THE ALBERTA WIM/AVI

INTERFACE DEMONSTRATION

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DEMONSTRATION

ABSTRACT

In response to some of the issues and concerns revolving around the trucking industry, Alberta Transportation and Utilities has sponsored a two-phase study to install and evaluate the performances of weigh-in-motion (WIM) and automatic vehicle identification (AVI) devices. The WIM equipment that will be tested include a piezo cable sensor type and a capacitance strip type; for the AVI, a video camera-based system and a microwave transponder system will be examined separately. The first installation is scheduled for mid-June with the final evaluation to carry through to next spring. The WIM that is deemed to be the best of the two will be interfaced with the two AVI systems at two permanent operational sites. The successes and problems associated with integrating the two technologies will help to define and develop a stand alone system for practical applications in a truck-oriented environment. This paper describes the detailed plans of the demonstration program; the report on the project progress will be contained in the oral presentation.

1.0 INTRODUCTION

1.1 Objectives

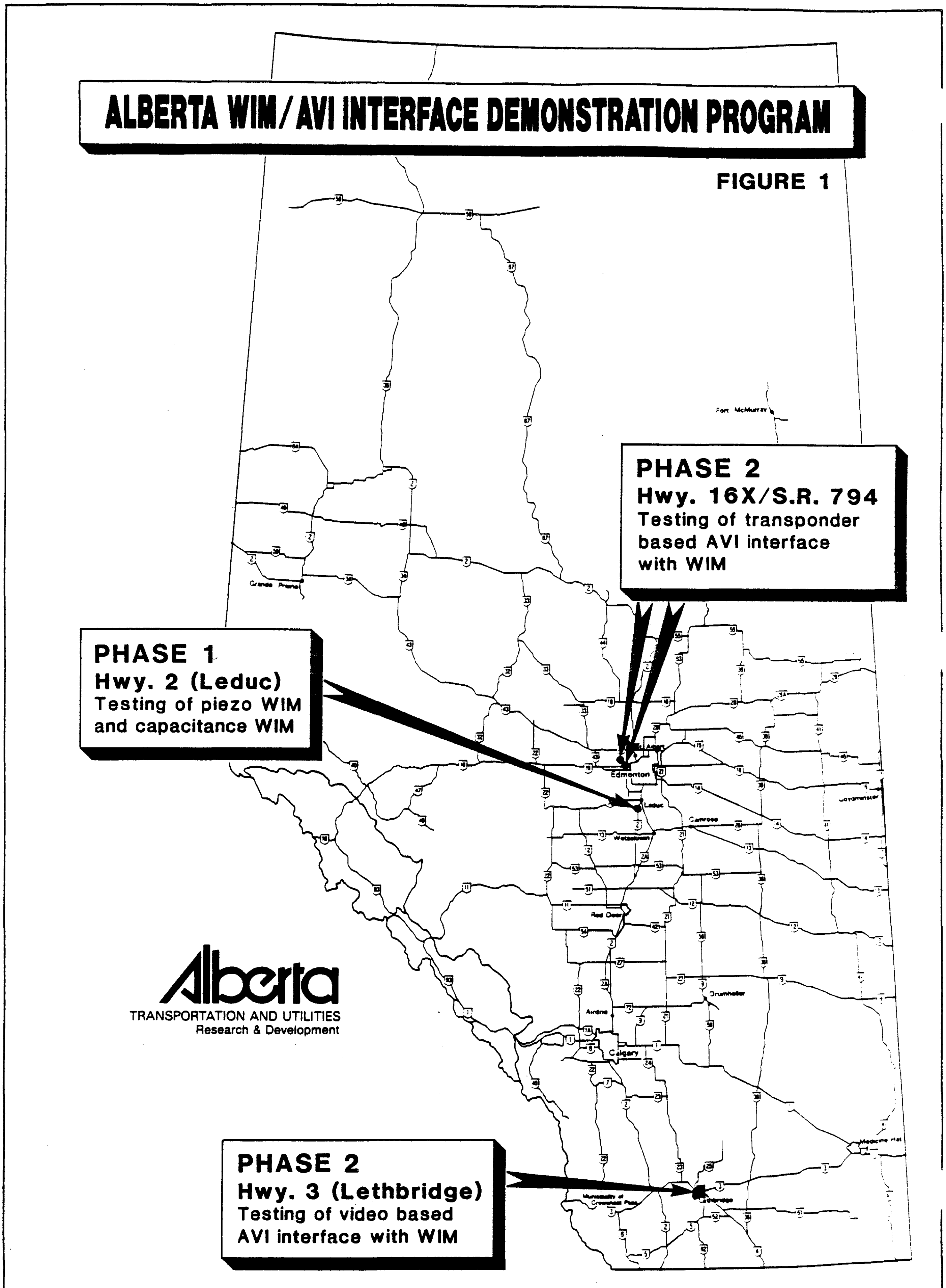
The very essence of this demonstration can be described in two stages. In Phase One, the goal is to determine if the advances in weigh-in-motion (WIM) technology have come of age, and if the new low-cost WIMs have attained accuracy approaching that of the static scales. Complementary to the WIM technology is the automatic vehicle identification system or AVI as its acronym, which will be the focus of research in Phase Two. The second goal is to demonstrate a workable AVI system with an acceptable rate of errors and a functional interface with the WIM system. The final result will culminate in a fully merged package so that the end users (who in this case are the trucking industry regulators) will be able to adopt it as a production system for broader applications.

Along the way, there will be other objectives. Two different types of weigh-in-motion equipment will be under scrutiny - the piezo-based and the capacitance-based types. Accuracy will be the main criterion; but costs, durability, and flexibility in hardware and software will also be judged for the best results. (It will take longer than the slated two months of testing for Phase One to answer the question about durability.) At the conclusion of this demonstration, it is intended that minimum performance specifications for future WIM installations are identified.

The AVI system will also come in two varieties - one a video camera-based and the other a microwave transmission-based system. Another objective is to determine which of the two technologies will offer the most in accurate detections and reliability while being cost effective. From this, a platform of standards for future AVI systems will be built.

1.2 Background

Technical and not-so-technical issues in the commercial vehicle scene have recently come into the limelight, as underscored by some of the more notable events: the RTAC/CCMTA sponsored Heavy Vehicle Weights and Dimension Study and the implementation of the National Safety Code across Canada. The theme that prevailed through much of the discussions centred around how to increase the efficiency of truck transport while at the same time enhance safety and protect the infrastructure. In recognition of these and other pressing developments, Alberta Transportation and Utilities have created an intra-departmental task force to review and recommend actions that will allow the department to be at the forefront of solutions to these issues. One mission is to explore the possibility of developing a prototype integrated system of weigh-in-motion and automatic vehicle identification for Alberta Transportation officials to use for monitoring and enforcement purposes. With the direction leaning more and more towards a "de-regulated" and self-governing environment, the government will need in place the state-of-the-art equipment to ensure that no intentional or unintentional compromises are being made.



ALBERTA WIM/AVI INTERFACE DEMONSTRATION PROGRAM
FIGURE 1
PHASE 2
Hwy. 16X/S.R. 794
Testing of transponder based AVI interface with WIM
PHASE 1
Hwy. 2 (Leduc)
Testing of piezo WIM and capacitance WIM
PHASE 2
Hwy. 3 (Lethbridge)
Testing of video based AVI interface with WIM
Fort McMurray
Grande Prairie
Edmonton
Leduc
Camrose
Wetaskiwin
Red Deer
Drumheller
Airdrie
Calgary
Medicine Hat
Lethbridge
Alberta
TRANSPORTATION AND UTILITIES
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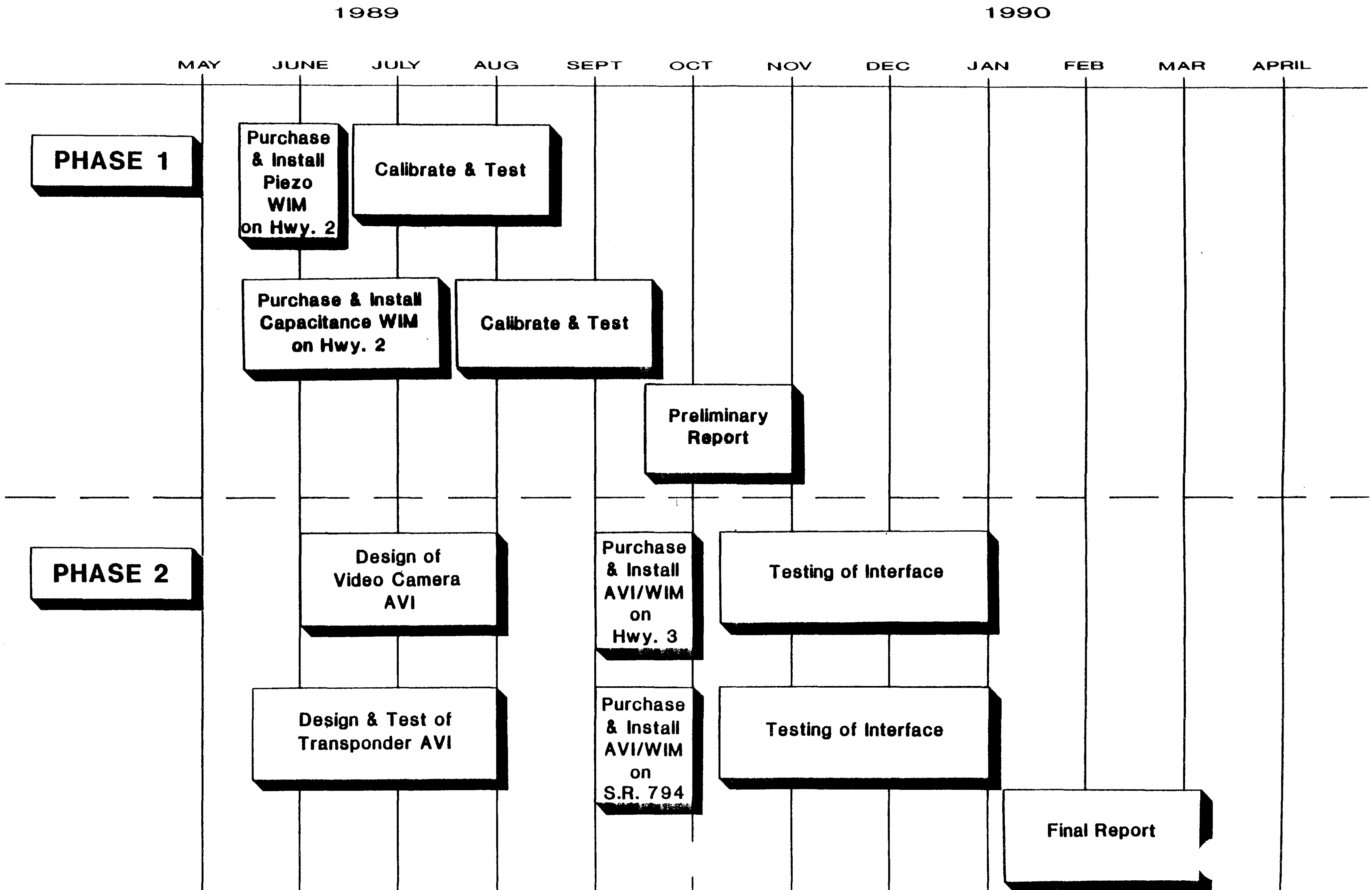
The timing of this project has never been better; there are new technology breakthroughs in the market which have the potential of reducing the price barrier to such a degree that the road authority may be able to afford a blanket coverage of WIM/AVI systems. In fact, Alberta may be one of the first in Canada, if not in North America, to test some of the new equipment and the interfacing aspect. The Alberta experience will augment testings that are underway or being contemplated across Canada and the United States: the HELP project and the associated Crescent Implementation program in the U.S., and the Manitoba monitoring program which may use the WIM technology to fulfil the data-gathering requirements of C-SHRP. The project will give Alberta an opportunity to learn first hand about the technologies involved and be able to exchange and furnish new information on the system performance in a colder climate setting.

The work plan is formulated in the same manner as the development of the key objectives mentioned earlier. Some work in each phase will be initiated independently, but the overall flow will be a continuum from the completion of Phase One into the start of Phase Two (Figure 2). Many important questions will have to be answered in the earlier phase before the next one can begin.

WORK PLAN SCHEDULE

FIGURE 2



2.0 Phase One - Testing of Two New WIM Technologies At Leduc

2.1 Weigh-In-Motion Technology

The technology has been established around the world for several decades now, and while it is considered to be mature, there is still room for improvements. For one, the weighing errors inherent in various WIMs continue to be a major obstacle to the system's effectiveness from an enforcement perspective. It has traditionally confined the application of WIMs to population data collection and as a sorter scale in advance of a static scale operation. In response to this accuracy problem, the industry has only been able to improve the situation through the sacrifice of economy or efficiency; the former is exemplified by the heavy price tag of a deep pit load cell scale, and the latter belongs to those WIMs that require vehicles to travel at very low speeds on an off-highway pad.

It is therefore exciting news when the industry now claims that low-cost WIMs can perform just as well as the expensive counterpart at highway speeds, for a fraction of the deep pit scale cost. Outwardly, the installation involves no more than simply embedding classification loops and sensors into the pavement. The two candidate systems are both similar in a major way, that they both rely on the physical/electrical response of a certain material when subjected to a load. Where the differences lie are in the sensitivity of the material to the corresponding stress, and the way the manufacturer software interprets the output signals from the sensors.

2.2 Installation

The test site selected for both WIM systems is located on the southbound outside shoulder lane approaching the exit into the Leduc VIS or Vehicle Inspection Station (Figure 3). The distance is approximately 200 to 250 m from the exit taper. While the trucks may not be travelling at the legal maximum speed of 100 km/h over the sensors due to the proximity of the exit, a preliminary study showed that the speeds will be between 70 to 100 km/h which will allow a test of the sensors under varying speed conditions. The sign which informs all truckers to report to the station is about 150 to 200 m north of the WIM sites, so there should be very few late lane changes over the sensors. The road section is basically straight and level , and the pavement consists of eight year old asphaltic concrete. Some transverse cracking exists through the chip seal coat; but otherwise, surface undulations are at a minimal.

The biggest advantage of locating the systems near a VIS is to be able to use the static scale for direct comparisons. One other consideration was that an IRD (International Road Dynamics) plate WIM that was installed back in 1982/83 as a sorter scale is also located nearby on the off-ramp to the station; a comparison with this particular WIM may prove interesting.

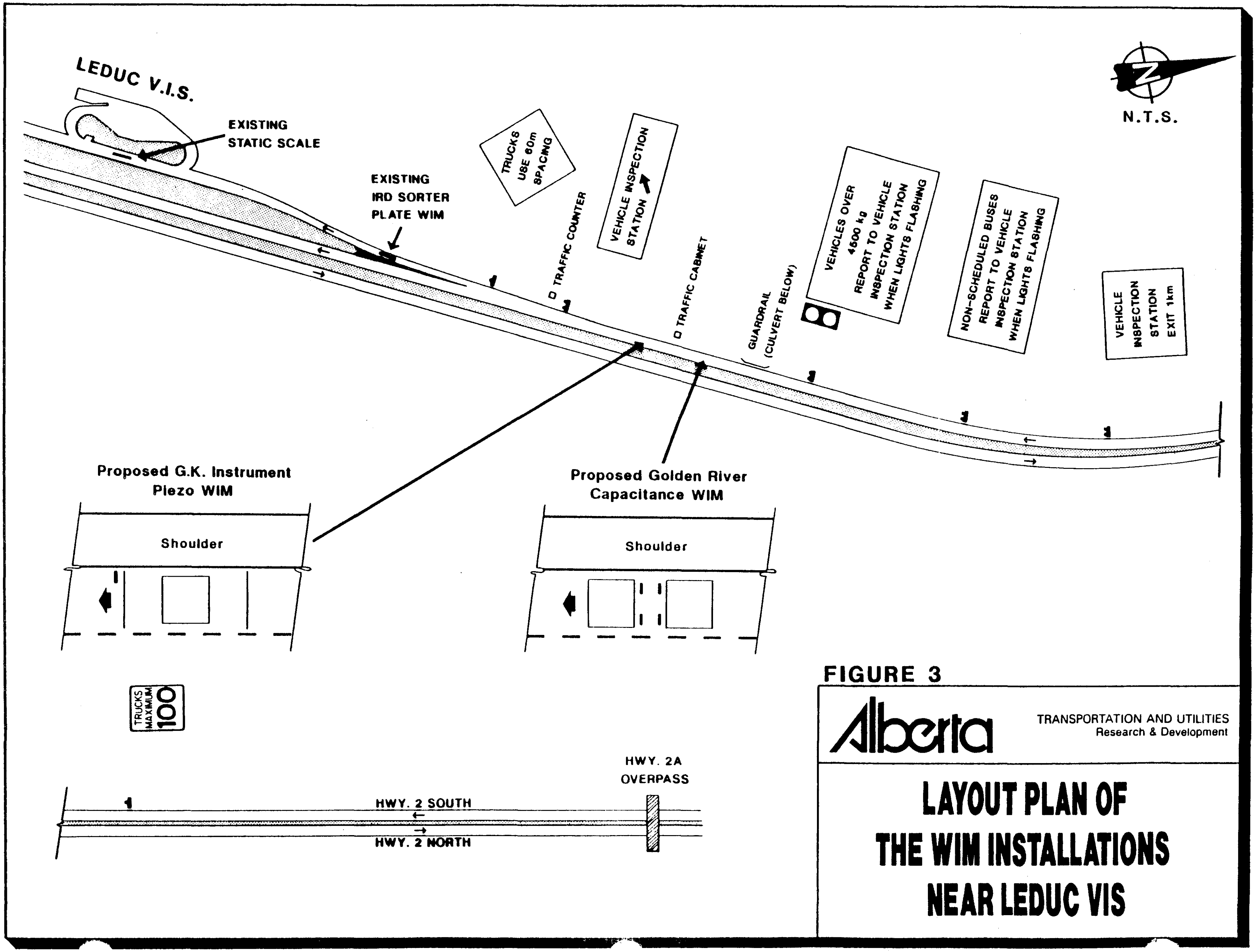


FIGURE 3

LAYOUT PLAN OF THE WIM INSTALLATIONS NEAR LEDUC VIS

2.2.a Piezo-based Weigh-In-Motion System (G.K. Instrument)

The heart of the system lies in the piezo-electrical property of the ceramic material. When subjected to stress, as in axle loadings onto the pavement, the ceramic material discharges an electrical current and this current varies as a function of the applied stress. Vibracoax, manufactured in France, is a commercially available coaxial cable that makes use of this phenomenon. Through the use of common conductors, the electrical charge is carried from the sensor to the instrumentation. The traditional use of these piezo cables has been in the field of vehicle classification. In the design of the G.K. Instrument sensor, the cable is actually embedded into a rubber-filled aluminum extrusion shaped like a "U" channel (Figure 4).

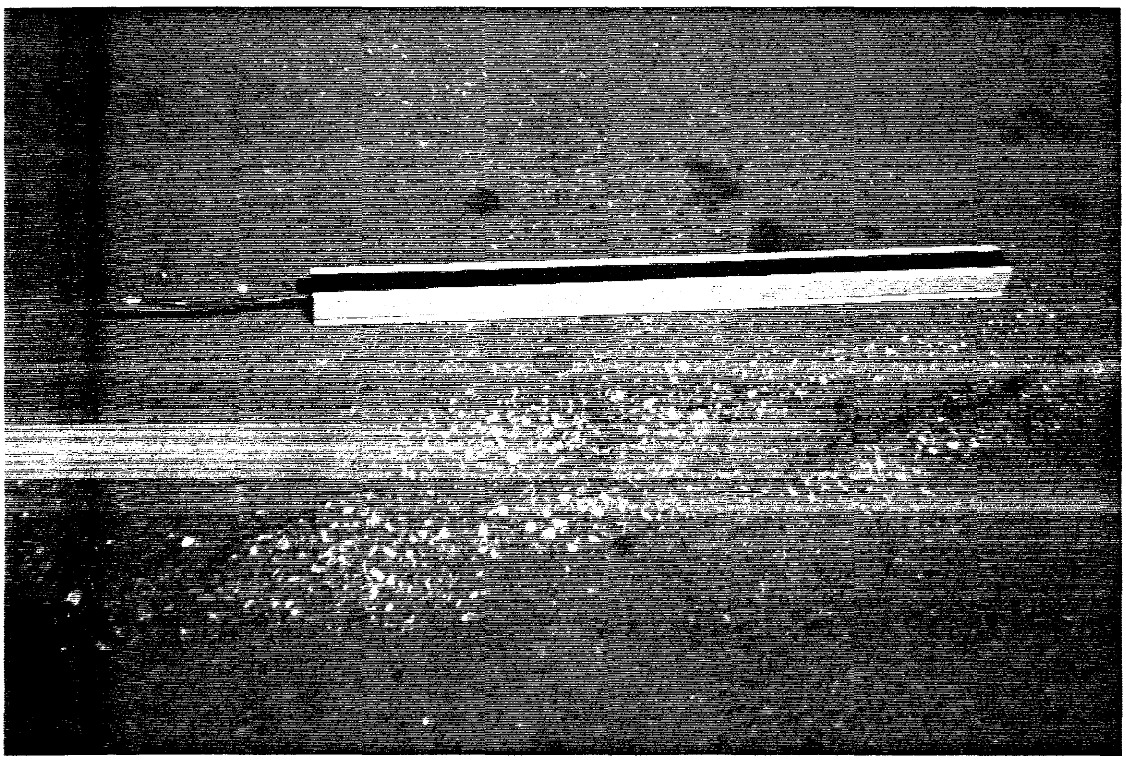
For the standard configuration, two piezo full length sensors (3.5 m) will be laid perpendicular to the traffic flow. A loop detector located between the two parallel sensors is for vehicle detection. In addition, an off-scale sensor is to be included to ensure the vehicle being weighed is not in the middle of a lane change. It is noted that temperature sensors will be installed for software adjustments, in response to severe pavement temperature changes. The entire installation will encompass 6 m of road length (Figure 3).

The cables will feed into the 6000 series AWACS Recorder (Automatic Weight and Axle Classification System). A Data Module will collect and store the data for approximately one week, after which an operator from the office will download the data directly onto a laptop microcomputer on-site. It is expected that for future applications, telemetry (via telephone and modem) will be the medium for data-gathering. Solar panels and rechargeable batteries will be the source of power for the test site.

In the office, vendor software will then aid in analyzing the raw data and produce classifications, counts, gross vehicle weights, single axle weights, tandem axle weights and tridem weights for total population. For each individual vehicle, data will include time of arrival, speed, classification, gross vehicle weight, individual axle weights and axle spacings. The software will have the FHWA 13-class classification system for identifying vehicles.

The expected delivery time for this product is in around the middle part of June. One and possibly two days will be the anticipated need for the the on-road installation. All the saw-cutting, epoxy laying and electrical trenching/wiring work are to be done by the Alberta Transportation crew, as well as the provision of materials, tools, and cabinet, and traffic control. A representative from G.K. headquarters in United Kingdom will be on hand to ensure the cables are placed according to specifications. It is expected that departmental staff will perform future installations independently.

Figure 4 - Piezo-electric Sensor



2.2.b Capacitance-based Weigh-In-Motion System (Golden River)

Similar to the piezo system, this particular system utilizes the relationship between pressure and electrical properties found in capacitors. In the Golden River system, the capacitor is charged with a certain electrical potential; when a force from the axle load is exerted onto the sensor, it will cause a change in that potential. The sensor itself consists of the capacitor built into a strip that is about 50 mm wide and 5 mm thick.

The test configuration will have four one-metre long sensors embedded in one lane. As a minimum installation, two sensors are usually placed one after the other on one side of the wheel path. Presumably, the sensors measure only half the axle weight, and it is left for the software to double the amount to arrive at the figure for the complete axle. Having the second set on the other half of the wheel path supposedly improves the axle weight calculations because any unbalanced loading would be accounted for. One of the objectives will be to compare the accuracy of using the two sensors versus four. The other required part of the installation will be the two inductance loops, one upstream and another downstream of the sensors for the purposes of vehicle detection and speed readings (Figure 3). The total length of roadway needed will be around 6 - 7 m, and the installation will be north of the G.K. site.

A Marksman 600-WIM will house all the necessary electronics and software and processing capability to collect and analyze the data signals from the sensors and loops. It has a 512 kilobyte memory cartridge for storage; for the study, an operator with a laptop will be used to download the data from the cartridge while at the site. In future permanent installations, a modem and telephone line will permit data transfer via the telephone system. For the source of power at the Leduc site, solar energized batteries will be installed.

The type of data collected will be very similar to those of the G.K. system. Some additional features include three possible classification systems - FHWA (American), Australian, and European; the initial attempt will use the FHWA system. As well, ad hoc reports can be generated by user fields.

All sublet contract work for saw-cutting and electrical work will be the responsibility of Trafco of Edmonton and Golden River. An engineer from the U.K. may visit the site when installation begins. Like a turnkey project, Alberta Transportation will essentially receive a finished product at completion, and will only need to supply traffic control. The expected delivery schedule is between July and August, which means it will go in after the G.K. system. The installation time is also one to two days.

2.3 Testing

The first series of tests essentially involves calibration of the system to weed out the systematic errors. Afterwards, verification of the WIM outputs through the use of static scale readings taken at the inspection station, will be performed. One of the prime objectives is to obtain the accuracy rating of the new WIMs, which would dictate the usefulness in any particular application, be it for monitoring and compliance or for enforcement purposes. Aside from this, there is also the ability to compare directly the sorter plate WIM with these newer systems.

The WIMs are laid out adjacent to each other on the same lane so as to obtain the same vehicle data going over both systems. The intention is to compare the accuracy rates between the WIMs and then to select the best one for use at a permanent operation site.

The amount of time needed for gathering and analyzing the data is approximately two months (towards September) depending on what unforeseen problems with the equipment may develop, and how quickly the vendors can rectify these. It should be noted that from experience by others with in-laid sensors that asphalt pavement, being a highly flexible medium, may affect the long-term performance of these WIMs. The two months of traffic exposure may not be adequate to address this question properly at the end of Phase One.

2.3.a Comparing Classifications

A manual truck classification count, based on the FHWA classification system, will be done while the trucks are stopped at the VIS for weighing. At least 100 samples will be obtained for each type of classification. Correlation of the manual data with each of the WIM's tabulations (including the IRD scale) will be made. All the data can be input into a microcomputer spreadsheet program for comparative analysis of the errors.

2.3.b Comparing Speeds

A radar speed study will be performed while the classification count is being carried out. On a real-time basis at the site, one operator with a laptop computer will be monitoring the WIM data for the passing trucks, while doing the radar speed recordings. Another person will operate the second radar near the IRD scale. Ideally, the radar readings will be taken only during or right after the vehicle has traversed over the WIM itself. About 100 samples per WIM will suffice. The speed distributions can be compared using the paired sample method which calculates the mean and standard deviation of the differences.

2.3.c Comparing Weights

The weighing errors of any WIM are inherently very sensitive to the speeds of the vehicles; therefore, it becomes important to sort out the comparative weights based on some sort of speed intervals, say 51-60 km/h, 61-70, 71-80, and so on. A criterion will be set up to screen out some of the empty units so as to not overload the station operators with manual measurements.

The paired sample method will also be used to assess the accuracy statistics. A 100 samples of a cross-section of various truck classifications under the applicable speed group would be strived for, depending on time constraints. Tabular and graphical plots of the differences in data can be used to present the results. The objective is to produce an accuracy value for the different weights at a specified confidence level (say 95%) and the associated standard deviations.

2.3.d Comparing Axle Spacings

In addition to recording the various axle configuration weights, the scale operation will also permit a check on the accuracy of the axle spread readings. Similarly, the results will be analyzed using the paired sample technique.

3.0 Phase Two - Interfacing Two AVI Systems With The WIMS

3.1 Automatic Vehicle Identification Technology

The origins of AVI can be traced back to the initial application of monitoring train movements on rails. The progression of the technology from the railway to roadway is natural, but not without some of the pitfalls. In the railway's case, the vehicles are restricted to the travel way and more often than not, the vehicles are owned by the company that also owns the rail tracks. This greatly simplifies the technology needed and the political process of implementing the system. The first generation of AVI is rapidly improving in getting over the technical hurdles of the "uncontrolled" road-vehicle environment. One such system is the transponder-based system made by AUSTEC of Edmonton, an offshoot from the railway variety; another is a visual image system that utilizes state-of-the-art cameras that were not available a few years ago.

For Phase Two to be successful, at least one of the two AVI systems should function with a high degree of accuracy, and that an interface can be established between the AVI and the WIM equipment.

3.2 Installation

3.2.a Video-based Automatic Vehicle Identification (ADEC Systems)

This is a video based system comprised of a closed circuit television (CCTV) and an interface that is capable of accepting signals from the WIM equipment and then superimposing the relevant data onto the video images. The "eyes" of the system are a high resolution, high shutter speed camera with low lux capability to provide surveillance during low light conditions. Considerations will be given to site illumination at a later date; however, the ideal 24-hour monitoring target may still not be feasible due to inclement weather conditions.

The camera will be located at some distance downstream from the WIM sensors, housed in a weatherproof compartment and aimed to focus onto the front end of a typical truck. The focal point will be a tradeoff between getting a high resolution picture of the license plate details and getting a large enough of an area that will contain the license plate. The other major component is the computer processing unit that will retrieve the raw data from the WIM equipment and combine it with the video data (Figure 5). The recordings are based on real-time lapse shots of vehicles; that is, the camera will only be triggered on when the vehicle is over-weight according to a certain formula of axle loads and gross loads (as will be recommended by Motor Transport Services). The medium for the storage of the combined video-WIM data has not been decided yet. For the WIM data itself, it will be downloaded to central office via a telephone connection.

Figure 5 - A Possible Video/WIM Interface

Once it has been determined which WIM being tested from Phase One is best suited for permanent installation, the selected WIM will be re-installed (leaving the sensors and loops behind) on Highway 3, west of Lethbridge, along with an integrated ADEC system. This will be a double lane installation on the westbound lanes of the divided highway. The projected schedule for installation is in August or September depending on the completion date of Phase One. ADEC will be contracted to install their system right from the interface at the cabinet to the pole where the camera sits. Note that a permanent source of power and telephone link-up will be a necessity in a fully operational setting.

3.2.b Transponder-based Automatic Vehicle Idendification System (AUSTEC Electronic Systems)

Utilizing the technology of microwave transmission, the concept of the system is to have a transponder or an "electronic tag" located in the vehicle which will respond to a roadside interrogator unit. The transponder is a self-contained tamper-proof unit that has a built-in memory of identification unique to the specific vehicle it is installed on. It remains dormant until the vehicle comes within close proximity of an antenna in the roadway, which acts as a trigger through its transmission of a microwave signal. Once activated, the transponder sends a coded message to an interrogator, and it is there that the information gets decoded and stored.

AUSTEC Electronic Systems of Edmonton is currently refining some of the electronics involved in this technology. The contract will call upon them to develop an appropriate interface with whatever WIM that will be chosen. Some initial testing by the manufacturer is underway on a service road next to Highway 16X. When Phase Two actually begins, the AUSTEC interrogator and antenna system will be placed at another permanent site on S.R. 794, and will be tieing it in with one of the WIMs (from Phase One). The new site is a two-lane undivided facility, and both directions of travel will have an antenna.

One of the distinct disadvantage of this system as opposed to the camera system is that it will require "voluntary" participation from the trucking operators. The trucking industry will be contacted by Motor Transport Services for participation in this part of the project. It is hoped to have at least twenty transponders on various trucks for the demonstration.

3.3 <u>Testing</u>

3.3.a Video System

The most relevant attribute will be the clarity and definition of the video images of the license plates taken at highway speeds and during poor ambient conditions. How much zooming, how much lighting, and what problems will develop under rain or snow conditions will be operational questions that may have to be resolved.

Storage and communication of the data, and how accurate the interface is with the WIM system are also important technical issues that will be addressed. To evaluate the accuracy question, an on-site separate camera will be manned to record the truck samples and correlate these with the on-line WIM readouts. This will ensure capture of any misses and erroneous recordings that may be made by the ADEC system.

3.3.b Transponder System

In order to verify the correct detection of all transponders, the operators of the truck units will be asked to record the times and direction of travel as they drive by the test sites. One of the main concerns with the system is its ability to function properly under wet and snowy pavement conditions. Therefore, the test is expected to last at least through the first winter period.

4.0 APPLICATIONS

As hinted early on, the real story will only begin to unfold at the completion of Phase Two. At that time, a glimpse into the kind of possibilities that an integrated WIM/AVI system will bring will have been achieved. By default due to the nature of the older WIM technology, the typical application has been to use it only as a sorter scale. While it is expected that the new WIMs will be able to fulfil this task, the broader vision is for the new WIM/AVI to outgrow this typecasting.

One feasible proposal is to build many of these systems at strategic locations along the main highway routes for monitoring of the compliance rate. Alternatively, automated VIS can be constructed; coupled with "smart card" systems, the station would be unmanned and would provide the truckers with many of the services that a manned station would have. Savings in manpower would be enormous and this could lead to more "automated teller machines" around the province for a greater coverage. Other special applications in the area of commercial vehicle include monitoring of hazardous material transport, and fleet management which is already being used by some American truck firms. Lastly, there will be even more benefit on the horizon for the road authority, in terms of data assimilation for pavement design and transportation planning, and in terms of traffic surveillance and control for traffic management systems.