North Dakota State University
Upper Great Plains Transportation Institute
Agency 627
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2019-2021 Biennial Budget Request

Presented to:
The Education and Environment Division
of the House Appropriations Committee

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INTRODUCTION

Greetings, Chairman Monson and members of the Education and Environment Division of the House Appropriations Committee. My name is Denver Tolliver. I am the director of North Dakota State University's Upper Great Plains Transportation Institute (UGPTI). Thank you for the opportunity to present UGPTI's 2019-2021 budget requests to you today. In Legislative Council's letter (dated December 19, 2018), Chairman Delzer asked me to discuss the following items:

- Any financial audit findings related to the Upper Great Plains Transportation Institute
- The major components making up the "base level" amounts of UGPTI's budget
- A list of proposed budget reductions identified to meet the Governor's 95% budget request guideline
- 2019-21 budget changes recommended by the Governor to the "base level" identifying each increase or decrease with explanations or justifications for each change
- Any known or potential changes in the level of federal funding to be received by UGPTI and how the agency plans to address these changes

The Upper Great Plains Transportation Institute is not the subject of a financial audit and I have nothing to report in this regard. Instead, I will focus my presentation on the remaining items requested by Chairman Delzer. In addition, I would like to introduce two budget requests recommended by the Upper Great Plains Transportation Institute's Advisory Council and the State Board of Higher Education. In addition to this narrative, I will be using slides during my presentation to make effective use of time. The slides will follow the narrative directly.

2017-2019 BASE LEVEL BUDGET

The Upper Great Plains Transportation Institute's base level budget is shown in Table 1, by funding source. These values represent UGPTI's current appropriations for the 2017-2019 biennium, minus carry over funds and one-time funding.

Table 1. UGPTI's 2017-2019 Base Level Budget: By Funding Source

Line	Item	Amount	Percentage
1.	General funds	$3,443,174	15.5%
2.	Special funds	$6,338,850	28.5%
3.	Federal funds	$12,478,218	56.0%
4.	All funding sources	$22,260,242	100.0%

GENERAL FUND COMPONENT

All of UGPTI's general funds are used for research, technology transfer, training, technical assistance, and other purposes directly related to the agency's mission. These activities comprise UGPTI's *Core Program*. UGPTI's general fund budget is distinct from NDSU's. The agencies' funds are not co-mingled.

Critical Agency Objectives

UGPTI's research, training, and technical assistance activities that comprise its Core Program provide timely and essential information to state agencies, shippers, businesses, counties, townships, cities, and tribal governments. Some of the agency's leading objectives are to:[1]

- Support urban planning by offering expertise in: a) traffic analysis software (e.g., traffic signal optimization and simulation), b) metropolitan travel demand modeling, and c) automation of traffic data collection
- Improve mobility by providing transit stakeholders, users, providers, suppliers, and agencies with the information and human resources needed to deliver cost-effective services in rural areas and small urban centers
- Enhance the competitiveness of North Dakota producers and businesses through freight transportation, supply chain, and logistics research
- Improve transportation infrastructure management through statewide models of economic production, truck traffic, road/bridge investment analysis, and asset management
- Support Vison Zero through an improved understanding of safety risks and mitigation strategies for rural areas and tribal communities, and through motor carrier safety research
- Enable the transfer of technology and information to state, local, and tribal units of government through technical assistance, training, and workforce development
- Facilitate the deployment of Intelligent Transportation Systems that use sensors, automated controls, and integrated communication systems to inform travelers and improve highway safety and efficiency

Importance of General Funds

Although state general funds comprise a minor percentage of UGPTI's overall budget, they are vital to the agency's success and sustainability. State funds are needed to match federal grants and provide continuity in times of delay or disruption in federal funding. Most federal grants require matching funds, which must consist entirely of non-federal funds or state planning and research dollars. Many of UGPTI's direct grants (such as the University Transportation Center grant) require a 100% match. UGPTI's general funds are the only dependable source of match for these grants.

SPECIAL FUND COMPONENT

Special funds include grants and contracts from state and local agencies and private industry. Most of UGPTI's special funds originate from the North Dakota Department of Transportation (NDDOT) under a strategic agency partnership that has benefited North Dakota for the last four decades. In addition to NDDOT funding, an annual grant from the Wheat Commission has allowed UGPTI to continuously track and report on grain shipments exported from the state over time.

Several of North Dakota's Metropolitan Planning Organizations (MPOs) provide regular (although not necessarily annual) funding to UGPTI for travel demand modeling and technical assistance in urban transportation planning. The remainder of UGPTI's special funds consist of one-time funding from commodity groups, the South Dakota Department of Public Health (for safety studies), the

[1] The objectives are not prioritized.

Montana Department of Transportation, the Minnesota Department of Transportation, and counties in Minnesota.

While UGPTI receives funds from these organizations to cover the costs of specific studies, UGPTI does not assess fees or operate facilities that generate revenue on a continuous basis. The only fees assessed by UGPTI are those charged for short courses and workshops, which are only intended to reimburse the costs of these events.

FEDERAL FUNDS

More than half of UGPTI's funding comes from federal grants and contracts. The vast majority originates from the U.S. Department of Transportation (U.S. DOT), including grants from the Office of the Secretary, Federal Highway Administration, Federal Transit Administration, Federal Motor Carrier Safety Administration, and the National Highway Traffic and Safety Administration. Some grants (such as the University Transportation Center grant) are provided directly to UGPTI by federal agencies. In other cases, the funds are "federal source funds" provided by third parties through the federal procurement process.

In addition to the U.S. DOT, the U.S. Department of Agriculture provides UGPTI with regular funding for transportation and market reports (typically less than $50,000 per contract). Periodically, UGPTI receives grants from the U.S. Army Corps of Engineers. However, Corps of Engineers grants are infrequent and less than $100,000 per award. From a federal funding perspective, UGPTI is almost entirely dependent upon the U.S. Department of Transportation.

Although federal funds are important to UGPTI's budget, they have pre-determined uses. Federal funds must be used to analyze national priorities. They cannot be refocused on state and local issues. Ultimately, UGPTI has limited discretion in determining which critical issues are researched with federal funds, as these objectives are prescribed in law. Federal research funds are not a substitute for state research dollars.

BUDGET UNCERTAINTIES

The Legislature's special and federal funds appropriations enable UGPTI to collect grants and contracts up to the amounts shown in Table 1. These values represent the agency's best projections of the authority needed to procure all funds that may become available during the biennium. These forecasts reflect historic grant levels, applications in progress, and anticipated RFPs.

Most grants are competitive in nature and subject to the budget constraints of the sponsoring agencies. Therefore, UGPTI's federal and special funds appropriations reflect a range of uncertainties. The only hard dollars in UGPTI's budget are the state general funds. Federal and special funds are provided at the discretion of intermediate agencies and are subject to the budget limits experienced by those agencies.

2019-2021 EXECUTIVE RECOMMENDATION

GENERAL FUND RECOMMENDATION

As shown in Line 1 of Table 2, UGPTI's general fund appropriation for the 2017-2019 biennium

(exclusive of carry over funds) was $3,543,174. However, this total included $100,000 of one-time funds provided by the Legislature for road asset management. The removal of these funds results in the base budget of $3,443,174 shown in Line 1 of Table 1 and Line 3 of Table 2.

Table 2. Executive Recommendation for UGPTI's 2019-2021 General Fund Appropriation		
Line	**Item**	**Amount**
1.	General fund appropriation 2017-2019	$3,543,174
2.	One-time (asset management) funds	($100,000)
3.	Base level general fund appropriation (Line 1, Table 1)	$3,443,174
4.	5% reduction under budget limit guidelines	($172,159)
5.	Adjusted budget base	$3,271,015
6.	Compensation package	$193,185
7.	2019-21 Executive Recommendation	$3,464,200

The Executive Recommendation calls for a 5% reduction in general funds (Line 4, Table 2). If implemented, this cut would reduce UGPTI's base level appropriation to $3,271,015 (Line 5, Table 2). As discussed later, the State Board of Higher Education (SBHE) recommended the restoration of this cut. However, the Governor declined UGPTI's request to restore the funds. The addition of the compensation package envisioned by the Governor (shown in Line 6 of Table 2) brings his final Executive Recommendation to $3,464,200 (Line 7).

SPECIAL FUNDS RECOMMENDATION

As shown in Table 3, UGPTI's 2017-2019 special funds appropriation was $6,338,850. However, this total included $200,000 of special fund authority to allow UGPTI to collect non-state funds to match the $100,000 of general funds provided by the Legislature for the asset management program (Table 2). The removal of this one-time appropriation leaves the adjusted special funds base of $6,138,850 shown in Line 3 of Table 3.

Table 3. Executive Recommendation for UGPTI's 2019-2021 Special Funds Appropriation		
Line	**Item**	**Amount**
1.	2017-2019 appropriation	$6,338,850
2.	Removal of one-time appropriation	($200,000)
3.	Special funds base level	$6,138,850
4.	10% reduction in special funds appropriation	($613,885)
5.	Adjusted base level: special funds appropriation	$5,524,965
6.	Restoration of 10% cut	$6,138,850
7.	Compensation package	$32,752
8.	2019-2021 Executive Recommendation	$6,171,602

The Governor's guidelines originally called for a 10% cut to the base level shown in Line 3 of Table 3, which would have reduced UGPTI's special funds appropriation to $5,524,965 (Line 5, Table 3). However, UGPTI requested the restoration of this cut and the Governor has agreed to restore it (Line 6, Table 3). After adding the portion of the Governor's compensation package that would be reimbursed from special funds (Line 7, Table 3), his final recommendation for UGPTI's special funds appropriation for the 2019-2021 biennium comes to $6,171,602 (Line 8, Table 3).

FEDERAL FUNDS RECOMMENDATION

The only recommended change to UGPTI's federal funds appropriation from the base level shown in Table 1 is the portion of the compensation package to be reimbursed from federal funds (Line 2, Table 4). This adjustment brings the Governor's recommended appropriation for UGPTI's federal funds to $12,785,620 for the 2019-2021 biennium (Line 3, Table 4).

Table 4. Executive Recommendation for UGPTI's 2019-2021 Federal Funds Appropriation

Line	Item	Amount
1.	2017-2019 appropriation	$12,478,218
2.	Compensation package	$307,402
3.	2019-2021 Executive Recommendation	$12,785,620

The Executive Recommendation is summarized by funding source in Table 5. As a point of reference, UGPTI's adjusted base level appropriation heading into the 2017 legislative session was $3,900,791. UGPTI started the 2015-2017 biennium with a general fund budget of $4,847,099.

Table 5. Executive Recommendation for UGPTI's 2019-2021 Appropriations: By Funding Source

Line	Item	Amount
1.	General funds	$3,464,200
2.	Special funds	$6,171,602
3.	Federal funds	$12,785,620
4.	All funding sources	$22,421,422

STATE BOARD OF HIGHER EDUCATION RECOMMENDATION

Table 6 shows UGPTI's general fund budget recommendation as approved by the State Board of Higher Education in the summer of 2018. The State Board's recommendation agrees with that of UGPTI's Advisory Council, which was adopted in the spring of 2018. In the SBHE's recommendation, the 5% reduction in funding called for in the Governor's budget is restored. Consequently, UGPTI's starting base budget is $3,443,174 (Line 3, Table 6).

Table 6. General Fund Budget Recommendation from the State Board of Higher Education and UGPTI's Advisory Council		
Line	**Item**	**Amount**
1.	Adjusted budget base from Table 2	$3,271,015
2.	Restoration of 5% cut shown in Table 2	$172,159
3.	Base budget recommendation	$3,443,174
	Optional requests	
4.	County road & bridge planning center	$975,000
5.	Transformative technologies program	$500,000
6.	Total budget request	$4,918,174

RESTORATION OF 5% CUT IN EXECUTIVE RECOMMENDATION

If implemented, the 5% cut called for in the Executive Recommendation would erode UGPTI's ability to meet the demands of state and local agencies. UGPTI receives many requests for research and technical assistance from agencies that do not have funds in their budgets to provide contracts. In fact, much of UGPTI's rail and freight analysis is supported by general funds. The restoration of these funds to UGPTI's base budget would allow UGPTI to work with the Public Service Commission and Federal Railroad Administration on railroad safety, a critical issue in the state. With the restored funds, UGPTI could develop an annual railroad traffic report featuring major commodities imported to and exported from the state—which would be useful to state agencies, as well as to business and industry groups. In addition, critical software upgrades can be purchased and federal grants matched. For these reasons, UGPTI is requesting that the Education and Environment Division set the agency's base general fund budget at its current level from the 2017-2019 biennium, minus carry over funds and one-time funding (i.e., $3,443,174).

OPTIONAL REQUESTS

In addition to restoring the 5% cut called for in the Executive Recommendation, UGPTI is requesting the consideration of two proposals of great importance to the state. The first is a request for $975,000 for a county road and bridge planning center (Line 4, Table 6), which is needed to support commerce and mobility throughout the state. The second request is for $500,000 in base funding to establish a research program in transformative technologies that will focus on the deployment and impacts of vehicle automation and the utilization of real-time information systems in transportation planning. The two requests are described next.

COUNTY ROAD AND BRIDGE PLANNING CENTER

Movements from farms to initial storage or transfer facilities depend on county and township roads. Much of the crude oil produced in western North Dakota moves from wells to pipeline and rail transfer facilities by truck. Similarly, most of the inputs needed for oil production are delivered by

truck to remote production sites located off the state highway system. County and township roads are heavily utilized in many areas of the state and are essential to the state's rural economy.

Biennial Road and Bridge Investment Needs and Condition Report

In 2012, 2014, and 2016 the Upper Great Plains Transportation Institute provided the Legislature with reports of needed investments in county, township, and tribal roads. These studies were financed with one-time appropriations. The Legislature did not provide funds for a study in the 2017-2019 biennium. Hence, UGPTI's latest traffic, road condition, and investment needs estimates are three years old. With a dynamic economy, it is important to have up-to-date information and forecasts of road conditions and investment needs when setting priorities and determining funding levels.

If this request is funded, UGPTI will collect traffic data in partnership with the NDDOT at more than 1,000 locations on county and local roads each biennium, develop current estimates of the surface conditions of all paved county and local roads, and forecast truck traffic levels resulting from economic activity in the state. These inputs will be used to predict the resurfacing, rehabilitation, graveling and other maintenance needs of county and local roads throughout the state for the next 20 years.

UPGTI's traffic model is illustrated in Figure 1. Truck trips are predicted from and to each oil spacing unit, cropland section, and major processing plant in the state. The predicted trips generated from each activity are accumulated for individual road segments. The predicted trips are compared to observed truck volumes (derived from UGPTI's traffic counts) on principal road segments. In this way, the model is calibrated against observed traffic levels in the base year. As this relationship suggests, detailed economic modeling and traffic data collection are both necessary on a regular basis to achieve the desired level of accuracy.

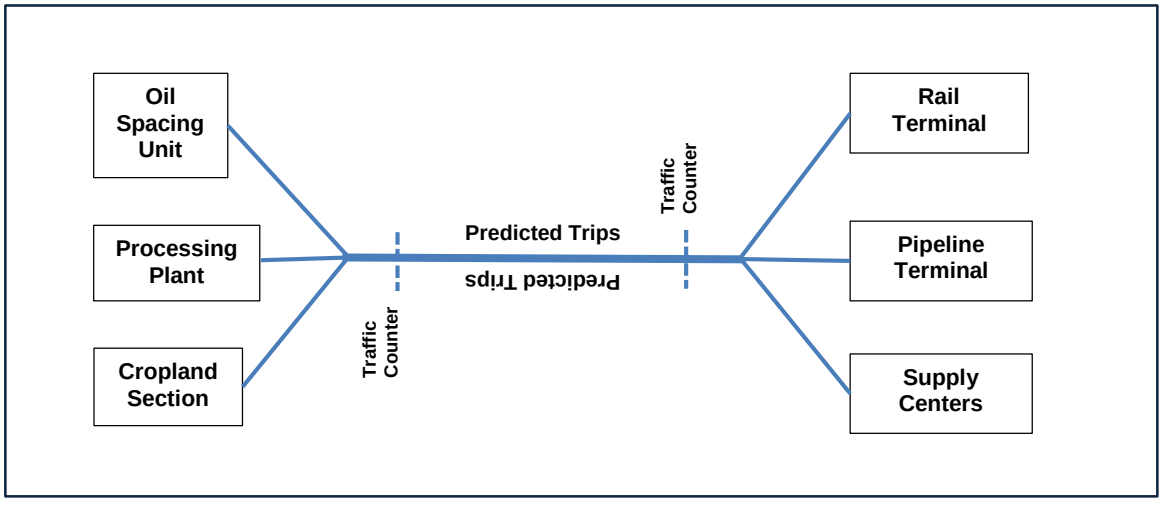


Figure 1. Truck Traffic Counting and Forecasting Process

County bridge replacement and maintenance needs are quantified in a similar manner, using a bridge deterioration model that considers age, traffic, and design factors, as well as typical

inspection/maintenance needs. If this request is funded, UGPTI will prepare road and bridge reports for the Legislature and function as a center of expertise (and source of technical information) for counties, townships, and tribal governments. In addition, UGPTI will provide the information needed for legislative proposals such as Operation Prairie Dog.

Impacts of Road Condition on Freight Costs

Good roads are vital to North Dakota's export competiveness and economic development. Most freight travels the first and last miles in trucks. As shown in Table 7, trucking costs increase by more than 35% when road condition deteriorates from good (a Present Serviceability Rating (PSR) of 4) to very poor (a PSR of 1). These costs ripple throughout the economy, affecting merchandisers and producers.

Table 7. Trucking Cost as a Function of Road Condition

Road Condition	Present Serviceability Rating (PSR)	Cost Index
Excellent	5	0.91
Good	4	0.93
Fair	**3**	**1.00**
Poor	2	1.14
Very Poor	1	1.26

Note: Exclusive of fuel costs.

Source: National Academies of Sciences. 1990. *New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal – Special Report 227*. Washington, DC.

Trucking costs affect the net prices received by producers. By providing better roads, the Legislature is enhancing the competitiveness of North Dakota producers and increasing their access to markets.

Benefits of Road Investments

According to Federal Highway Administration, each dollar spent on roads, highways, and bridges returns more than $5 in savings on vehicle maintenance and repairs; lower road, highway, and bridge maintenance costs; improved safety; and less fuel consumption and tailpipe emissions.[2] As shown in Figure 2, routine maintenance costs (such as patching and crack sealing) increase by 186% as road condition deteriorates from fair (PSR = 3) to poor (PSR = 2). In a related example, maintenance costs increase by 129% as road condition deteriorates from a PSR of 2.5 (at which time the road should be resurfaced) to a PSR of 1.5, at which point the road must be reconstructed.

As shown in Table 8, deferring improvements ultimately increases capital costs. If a road can be resurfaced at the optimal time (e.g., PSR = 2.5) it can be restored to a smooth, serviceable highway (e.g., PSR $\geq$ 4.2) at minimal cost (e.g., $200,000 per mile) with a thin 2-inch overlay. If, however, the improvement is deferred until the PSR drops to 2.0, a thicker overlay (e.g., 4 inches) will be needed at a higher cost ($375,000 per mile). If the condition of the road deteriorates further (e.g.,

[2] Kahn, M. and D. Levinson. *Fix It First, Expand It Second, Reward It Third: A New Strategy for America's Highways*. The Brookings Institute, 2011.

the PSR drops to 1.8), the existing surface and base layers will be too cracked, rutted, and deformed to provide structural support for an overlay. In this case, the layers must be removed (mined) and blended with new material before being replaced on the subgrade. The minimum cost of such a mine and blend operation is $600,000 per mile. In some cases, the roadway width may be insufficient for the thicker layers. If so, the road must be widened—in which case, the cost of rehabilitation could be as much as $1 million per mile. If the PSR drops below 1.8 (e.g., to 1.5), the road must be fully reconstructed from the subgrade up at a cost of $1.25 million per mile.

As these illustrations suggest, timely road investments pay for themselves. The same is true of UGPTI's biennial needs and condition studies. By quantifying the near term investments needed, UGPTI's studies return cost savings far greater than the costs of the studies themselves.

Road Investment and Condition Monitoring

If the county road and bridge planning center is funded, the Upper Great Plains Transportation Institute will provide the Legislature with objective and consistent estimates of investment needs and measures of effectiveness—e.g., how road conditions are improving or stabilizing over time. With the assistance of counties and the NDDOT, UGPTI will maintain a list of all resurfacing, reconstruction, and surface improvements. Given this information, UGPTI can report effectiveness measures to the Legislature, such as the number of miles improved, trends in road condition, and the freight traffic volume benefitting from the investments.

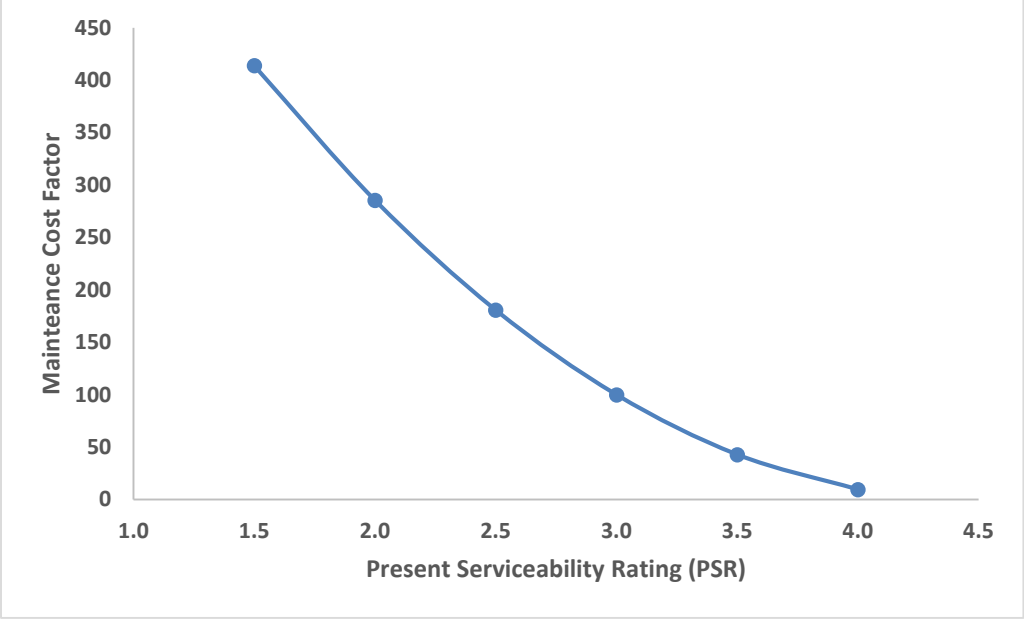


Figure 2 Change in Routine Maintenance Cost with Road Condition[3]

[3] U.S. Department of Transportation. *Highway Economic Requirements System: Technical Report*, 2001, Table 7-10. Original source: Witczak, M. and G. Rada. *Microcomputer Solution of the Project Level PMS Life Cycle Cost Model*, University of Maryland, Department of Civil Engineering, December 1984.

Table 8. Typical Improvement Costs for Paved Two-Lane County Road (e.g., CMC)			
Improvement	**Thickness (inches)**	**PSR Threshold**	**Cost per Mile ($000)**
Thin Overlay	2	2.5	$200
Structural Overlay	4	2.0	$375
Rehabilitation (Mine/Blend)		1.8	$600-$1,000
Reconstruction		< 1.8	$1,250

ASSET MANAGEMENT PROGRAM

Capital investments in roads and bridges can be optimized through a timed sequence of preservation and maintenance activities. Without timely maintenance, roads may deteriorate more rapidly than anticipated. According to several studies, $1 spent on maintenance at the right time (e.g., spending on crack seals, chip seals, and other surface treatments) could save $4 to $5 in the future.[4] When properly implemented, asset management can provide better road service for longer periods of time.

Basic Inventory

As envisioned, UGPTI's asset management system will have several levels. The pace of implementation will be determined by the amount of funding available. The first level consists of a comprehensive (up to date) inventory of road and bridge assets. Each major segment of a county road between two junctions is part of this inventory. For each segment, the information shown in Table 9 will be compiled and updated biennially.

Table 9. Level 1 of Road Asset Management System − Basic Inventory	
Length of segment	Road name
Number of lanes	Owner
Roadway width	Classification (e.g., CMC or local)
Surface type	Geo-coordinates (end points of the segment)
Shoulder type/width	Public grade crossings
Structures (bridges, culverts)	Traffic control devices

If a road segment includes a bridge that is part of the National Bridge Inventory (NBI), a set of attributes will be derived for the structure (e.g., design type, age, and weight limits) using its geo-coordinates. If the bridge's weight limit is less than 80,000 pounds, smaller trucks must be used on the segment or the payload must be reduced, thus impacting logistical efficiency. In addition to bridges included in the National Bridge Inventory, UGPTI's asset management system will include information on minor structures – i.e., those that are less than 20 feet in length. The number of minor structures exceeds the number of NBI bridges in North Dakota. An inventory of these smaller structures would allow for better infrastructure management and load-carrying decision making at

[4] Kahn, M. and D. Levinson. *Fix It First, Expand It Second, Reward It Third: A New Strategy for America's Highways*. The Brookings Institute, 2011.

the county level.

The attributes of an at-grade railroad crossing on a road segment can be accessed by querying FRA's Grade Crossing Database, which includes the type of crossing protection and the average number of trains per day at the crossing. Although counties are not responsible for grade crossing improvements or maintenance, the presence of crossings on a segment may affect traffic flow and safety.

A key to ensuring that all inventory items are accurate and up to date is an easy to use tool that allows local road managers to update the information online. This goal has been accomplished with the initial development of the Geographic Roadway Inventory Tool or GRIT. This web tool (which is already operational and in use by most counties in North Dakota) provides the capability to edit and maintain data in a geographical or map-based environment. In addition, GRIT provides online mapping tools that allow road managers and the public to view and understand the information. With GRIT, all the data collected by UGPTI each biennium will be geographically combined with basic inventory data updated by local road managers.

Road Condition

In addition to a basic inventory, Level 2 includes essential information about the condition and quality of a road (Table 10). The relevant characteristics may vary with the type of surface (paved versus aggregate). However, for a given surface, the information listed in Table 10 is essential to determining the condition and quality of the road. Ideally, all investments (using federal, state, or local funds) will be reflected in the improvement list.

Table 10. Level 2 of Road Asset Management System – Condition and Quality

Paved Surfaces	Aggregate Surfaces
Surface condition rating	Aggregate class
Structural rating	Gravel depth
Improvements made	Date of last gravel placement
Dates of improvements	Blading frequency
Costs of improvements	Cost per mile

Substantial progress has been made during the last four years toward a consistent inventory of assets (Level 1) and surface conditions (Level 2). However, further development is necessary. By taking advantage of emergent technologies, many data collection efforts can be automated, thereby reducing the costs of maintaining an up-to-date inventory. A cost-effective method of collecting condition data can be achieved by deploying low-cost sensors in vehicles. With widespread use of these devices, the roughness of a road surface can be approximated by monitoring the motion, acceleration, and responses of vehicles. Once this new technology is deployed, road condition data can be collected each year on all segments in the state, not just on a sample of roads. Moreover, the condition assessments will be consistent from county to county and across segments.

Traffic and Operations

In Level 3, current estimates of traffic, truck factors, and roadway characteristics can be used to develop biennial assessments of the operational characteristics and utilization of roads. The average annual daily traffic (AADT), percent trucks, and distribution of traffic during the week and day are key indicators of traffic conditions and levels of service (Table 11). In addition, the annual equivalent single axle loads (or ESALs) are indicators of the structural demands being placed on roads.

Table 11. Level 3 of Road Asset Management System –Traffic and Operations	
AADT – all vehicles	Speed limit
Truck AADT (by class)	Directional traffic distribution
Weekday average daily traffic	Peak hour factor
Annual ESALs (paved roads)	No passing zones

Decision Making Tools

The Surface Selection tool (which has already been developed) provides technical assistance in determining when an unpaved road could be economically paved, based on life-cycle cost comparisons of paved and unpaved roads. A traffic/road condition forecasting model (which will be added in the near future) will allow counties to estimate future rates of road deterioration (based on projected traffic levels) and the timing of future improvement needs. In addition, the development of a gravel road component will provide information about graveling frequency and depth, dust control applications, and other costs (such as blading frequency), which vary with levels of truck traffic (Table 12).

Table 12. Level 4 of Asset Management System – Decision Tools	
Function	**Decision Information**
Surface selection	Paved versus aggregate surface
Condition forecasting	Deterioration of condition with time and traffic
Remaining life	Remaining ESALs or equivalent truck trips
Preservation treatments	Type and timing of treatment

In Level 4, improvement selection tools will provide technical information about the many types of improvements that could be considered for a road segment. For paved roads, these options include a range of improvements such as a thin overlay, a structural overlay, rehabilitation, and shoulder improvements; as well as typical maintenance treatments such as crack seals, chip seals, patches, and microsurfacing. For unpaved roads, the improvement selection process will consider various frequencies of blading, graveling, and gravel depth.

Consistent Comparable Measures

The ideal situation is for all counties in the state to use the same asset management system, which will generate consistent performance measures and allow UGPTI to develop comparable estimates of investment needs across jurisdictions. If each county develops its own system and measures, the Legislature must compare requests from individual counties based on different assumptions and

metrics. If each county develops its own system, large-scale duplications of effort will result. With base-level funding, UGPTI can host an asset management system for the entire state and add functions over time to make it a decision making tool similar to the one used by Federal Highway Administration.

TRANSFORMATIVE TECHNOLOGIES RESEARCH PROGRAM

Transportation (driven by advances in telecommunications and technology) is changing at a dramatic pace. Assisted driving and quasi- and fully-autonomous vehicles are only part of the wave of changes that will impact North Dakota in the future. Robotic freight yards, quasi- and fully-autonomous freight trains and commercial motor vehicles, and truck platooning are emerging realities. Connected vehicle (CV) technologies (in which vehicles communicate with each other and roadway devices) are operational and being tested in several states. In addition to offering great efficiencies and safety benefits, CVs generate massive amounts of data, such as location, speed, and vehicle performance in real time. CVs generate so much data, in fact, that they pose opportunities and challenges in data analysis that have never been experienced. "Big data" will radically change the way transportation planning takes place in the future. "Smart vehicles" and "smart infrastructure" will provide capabilities only dreamed of a few years ago. Vehicle automation (eventually leading to "driverless" vehicles) is a longer-term vision that will be improve safety and provide greater mobility.

In this rapidly changing but opportunistic environment, North Dakota needs an objective entity to provide assessments of the potential benefits and costs of various technologies and their potential impacts on the state. With $500,000 of base funding, UGPTI can establish itself as a confidential data repository and analytical center where CV data can be confidentially assembled from many sources and harnessed under confidentiality agreements. In addition to benefiting transportation planning in a variety of ways, CV (and other futuristic) technologies will improve safety, reduce congestion and travel time by providing dynamic route information and better trip planning options for travelers, improve freight efficiency and reduce business logistics costs, and optimize the dispatching and routing of emergency vehicles. Harnessing these technologies to achieve the state's goals is essential for growth and prosperity. Moreover, the requested program will create substantial leveraging opportunities. With a modest commitment from the state, matching and additional funds can be requested from private entities. The requested program will focus primarily on technology deployment and efficiency gains in the trucking sector, which are vital to North Dakota's economic competitiveness.

TECHNOLOGY DEPLOYMENT IN COMMERCIAL TRUCKING

Potential Benefits of Automation

Driver shortages and turnover rates, crashes due to human factors, and fluctuating fuel prices impact the trucking industry and create logistical uncertainties. In 2017, fuel and driver-related costs comprised 22% and 43% of the marginal trucking cost per mile, respectively.[5] The automation of

[5] Hooper, A. and D. Murray. *An Analysis of the Operational Costs of Trucking: 2018 Update*, the American Transportation Research Institute, Arlington, Virginia, October 2018.

commercial trucking (which will occur in the near future) offers substantial cost savings, as well as safety and environmental benefits. The range of potential benefits include:

1. Reductions in vehicle crashes and crash-related costs, including secondary benefits such as savings on insurance and casualty costs
2. Greater fuel efficiency and an attendant reduction in emissions (as fewer gallons of fuel are consumed per cargo-mile)
3. Increased vehicle productivity
4. Improved driver productivity and satisfaction due to lower stress and fatigue levels
5. Reduced labor costs (in the long run) from full automation of vehicle controls
6. Supply-chain savings stemming from reductions in private trucking costs and enhanced reliability
7. Moderation of congestion, as automated trucks and platoons optimize flows in traffic lanes

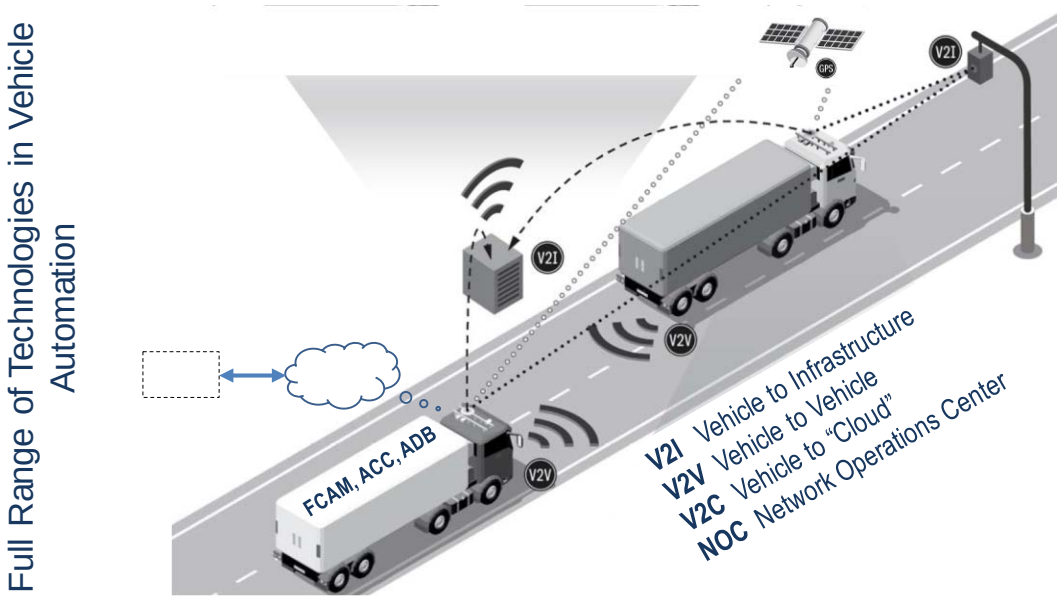
All these benefits will not be realized immediately. Nevertheless, significant efficiency and safety improvements are achievable in the short run. Moreover, benefit levels will grow over time.

Enabling Technologies

As shown in Figure 3, automation will build on baseline vehicle safety systems that are now available on new trucks (or which will become available in the near future) including: Adaptive Cruise Control (ACC), Forward Collision Avoidance and Mitigation (FCAM), Air Disc Brakes (ADB), and lateral placement technologies (e.g., lane keep assist and lane centering), which have the potential to automate certain driving tasks. In addition to RADAR and LIDAR, video camera systems are vital to automation. They can be used to read signs and roadway striping (thus enabling automated steering under most conditions) and provide warnings of possible collisions with vehicles and pedestrians. When enhanced L5 satellite signals (which will be commercially available within the next few years) are combined with differential real-time kinematic (D-RTK) GPS, centimeter level location accuracy is possible. Dedicated Short-Range Communications (DSRC) enable vehicle-to-vehicle (V2V) communication, which is essential to truck platooning. In addition to V2V communication, vehicles can be connected wirelessly to a Network Operations Center (NOC), which provides updated traffic and road condition data and "beyond the horizon" information. Although vehicle-to-infrastructure (V2I) communication is essential for automation in urban areas, V2I systems are not required for platooning on interstate highways.

LEVELS OF FUTURE AUTOMATION

Levels of vehicle automation are summarized in Table 13. The first level includes driver-assistive truck platooning (DATP), which is currently being implemented in many areas of the United States and European Union. In DATP, drivers are fully engaged in all tasks except the acceleration and braking of vehicles and the spacing of vehicles within platoons.



Adapted from: National Academies of Sciences. NCHRP Web Document 31, 2017

Figure 3 Automation of Commercial Trucking

Table 13: Levels of Future Vehicle Automation	
Level	**Automation/Driver Engagement Levels**
1	Automation of acceleration, braking, and vehicle spacing. The driver is responsible for all other aspects of driving.
2	An additional task is automated (e.g., steering). All other driving tasks remain under human control.
3	Vehicles operate fully under automated controls. However, drivers must be ready to intervene to perform certain tasks as requested by the control system.
4	The autonomous driving system continues to function under most conditions even if the driver does not respond to a request to intervene.
5	The fully autonomous (driverless) system functions under all operating conditions without human intervention.
Based on Society of Automotive Engineers Classifications	

At the second level of automation, the driver of the lead vehicle of a platoon may be responsible for steering. However, the lateral placement of trailing vehicles is automated. These drivers can take their feet off the brakes and hands off the steering wheel. However, they must be fully engaged, monitor the surroundings, and be prepared to intervene if necessary. In Level 3, the operation of at least some vehicles in a platoon is fully automated. However, drivers must be ready to intervene to perform certain tasks as requested by the control system. Consequently, drivers must be alert and aware of their surroundings. Nevertheless, the stress and fatigue levels of following drivers can be reduced on lengthy journeys. In Level 4, the operation of all vehicles is fully automated. The trucks

in a platoon can operate independently of humans under most circumstances. However, a person may be aboard the lead vehicle to perform non-driving tasks. Even at Level 4, autonomous operations may be prohibited in certain conditions (such as dense fog, icy roads, etc.). When the control system cannot safely navigate or space vehicles, the trucks will be brought to a stop in a failsafe manner. In Level 5, vehicles can operate autonomously under any condition. Nevertheless, automated vehicles should not be dispatched during travel advisories or in no-travel conditions (e.g., blizzards). In Levels 4 and 5, drivers may be aboard, but they are resting or sleeping in the truck's berth.

Truck Platooning

In platooning, vehicles can be spaced closer to each other because of automated and connected braking. Optimal spacing reduces aerodynamic resistance and turbulence, resulting in significant fuel savings. In first-generation platooning systems (which are now commercially available), the lead driver will operate in a normal manner and may choose to use Adaptive Cruise Control. Meanwhile, the follower is responsible for steering and retains responsibility to monitor/respond to the surrounding traffic. Substantial fuel savings have been demonstrated for two-truck platoons: 4.5% to 5% for the lead unit and 10% for the trailing unit.[6] Moreover, savings in labor and vehicle maintenance are possible. Truck platooning cost with drivers is expected to be 90% to 95% of traditional trucking cost. However, a quasi-automated three-truck platoon with one driver in the lead cab could reduce trucking costs by more than 25% (Figure 4).[7] In addition to cost savings, driver fatigue can be reduced by platooning because drivers in trailing units can rest part of the time.

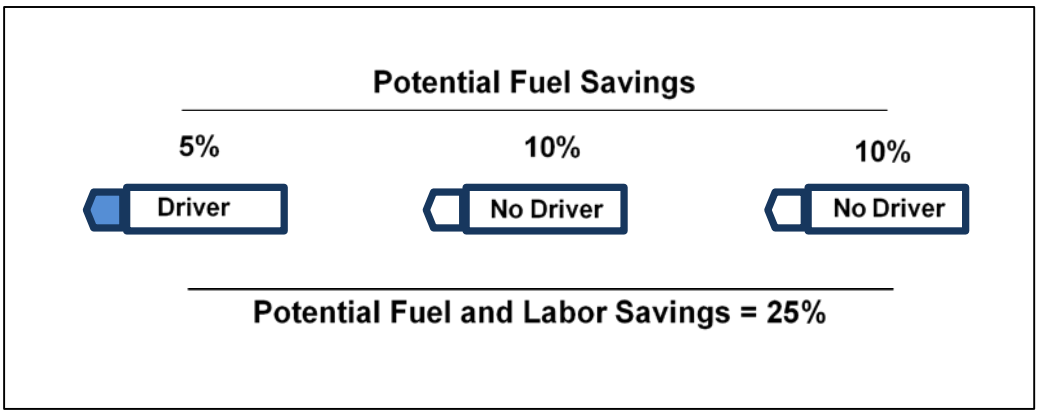


Figure 4 Potential Efficiency Gains from Truck Platooning

Partially Automated Platoons

Trucks may be operated autonomously within platoons or as stand-alone vehicles. However, the best fuel economy is achieved in platoons. Moreover, platoons optimize highway capacity better than individual autonomous vehicles. On rural freeways with multiple lanes in each direction, truck platoons in a dedicated lane can achieve maximum throughput. In one futuristic scenario, a platoon

[6] FHWA-Funded Auburn University study: *Heavy Truck Cooperative Adaptive Cruise Control: Evaluation, Testing, and Stakeholder Engagement for Near Term Deployment: Phase Two Final Report.* Available at http://eng.auburn.edu/~dmbevly/FHWA_AU_TRUCK_EAR/

[7] Ibid.

may operate autonomously (or with only a lead driver) between two major interchanges of a rural freeway. However, when the platoon reaches an outlying terminal at the perimeter of a congested city, drivers are placed in the unmanned vehicles for delivery through urban areas. In this arrangement, most truck drivers remain in their home territories near the origins and destinations of the corridor.

Safety Improvements

Truck following distances are determined largely by driver perception and reaction times. There is also a braking delay with radar, as the FCAM system in the following vehicle must detect a slowing vehicle in front of it before the brakes can be automatically applied. In comparison, when trucks in a platoon are connected with wireless DSRC, the following truck reacts automatically to the activation of the lead truck's brakes. In many respects, trucks in platoons will be the safest vehicles on the road.

CONCLUSION

Thank you for the opportunity to present the Upper Great Plains Transportation Institute's 2019-2021 budget requests. UGPTI's general fund budget request (exclusive of the compensation package) is summarized in Table 14.

Table 14. UGPTI's 2019-2021 General Fund Budget Request

Line	Item	Amount
1	Base level budget	$3,443,174
2	County road & bridge planning center	$975,000
3	Transformative technologies program	$500,000
4	Total general fund budget request	$4,918,174