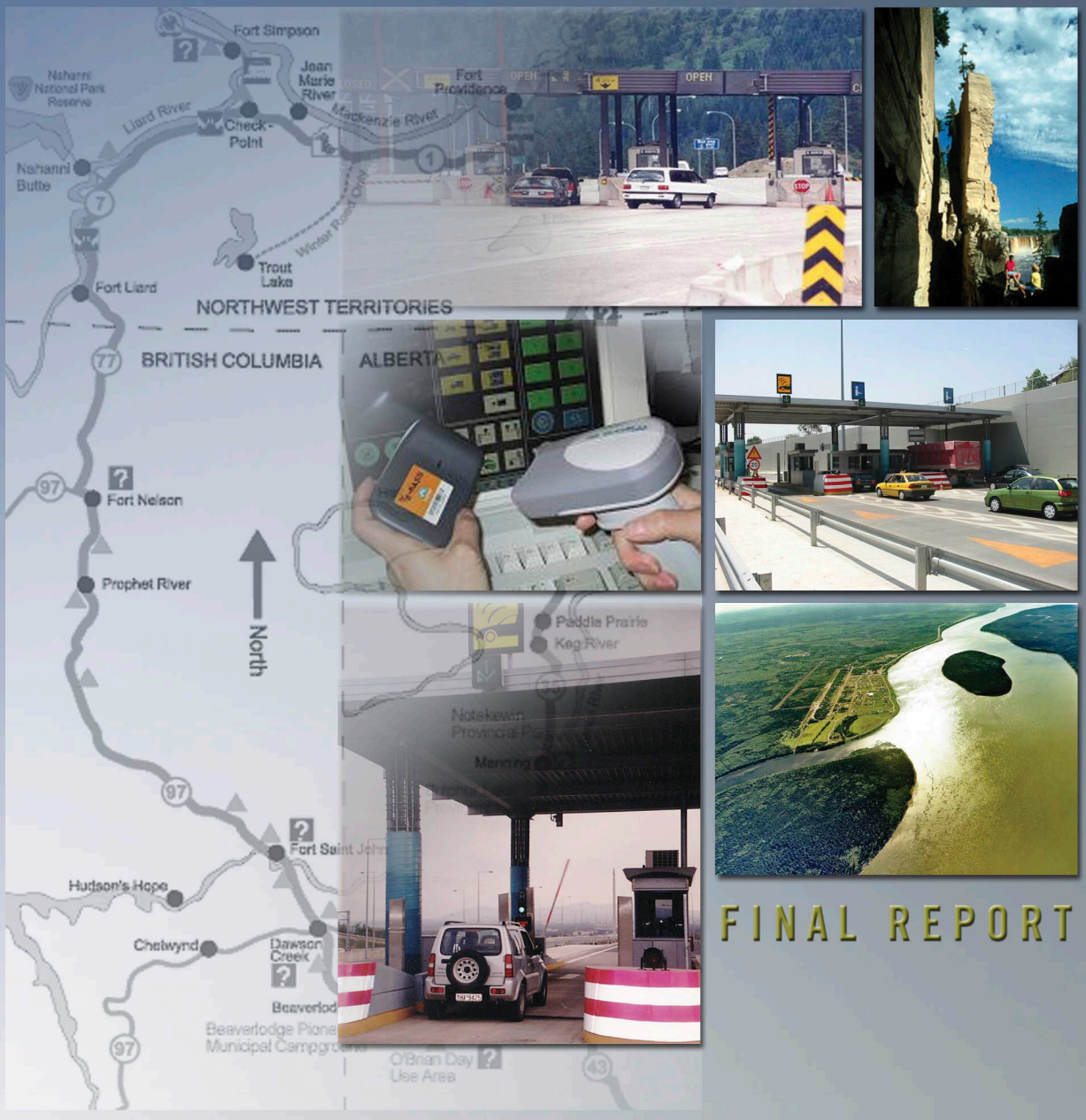
GOVERNMENT OF THE NORTHWEST TERRITORIES
DEPARTMENT OF TRANSPORTATION

DEH CHO BRIDGE - TOLL COLLECTION AND TRAFFIC COUNTING SOLUTIONS



FINAL REPORT

2004 SEPTEMBER

IBI GROUP

Government of the Northwest Territories
Department of Transportation

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REPORT SUMMARY

The Government of the Northwest Territories (GNWT) has entered into negotiations with the Deh Cho Bridge Corporation Ltd. (DCBC) to form a public-private partnership that will build and maintain a bridge across the Mackenzie River on Highway 3 near Fort Providence. The bridge will replace the existing ferry and ice bridge. The concession is to be for 35 years with funding to come from an annual government subsidy and tolls charged to commercial vehicles.

The objectives of this study were to: identify tolling and traffic classification and counting solutions for the Deh Cho Bridge; provide cost estimates for all solutions; and provide a report with identified options and recommendations for a preferred solution. Solutions are defined in terms of operations concepts (from the perspective of customer and the operator), as well as technology. The benefits of each identified solution are described in conjunction with the cost estimates. Additionally, cost estimates are broken out by capital, operating and maintenance components, and include an indication of likely capital costs for device replacement during the 35-year concession period. Evaluation criteria were developed in close coordination with GNWT representatives to ensure that recommendations reflect local concerns and priorities. The NWT Motor Transport Association was also consulted.

Tolls are to be collected from commercial vehicles in direct relation to northbound bridge crossings. Three vehicle categories (single-unit, semi-trailer, multiple-trailer) are anticipated. Tolls will be collected by GNWT and funds will be transferred to the Deh Cho Bridge Corporation based on traffic data that must be available for audit by DCBC.

The study includes a thorough Technology Review, a detailed discussion of Operating Concepts, and an Evaluation of costs and functionality.

The operation concept for tolled commercial vehicles should meet the needs of both frequent and infrequent customers. Infrequent customers will arrive at Deh Cho Bridge expecting to stop and pay the toll using conventional media (cash, credit card, debit card). Frequent users are interested in options that allow the toll payment to be charged against an account so that drivers do not have to pay at the toll facility, and options that allow vehicles to proceed through the toll facility with as little delay as possible.

Based on the project background, the operating environment, the available toll technologies, and the range of toll operation concepts presented in this report, IBI Group believes that the following selection of options is most suitable for initial operation of the Deh Cho Bridge.

Vehicle Count and Classification: Multiple inductive loop installation in northbound and southbound lanes as close to the bridge as possible. GNWT should consider the definition of vehicle categories to facilitate electronic classification.

Toll Collection: A Self-serve kiosk with allowance for part-time Manual (attended) operation at a service counter and Account payment using a magnetic stripe card for vehicle identification. The collection would likely occur at the Enterprise weigh scale facility.

Violation Enforcement: Random spot checks conducted on the highway between the bridge and Edzo. Drivers will be required to produce a valid receipt for toll payment.

Report Summary

This system definition would provide GNWT with a relatively basic approach, while maintaining a large degree of flexibility. It allows for cash, credit, debit, and account payment right from the start.

The total capital cost is estimated at $1 370 000. and the annual operating & maintenance cost is estimated at $660 000. for the initial year. These costs do not include physical roadway construction, or the provision of power and communication to the designated sites.

The estimated revenue from tolls using the projected volume and estimated toll rates ranges from $3.4 million to $10.3 million during the duration of the concession. Operating costs are therefore approximately 20% of toll revenue. Annual GNWT subsidies to the DCB Concession are additional to this estimated toll revenue.

Subsequent stages in the life of the system could include:

1. Additional self-serve kiosks at the Fort Liard weigh scale and possibly at the restaurant / rest area at the turn off to Fort Providence. The Fort Providence location is attractive because drivers could be offered a “last chance” to pay for those who somehow miss the other options.

2. A comprehensive Violation Enforcement camera system at the bridge site to change the enforcement activity from general spot checks to targeted vehicle apprehension.

3. When account payment reaches a significant level, GNWT could consider adding electronic vehicle identification so that drivers could proceed without getting out of their vehicle. The vehicle identification could be read at slow speed while the driver passes through the weigh scale, or at highway speed near the bridge.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

EXHIBITS

1. INTRODUCTION

The economy of Yellowknife and other nearby communities has historically been constrained by the difficulty and inconsistency of crossing the Mackenzie River. Vehicle access is presently provided via a summer ferry and a winter ice bridge. The crossing is subject to a typical winter closure of 3 to 5 days during ice over and a typical spring closure of 4 weeks during thaw. As a result, residents, visitors, and businesses incur substantial delay, shipping, and inventory costs. The Deh Cho Bridge, to be the first fixed crossing of the Mackenzie River, will provide a much needed physical link and lifeline.

The Government of the Northwest Territories (GNWT) has entered into negotiations with the Deh Cho Bridge Corporation Ltd. (DCBC) to form a public-private partnership that will build and maintain a bridge across the Mackenzie River on Highway 3 near Fort Providence. The bridge will replace the existing ferry and ice bridge. The concession is to be for 35 years with funding to come from an annual government subsidy and tolls charged to commercial vehicles. It is anticipated that construction will commence during 2004 with completion targeted for early 2006.

GNWT is undertaking this study to evaluate alternatives for toll collection and traffic counting that are suitable for the Deh Cho Bridge.

2. PROJECT OBJECTIVES

The objectives of this study as set forth in the RFP, and expanded by IBI Group, are the following:

- "Identify tolling and traffic classification and counting solutions for the Deh Cho Bridge."

  It is important that the "solutions" are defined in terms of operations concepts (from the perspective of customer and the operator), as well as technology.

- "Provide cost estimates for all solutions."

  It is important that the benefits of each identified "solution" be described in conjunction with the cost estimates. Additionally, it is important that cost estimates be broken out by capital, operating and maintenance components, and include an indication of likely capital costs for device replacement during the 35-year concession period.

- "Provide a report with identified options and recommendations for a preferred solution."

  It is important that the evaluation criteria will be developed in close coordination with GNWT representatives to ensure that recommendations reflect local concerns and priorities.

3. OPERATING ENVIRONMENT

3.1 Roadway Network

Exhibit 3-1: Map Showing Access to Deh Cho Bridge Site

The primary roadway access into the Northwest Territories and to the Deh Cho Bridge site is the paved road from Edmonton, Alberta leading to Yellowknife, NWT. This route consists of Alberta #35 to the border – NWT #1 (Mackenzie Hwy) to just south of Fort Providence – NWT #3 (Yellowknife Hwy) across the Mackenzie River (the bridge site), past Fort Providence and north past Edzo. An unpaved road completes the route to Yellowknife.

Alternate routes leading to the Deh Cho Bridge site are:

- NWT #5 & #2, an unpaved road from Fort Smith to Hay River and connecting with the primary route at Enterprise (winter road access from Fort McMurray, AB);
- NWT #7 (Liard Trail) and NWT #1 (Mackenzie Hwy), an unpaved road from Fort Liard connecting with the primary route at NWT #3 south of Fort Providence (access from British Columbia).

The site for the Deh Cho Bridge crossing of the Mackenzie River is located on NWT #3 (Yellowknife Hwy), 24 km north of the junction with NWT #1 (Mackenzie Hwy) where the three routes converge. Since all traffic destined for Yellowknife and/or the communities and mines farther north must cross the Mackenzie River at this point, the Deh Cho Bridge is a critical link in the road network of the Northwest Territories.

At the location of the crossing, the highway runs along the south shore of the river on the east and along the north shore of the river on the west. There is a sharp right turn on approach to the bridge and a corresponding left turn on departure. The short length of roadway in line with the bridge will be a constraint on the possible location of a toll plaza and the associated deceleration / acceleration lanes.

Exhibit 3-2: Westbound / Northbound Approach to Deh Cho Bridge Site

3.2 Communities and Government Infrastructure

The closest community to the bridge location is the hamlet of Fort Providence (population 900) about 10 km away on the north side of the river. Ferry personnel presently live in a small camp on the south side of the river. To the north of Fort Providence, the Yellowknife Highway proceeds for over 200 km to Edzo, the next opportunity for service.

The Government of the NWT, Department of Transportation, Road Licensing and Safety Division operates a commercial vehicle Weigh Scale Station further to the south at Enterprise (approximately 150 km from the bridge site). This facility serves to inspect trucks and sell permits for travel in NWT. These permits are: Registration – to identify carrier for travel in NWT; Fuel Tax – since many vehicles can enter and depart NWT without filling up and paying tax at the pump;

Overweight – to monitor heavy loads that degrade infrastructure; and Oversize – for large loads that may require special escort; relatively common due the mining industry. A computer system known as the Motor Vehicle Information System (MVIS) is used to process sales and track permits issued across the NWT. MVIS supports cash, credit card, debit card and account based payments. Annual revenue processed through MVIS is $3.6 million.

The weigh scale facility is not open on a continuous basis. The hours of operation depend on the season and the available staff. If the scale is closed, drivers that have appropriate permits prior to arriving can proceed without stopping. Drivers that require permits are expected to leave pertinent information on a voice message and then stop on their departure to complete the process. If the weigh scale is open, all commercial vehicles must stop to be weighed and inspected, regardless of permit status.

There is another weigh scale located on NWT # 7near Fort Liard.

3.3 Traffic Demand

The present ferry service operates daily from 6 am to midnight. During 2001, the Average Annual Daily Traffic (AADT) was 220 vehicles per day (source: GNWT Highway Data Report). This includes both northbound and southbound traffic. The Average Daily Traffic (ADT) ranged from 130 during winter months to 310 in the summer. However, the summer peak is primarily related to private vehicles. Commercial vehicle demand peaks during the winter months due to re-supply of mines using winter ice roads. During 2001, the commercial vehicle AADT was 80 commercial vehicles per day, with a range in ADT from 50 in the summer to 120 in the winter.

2001 GNWT Traffic Data Parameter	Commercial Vehicles	Private Vehicles	Total Vehicles
AADT	80	140	220
ADT Summer	50	260	310
ADT Winter	120	10	130
Annual	29 000	51 000	80 000

Exhibit 3-3: 2001 GNWT Traffic Data for Ferry / Ice Bridge Crossing

A report prepared for GNWT provides a forecast of commercial vehicle traffic crossing the Deh Cho Bridge during each year of the 35-year concession period. Increased accessibility due to the Deh Cho Bridge and increased demand due to major NWT development projects are factored into the growth projections. Distribution of the commercial vehicles by three categories of truck was included.

There is a substantial difference between the 2001 GNWT data and the forecasting report in terms of the actual 2001 total commercial vehicles (29 000 vs. 38 000). Perhaps there was a different definition of commercial vehicle or the forecasting report used the winter ADT to estimate annual traffic?

GNWT Commercial Vehicle Forecast Year	3 Axle Trucks	Semi Trailers	Trains	Total Commercial Vehicles
2002	1 050 3%	16 520 42%	21 220 55%	38 790
2037	1 960 3%	30 960 42%	39 760 55%	72 680
Average Annual Growth (35 years)	1.8%	1.8%	1.8%	1.8%

Exhibit 3-4: Highlights of Commercial Vehicle Forecast Report

It is expected that annual traffic will be split 50 / 50 between northbound and southbound directions because there is no alternative route. For a design estimate, it is assumed that on an individual day, the split could be 80 / 20. Traffic data from 2001 indicate that the peak hour was approximately 6% of AADT. For a design estimate, a value of 10% of AADT will be used.

Using these factors, peak demand for toll collection is estimated as shown in the following exhibit.

GNWT Commercial Vehicle Forecast Year	ADT Winter 35 yr @ 1.8%	Directional 80 / 20	Peak Hour Peak Direction 10%
2002	120	100 / 20	10
2037	220	180 / 40	18

Exhibit 3-5: Estimated Demand for Toll Collection

3.4 Customer Profile

Three trucking companies (RTL Robinson, Grimshaw, and Northwest Transport) account for approximately 70% of the commercial vehicles. The remainder is distributed across as many as 300 companies or individual owners.

It is estimated that 90% of the commercial vehicle loads are regularly scheduled deliveries with the primary (50%) commodity being bulk fuel.

The NWT Motor Transport Association (MTA) represents the trucking industry. Representatives from MTA and RTL provided the following information about the fleet.

- It is common for a driver / tractor to switch between a single trailer and a multiple trailer configuration;
- Cellular telephone coverage is not generally available along NWT highways;
- Trucks are not outfitted with electronic identification devices for other applications in the NWT or adjacent provinces;
- Many of the vehicles do have satellite based systems for fleet management;
- Drivers from the major companies will have a fuel card.

With regard to the toll operation, the trucking industry prefers:

- Account based charging, so that the drivers are not responsible for toll payment;
- On-line, immediate access to a detailed record of toll transactions so that charges can be passed on to customers as quickly as possible;
- Non-stop passage through the toll station and across the bridge.

3.5 Toll Framework

The following statements define the framework within which tolls for the Deh Cho Bridge are to be applied:

1. Tolls are to be collected in direct relation to bridge crossings. Collection of tolls through an annual fee similar to the various existing permits is not to be considered.
2. Tolls will be collected from commercial vehicles only. These are officially defined as vehicles with a gross vehicle weight (GVW) exceeding 4500 kg and buses. Private vehicles and commercial vehicles not meeting the above criteria will not be tolled.
3. Tolls are to be collected from northbound vehicles only. This will facilitate enforcement activities that may be required.
4. The toll rate will be set by GNWT. The Concession Agreement states that the initial toll rate is to be in the range of $5 to $6 per tonne based on the vehicle GVW. Since GVW cannot be measured directly, it is anticipated that a surrogate for GVW will be used to simplify the toll classification and rate determination process. The commercial vehicle categories presently under consideration are single-unit, semi-trailer, and multiple-trailer (train).
    - Single-unit. The commercial vehicle forecast report uses the term 3-axle trucks; however, there are 2-axle buses and some 2-axle trucks with GVW greater than 4.5 tonnes. In the forecasting report, three-axle trucks are 3% of the commercial vehicles. The toll fare is expected to be approximately $50.

- Semi-trailer vehicles make up 42% of the commercial vehicles and the toll fare is expected to be approximately $100.

- Multiple-trailer (train) vehicles comprise the remaining 55%. The toll fare is expected to be approximately $200.

5. Tolls will be collected by GNWT. The toll collection system, collection procedures, and related violation enforcement/collection activities are the responsibility of GNWT.

6. Funds transferred to the Deh Cho Bridge Corporation will be based on the volume and classification of vehicles crossing the bridge. The traffic counting and classification components of the toll collection system will be audited from time to time by DCBC.

4. TECHNOLOGY REVIEW

This section of the report provides background on the typical devices used in toll collection and traffic counting applications. More detail is available in a separate Technology Review document previously submitted.

4.1 Vehicle Count & Classification

4.1.1 OVERHEAD PROFILER

The profiler units, mounted above the roadway, utilize an eye safe laser to scan the roadway below. Vehicles passing through the sensor's beam field reflect the laser beam back to the sensor, which interprets the reflected pattern and generates a vehicle profile. The resulting profile is compared to a database of standard templates and the vehicle class is determined. In addition to the vehicle's profile, these devices can also detect vehicle direction and speed using an integrated second scanner beam.

Historically, these devices had trouble in poor weather conditions (wet road surface, fog, snow), but it is claimed that recent improvements have addressed this problem. These scanners are considered efficient at distinguishing between a vehicle – trailer combination and two separate vehicles. Multiple scanner devices are used to cover multi-lane and shoulder environments.

Typical Device Cost: Cdn$12 000.

Vendors:

- OSI Laser Scanners, AUTOSENSE II
- Transportation Data Systems, Overhead AVC
- SICK, TCS 200
- EFKON, TOM 2000, Ecotoll

4.1.2 GROUND BASED PROFILER

Ground based vehicle profile devices use a horizontal light curtain to generate a side profile of passing vehicles. A transmitter located on one side of the roadway emits a series of horizontal beams of light to a receiver on the opposite side of the roadway. Vehicles passing between transmitter and the receiver prevent the beams of light from reaching the receiver; the resulting pattern of interruption is translated into a vehicle profile by the system software.

This type of scanner is most suitable for single lane applications such as individual toll lanes separated with medians. Operational problems may result from misalignment of the receiver – transmitter, or sun interfering with the receiver. Horizontal scanners are also considered efficient at distinguishing between a vehicle – trailer combination and two separate vehicles. A single horizontal scanner does not detect vehicle direction or speed.

Typical Device Cost: Cdn$6 000.

Vendors:

- Transportation Data Systems, Lateral AVC
- Sti Scanners, Side profiling vehicle scanners
- Banner, MINI-ARRAY AVC System

4.1.3 INDUCTIVE LOOP

Inductive loop technology can be used for automatic vehicle classification, as well as its traditional use for vehicle counting. Vehicles passing over an inductive loop produce a magnetic profile determined by the distribution of metal within the vehicle. By examining this profile, features such as signal height, peaks and troughs can be analysed and compared with the signatures of known vehicles to determine classification. Multiple loops are combined in each lane to improve the capability for classification and distinguishing between closely following vehicles, as well as to detect vehicle direction and speed.

Inductive loop technology is in wide use throughout the world and relatively impervious to weather. Maintenance problems are generally limited to physical break-up of the road surface. Loops can be used in single and multi-lane environments, but vehicles changing lanes in the vicinity of the loops will introduce some counting error.

Typical Device Cost (classification and counting station): Cdn$12 000.

Typical Device Cost (counting station): Cdn$4 000.

Vendors:

- Intertraffic, Loop Profiler
- PEEK Traffic, Idris
- Counting only ~ numerous vendors

4.1.4 AXLE TREADLE

Treadles consist of several fibre-optic or piezo-electric sensors housed in a frame and set in the roadway. The sensors emit a signal that is distorted as vehicles drive over them. Software interprets the amplitude and frequency of the distorted signal and is able to determine a vehicle classification based on axle count, axle spacing, dual tires, and single wheel (motorcycle) parameters. Vehicle direction and speed is also detected.

Treadles are most suitable for single lane applications such as individual toll lanes separated with medians. The sensor strips are subject to wear from the sustained physical contact with vehicle wheels. However, it is not difficult to replace individual sensor strips. The treadle frame is designed to lift snowplow blades over the sensor strips, but it is desirable not to plow over treadles.

Typical Device Cost: Cdn$6 000.

Vendors:

- International Road Dynamics, DYNAX
- Measurement Specialties

4.1.5 WEIGH-IN-MOTION

Weigh-in-motion devices consisting of bending plate or piezo-electric technology are increasingly in use. The amount of deflection or strain in the sensor is measured and translated into a weight for each axle.

This technology is very useful for measuring road surface usage and identifying over-weight vehicles. However, it is important to note that actual weight is not the same as vehicle GVW; the maximum load capacity of a vehicle.

The presence of snow build up may affect device accuracy or obstruct use.

Typical Device Cost: Cdn$20 000. (Bending Plate System: For 3.5m lane width)

Vendors:

- International Road Dynamics
- Mettler Toledo

4.2 Toll Payment

In addition to cash (sometimes in multiple currencies), most toll agencies offer customers a variety of electronic media for toll payment. Electronic media range from secure credit, debit, or smart card payments to complex post or pre payment billing arrangements where no cash exchange takes place at the time of the transaction. Collecting tolls without the handling cost and potential for "leakage" that are inherent with cash is a significant benefit to customers and operating agencies.

With pre or post transaction billing, the driver or owner of the vehicle(s) sets up an account with the operating agency before using the toll facility. Account statements show all trips during a statement period and payment can be automated via direct link to a bank account or credit card.

4.2.1 SMART CARD

A smart card is a standard credit card-sized plastic device with an embedded microchip. They can store identification data and electronic purse value. Smart card chips come in two broad varieties: memory-only chips, with storage space for data and a reasonable level of built-in security; and microprocessor chips which, in addition to memory, contain a processor that has the ability for specialized local applications. The main storage area in such cards is normally EEPROM (Electrically Erasable Programmable Read-Only Memory), which - subject to defined security constraints - can have its content updated, and which retains current contents when external power is removed.

These cards can be either contact or contactless. Traditionally, the contact card (with gold-plated electrical contacts embedded in the surface of the plastic on one side) is used in retail or banking environments. With the contact card technology, the user inserts the card into a slot in a card reader, which has electrical contacts that connect to the contacts on the card face.

Contactless cards are more suitable in transportation applications, or wherever the customer's ability to insert the card into a reader is constrained. Radio frequency technology is used to transmit power from a reader to the card, and transfer data over a range of up to 10 cm. This contactless card technology utilises an aerial coil laminated into the card, and allows communication even if the card is within a wallet.

Selling smart cards with an electronic purse results in up-front cash, which is an attractive scenario for transport operators, telephone operators and retailers. The cards can be disposable or replenished as needed.

Typical Device Cost: Contactless smart card reader only Cdn$1 000.

Typical Device Cost: Contactless smart card Cdn$3 to $5.

Vendors:

- Gemplus

4.2.2 SELF-SERVE KIOSK

Kiosk vendors / manufacturers provide a wide selection of standard frames, which can be customized to meet customer requirements. Kiosks can be fitted with a selection of vending, payment, and/or read-write options. In addition, several user interface options are available (touch screens, keyboards, mouse, or trackballs for example). Some vendors offer kiosks that can be located outdoors or in more harsh environments (e.g. factory floors, isolated regions). These are more durable and offer greater protection from weather and/or vandals. Outdoor units often feature tamperproof, insulated, stainless steel casings fitted with heaters and/or air conditioners. In all instances, outdoor kiosks cost more than the equivalent indoor model due to their more robust construction and typically higher installation costs. To date, none of the kiosk vendors / manufacturers researched have referred to, or provided examples of, outdoor kiosk operating in conditions similar to the NWT. Standalone and wall-mounted kiosks are available for both indoor and outdoor environments.

Customer interface with a kiosk in an outdoor, harsh weather environment is a significant problem. Screen visibility, using buttons, inserting cards, and retrieving receipts are difficult when contending with sun, wind, precipitation, and cold. In a toll collection environment, the driver's manoeuvrability is further limited by the vehicle size and window operation.

Typical Device Cost: Credit – debit – smart card Cdn$40 000. (Indoor)

Typical Device Cost: Credit – debit – smart card + cash Cdn$50 000. (Indoor)

Vendors:

- The Kiosk Factory
- Kiosk Information Systems Inc.

4.2.3 DEDICATED SHORT RANGE COMMUNICATION (DSRC)

This technology is attractive for toll collection because it allows communication from a moving vehicle without direct interaction with a toll device. Each vehicle has an on-board unit called a transponder or tag, usually mounted on the inside of the windshield behind the rear-view mirror. As a minimum, the transponder contains a unique identification code. Other information such as designated vehicle category may be included.

At toll collection points, antennas are mounted over the lanes on a gantry or toll plaza canopy (side mounted antennas are possible, but less efficient). RF or infrared communication is used to read identification data from the transponder as it passes by the antenna. It is also possible to transmit information to the transponder with more advanced systems. DSRC systems can operate at freeway speeds of up 200 km/h, allowing for maximized toll lane capacity i.e. minimal delay.

There are active (powered by batteries) and passive (without batteries, sometimes called "backscatter") transponder technologies. Type I systems, which use removable passive read-only tags, currently dominate the market because they are inexpensive and compact, operate on low power, and exhibit few environmental problems. Type II systems, with removable read-write active transponders, can exchange information such as updates of a customer's balance after a transaction has been made. These are more expensive, but provide greater application flexibility.

A new generation of Type III system using a read-write on-board unit is now under trial in non-stop tolling environments. The transponder incorporates a removable smart card, enabling increased services, such as electronic purse functionality, encrypted information, billing specifications, and personalized transportation schedules and data.

Equipment required for a toll lane includes the vehicle transponder, an antenna (usually overhead, but can be roadside), and a reader (typically each reader can handle 2 antennas). DSRC has allowed toll collection to move away from lane based toll plazas to open road tolling. These installations require more equipment than the corresponding lane based designs because of the complexity of detecting transponders in vehicles changing lanes or driving on the shoulder.

Typical Cost: DSRC reader Cdn$10 000. + antenna Cdn$2 000. (typically 2 antenna per reader)

Typical Cost: DSRC active transponder Cdn$40.; new passive "sticker" tags Cdn$10.

Vendors:

- Raytheon, ETC (RF)
- TransCore, Amtech RFID Systems (RF)
- EFKON (infrared)

4.2.4 AUTOMATIC NUMBER PLATE RECOGNITION (ANPR)

ANPR uses cameras mounted at the toll station to capture images of the vehicle license plate(s) and a video image processor to determine the plate number. The image processor includes devices and processes to capture, compress, and transmit the image to an image-processing centre. However, it is possible to store the images locally for subsequent batch retrieval and processing. Vehicle detection devices are typically required to trigger the image capture sequence.

This technology can be used to identify all vehicles in order to charge the toll to an account, i.e. the plate number is the equivalent of the DSRC transponder identification. The City of London, England is using this technology for Congestion Charging.

Snow and dirt covering plates is a concern for use in the Northwest Territories. Infrared lighting improves readability with obscured plates.

Typical Device Cost: Image capture and image management for 2 camera treatment of lane with high-speed traffic Cdn$25 000.

Typical Device Cost: Optical character recognition application for automatic licence plate recognition and processing Cdn$10 000.

Vendors:

- Transportation Data Systems
- Tecnicon International Inc, Toll Enforcer
- Transformation Systems Inc
- Computer Recognition Systems
- PIPS Technology

4.2.5 GLOBAL POSITIONING SYSTEM (GPS)

An on-board unit incorporating GPS to track vehicle location and GSM to transmit data to a monitoring system is combined with known geographic coordinates of virtual toll barriers to determine if the vehicle should be charged a toll. Payment processing is via pre or post paid accounts similar to DSRC.

There are numerous benefits of fitting vehicles with sophisticated GPS equipment. Since GPS can be used to monitor a vehicles position in real-time, fleet managers have the capability to track the progress and status of their equipment. Accurate data regarding journey length and travel time can be recorded. Also, knowing the precise route traveled by a vehicle would permit toll operators to record the exact number of times that a GPS equipped vehicle passed through a toll site, enabling them to charge the operator accordingly. Additional vehicle identification and performance auditing equipment mounted at the toll location would help to ensure accurate counting. The cost of sophisticated GPS equipment is still prohibitive for the average commuter. However, the added tracking capabilities could justify the cost for commercial carriers making frequent trips through toll areas. The first major system using GPS is scheduled to go into service in Germany later this year.

Typical Device Cost: The vehicle unit with GPS and GSM radio is expected to cost several hundred dollars.

Vendors: Toll Collect (Germany)

4.3 Violation Enforcement

4.3.1 IMAGE CAPTURE SYSTEM (ICS)

Automatic violation enforcement (AVE) is the process of using Automatic Number Plate Recognition (ANPR) to identify toll violators, rather than all vehicles. Following ANPR capture of plate images, the toll lane controller determines if the vehicle was in violation and instructs the image processor to keep or discard the images. Subsequently, a toll collector reviews images to determine the vehicle's licence plate number for enforcement action.

Typical Device Cost: Image capture and image management for 2 camera treatment of lane with high-speed traffic Cdn$25 000.

Vendors: See Section 4.2.4 Automatic Number Plate Recognition

4.4 Security and Audit

4.4.1 CLOSED CIRCUIT TELEVISION (CCTV) SURVEILLANCE

CCTV can be employed for both performance auditing and system monitoring as a means of protecting against fraud and on-site vandalism. CCTV can be used to record vehicles and optionally the transfer of payment between toll collectors and drivers. Transaction data from the toll system is inserted on the image to enable auditing of the toll collector and customer actions.

Video surveillance is also useful for confirming proper operation of lane devices, current traffic demand at remote plazas, and general security of personnel and property.

Typical Device Cost: Camera and Support Devices Cdn$4 000.

Monitor and small video switch Cdn$10 000. (good for several cameras)

Vendors:

- Pelco
- Cohu

4.4.2 MISCELLANEOUS

Transaction gates provide a direct form of lane-based enforcement.

An audible and visual violator alarm can be installed in each lane to provided a direct indication to customers and on-site enforcement personnel that a vehicle is in violation.

A category indicator sign can be mounted on the exit of a toll lane to display the vehicle category selected for the current vehicle. On-site or remote video surveillance of this sign and the departing vehicle can be used to audit the classification process (toll collector or customer).

4.5 Customer Guidance

When the toll transaction requires that vehicles stop or proceed slowly, a series of information devices is used to guide customers through the toll plaza and lane.

- Lane open / closed signal – a green arrow / red "X" LED signal over the entrance to each toll lane to indicate its open or closed status.

- Vehicle types accepted and / or payment types accepted sign – a sign over the entrance to each toll lane to indicate any vehicle limitations (e.g. cars only) that may exist. The sign may also indicate payment limitations (e.g. credit card only). This sign may also be used to indicate lanes that have a toll collector present.

  Many toll plazas have a combination of lanes that are designed for fixed or variable use. Therefore, static and dynamic sign displays are required. Rotating prism sign devices are used in order to achieve common display parameters alongside static signs.

- Fare indicator sign – a small variable message text sign is used display the amount due and other transaction information (e.g. low account) to drivers as they pass through a toll lane. These signs are situated to be visible as a driver enters and passes through the lane.

- Transaction signal – a standard red / green traffic signal is used to provide direct feedback to the driver regarding the status of the toll transaction.

- Transaction gate – a gate that blocks passage until each toll transaction is complete is historically used to stop customer toll violations. If every lane available has a gate, other forms of enforcement may not be required. However, gates are inherently mechanical and the arms will be hit from time to time. A relatively high level of maintenance is required.

- Intercom or telephone – unattended lanes require some type of communication device for customers to request assistance. If the assistance will be provided from a remote site, video surveillance (as discussed previously) is important to allow confirmation of the customer scenario.

4.6 Point of Sale

Toll lanes designed for attended operation with a toll collector require a variety of standard point of sale devices. These include: a user interface for processing toll transactions and managing lane devices (LCD touch screen recommended), cash drawer, receipt printer, and other devices to support the payment media accepted (magnetic stripe credit and debit card reader, smart card reader / writer, cheque canceller, PIN pad).

Miscellaneous items used in the cash handling process may include special lights for currency validation, pneumatic tube systems for transferring cash from booths to a central facility, uniquely numbered, tamper resistant deposit bags for moving cash between toll collector and bank.

5. OPERATING CONCEPTS

Toll collection and traffic counting systems are comprised of four major functions:

- Vehicle Counting & Classification;
- Toll Collection;
- Violation Enforcement;
- Administration.

In a typical toll collection setting, the count, classification, collection, and enforcement functions all take place in a single toll transaction sequence. However, for the Deh Cho Bridge operating environment, separation of these functions in time and location may be beneficial.

5.1 Vehicle Count & Classification

5.1.1 GENERAL

It is a requirement of the DCB Concession agreement that the GNWT toll system count and classify each vehicle that crosses the bridge. The counting and classification system needs to operate continuously, be located on or very close to the bridge site, and be independent of the toll collection process.

The minimum requirement for toll reconciliation is to monitor all northbound traffic. However, it is desirable to both GNWT and the DCB Concession to have accurate data for all traffic using the bridge (northbound and southbound). It is assumed that the roadway cross-section will be a typical paved two-lane highway, with paved shoulders near the bridge. The counting and classification system will have to properly process vehicles proceeding in either direction, in any position across the road.

Accurate vehicle counting is not expected to be a problem. However, vehicle classification with respect to the desired toll categories and the operational environment will be difficult. The officially designated toll threshold of commercial vehicles with GVW greater than 4500 kg and buses may be impossible to evaluate electronically. There can be pickup trucks, box trucks, and vans with GVW greater or less than 4500 kg. More importantly, GVW is the capacity of a vehicle; not its current weight. Commercial buses can be large inter-city or smaller van types. Private vehicles can be large recreational vehicles and can have more than two axles if pulling a trailer.

The GNWT proposed surrogate toll categories of single unit, tractor-trailer, and multiple trailer (train) commercial vehicles are more practical to evaluate visually, but pose some problems for electronic evaluation. Tractor-trailer and multiple trailer (train) vehicles are always considered commercial and can be identified by length and/or number of axles. However, some recreational vehicles with trailers will have similar characteristics. The single unit category includes a mix of private and commercial vehicles from small cars to large buses and dump trucks.

5.1.2 CLASSIFICATION CRITERIA AND DEVICES

A description and evaluation of possible vehicle classification criteria and measurement devices follows:

- Weight – actual weight on each axle can be obtained with a Weigh-in-motion device. However, actual weight is not gross vehicle weight, an additional device is required to determine vehicle separation (and thus the axles to aggregate to an individual vehicle), and operation in exposed winter conditions is not recommended.

- Height – it is possible to determine a vehicle height profile, including maximum height, with overhead scanner devices (accuracy +- 10cm). Side scanner devices are not feasible in an open roadway cross-section. Operation of scanner devices in exposed winter conditions is not optimal.

- Length – it is possible to obtain estimated vehicle length with overhead scanner or loop devices. Accuracy depends on vehicle maintaining constant speed through detection zone. This should not be a problem near the bridge.

- Number of axles – Axles can be counted with treadle or multiple loop devices. A treadle will not count raised axles and needs an additional device to determine vehicle separation. Operation of treadles in exposed winter conditions is not optimal. Multiple loop devices will count raised axles and determine vehicle separation reasonably well.

- Dual Wheels – The presence of dual wheels on an axle can be determined with treadle or loop devices. This parameter is sometimes used as an indicator of load capacity for 2 and 3 axle vehicles. Other comments from the Number of Axles criteria apply.

- Visual Characteristics – Given the low traffic volume using the Deh Cho Bridge, it would be possible to count and classify each vehicle through a combination of digital and manual video image processing. This would allow personnel to decide on the appropriate category for otherwise ambiguous vehicles, and in theory provide perfect results. However, this process would also be subject to human error / fraud. Operation of the camera in exposed winter conditions and the digital software in the two-direction highway environment is not optimal.

5.1.3 TOLL CATEGORIES

In order to address the difficulty of classifying tolled and non-tolled single unit vehicles, GNWT and the DCB Concession may wish to modify the toll categories.

The commercial vehicle forecasting report done for GNWT estimated that 3-axle vehicles would be 3% of the total volume of commercial vehicles. If "single unit vehicle" were changed to "3-axle vehicle", the electronic identification would be more precise. Note that private cars with a trailer would be incorrectly counted as tolled vehicles.

An alternate approach could be to eliminate the "single unit vehicle" category and adjust the remaining categories to include the largest single unit vehicles. Possible thresholds for this scenario are listed below. The length and axle values are estimates. Real vehicle data should be obtained.

- Length 25m+ or axles 6+. It is believed that these criteria will identify multiple trailer (train) vehicles subject to an initial toll of approximately $200.

- Length 10m to 25m and axles 3 to 6. These criteria should identify large single unit and tractor-trailer vehicles subject to an initial toll of approximately $100.
  Note: To identify tractor-trailer vehicles only, the criteria are believed to be length 13m to 25m and axles 4 to 6.

There are some tractor-trailer configurations with more than 6 axles, but if their load capacity is that large, the $200 toll may be justified. Note that private vehicles with trailers having a total length greater than 10m would be incorrectly counted as toll vehicles.

If the classification criteria cannot be changed, then the visual image processing technology will be required with manual evaluation of single unit vehicles into toll and non-toll categories.

5.1.4 RECOMMENDATION

It is recommended that the vehicle counting and classification system consist of a multiple loop device system placed as close to the bridge as practical, likely just off the structure on the south side. The most comprehensive product of this type is IDRIS from Diamond Consulting Systems. This system supports toll categories based on length, supplemented with number of axles and dual wheel data. An in-road installation in coordination with the roadway construction offers the best performance and maintenance characteristics for the harsh environment of the NWT.

An alternate technology that may be considered is the overhead profiler (laser scanner).

If video image review is subsequently determined to be required for additional classification data, it can be installed later without disruption of the road surface.

Required Infrastructure for the counting and classification system is:

- Inductive loops set in the road prior to final surface layer. Coverage to be the northbound lane, the southbound lane, and possibly each shoulder,
- Roadside cabinet with base to house controller,
- IDRIS controller and software,
- Power with UPS and optionally a generator,
- A data access computer (data storage and workstation) located in a convenient administration facility for DCB Concession use,
- A system management computer (server and workstation) located in a convenient administration facility for GNWT toll system use. This computer will be the toll system central computer described later.
- A dedicated, continuous communication link to both administration facilities is desirable, but not critical to the data collection process. Dedicated communication allows continuous display of current traffic information and continuous monitoring of the data collection system. A dial-up communication link allows data to be retrieved as often as desired, i.e. when someone is available to look at it. Data could also be retrieved by transfer to removable media and manual collection. This should only be considered as a backup process.

5.1.5 PERSONNEL ACTIVITIES

Typical management and operation activities that will be required in conjunction with the count and classify system are:

- Review count & classify data from devices – daily;
- Reconcile count & classify data with toll collection data – daily;
- Prepare DCB settlements – weekly;
- Review & analyse DCB questions about settlements;
- Audit & validate count & classify devices – 2 times per year is reasonable;
- Monitor the overall process;
- Respond to problems.

5.2 Toll Collection

Three factors will define the toll collection function recommended for the Deh Cho Bridge. These factors are:

- Where the toll collection and administration will take place?
- How the non-tolled vehicles will be processed?
- How the toll payment will be collected?

The relatively remote location of the bridge site and the low volume of tolled vehicles have resulted in consideration of somewhat unusual approaches to the toll collection function.

5.2.1 WHERE THE TOLL COLLECTION AND ADMINISTRATION WILL TAKE PLACE?

Toll collection for bridge facilities invariably takes place within sight of the bridge. This provides a direct association between the toll and the facility for customers. It also ensures that all vehicles crossing the bridge pass through the toll collection area. Administration functions are usually housed within a building adjacent to the toll plaza if the site is the only one operated by the agency. When more than one toll site is operated, the administration functions are usually consolidated at one location.

5.2.1.1 At the Bridge Site

A toll collection facility can be located on the northbound approach to the Deh Cho Bridge, although it may have to be prior to the final turn and therefore out of sight of the actual bridge. All required infrastructure for toll collection (roadway area, toll plaza structures, and toll devices) would have to be built new. Administration functions will likely be conducted remotely from the site regardless of the toll collection location because the low volume of toll transactions will not require the full time attention of a supervisor or manager. Depending on the method of toll collection, there will be

periods when a single toll collector would be required at the site posing personnel security and labour efficiency issues.

5.2.1.2 At the Enterprise Weigh Scale

The weigh scale facility at Enterprise is a viable alternate location for toll collection. This location offers the benefit of existing infrastructure that could be adapted / enhanced for toll collection (roadway area and building structures). It also may be a suitable location for the administration functions. All commercial vehicles already have to stop at the weigh scale *when it is open*. GNWT will have to address the hours of operation if this location is selected, although some toll collection methods could continue while the scale is closed. As discussed in section 3.1, there are routes leading to the Deh Cho Bridge that do not pass the Enterprise weigh scale.

5.2.2 HOW THE NON-TOLLED VEHICLES WILL BE PROCESSED?

Tolls will only be collected from commercial vehicles. Two operation concepts are available for the non-tolled private vehicles.

5.2.2.1 Stop for Zero Toll

One approach is to assume that the Deh Cho Bridge is a toll facility for all vehicles, but private vehicles are presently exempt from paying. In this case, the toll facility would span the entire roadway. Private vehicles would be stopped, a toll collector would classify them, and they would be allowed to proceed with no toll payment due.

The major benefit of this approach is that it facilitates the future possibility of applying a toll to private vehicles. Other benefits are that customers in private vehicles will be more aware of their present non-tolled status, and a common toll plaza design can be applied for all vehicles. If all vehicles must stop for a toll barrier (gate), customer toll violations are minimal.

The delay imposed on each private vehicle is a significant disbenefit. Customers will soon realize that the delay is needless, and toll collectors will start processing transactions as vehicles approach, so that most vehicles end up not stopping. These scenarios will lead to dangerous driver actions. Additionally, more toll collectors will be required.

5.2.2.2 Free Flow

The second approach is to design for free flow passage of private vehicles assuming that there will not be a change in the toll framework.

This will provide the best possible service to customers in private vehicles and it will reduce the overall size of toll plaza required.

However, enforcement issues are more difficult to address because the free flow lane should be monitored for illegal use by commercial vehicles. Geometric design of the plaza area must provide safe separation of decelerating / accelerating commercial vehicles from private vehicles proceeding at the highway speed.

5.2.3 HOW THE TOLL PAYMENT WILL BE COLLECTED?

Toll payments can be collected with manual, self-serve, or electronically initiated transactions. Depending on the collection method, the toll can be paid with cash, credit card, or debit card; or the

toll can be charged against a pre or post paid account. Smart cards with electronic purse are not practical for the Deh Cho Bridge because of the relatively large value of the toll.

5.2.3.1 Manual (Attended) Toll Collection

This is the traditional toll collection scenario. All commercial vehicles would stop at a toll plaza facility on each northbound trip. The plaza would require a toll lane with tollbooth, as well as basic staff amenities (toilet, kitchen) and secure cash storage. Point of sale devices and software will allow the toll collector to classify and process payment for each commercial vehicle; accepting cash, credit card, or debit card. The driver will receive a receipt.

Automated Vehicle Classification (AVC) devices are typically used to scan each vehicle as it exits the toll lane to verify the classification entered by the toll collector. AVC can be used to classify vehicles on entry (so that the toll collector does not classify), but this approach is not recommended. It requires a more complex and larger plaza design since the devices must be far enough upstream to define the longest category distinction (multiple trailer). Classification ambiguities are generally more of a customer relations problem with pre-classification.

Gates are typical in this type of toll collection, but if private vehicles have a free flow lane, there is no purpose in using gates in the commercial vehicle toll lane. Since there is only one lane, a lane open / closed sign is not required. A transaction signal (red / green) and a variable fare indicator sign should be used.

A good quality communication link is required for debit card processing, highly desirable for credit card processing, and useful to the toll system overall. Operation can be adapted to lower level communication capability, but there will be constraints on toll system functionality.

Remote video surveillance is highly beneficial for monitoring toll collector and customer actions.

Manual collection can be conducted at the bridge site or the weigh scale location. The bridge site location would require the construction of required infrastructure (i.e. toll booths, canopy structure, etc.) while the weigh scale site will likely require some modification of existing facilities. At the weigh scale, the scale attendant would probably collect tolls from drivers in their vehicles, although the tolls could be collected inside the administration building where permits are issued.

It is good practice to build a minimum of two lanes to avoid single point of failure situations (device failure or vehicle breakdown). However, this cannot be justified with the low volume at Deh Cho Bridge. Design should accommodate device or vehicle breakdowns with the ability to operate in unusual degraded scenarios.

Benefits: Human interaction provides flexibility to deal with unique customer situations. Toll collectors can adapt to varying driver positions so that drivers can remain in their vehicle.

Disbenefits: At the bridge site, providing staff on a continuous basis for the relatively low commercial vehicle volume is not efficient. Working alone in a remote location is dangerous. All commercial vehicles have to stop.

5.2.3.1.1 Plus Account Payment

A large component of the commercial vehicles that will use the Deh Cho Bridge are operated by a few large trucking companies. These companies would prefer that their drivers not be responsible for paying the bridge toll each time they make a trip.

The toll system can include customer account functionality. Customers open an account with GNWT for the Deh Cho Bridge tolls. An identification device is assigned to each vehicle that the customer wishes to equip. The identification device for use with manual toll collection would be a magnetic stripe card, although a smart card could be considered for increased security.

Each time the driver stops to pay the toll, the identification magnetic stripe card is handed to the toll collector who swipes it in the same card reader used for credit and debit cards. The toll system account process checks that the card is valid and the associated account is valid, and records a successful toll transaction against the identification card. All transactions are aggregated and a regular statement produced for each account. The account can be pre-paid with manual or automatic replenishment of funds to maintain a balance in the toll agency's favour. Alternatively, the account can be post-paid with manual or automatic payment of the amount owing. The card may be rejected for payment if the account balance is too low or the card has been reported lost. A third type of account is a direct link to a credit card for processing of each transaction as it occurs (similar to several current gas company initiatives).

Incremental Benefits: Drivers do not pay the toll directly from their pocket. Account holders get a detailed statement showing all trips by each identification card.

Incremental Disbenefits: Account holders have to watch for drivers using the identification card to charge tolls for trips that are not company business.

5.2.3.2 Self-Serve Payment Processing

Self-serve toll collection using a kiosk type device is a viable option for the Deh Cho Bridge. Drivers would get out of their vehicle and enter a weather protected booth or building. The driver would enter the classification of vehicle, make payment using credit or debit card, and receive a receipt. Kiosk devices can also be configured to accept cash if the operating agency wants to take on the security risks and the cash handling costs.

Note that self-serve collection from drivers in their vehicles is possible, but not considered practical for NWT due to the difficulty of adapting the device to the driver's position and the weather extremes.

Customers should have intercom / telephone access to someone for assistance while standing at the kiosk.

Since drivers will exit their vehicle to make the toll payment, it is not reasonable to expect them to enter and depart the toll "plaza" in sequence. Therefore, transaction gates and classification devices are not practical for self-serve toll collection. Other methods of violation enforcement are required as discussed section 5.3.

A good quality communication link is required for debit card processing, highly desirable for credit card processing, and useful to the toll system overall. Operation can be adapted to lower level communication capability, but there will be constraints on toll system functionality.

Remote video surveillance is highly beneficial for monitoring customer actions.

Self-serve payment processing can be applied at the bridge site or the weigh-scale location. The bridge site location would require construction of a lay-by area with room for 2 or 3 trucks and a weather-protected booth to house the kiosk. The site facility may require a toilet for customer use. The weigh-scale site will likely require some modifications to existing facilities.

It is good practice to provide a minimum of two kiosks to avoid single point of failure situations. However, this may not be justified with the low volume at Deh Cho Bridge. Design should accommodate device breakdowns with the ability to operate in unusual degraded scenarios (e.g. manual collection while kiosk out of service).

Benefits: 24 / 7 operation while reducing the requirement for toll personnel. Additional self-serve kiosks can be deployed anywhere there is a good communications link (e.g. the Fort Liard weigh scale, the restaurant / rest area at the turnoff to Fort Providence.

Disbenefits: Drivers have to understand the classification structure. If cash is not supported, some customers may claim that they are unable to pay. All commercial vehicles have to stop. All drivers have to get out of their vehicle.

5.2.3.2.1 Plus Part-Time Manual Collection

The facility housing the self-serve kiosk could be expanded to accommodate a service counter or desk with a manual collection point of sale workstation and staff amenities.

Incremental Benefits: This may be desirable to GNWT in order to allow the benefits of manual collection (customer contact, cash payment) during designated periods. It would also provide backup for possible kiosk failure.

Incremental Disbenefits: The same disbenefits noted for manual toll collection.

5.2.3.2.2 Plus Account Payment

The addition of account payment functionality to self-serve toll collection has the same implications as discussed in section 5.2.3.1.1 for adding account payment to manual toll collection.

5.2.3.3 Electronic Toll Collection

Electronic Toll Collection is a special approach that can be applied to account or credit card payment. The premise is to identify the vehicle without forcing the driver to come to a stop and exchange information with a toll collector or kiosk. This is done with Dedicated Short Range Communication (DSRC) RF technology or Automatic Number Plate Recognition (ANPR) video technology. GNWT does not wish to issue toll invoices to non-account holders based on vehicle registration data. Therefore, ETC is an incremental option to manual or self-serve toll collection. ETC also puts more emphasis on violation enforcement since vehicles proceed without any visible sign of payment and drivers will not have a receipt to verify payment.

The DSRC version uses an RF transponder assigned to each vehicle of an account. Antennas and associated reader electronics are installed at the threshold to read the identification number of transponders as they pass. This can be done at highway speeds with a mix of transponder-equipped vehicles and non-transponder equipped vehicles. If desired, information can be written back to the transponder (usually just a indicator of a successful transaction).

ANPR uses the vehicle license plate as the vehicle identification device. The plate number is determined from automatic and/or manual review of video images. For tractor-trailers and multiple trailer vehicles, the front pate is required. This is somewhat difficult to capture automatically because of the variety of mounting locations however, the low volume at Deh Cho Bridge makes it feasible to look at each vehicle manually. If the plate is obscured in any way, the identification fails.

Electronic toll collection can be applied at either the bridge site or the weigh-scale location. The bridge site location would require construction of an overhead gantry to mount the antennas or cameras suitable for highway speed operation. At the weigh-scale site, it is assumed that vehicles will be identified while they are proceeding slowly for the scale functions. Therefore, less intensive infrastructure such as roadside poles will be sufficient. The transponders and antennas can also be less expensive if slower speeds are involved.

Benefits: High level of service for account holders who are typically frequent users.

Disbenefits: Enforcement is more difficult when tolled vehicles are allowed to proceed without stopping.

5.2.3.4 Recommendation

Each toll collection option is feasible for Deh Cho Bridge. Subsequent evaluation and costing will consider all of them.

5.2.3.5 Personnel Activities

Manual toll collection activities include:

- Manual (Attended) Toll collection – 24/7 in a single lane;
- Third-party services for cash pickup, delivery, counting, and deposit;
- Monitor toll collection process for personnel / device security & financial integrity via camera & phone;
- Review & reconcile cash deposits between bank, toll collector, and toll system;
- Review & reconcile credit / debit daily batch closing;
- Review & analyse toll collector data;
- Audit & validate toll devices;
- Data backup, archiving, and liaison with toll system support provider;
- Maintain toll devices;
- Toll application system support;
- Monitor processes;
- Respond to problems;
- Prepare performance reports.

Adding account payment includes these activities

- Manage AVI device (magnetic stripe card) inventory;
- Account & AVI device customer service – e.g. account setup, update, toll transaction queries, adjustments, information, distribute and reclaim AVI devices

- Generate and issue account statements;
- Receive account payments;
- Prepare commercial approaches (discount plans, marketing, etc.)

Self-serve toll collection activities are similar, but without the activities specifically related to cash processing. The specific toll devices to be monitored and maintained are different.

Self-serve plus manual collection requires all the activities above with the additional toll kiosk device. However, the manual toll collection would be less than full time.

The activities required for electronic toll collection using DSRC are the same as listed above for account payment with a different AVI device. If the AVI device is the vehicle license plate, there are additional activities required for

- Video image review and plate determination / verification.

5.3 Violation Enforcement

The DCB Concession is to receive funding based on data from the Counting and Classification system, regardless of whether tolls have been collected by GNWT. Violations are therefore a cost, as well as lost revenue, to GNWT. Some form of violation enforcement is required to maintain driver compliance.

Under the optimum scenario, the violation enforcement system will verify that the proper toll has been collected from the driver of each vehicle crossing the bridge and provide a means to collect an appropriate fee from those drivers who are in violation. This fee is typically mandated through official legislation and varies widely between tolling jurisdictions. Some look to recover the toll plus an administration fee, while others charge the driver with an offence and associated fine. Note that fines often go to the court system, not the toll agency.

Since drivers will not be required to pass through a mainline toll plaza prior to crossing the Deh Cho Bridge, there is no opportunity for physical enforcement with gates. There are two alternate approaches to violation enforcement.

5.3.1 COMPREHENSIVE ENFORCEMENT

A Violation Enforcement System (VES) is used. The overall violation process consists of the following activities:

- Video images of each vehicle, suitable for license plate identification, are captured at the defined violation threshold. This would be right at the bridge site. Since commercial vehicles are being processed, front images are required to get a plate. A side image is also desirable to enhance identification if the front is obscured by snow or dirt. Overhead and side mounted cameras, along with special lighting are required.
- The roadside image controller is linked with the classification system so that images of non-tolled vehicles can be discarded.

- The remaining images are transmitted to an office facility. An ADSL grade communications link is required.

- The images are viewed using special software that facilitates manual license plate determination. Optionally, sophisticated software that digitally finds the license plate and determines the plate number can be applied to reduce the number of images to be manually processed. However, the volume of vehicles to be processed for Deh Cho Bridge is small.

- The plate numbers are compared with the toll payment transactions to identify any violators (no payment for vehicle, or incorrect payment for vehicle category).

- Identifying information, possibly including the image, is sent to the enforcement personnel.

- These officers look for the offending vehicle, preferably on the highway between Fort Providence and Edzo, pull the vehicle over, and issue the violation notice.

GNWT does not believe that is practical to issue violation notices to vehicle owners through the mail due to issues with collection from out of territory residents.

The process of getting the information to enforcement personnel has to occur within 30 minutes to an hour for the officers to have 1 to 2 hours to find the vehicle while it is still northbound south of Edzo. This has implications on personnel availability to review pictures and enforce 24/7.

5.3.2 RANDOM ENFORCEMENT

In this scenario, enforcement officers set up random spot checks to stop commercial vehicles and verify that the driver has proof of toll payment.

The spot check could occur anywhere along the highway north of the bridge where it is considered safe to pull trucks over. From an absolute accuracy perspective, it should occur prior to the Fort Providence intersection so that any driver questioned must have crossed the bridge. However, if the spot check is done north of this intersection, a “last chance” toll collection kiosk could be provided at the restaurant / service area located at the Fort Providence intersection. This may be attractive depending on the toll collection scenario selected. The problem is that a driver could claim that he/she originated in Fort Providence and did not cross the bridge.

If toll collection is implemented at the bridge site, enforcement could focus directly on commercial vehicles that proceed past the toll collection point without stopping. Unfortunately, the drivers would be quick to alert each other that officers were in the area.

The proof of toll payment would be the receipt issued during the toll collection process unless account payment with automatic vehicle identification (DSRC, ANPR) is implemented. In this case, the officer would have to access the toll payment transactions and check for the vehicle plate number to determine if proper payment was received.

This random enforcement approach is attractive because there is no field infrastructure to purchase and maintain if all drivers have a receipt (with DSRC or ANPR account payment, a means to access the toll transactions remotely is required). The spot checks can be set up in safe locations, and the officers do not have to "find" a specific vehicle on the highway. Other GNWT enforcement checks can be combined.

The major drawback of random enforcement is that paying customers are forced to stop sometimes.

5.3.3 RECOMMENDATION

These enforcement approaches are well suited to a staged implementation. It is recommended that random enforcement be used for initial operation. After some time, the violation – successful apprehension performance should be evaluated and if necessary, comprehensive enforcement can then be implemented. The image capture equipment can be installed without significant roadway disruption.

To facilitate the possible future implementation of a violation enforcement system, civil provisions such as bases and ducting for a camera gantry coordinated with the counting and classification devices should be incorporated in the initial design.

5.3.4 PERSONNEL ACTIVITIES

Comprehensive VES operations activities include:

- Review images to identify violating vehicles – determine plate #, compare with toll transactions, pass vehicle info to enforcement officer; and
- Enforcement Officers find vehicle, pull over, and issue violation.

Operations activities related to random enforcement include:

- Enforcement Officers set up spot checks and pull over all tolled vehicles – toll transaction receipt for proper payment is verified – if AVI device does not provide toll transaction receipt, officer will access toll transactions to verify payment (phone to customer service personnel or voice response system)

5.4 Administration

Many of the activities described in the preceding sections for vehicle counting and classification, toll collection, and violation enforcement are processed and/or conducted in an administration facility using toll system central servers and other related devices.

The processes include:

- Store and archive data;
- Monitor system cameras;
- Cash tracking analysis;

- Credit / debit settlement analysis;
- Financial performance analysis;
- Vehicle capacity performance analysis;
- Toll collector performance analysis
- Customer service functions related to account management;
- Device monitor and maintenance scheduling.

The administration facility can be anywhere that is supported by a good communications link with the toll collection site(s).

In the case of the DCB application, the location of the administration building would likely be at an existing location, such as Enterprise, Fort Providence, or even Yellowknife.

Typical hardware at the administration facility includes a system server with current data storage and backup capabilities, multiple workstations for accessing the toll system functions, and video distribution devices with associated monitors. Operating system, database, reporting, and other general-purpose software are required. Account payment requires additional central computer size and power, and additional workstations for customer service. ANPR electronic toll collection requires additional storage and workstations for image storage and manipulation.

6. EVALUATION

The operation concept for tolled commercial vehicles should meet the needs of both frequent and infrequent customers. Infrequent customers will arrive at Deh Cho Bridge expecting to stop and pay the toll using conventional media (cash, credit card, debit card). They may have questions about the bridge and the toll. Frequent users are interested in options that allow the toll payment to be charged against an account so that drivers do not have to pay at the toll facility, and options that allow vehicles to proceed through the toll facility with as little delay as possible.

The following sections present an estimation of the capital and operating costs involved with each of the options discussed in Section 5. An evaluation summary table is then presented to facilitate overall evaluation.

The cost estimates include substantial contingency for uncertainties related to the functional requirements and the costs of working in the NWT. As the design progresses, these uncertainties will be reduced, and budgets that are more accurate can be determined.

6.1 Preliminary Capital Cost Estimates

All estimates in Canadian $

(1) Administration Office

Administration Office Equipment and Software	$100 000.
Increment Cost: Back-up Generator Option	$25 000.

(2) Vehicle Count & Classification

	Inductive Loop	**Overhead Profiler**
Vehicle Count & Classification	$74 000.	$129 000.
Increment Cost: Back-up Generator Option	$25 000.	$25 000.

(3) Toll Collection Alternatives

	Attendant Collection	**Self-Serve Collection**		**Electronic Toll Collection**		
		w/o Service Counter	**w/ Service Counter**	**DSRC**	**[1]ANPR**	**Identity Card**
At Weigh-Scale Site	$285 000.	$300 000.	$362 000.	$158 000.	$218 500.	$121 500.
At Bridge Site	$365 000.	$315 000.	$392 000.	$273 500.	$253 500.	$121 500.
Increment Cost: Back-up Generator Option at Weigh-Scale Site	$25 000.	$25 000.	$25 000.			

(4) Violation Enforcement Alternatives

	Image Capture System	**Random Spot Checks**
[1]Violation Enforcement	$122 500.	$10 000.

NOTES: (1) A savings of approximately $45 000. is expected for both Image Capture and ANPR with the use of a median at the bridge site.

Exhibit 6-1: Preliminary Capital Cost Estimate

6.2 Preliminary Operation and Maintenance Annual Cost Estimates

All estimates in Canadian $

(1) Administration Office

Administration Office Equipment and Software	$60 500.
Increment Cost: Back-up Generator Option	$220.

(2) Vehicle Count & Classification

Vehicle Count & Classification	$26 400.
Increment Cost: Back-up Generator Option	$220.

(3) Toll Collection Alternatives

	Attendant Collection	**Self-Serve Collection**		**Electronic Toll Collection**		
		w/o Service Counter	**w/ Service Counter**	**DSRC**	**ANPR**	**Identity Card**
At Weigh-Scale Site	$195 500.	$20 500.	$177 500.	$46 600.	$49 000.	$46 600.
At Bridge Site	$263 500.	$20 500.	$257 500.	$46 600.	$49 000.	$46 600.
Increment Cost: Back-up Generator Option at Weigh-Scale Site	$220.	$220.	$220.			

(4) Violation Enforcement Alternatives

	Image Capture System	**Random Spot Checks**
Violation Enforcement	$90 000.	$180 000.

Exhibit 6-2: Preliminary Operation and Maintenance Cost Estimate

6.3 Evaluation Summary

The following tables present a summary of the options for traffic counting and toll collection under the major functions discussed in Section 5: Vehicle Counting & Classification, Toll Collection, Violation Enforcement, and Administration. Administration is referenced within the tables for the other functions.

Count & Classify			
Criteria	**Multiple In Ground Loops**	**Overhead Profiler**	**+ Manual Video Image Review**
Technology	Inductive loop, Field controller, Admin computer, data storage, & workstation.	Laser scanner, Field controller, Admin computer, data storage, & workstation.	Digital camera, Field controller?, Admin computer, image storage, & workstation.
Vehicle Count	Accurate. Directional. Vehicles close together (< 0.5 m) may be counted as one. Not a likely scenario for DCB.	Accurate. Directional. Detects very small gap between vehicles. Some problems with wet or ice covered road surface.	Visual observation of recorded images. Intended to verify accuracy of other device.
Vehicle Classify	Number of axles, Dual wheels, Vehicle length (from speed).	Height profile, Vehicle length (from speed).	Visual observation of recorded images. Intended to verify accuracy of other device.
Installation	Placed in base coarse prior to final lift. Roadside cabinet & controller.	Mounted overhead on a gantry. Roadside cabinet & controller.	Mounted on roadside pole. Could be pan/tilt/zoom capable for general site observation as well.
Maintenance	None required unless road surface deteriorates.	Cleaning, alignment.	Cleaning, alignment.
Life Expectancy	Loops: pavement life Controller: 5-10 yr electronic obsolescence.	Scanner: 5-7 yr outdoor electronic device. Controller: 5-10 yr electronic obsolescence.	Camera: 5-7 yr outdoor electronic device. Digital recorder: 5-10 yr electronic obsolescence.
Operations Activities	Reports and data analysis.	Reports and data analysis.	Manual image review and tally.
Communication	Dedicated, continuous desirable – dial up possible.	Dedicated, continuous desirable – dial up possible.	Dedicated, continuous
Capital Cost	$74 000.	$129 000. More expensive due to gantry.	
Operating Cost	$26 000. Annual	$26 000. Annual	
Recommendation	Yes		Desirable Extra

Exhibit 6-3: Evaluation Summary – Vehicle Count and Classify

Toll Collection – Basic				
Criteria	**Manual**	**Self-Serve**	**Self-Serve + Manual Part-Time**	**Electronic – Not applicable without Account option**
Technology	Point of sale devices, Touchscreen interface, AVC devices, Lane devices, Lane controller, Admin server, database, & workstation(s).	Kiosk device, Touchscreen interface, Lane controller, Intercom, Admin server, database, & workstation(s).	Kiosk device, Point of sale devices, Touchscreen interface, Lane controller, Intercom, Admin server, database, & workstation(s).	
Payment accepted	Cash, credit, debit.	Credit, Debit	Cash, credit, debit.	
Customer receipt	Receipt	Receipt	Receipt	
Installation	Bridge Site: roadside area, toll lane with devices, tollbooth with amenities, cash storage.	Bridge Site: roadside area, booth with optional amenities.	Bridge Site: roadside area, booth with amenities, cash storage.	
	Weigh Scale: add toll devices to existing facility. Limited roadwork.	Weigh Scale: add toll devices to existing facility. Limited roadwork.	Weigh Scale: add toll devices to existing facility. Limited roadwork.	
Maintenance	Cleaning, alignment, replace receipt paper, replace lights. Software support.	Cleaning, alignment, replace receipt paper, replace lights. Repair possible vandalism. Software support.	Cleaning, alignment, replace receipt paper, replace lights. Repair possible vandalism. Software support.	
Life Expectancy	Devices: 5-7 yr outdoor electronic device. Controller: 5-10 yr electronic obsolescence. Server & workstations: 5-10 yr electronic obsolescence. Devices at the bridge site will suffer more abuse and damage than at the weigh scale site because of the isolation.	Devices: 5-7 yr outdoor electronic device. Controller: 5-10 yr electronic obsolescence. Server & workstations: 5-10 yr electronic obsolescence. Devices at the bridge site will suffer more abuse and damage than at the weigh scale site because of the isolation.	Devices: 5-7 yr outdoor electronic device. Controller: 5-10 yr electronic obsolescence. Server & workstations: 5-10 yr electronic obsolescence. Devices at the bridge site will suffer more abuse and damage than at the weigh scale site because of the isolation.	

Toll Collection – Basic				
Criteria	**Manual**	**Self-Serve**	**Self-Serve + Manual Part-Time**	**Electronic – Not applicable without Account option**
Operations Activities	Toll collection, Cash handling, Credit/debit handling, Supervision, reconciliation, auditing, System administration, Performance reports and data analysis.	Toll collection, Cash handling, Credit/debit handling, Supervision, reconciliation, auditing, System administration, Performance reports and data analysis.	Toll collection, Cash handling, Credit/debit handling, Supervision, reconciliation, auditing, System administration, Performance reports and data analysis.	
Communication	Dedicated, continuous desirable – dial up possible.	Dedicated, continuous desirable – dial up possible.	Dedicated, continuous desirable – dial up possible.	
Capital Cost	Bridge Site: $365 000.	Bridge Site: $315 000.	Bridge Site: $392 000.	
	Weigh Scale: $285 000.	Weigh Scale: $300 000.	Weigh Scale: $362 000.	
Operating Cost	Bridge Site: $263 500. Annual	Bridge Site: $20 500. Annual	Bridge Site: $257 500. Annual	
	Weigh Scale: $195 500. Annual	Weigh Scale: $20 500. Annual	Weigh Scale: $177 500. Annual	

Exhibit 6-4: Evaluation Summary – Toll Collection Basic

Toll Collection – plus Account Payment				
Criteria	**Manual + Account Payment**	**Self-Serve + Account Payment**	**Self-Serve + Manual Part-Time + Account Payment**	**Electronic Account Payment Used in combination with the other options.**
Technology	Magnetic stripe card for vehicle identification. Contactless smart card a more durable option.	Magnetic stripe card for vehicle identification. Contactless smart card a more durable option.	Magnetic stripe card for vehicle identification. Contactless smart card a more durable option.	DSRC transponder for vehicle identification ANPR for vehicle identification
Payment accepted	Above + charge to an account or direct link to a credit card.	Above + charge to an account or direct link to a credit card.	Above + charge to an account or direct link to a credit card.	Per a basic option + charge to an account or direct link to a credit card.
Customer receipt	Receipt	Receipt	Receipt	No Receipt – But vehicle does not have to stop
Installation	Uses manual credit card reader.	Uses self-serve credit card reader.	Uses self-serve credit card reader.	DSRC: antennas mounted overhead on gantry. ANPR: digital cameras mounted overhead on gantry and roadside on pole.
Maintenance	No incremental impact.	No incremental impact.	No incremental impact.	DSRC: antenna adjustments. ANPR: camera cleaning and alignment.
Life Expectancy	Magnetic Stripe Cards: 3 yr average assumed for cards kept in trucks.	Magnetic Stripe Cards: 3 yr average assumed for cards kept in trucks.	Magnetic Stripe Cards: 3 yr average assumed for cards kept in trucks.	Devices: 5-7 yr outdoor electronic device. Controller: 5-10 yr electronic obsolescence. Server & workstations: 5-10 yr electronic obsolescence. Devices at the bridge site will suffer more abuse and damage than at the weigh scale site because of the isolation. DSRC: transponder battery 3-5 yr. (not all transponder types need batteries)

Toll Collection – plus Account Payment				
Criteria	**Manual + Account Payment**	**Self-Serve + Account Payment**	**Self-Serve + Manual Part-Time + Account Payment**	**Electronic Account Payment Used in combination with the other options.**
Operations Activities	Manage AVI device inventory. Account customer service. Account statements. Account payments – customer initiated and pre-authorized.	Manage AVI device inventory. Account customer service. Account statements. Account payments – customer initiated and pre-authorized.	Manage AVI device inventory. Account customer service. Account statements. Account payments – customer initiated and pre-authorized.	Manage AVI device inventory. Account customer service. Account statements. Account payments – customer initiated and pre-authorized. ANPR: image review and plate determination
Communication	Dedicated, continuous very desirable. Dial-up should only be a backup scenario.	Dedicated, continuous very desirable. Dial-up should only be a backup scenario.	Dedicated, continuous very desirable. Dial-up should only be a backup scenario.	Dedicated, continuous very desirable. Dial-up should only be a backup scenario.
Capital Cost	Bridge Site: $121 500.	Bridge Site: $121 500.	Bridge Site: $121 500.	Bridge Site: DSRC $273 500. ANPR $253 500.
	Weigh Scale: $121 500.	Weigh Scale: $121 500.	Weigh Scale: $121 500.	Weigh Scale: DSRC $158 000. ANPR $218 500.
Operating & Maintenance Cost	$46 600. Annual	$46 600. Annual	$46 600. Annual	DSRC: $46 600. Annual ANPR: $49 000. Annual
Recommendation	3rd Choice	2nd Choice	1st At Weigh scale with account payment.	

Exhibit 6-5: Evaluation Summary – Toll Collection plus Account Payment

Violation Enforcement		
Criteria	**Comprehensive**	**Random**
Technology	Digital cameras, front & side images capture, license plate recognition, violation database check. On road apprehension. Admin computer, image storage, & workstation	On road check of proper payment. May require wireless database access.
Effectiveness	Violator determination – high. Violator apprehension – ? depends on personnel available & finding vehicle.	Very effective at finding violators among the vehicles stopped. Number of vehicles stopped depends on personnel availability.
Customer Relations	Paying customers are not inconvenienced.	Paying customers will be stopped when spot check is active.
Installation	Camera mounted overhead on a gantry. Roadside cabinet & controller.	N/a, unless wireless d/b access.
Maintenance	Cleaning, alignment.	N/a, unless wireless d/b access.
Life Expectancy	Camera: 5-7 yr outdoor electronic device. Digital recorder: 5-10 yr electronic obsolescence.	N/a, unless wireless d/b access.
Operations Activities	Manual image review. Vehicle apprehension	Vehicle spot checks.
Communication	Dedicated, continuous	N/a, unless wireless d/b access.
Capital Cost	$122 500.	N/a, unless wireless d/b access.
Operating & Maintenance Cost	$90 000. Annual	$180 000. Annual
Recommendation	Civil provisions for possible future use.	Yes

Exhibit 6-6: Evaluation Summary – Violation Enforcement

For reference, the estimated capital cost assigned to Administration facilities is $100 000. and the estimated annual operating & maintenance cost is $60 500. This is for equipment and software to support the functions evaluated in the preceding tables.

7. RECOMMENDATION AND STAGING

Based on the project background, the operating environment, the available toll technologies, and the range of toll operation concepts presented in this report, IBI Group believes that the following selection of options is most suitable for initial operation of the Deh Cho Bridge.

- ***Vehicle Count and Classification***: Multiple inductive loop installation in northbound and southbound lanes as close to the bridge as possible. GNWT should consider the definition of vehicle categories to facilitate electronic classification.

- ***Toll Collection***: Self-serve kiosk with allowance for Manual (part-time) at a service counter and account payment using a magnetic stripe card for vehicle identification. The collection would likely occur at the Enterprise weigh scale facility.

- ***Violation Enforcement***: Random spot checks conducted on the highway between the bridge and Edzo.

This system definition would provide GNWT with a relatively basic approach, while maintaining a large degree of flexibility. It allows for cash, credit, debit, and account payment right from the start. As drivers gain experience with the self-serve kiosk and companies sign up for accounts, the hours of attended operation can be reduced. All drivers who have paid will have a receipt greatly facilitating the operation of random spot checks for violation enforcement. Additionally, this operation is not dependent on high-grade communication to the bridge site.

Because of the low volume of toll transactions expected, many of the toll processes and devices exist as single entities. It would be desirable to design for redundancy; however, the economics of doubling the quantities is prohibitive. Adding the manual toll point of sale capability in conjunction with the self-serve kiosk provides a level of backup redundancy.

The following exhibit shows a summary of the estimated costs for the initial set of options at either the weigh scale or the bridge site. The total capital cost is estimated at $1 370 000. and the annual operating & maintenance cost is estimated at $660 000. for the initial year. These costs do not include physical roadway construction, or the provision of power and communication to the designated sites.

The estimated revenue from tolls using the projected volume and toll rates given in Section 3 ranges from $3.4 million to $10.3 million during the duration of the concession. Operating costs are therefore approximately 20% of toll revenue. Annual GNWT subsidies to the DCB Concession and the capital cost debt servicing cost are not available to IBI Group.

Potential Solution: Cost Summary

All estimates in Canadian $

	Weigh-Scale Site		Bridge Site	
	Capital	**Operations**	**Capital**	**Operations**
(1) Administration Office				
Administration Office Equipment and Software	$100 000.	$60 500.	$100 000.	$60 500.
(2) Count and Classification				
Inductive Loop	$74 000.	$26 400.	$74 000.	$26 400.
(3) Toll Collection				
Self-Serve Collection w/ Service Counter	$362 000.	$177 500.	$392 000.	$257 500.
Electronic Card Collection (Identity Card)	$121 500.	$46 600.	$121 500.	$46 600.
(4) Enforcement				
Random Spot Check Enforcement	$10 000.	$180 000.	$10 000.	$180 000.
Subtotal (Capital/Operations):	$667 500.	$491 000.	$697 500.	$571 000.
Delivery & Installation (40% Non Software Items)	$107 000.		$119 000.	
Subtotal (Capital + Installation):	$774 500.		$816 500.	
Engineering (20%)	$154 900.		$163 300.	
Project Management (5%)	$38 725.		$40 825.	
Implementation (10%)	$77 450.		$81 650.	
Expenses	$50 000.		$50 000.	
Subtotal System Installation+Integration:	$1 095 575.		$1 152 275.	
Contingency (20%)	$273 894.		$288 069.	
Total Capital Cost:	**$1 369 469.**		**$1 440 344.**	
Maintenance (15%)		$116 175.		$122 475.
Replacement		$50 000.		$50 000.
Total Operations & Maintenance Cost (Annual):		**$657 175.**		**$743 475.**

Exhibit 7-1: Potential Solution – Cost Summary

Subsequent stages in the life of the system could include:

1. An immediate stage for consideration would be additional self-serve kiosks at the Fort Liard weigh scale and possibly at the restaurant / rest area at the turn off to Fort Providence. The Fort Providence location is attractive because drivers could be offered a “last chance” to pay for those who somehow miss the other options.

2. When high grade communication is available, and based on input from the enforcement personnel, a comprehensive Violation Enforcement camera system could be installed at the bridge site. This would change the enforcement activity from general spot checks to targeted vehicle apprehension. Paying customers would no longer be stopped at the random checks. Civil and electrical provisions for this should be included with the initial installation of counting and classification devices.

3. When account payment reaches a significant level, GNWT could consider adding electronic vehicle identification so that drivers could proceed without getting out of their vehicle. The vehicle identification could be read at slow speed while the driver passes through the weigh scale, or at highway speed near the bridge. Waiting for this upgrade will also allow time for potential interoperability with other pending initiatives, e.g. trucks may get transponders for border crossing that could also be read by GNWT.

8. APPENDICES

8.1 Detailed Capital Cost Estimate

Available separately.

8.2 Detailed Operations Cost Estimate (Annual)

Available separately.