborating with Minnesota to improve research network access and performance.