

Transportation Partnerships Using an Automated Vehicle Monitoring and Audit System

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ABSTRACT

Saskatchewan Department of Highways and Transportation (SDHT) has been a leader in innovative road and short-rail transportation systems designed to help facilitate efficient commercial transportation to remote northern and rural areas. Over recent years, SDHT has partnered with commercial carriers to allow larger more efficient truck configurations and primary weights on select secondary roads if the carriers employ road friendly vehicle technologies, such as air-spring suspensions and central tire inflation. Under these partnership haul agreements, SDHT and the commercial carrier agree to share in the haul cost savings generated by the increased allowable weights. Presently, haul cost savings are determined manually, which is labor intensive and prone to accounting errors. For the partnership program to be expanded to include additional commercial carriers and public road authorities, such as rural municipalities and cities, a system that automatically determines the allocation of partnership cost savings is required. Furthermore, a system that can automatically monitor the proper deployment of road friendly technologies like central tire inflation will also be needed. Therefore, International Road Dynamics Inc. (IRD) has developed an automated vehicle monitoring and audit system that is specifically designed to assist in the expansion of the partnership program. This paper discusses the needs and benefits of Saskatchewan partnership program and describes the technological features of the automated vehicle monitoring and audit system. This paper also discusses other potential applications of the automated vehicle monitoring and audit system.

1.0 INTRODUCTION

Saskatchewan is a land locked province that is dependent on surface transport to move bulk commodities to export positions. These commodities comprise two thirds of the provinces gross domestic product. In this respect, transportation has a significant impact on whether Saskatchewan industry can compete in national and international markets.

The Saskatchewan surface transportation system is comprised of approximately 198,000 kilometers of two lane equivalent roads. The provincial rail system is comprised of approximately 3,500 km of main line and 3,500 km of branch line, or collector system. The bulk of the traffic on the rail collector system is mostly export grain. Elevator companies and railways are in the process of rationalizing and consolidating their grain handling and transportation system.

Saskatchewan Department of Highways and Transportation (SDHT) has been providing assistance to local producers and communities to establish short line rail service on branch lines threatened with the loss of elevator and rail service. In cases where it isn't feasible to establish short line rail service or in other areas of the province without rail service, SDHT has attempted to improve the efficiency of truck transportation giving due consideration to highway safety and management of the highway system. This initiative has been implemented through the Saskatchewan Transportation Partnership Program.

The objectives of the partnership program are to:

- Support economic development through reducing truck haul costs;
- Provide additional revenue for the highway improvement projects;
- Encourage the use of more road friendly truck equipment;
- Improve highway safety; and,
- Provide a mechanism to manage truck traffic on the highway system (i.e. select optional route, time of year for moving commodities).

The delivery mechanism for the partnership program is an agreement between the department and the shipper/carrier client. These agreements contain details related to the following matters:

- Vehicle configurations;
- Vehicle weights and dimensions;
- Vehicle specifications related to design and load bearing capability of specific components;
- Vehicle operating and maintenance procedures;
- Driver qualifications;
- Vehicle operating cost profiles and the financial obligations related to contributions to the partnership fund; and

- Highway improvement projects.

One of the main principles of the partnership program is that the commercial carrier make a financial contribution towards funding highway construction and maintenance improvement projects. The specific contribution is determined by the difference in trucking costs with and without an overweight and/or over dimension permit. Any incremental pavement or bridge costs are deducted from this difference and the remainder is divided equally between the shipper/carrier client and SDHT. The incremental cost plus half the net difference in trucking cost is deposited in the Transportation Partnership Fund and used for specific highway maintenance and improvement projects. The contribution or fee required from each vehicle is usually based on a loaded vehicle km. The fee varies depending on the gross vehicle weight on the truck and the regulation weight the fee is benchmarked against. At the end of every accounting period the total km for each vehicle must be multiplied by the appropriate fee in order to determine the contribution required for each vehicle operating under TPP overweight/over dimension permits. If the vehicle has traveled on any municipal roads the portion of revenue allocated to each jurisdiction must also be determined.

2.0 NEEDS AND BENEFITS FOR PARTNERSHIP HAUL AGREEMENTS

These partnership agreements allow commercial carriers to carry primary weights on select secondary roads if road friendly vehicle technologies, such as air-spring suspensions and central tire inflation are employed. Figure 1 illustrates three pilot partnership haul scenarios that have been adopted in Saskatchewan. Scenario A allows primary weights on secondary roads which increases haul cost savings by up to 20% with a standard 6-axle vehicle configurations. Scenario B includes the addition of a tridem pup trailer increasing the maximum allowable primary gross vehicle weight to 72,500 kgs, increasing haul cost savings by up to 33%. Scenario C includes the addition of a tridem pup trailer increasing the maximum allowable primary gross vehicle weight to 92,500 kgs, increasing haul cost savings by up to 50%.

Presently, haul cost savings from the partnership program are determined manually from the truck operators' logbooks and invoices. Manual administration of the partnership program is possible if the shipper/carrier client has well-developed automated accounting systems in place. The process becomes more difficult and less efficient when dealing with smaller shipper/carrier clients that do not have sophisticated accounting systems. Furthermore, it is difficult to manually perform compliance audits and identify agreement infractions when they occur. Although large commercial carriers and public road agencies typically have automated accounting and monitoring systems already in operation which improves partnership program administration, there is a clear need to expand the partnership program to include the large number of small to mid-size commercial carriers and smaller public road authorities, such as rural municipalities and cities. As a result, International Road Dynamics Inc. (IRD) has developed an automated vehicle monitoring and audit system to

assist in the widespread implementation of the partnership program. This paper discusses the needs and benefits of the partnership program in Saskatchewan and describes the technological features of the automated vehicle monitoring and audit system specifically designed for the Saskatchewan partnership program. This paper also discusses other potential private and public applications of the automated vehicle monitoring and audit system.

3.0 AUTOMATED VEHICLE MONITORING SYSTEM

An overview of the automated vehicle monitoring and audit system is illustrated in Figure 2 and employs four primary systems: onboard vehicle data collection/storage system, communication network, central administration system, and remote user query systems. The automated vehicle monitoring system has the ability to continuously monitor and sample data from a wide variety of onboard vehicle sensors. All information is transferred to the central administration system and may be queried at any time by the public road authorities and commercial carriers involved in the partnership program. Queries may be in the form of billing invoices, logistics summary reports, audit reports, or user defined special reports. In addition, public road authorities can use the assembled data to perform commercial traffic studies, road use evaluation, regional economic activity studies, and road preservation planning based on truck traffic and/or economic activity.

3.1 Onboard Data Collection/Storage System

The onboard data collection/storage system continuously monitors and samples data from onboard systems such as global positioning systems (GPS), central tire inflation (CTI), and air-spring suspension weight sensors as illustrated in Figure 3. The onboard system samples onboard sensors up to once per minute. Onboard sensor data and driver inputs are stored by the onboard data storage system. The vehicle battery powers the onboard system when the vehicle ignition is on. A battery power system keeps the unit operational without drawing power from the vehicle battery when the vehicle ignition is off. The battery power system is automatically recharged when the vehicle is operating.

Most commercial vehicles employ air-spring suspension systems, which have been proven to provide reduced dynamic loading effects. In normal operation, as the axle load increases, the pressure in the airbag also increases to maintain the same vehicle height. The central administration system can determine the approximate weight of the vehicle according to the pressure in the airbag. The onboard system can be programmed to automatically collect pressure readings whenever the vehicle stops for more than one minute.

CTI sensors are used to monitor the inflation pressures of all tires. The central tire inflation pressure information is used to determine if tire pressures are correctly set in relation to the allowable axle weights. An onboard keypad and monitor screen is installed in the truck cab within easy reach of the driver. The keypad is shock mounted in a rugged, dust-proof housing and is used to enter driver and vehicle information. This information is

automatically stored to cross reference all sensor data stored by the onboard unit. Several standard user defined messages can also be pre-programmed into the keypad to help facilitate efficient communication and data storage. As well, the onboard keypad can be used to send messages to the central dispatch or other vehicles within the fleet. For direct voice communications, cellular phones can also be integrated into the onboard system.

3.2 Central Administration System

The primary function of the central administration system is to create and maintain a truck fleet database, perform compliance audits and billing, and to summarize data for user defined queries. The central administration system uses an Oracle database and is operated and maintained by the system administrator. The central administrative system stores data from on-board data collection systems for 90 days from time of receipt. However, the central administration system's storage capacity can be expanded to accommodate additional data and/or onboard inputs as required.

Because many public road authorities employ a geographic information system (GIS), the automated vehicle monitoring system is designed to interface with industry standard GIS systems to provide highway names and section locations referenced by GPS coordinates. Based on the highway identification and chainage, the central administration system can determine truck routing and the corresponding road usage and display this information graphically. When integrated with GIS, each vehicle trip can be traced to specific routes and automatically assign road usage and revenue generation allocation.

The central administration system maintains a comprehensive database with which the public road authorities and carriers can easily obtain historic information based on user-defined queries. For example, the database can be used to determine the revenue generated by each highway according to season, the comparison of highway usage according to jurisdiction, the frequency of road usage, and so forth. The central administration system employs simplified windows based screens, point and click commands, and drop down menus to help facilitate user queries and report generation. The prototype system employs five main menus:

- Reports: daily non-compliance, monthly routing for invoicing purposes.
- Audit: information checks on an as-needed basis.
- Configuration: permit rates according to season, company information, vehicle information.
- Editing: to enter missing data or to correct data.
- Registration: to register new companies, trucks and other identifiers.

The central administration system performs regular quality control and quality assurance checks on all data incoming from the onboard units. In case of any data inconsistencies,

discrepancies or system failures, the central administration system produces a warning report and identifies the specific problem.

3.3 Communication Network

The automated vehicle monitoring system employs a communication network to transfer data from the onboard units to the central administration system and onto remote query systems employed by public road authorities and commercial carriers as shown in Figure 4. Once per day, the data stored by the onboard units is downloaded to the central administration system. This transmission is over circuit switched cellular network and can be programmed to transfer data only during off peak hours to minimize transmission costs. During a normal day of operation, approximately 50 kilobytes of data is collected by each onboard unit and can be transmitted less than ten minutes. In the case of congested data transmission from a fleet of onboard units, the units may be programmed to occur over a period of two or three hours. If transfer problems occur, the units automatically retry transmission up to four times per night.

The central administration system is connected to the cellular network via a high-speed internet data line. This internet line has a capacity of transferring 1.5 megabytes per second resulting in a download time from a fleet of 1,000 vehicles in less than 30 minutes. Remote terminals are connected to the central administration system for commercial carriers and public road authorities to extract data to perform audits, print reports, and perform other specialized functions specified by the partnership agreement. Communications to all public road authorities and commercial carriers are via a secured, restricted internet link.

Enhanced features of the communication network include real time two-way messaging, real-time vehicle tracking, and other communication methods for remote region operations such as satellite modem, cellular data packet and trunk radio.

3.4 Remote Query Systems

Remote query systems provide the ability for commercial carriers and public road agencies to generate different types of reports including vehicle routing, non-compliance, and audit reports. Routing reports are provided for billing and revenue allocation purposes and may include a summary of trips with a daily breakdown with respect to primary, secondary and municipal roads by route number, section number, and public road authority. Usage can be provided across commercial carriers and road authorities by truck and/or road section.

Non-compliance reports can be created daily and may be viewed or printed from remote query systems. Trucks with non-compliance infractions are grouped according to carrier, with one report issued for each carrier. Non-compliance reports, as shown in Figure 4, may include such information as:

- No driver identification/invalid driver identification.

- No configuration/invalid configuration.
- Speeding.
- Overweight.
- Excessive tire pressure corresponding to the specified weight and road section.
- No data received (unable to communicate with communications network).
- Malfunction of onboard units (sensors not working properly).
- Non-highway location (truck location is not on a highway).
- Permit violation (such as period of travel limitations).
- Time stamp.
- GPS coordinates (highway name and chainage).
- Onboard vehicle sensor information (tire pressure, axle weights, etc.).
- Truck specific information (configuration, suspension type, etc.).
- Total usage of non-compliance criterion.

For confidentiality, commercial carriers are not able to access information on other carriers and public road authorities are not able to query data regarding other road authorities.

4.0 OTHER SYSTEM APPLICATIONS

The primary advantages of the IRD automated vehicle monitoring and audit system is its reduced communications costs relative to other commercial tracking systems and the inherent flexibility for diverse fleet management applications. As a result, the automated vehicle monitoring and audit system can be readily customized for small to mid-size fleets in both public and private sector applications. These applications include: near real time vehicle tracking, dispatch and communication, traffic generation/destination studies, road preservation operations management, traffic data collection, onboard system monitoring, fleet logistics administration, and cargo tracking.

5.0 SUMMARY AND CONCLUSIONS

SDHT is investigating the use of partnership haul agreements to allow commercial carriers to employ larger configurations and to carry increased weights on select secondary roads if road friendly vehicle technologies such as air-spring suspensions and central tire inflation are employed. Within these agreements, SDHT and the commercial carrier agree to share in the incremental haul cost savings generated by the increased allowable weights. Although the partnership program shows the potential for significant benefits (up to 50% reduction in haul costs), current manual methods for determining haul cost savings is labor intensive and prone to accounting errors. Given the required administrative effort necessary to effectively facilitate the partnership program, many small to mid-sized carriers and public road authorities may not have the administrative resources to participate in the partnership program. Therefore, if the partnership program were to be expanded to include small to mid-size carriers and public road authorities, it would be difficult to accurately quantify and allocate partnership haul cost savings and to enforce the partnership program. As a result,

the IRD automated vehicle monitoring and audit system has been developed to provide the enabling technology to facilitate the widespread implementation of partnership program. In addition to administering partnership haul agreements, the reduced communications costs and inherent flexibility of the automated vehicle monitoring and audit system renders the system applicable for several other private and public sector fleet management applications.

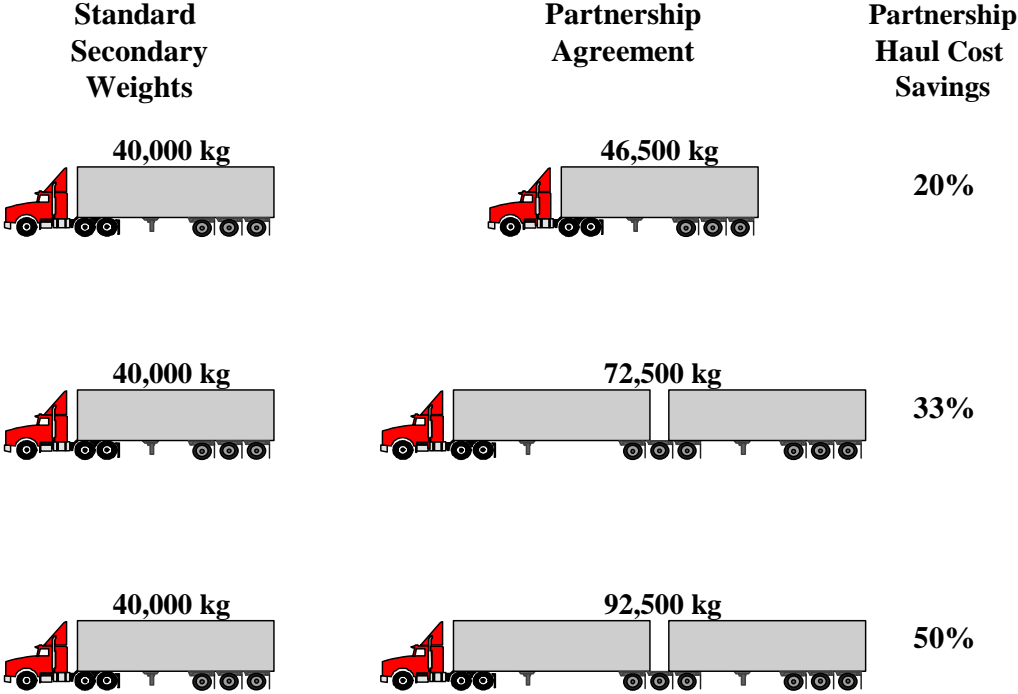


FIGURE. 1. Partnership Haul Cost Savings

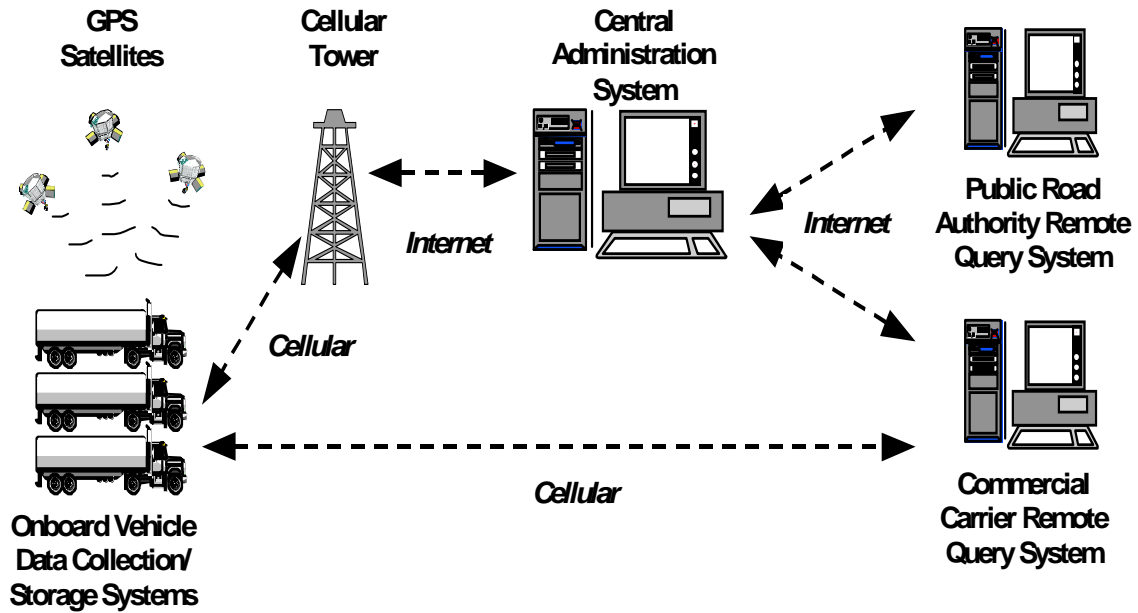


FIGURE. 2. System Overview

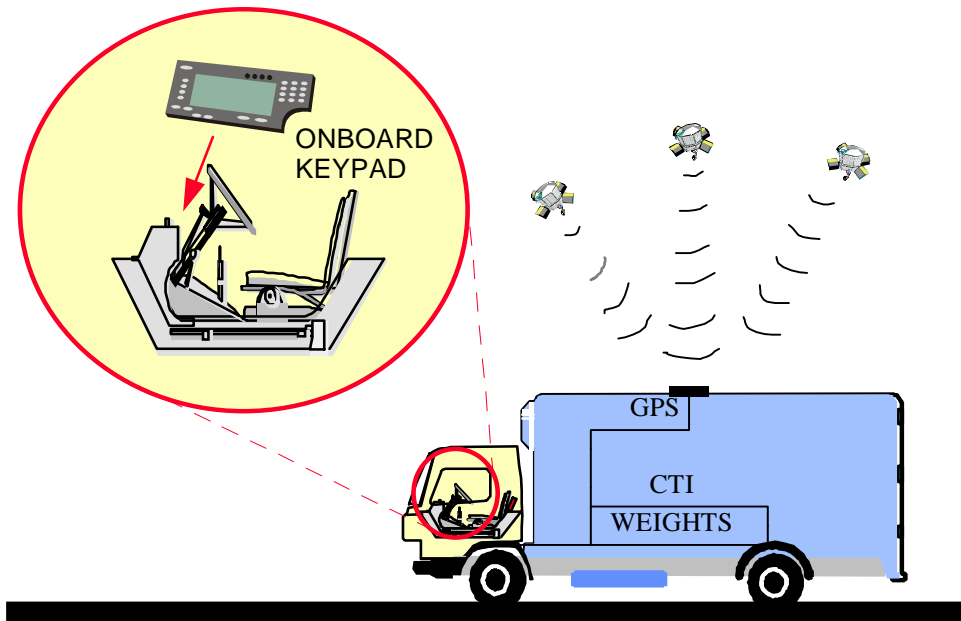


FIGURE. 3. Onboard Data Monitoring System

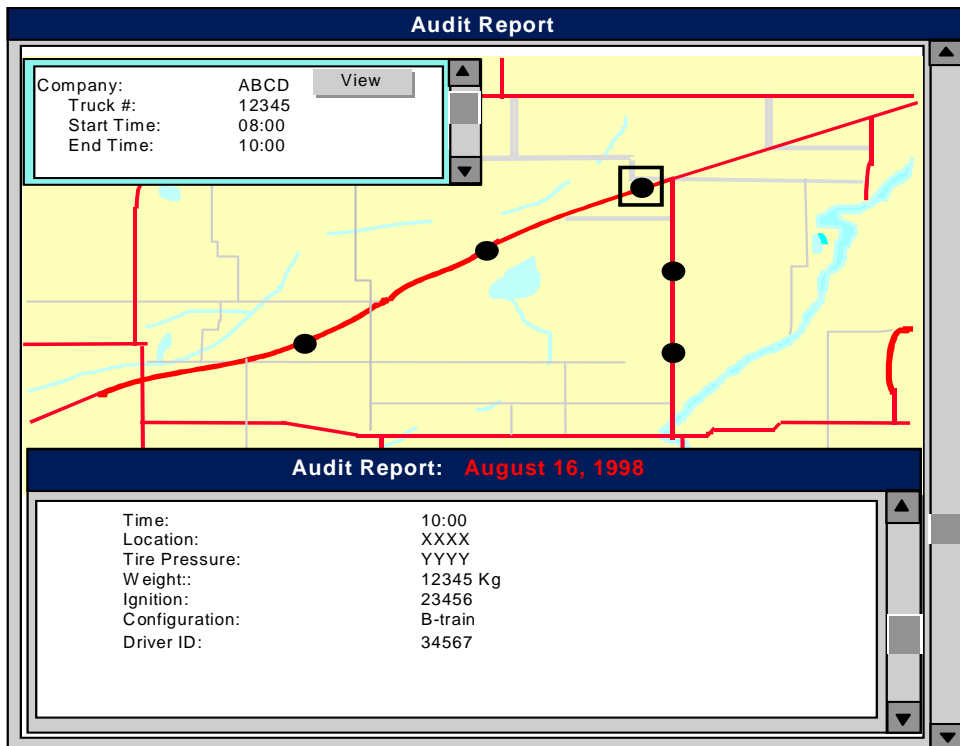


FIGURE. 4. Example GIS Based Compliance Report